July 2019

Feasibility, Acceptability, and Preliminary Efficacy of an Academically-Integrated Physical Activity Program on Classroom Behavior in Preschoolers

Sarah Burkart
University of Massachusetts, Amherst

Feasibility, Acceptability, and Preliminary Efficacy of an Academically-Integrated Physical Activity Program on Classroom Behavior in Preschoolers

A Dissertation Presented

by

SARAH A. BURKART

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2019

Department of Kinesiology

Feasibility, Acceptability, and Preliminary Efficacy of an Academically-Integrated Physical Activity Program on Classroom Behavior in Preschoolers

A Dissertation Presented

by

SARAH A. BURKART

Approved as to style and content by:

_____
Sofiya Alhassan, Chair

_____
John Sirard, Member

_____
Elizabeth Harvey, Outside Member

_____
Lisa Keller, Outside Member

_____
Jane Kent, Department Chair
Department of Kinesiology

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Sofiya Alhassan, for her support, feedback, and guidance over the past six years. I would also like to thank my committee members Drs. John Sirard, Lisa Harvey, and Lisa Keller for their advice and help in shaping this dissertation project. Each of them has helped me to grow and develop as a researcher over the years.

I am so grateful for the support from faculty and fellow graduate students, and most importantly for the friendships that developed in the Totman hallways. I would also like to thank the members of the Pediatric Physical Activity Lab and the Physical Activity and Health Lab for their friendship and support, which truly made the past six years a wonderful experience. I would especially like to thank my lab mate, Christine St. Laurent, for constantly supporting, inspiring, and laughing with me these past five years.

This project would not have been possible without our community partners, UMass Center for Early Education and Care, Children's House, and YMCA Learning Center in Wilbraham. Preschool center directors, teachers, staff, and families were a pleasure to work with on this project. I would also like to acknowledge the American College of Sports Medicine Foundation, the North American Society for Pediatric Exercise Medicine, and the UMass Graduate School for funding this dissertation project.

Finally, I am eternally grateful to my family and friends who have stood by my side every step of this journey. My parents have given me the world and I truly appreciate the sacrifices they have made to get me to this point. I'd also like to thank my fiancé, Bryan, who reminds me to take a step back and enjoy the ride.

ABSTRACT

FEASIBILITY, ACCEPTABILITY, AND PRELIMINARY EFFICACY OF AN ACADEMICALLY-INTEGRATED PHYSICAL ACTIVITY PROGRAM ON CLASSROOM BEHAVIOR IN PRESCHOOLERS

MAY 2019

SARAH A. BURKART, B.S., SACRED HEART UNIVERSITY

M.S., UNIVERSITY OF MASSACHUSETTS AMHERST

Ph.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Sofiya Alhassan

Maladaptive classroom behaviors (i.e., hyperactivity, inattention) are common in preschoolers, yet elevated levels of these behaviors may lead to academic difficulties or future attention-deficit/hyperactivity disorder (ADHD). Physical activity (PA) may be one way to alleviate these maladaptive behaviors within the classroom setting, yet little data exists in preschoolers. Additionally, preschoolers are not meeting PA guidelines. Previous preschool-based PA interventions have shown minimal effects primarily due to lack of intervention implementation compliance. One solution to this problem may be to integrate PA into early learning standards, which teachers are already required to teach. Implementing academically-integrated PA may serve a two-fold benefit of enhancing preschool children's PA and classroom behavior. However, process evaluation data describing academically-integrated PA interventions designed to impact academic-related outcomes (i.e., classroom behavior) are rarely published. Therefore, the purpose of this study was to examine the feasibility, acceptability, and preliminary efficacy of a 12-week PA intervention integrated into early learning standards on classroom behavior in

preschoolers. Two preschool centers were randomized to either the Preschoolers Actively Learning (PAL) intervention group or the health-tracking control (CON) group. All children at the preschool participated in their assigned activities, but children (n = 58, age = 4.0 ± 0.8 years) and teachers (n = 8) were individually recruited for participation in the assessment portion of this study. The PAL PA lessons were integrated into early learning standards and offered for 10-15 minutes during morning circle time four days per week for 12 weeks. The CON group was asked to maintain their typical curriculum activities during the study. Feasibility, acceptability, and fidelity data were collected daily, weekly, and post-intervention. PA levels and directly observed classroom behavior were assessed at baseline, 6-weeks, and 12-weeks, while teacher-reported classroom behavior was assessed at baseline and 12-weeks. Process evaluation data indicated that 93% of PA lessons were implemented as intended and held the interest of children. Modifications were made to 34% of the lessons. Children and teachers appeared to enjoy participating in the lessons 99% and 85% of the time, respectively. Children spent 40.5% of the lesson time engaged in moderate to vigorous PA (MVPA). Despite lower than anticipated lesson intensity, children in the PAL group engaged in 5.0 ± 2.3 minutes of MVPA during circle time compared to 2.8 ± 2.8 minutes in the CON group ($t = -7.12$, $p < 0.0001$). However, there were no differences in preschool-day PA or classroom behavior. While feasibility and acceptability were established, preliminary efficacy was not. Teachers expressed interest in future use of the PAL lessons, but modifications to the intervention should be made to influence classroom behavior and PA levels. Strategies to enhance lesson intensity, preschool day PA, and assessment compliance are needed in future studies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Background

Attention-deficit/hyperactivity disorder (ADHD) is the most commonly diagnosed developmental disorder in children in the United States and is a major public health concern (200). Behaviors associated with ADHD include inattention, hyperactivity, and impulsivity, which present as difficulty sustaining attention, fidgeting, and interrupting frequently (from here on referred to as ADHD-related behaviors) (8). These problematic behaviors can manifest in the classroom setting and can lead to poor academic achievement, cognitive challenges, and maladjustment to the school environment (23, 116, 218). Preschoolers typically exhibit hyperactive and impulsive behaviors, yet elevated levels of these behaviors can be a risk factor for developing ADHD (108). In addition to the signature inattentive and hyperactive/impulsive symptoms, children with ADHD typically present with difficulties in executive functioning (i.e., cognitive processes to select and monitor behavior to reach a goal), and social and emotional challenges (23, 116, 145, 257). Approximately 2-8% of preschoolers (2.9 – 5 years old) have an ADHD diagnosis (83, 140, 250). ADHD is a disorder that can largely impair an individual across various settings (i.e. school, home, with friends/relatives, in other activities) (8), yet these behaviors can impair one setting without reaching the criteria for full diagnosis. In preschoolers specifically, these behaviors may be prevalent at preschool, but fail to carry into the home environment (165). Although diagnosis in preschoolers is uncommon, evidence suggests that symptom onset can begin in children as young as three years of age (13). Despite childhood presentation, ADHD can track into

adolescence and adulthood (20, 130), suggesting the need for early intervention. Common treatment methods for children with ADHD include stimulant medications and behavioral therapy, both of which can provide short-term benefit, but lack sustained effects once the intervention ends (57, 102, 183, 203). These common methods are also unfavorable as parents may find medication side effects worrisome or do not have access to intensive therapies, which emphasizes the need for non-pharmacological, low-cost intervention strategies.

Preschool Physical Activity

Physical activity (PA) can be an effective way to improve ADHD-related behaviors (i.e., hyperactivity, impulsivity, and inattention) in children (6-17 years) by enhancing neural development in the brain which can lead to potential long-term improvements in behavior (103), yet limited research exists in preschoolers. Currently, it is recommended that preschoolers engage in 15 minutes of PA (i.e., light, moderate, or vigorous intensity) per waking hour (80). This amounts to approximately 120 minutes of PA over the course of an 8-hour preschool day and 180 minutes for a typical 12-hour day (80, 237). However, nearly half of all preschoolers are not meeting PA guidelines (178, 235). Low PA in this age group is alarming because health behaviors learned in childhood have been shown to track into adolescence and adulthood (175).

The Role of Classroom Behavior

While ADHD-related behaviors encompass a global measure of behavior, in this study, classroom behavior will refer specifically to inattention and

hyperactivity/impulsivity within the preschool setting. The preschool years are critical in the development of appropriate social, behavioral, and academic behaviors which help children adjust to elementary school (218). Attending preschool exposes children to situations in which they learn to focus their attention on tasks, interact appropriately with teachers and peers, and adjust to the rules of the classroom (218). However, some children may not adapt these skills before leaving preschool for several reasons including, but not limited to, different developmental trajectories and varying preschool curricula. This limits their ability to utilize these skills and be successful in later academic settings, and may lead to ADHD development (218). Teachers estimate that developmentally deviant (i.e., exceeding that of age- and gender-matched peers) levels of classroom behavior impact 18% of preschoolers (165). Further, when asked about factors that are detrimental to their classroom and student progress, teachers list classroom behavior as a major contributing factor (184). This maladaptive behavior is not only acknowledged by classroom teachers, but also by preschool center directors. In a sample of Head Start directors, 37% identified classroom behavior as a major problem for the children and families attending their preschool centers (184). While both teachers and directors recognize maladaptive classroom behavior as a problem, there is limited data to support evidence-based strategies and solutions. Therefore, this study examined classroom behavior, as it can hinder preschoolers' academic experiences, cause difficulties for the child, and potentially progress to the development of ADHD.

Rationale for Early Intervention

Approximately 61% of preschoolers spend most of their day (8:30 am - 4:30 pm) in some form of non-parental childcare setting (e.g., preschool centers) (88), indicating that this environment may be an ideal location to identify a child who is exhibiting developmentally deviant behaviors and early signs of ADHD as these behaviors are prevalent in the preschool setting (101). Moreover, childcare center interventions can target both children with maladaptive classroom behavior and typically developing children (as a preventative measure). Early intervention in this age group is ideal due to prime brain development, neural plasticity, and lack of comorbid disorder emergence (101). The first five years of life are often viewed as a critical period or window of opportunity with respect to brain development. By age five, the child's brain will only change minimally in overall size and will be in a period where the overabundance of synapses is organized into dendritic trees (34, 161). This allows the child to easily learn new skills and appear to have increased brain plasticity, which is the brain's ability to adapt (9). It has been suggested that low PA may have unfavorable effects on children's cognitive development (51). Therefore, it is possible that incorporating PA into a young child's preschool day routine may impact cognitive development. Intervening in a child's life prior to age five also limits the likelihood of the need to address comorbid disorders such as anxiety, depression, conduct disorder, oppositional defiant disorder, and mood disorders, all of which tend to develop during the elementary school years (82). Prevention and treatment options later in life would expectedly address both ADHD-related symptoms, if the disorder develops, and the comorbid disorder, thus complicating mechanisms of change. It is also possible that early intervention may reduce the

likelihood of the development and/or severity of some comorbid disorders later in the child's life (101). Additionally, impairments associated with classroom behavior such as poor academic outcomes, peer relations, self-esteem, and familial relations may be diminished or avoided completely with early intervention.

Mechanisms Linking Physical Activity and Classroom Behavior

Evidence for PA as a potentially beneficial alleviative option for individuals with maladaptive classroom behavior stems from animal studies examining the impact of exercise on neural function, data from healthy children examining cognitive benefits of PA, and limited preliminary data in children with ADHD (66, 102, 113, 251). While there is no definitive understanding regarding the exact mechanism by which PA can alter classroom behavior, researchers have suggested possible hypotheses. The three leading potential physiological mechanisms by which PA may reduce maladaptive classroom behaviors are: 1) via improvements in catecholamine neurotransmission (e.g., serotonin, norepinephrine, dopamine) (149, 158, 172), 2) via increasing brain blood flow and cerebral capillary growth (103, 137, 163, 186), and 3) via increasing nerve growth factors (i.e., brain-derived neurotrophic factor, BDNF) to increase plasticity (63, 103, 112, 149, 207). It is important to note that it may not be one finite mechanism, but rather a combination of each of the mechanisms leading to overall improved brain health. However, it is difficult to measure the amount of change in these physiological mechanisms especially in field-based settings, as they require invasive techniques (48, 136).

Although physiological mechanisms are important, it is not feasible to assess these variables in the preschool setting. Another mechanism that could explain the

change in classroom behavior is by altering the environment to increase preschool day PA which, in turn, can alter physiological mechanisms. To change PA behavior in preschoolers, researchers should utilize theory in designing the intervention. The use of theory in preschool settings is not yet definitive as its use has shown mixed results (89, 214). However, theory-based interventions are likely to be more sustainable in changing PA behavior, which can impact classroom behavior. This suggests that the use of theory should not be overlooked, and should be utilized to design effective programs to promote behavior change if incorporated correctly (18). The most commonly utilized theories in preschool PA interventions are the Social Ecological Model (SEM) and the Social Cognitive Theory (SCT) (214). Briefly, SEM is a comprehensive framework that suggests health behaviors can be influenced across several levels, specifically the individual, interpersonal, and organizational levels in preschoolers (155, 221). According to SCT, human behavior is learned through modeling and observation of peers and role models (17), and utilizes self-efficacy as the mediating variable (16, 74). It posits that change occurs based on the interaction of personal, behavioral, and environmental factors. Thus, it is possible that theoretical constructs could lead to a change in physical activity behavior, which could impact classroom behavior.

Preschool Physical Activity Interventions

With high rates of childcare attendance, the childcare center has been identified as a critical environment in helping children meet PA recommendations and build healthy habits. However, evidence suggests that children are not active enough during the preschool day (27, 29, 76, 191). Due to the low percentage of preschoolers meeting PA

guidelines (25, 177, 235), and a high percentage attending childcare centers (88), several interventions have been conducted in the preschool setting aiming to improve children's PA levels. The number of preschool PA interventions has been consistently growing over the last decade, as evidenced by several published reviews (32, 61, 89, 120, 214, 223, 227, 239, 246). However, preschool PA interventions have generally led to mixed results due to factors such as who delivered the program, selection of outcome measures, modality used, or if they were pragmatic (i.e., delivered under "real-world" conditions), which can limit understanding of findings (89, 214). A systematic review of randomized controlled trials utilizing an objective measure of PA for the outcome denotes that interventions in this setting are able to increase PA with associated characteristics such as structured PA lessons, no parent component, researcher or expert delivered, based on theory, and study length less than 6 months (239). The minimal impact of pragmatic interventions implies that teachers experience difficulty in implementing programs with high levels of fidelity which results in low compliance (4, 214, 256). However, to develop sustainable intervention strategies, PA interventions must not only work, but also be easily implemented by teachers and staff. One way to combat low teacher compliance is by reducing burden of added activities and incorporating PA into the preschool learning standards. Most preschool centers are required to implement state-mandated early learning standards during the preschool day, so this may be one potential way to improve teacher compliance while enhancing preschool children's PA. This is an emerging area of research, with limited studies showing positive changes (176, 231). However, before we can examine the ability of the researcher to train the teachers to

deliver the intervention, the efficacy of the intervention with a researcher delivering it must first be demonstrated, which was assessed in the present study.

Physical Activity Interventions & ADHD-Related Behaviors

Interventions in school-age children and adolescents have shown positive changes in ADHD-related behaviors and executive functioning, yet these studies vary in their measures of PA and ADHD outcomes, as well as PA modality (1, 38, 52, 87, 95, 98, 110, 123, 126, 128, 129, 148, 154, 157, 173, 187, 197, 215, 225, 240, 251, 258). Lab-based studies have allowed researchers to examine the acute effects of PA on behavior and cognition. Overall, findings support medium to large effects on executive functioning, specifically attentional control (52, 157, 164, 187). In contrast to acute PA studies, long-term effects of PA interventions seem to be stronger in the emotional and behavioral domain according to parent and/or teacher reported outcomes (1, 38, 54, 110, 126, 128, 148, 154, 215). Additionally, objective executive functioning tests demonstrated medium to large effect sizes on attentional control, inhibition, and working memory in this population (38, 52, 54, 128, 240). However, these results should be interpreted with caution due to differing frequency, duration, intensity, and modality of PA, as well as inconsistent assessment methods.

Among the few studies that increased preschool-day PA, none have examined the potential effect of increased PA on classroom behavior (214). Thus, there is a need for PA interventions specifically designed to improve classroom behavior in this age group. Currently, very little is known about the relationship between PA and cognitive development in typically developing preschoolers (46, 228). A systematic review of only

seven published studies demonstrated that higher intensity or duration of PA led to improvements in at least one cognitive variable, yet interpretation should be cautious due to poor study quality (46). Cross-sectional and quasi-experimental studies conducted in typically-developing preschoolers and preschoolers with elevated levels of hyperactivity/impulsivity and inattention have shown benefits of acute bouts of exercise on executive functioning tasks, in which low levels are indicative of inattention and future ADHD development (24, 41, 104, 109, 134, 171, 248). For example, Palmer et al., demonstrated that an acute 30-minute bout of locomotor-based PA improved preschoolers' (n = 16, 81% male, age = 4.1 ± 0.4 years) performance on a sustained attention task (171).

Despite the growing research surrounding PA as a potential alleviative tool in school-age children, very little is understood about this relationship in preschoolers. The knowledge in this area is limited by inconsistent assessment methods and lack of studies in this age group. Research from our lab indicated that a 6-month locomotor skill-based PA intervention showed improvements in teacher-reported hyperactivity and inattention (35). Interestingly, these changes in classroom behavior occurred without a statistically significant change in PA levels, although these values did trend in the expected direction (4, 35). There was a significant decrease in sedentary time as well as an improvement in leaping skills (4). This suggests that changes in classroom behavior could be attributed to a significant reduction in sedentary time. A major limitation of this study was varying levels of intervention fidelity across classrooms (4). Teachers commented that they were not likely to implement the program as frequently as intended because it was an added burden as opposed to a program that was incorporated into their daily schedules.

Therefore, the purpose of this study was to examine the feasibility and acceptability of integrating PA into early learning standards, and the potential impact on preschoolers' classroom behavior.

Research Aims and Hypotheses

Aim 1: To examine the feasibility, acceptability, and fidelity of a 12-week PA intervention integrated into early learning standards on classroom behavior in preschoolers.

H_{1a}: It was hypothesized that feasibility would be achieved with recruitment (n = 42 children) and retention (80% at 12-week data collection) goals met.

H_{1b}: Children and teachers would demonstrate enjoyment and satisfaction, respectively, with the intervention program. It was hypothesized that children would demonstrate enjoyment of the PA intervention as assessed by daily semi-structured questionnaires completed by researchers. It was hypothesized that teachers would demonstrate high levels of satisfaction with the PA intervention as assessed with weekly and post-intervention surveys.

H_{1c}: Fidelity of the PA intervention was determined by participant adherence and intervention implementation compliance (i.e., children's participation rates and duration of participation). It was hypothesized that children would engage in MVPA for at least 50% of the PA intervention session. It was also hypothesized that interventionists would deliver the intervention as originally planned 80% of the time.

Aim 2: To examine the efficacy of a 12-week PA intervention integrated into early learning standards on classroom behavior in preschoolers.

H_{2a}: Children randomized to the intervention group would demonstrate a healthier movement profile (i.e., less sedentary time, increased light, moderate, and vigorous PA) compared to those randomized to the control group.

H_{2b}: Children randomized to the intervention group would exhibit improvements in directly observed classroom behavior (i.e., on-task time) compared to those in the control group.

H_{2c}: Children randomized to the intervention would exhibit improvements in teacher-reported classroom behavior (i.e., hyperactivity/impulsivity and inattention) compared to those in the control group.

Exploratory Aim 3: To examine the relationships between directly observed off-task time, teacher-reported inattention, and an objective cognitive task of inattention in preschoolers.

H_3: Based on limited data in elementary school-aged children, we hypothesized that there would be a relationship between directly observed off-task time, teacher-reported inattention, and an objective task of inattention in preschoolers.

Summary

Currently, ADHD is the most commonly diagnosed developmental disorder in young children, and tracks into adolescence and adulthood. Evidence suggests that symptoms (hyperactivity/impulsivity, inattention) may be present in children as young as

three years of age. ADHD-related behaviors tend to describe global behavior, but classroom behaviors refer specifically to inattention and hyperactivity/impulsivity in the preschool setting and can be considered a subcategory of ADHD-related behaviors. While these behaviors are common in preschoolers, developmentally deviant levels can impact academic progress and may even lead to ADHD development. Physical activity may be one way to improve classroom behavior in children. However, most preschoolers are not meeting PA recommendations. Preschoolers spend much of their day at a childcare center, making this site a viable option for intervention. Previous studies have shown that additional daily programming can be cumbersome for teachers, thus reducing intervention compliance. Therefore, integrating a PA intervention into pre-existing learning standards that teachers are required to teach was a novel way to target improved compliance. This study allowed us to examine if short bouts of academically-integrated PA were feasible and acceptable to teachers and children in a preschool classroom. Data supporting feasibility and acceptability are crucial to future program development yet are sparse within the literature. We also were able to evaluate preliminary efficacy of academically-integrated PA on classroom behavior, which is an understudied academic-related outcome in preschoolers. Data from this study provided important information to help modify this preschool intervention so future studies can better examine efficacy.

CHAPTER 2

REVIEW OF LITERATURE

Overview

Because attention-deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in children, it has become a public health concern (200). Despite typical diagnosis in the elementary school years, symptom onset can begin during the preschool years (13). In preschoolers, ADHD-related behaviors such as impulsivity/hyperactivity and inattention can manifest in the classroom setting and lead to maladaptive classroom behavior. Because preschoolers spend a large portion of their day (8 am – 4:30 pm) in a preschool center (88), this could be a viable intervention setting to foster healthy behaviors. Treatment strategies for maladaptive classroom behavior such as medication and intensive therapy are often used in elementary school children, yet may not be favorable in preschoolers due to a lack of sustained effects beyond use and the harsh side effects associated with medication use (102). Thus, alternative strategies to alleviate maladaptive classroom behaviors are needed. Recently, it has been suggested that physical activity (PA) may be one effective method to improve ADHD-related behaviors in children, such as those that manifest within the classroom setting (103). Most preschool-age children in the United States attend some form of non-parental childcare (88), and are often inactive for the majority of the day in this setting (235). Due to this, several preschool interventions aimed at increasing PA have been conducted, yet a common limiting factor is the lack of intervention compliance by teachers (32, 61, 89, 120, 214, 223, 227, 239, 246). Therefore, it is critical that effective behavioral interventions are designed in way that is easily implemented by teachers in a

preschool classroom setting. The present study sought to address key research gaps by assessing the feasibility, acceptability, and efficacy of an academically-integrated PA intervention on classroom behaviors (i.e., early ADHD-related behaviors and on-task time) and PA levels in preschool-age children.

For the purpose of this document, ADHD-related behaviors are defined as hyperactive, impulsive, and inattentive behaviors. Classroom behavior was defined as the ADHD-related behaviors that occur specifically in the classroom setting during the preschool day. This review of literature was separated into five sections. The first section described current prevalence estimates, etiology, symptomology, sequelae, and assessment methods in children with ADHD as well as how elevated levels of these behaviors can impact children in the classroom. The second section defined the importance of PA in the preschool-age population, as well as assessment methods, and determinants of PA. The third section provided a mechanistic explanation of the link between PA and ADHD-related behaviors, in addition to theoretical underpinnings of this relationship. The fourth section highlighted key intervention studies, specifically preschool PA interventions and interventions to improve ADHD-related behaviors and classroom behavior, respectively. Finally, the last section emphasized the limitations of current research and how they were addressed in the present study. This review of literature focused on both children with an ADHD diagnosis, as well as children who did not meet the full diagnostic criteria but exhibit early behaviors that may be indicative of potential ADHD development. This approach was taken as clinicians are reluctant to diagnose children with ADHD during the preschool years based on behaviors that may change with development or new environments. Therefore, children exhibiting

hyperactive, impulsive, or inattentive behavior beyond a developmentally appropriate level were referred to as children exhibiting ADHD-related behaviors or classroom behaviors if taking place in the preschool setting.

ADHD in Young Children

Currently, one in six children has a developmental disorder in the United States (30). The most common is ADHD, which is a neurodevelopmental disorder that presents in early childhood and continues into adolescence and adulthood (241). In 2011, the National Survey of Children's Health indicated that 11% (i.e. 1 in 10) of elementary school-age children were diagnosed with ADHD by a health care provider (241), although estimates vary widely (53). Additionally, it has been reported that approximately 2-8% of preschoolers (2.9-5 years) are diagnosed with ADHD (83, 140, 250). Based on teacher reports alone, regardless of official diagnosis, the estimated prevalence is higher than national reports, with 18.2% of preschoolers and 15.9% of elementary school children exhibiting ADHD-related behaviors (165). Typically, diagnosis occurs during the elementary school years, yet evidence suggests that symptom onset can begin in children as young as three years of age (13). It is important to note that preschoolers naturally exhibit hyperactive and impulsive behaviors, yet elevated levels of these behaviors can be a risk factor for ADHD development (108). ADHD is more prevalent in boys, with reports suggesting somewhere between a 3:1 and 5:1 diagnosis ratio in boys compared to girls (14, 55, 138). Furthermore, racial/ethnic minority children are less likely to receive an ADHD diagnosis compared to their Caucasian counterparts, with African Americans 69% and those with Hispanic ethnicity 50% less likely to be

diagnosed (160). Among those diagnosed, children of color are also less likely to be taking medication for their ADHD symptoms compared to Caucasians (160), potentially due to lack access.

The etiology of ADHD is complex and not well understood (205, 224). The disorder is highly genetic, but variability can be explained by environmental influences as well (205). A child whose parent has been diagnosed with ADHD has >50% chance of also being diagnosed with the disorder (224). Additionally, if a child has a first-degree relative with ADHD, he or she is 2-8 times more likely to be diagnosed (224). Environmental risk factors for ADHD development include low birth weight, traumatic brain injury, maternal substance use during pregnancy, prenatal toxin exposure, lead exposure, and perinatal stress (96, 97, 119, 139, 205, 224). Despite research efforts, no prenatal risk factors have been deemed causal in this relationship.

Symptomology & Treatment Options

ADHD-related behaviors can be split into two broad categories, inattention and hyperactivity/impulsivity. Inattentive behaviors include difficulty sustaining attention, difficulty organizing tasks, and distraction by external stimuli. Hyperactive/impulsive behaviors include interrupting or blurting out answers, fidgeting, or seeming to always be "on the go." According to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-V), diagnostic criteria includes at least six symptoms in a single domain, occurrence over a 6-month period, symptom presentation before age 12, symptoms across 2+ settings, impaired functioning, and symptoms not explained by other mental disorders (8). Although the DSM-V provides a clear, concise method for identifying ADHD, it has

been reported that children exhibiting these behaviors without meeting full diagnostic criteria (i.e., subthreshold symptoms) may experience similar poor behavioral and academic outcomes as those with a formal diagnosis (36).

Children with ADHD typically exhibit a multitude of problems in school including poor academic achievement, inattention, and challenges with cognitive functioning such as time management, executive functioning (i.e., cognitive processes to select and monitor behavior to reach a goal), organization, flexibility, and problem-solving (23, 116, 145). Problems with peers and emotional distress are also associated with ADHD, which can lead to children feeling anxious, sad, alone, and less confident; all of which impact classroom behavior (257). Children with ADHD are also likely to develop comorbid disorders such as oppositional defiant disorder (ODD, 8 times as likely), conduct disorder (CD, 26 times as likely), and depressive symptoms (9 times as likely) (83). In addition to risk of comorbid development during childhood, children with ADHD also have an increased risk of developing these disorders as they age, which can be linked to negative outcomes in adolescence and adulthood (56, 107).

After diagnosis, ADHD is typically treated with either stimulant medication or some form of behavioral therapy. From 2007 to 2011, there was a 28% increase in the percentage of children taking medication for ADHD (241). However, medication is not always a viable treatment option as it has been associated with harsh side effects, lack of efficacy, and parental discomfort with placing a child on medication, all of which contribute to discontinuation within the first year (102, 183, 203). Current intervention studies have shown that medication and behavioral therapy provide short-term benefits, but symptoms typically return once the intervention ends (102). In preschoolers

specifically, a parent behavior training program with the goal of managing a child's behavior with rewards and consequences is recommended as the first treatment option (53, 224). It is also recommended that behavioral interventions last for at least eight weeks before deeming it a failure and beginning use of medication (58). In an eight-week study by Sonuga-Barke et al., researchers reported that a parent training program (n = 78) was effective in improving ADHD-related behaviors which were assessed both clinically and through direct observation in preschoolers when compared to a parent support group (217). However, this treatment option did not acknowledge the child's behavior within the preschool classroom setting, where these ADHD-related behaviors are commonly expressed. Furthermore, 17.5% of children do not receive any type of treatment for ADHD-related behaviors (241), with disparities across socioeconomic groups (37, 160). This lack of treatment effectiveness and options paves the way for research into alternate methods of reducing ADHD-related behaviors in young children.

Classroom Behavior

It is possible that a child may exhibit ADHD-related behaviors in one environment, and not multiple environments, which would not qualify for diagnosis. Teachers reported that 18% of preschoolers exhibit developmentally deviant classroom behaviors (165), and this is reiterated by preschool center directors, of which 37% identified classroom behavior as a major problem for children attending their centers (184). Thus, there is evidence to suggest that children without an ADHD diagnosis struggle with developmentally-appropriate classroom behavior. Therefore, improving classroom behavior is beneficial for not only children experiencing ADHD-related

behaviors, but also typically developing children. Attending preschool is crucial to a child's social, behavioral, and academic development, as this environment prepares the child for kindergarten and elementary school (218). One of the main goals of preschool is for children to learn how to focus their attention on academic tasks given by a teacher, interact appropriately with teachers and peers, and adjust to the written and unwritten rules of the classroom setting (218). When a child is unable to develop these skills, it can impact their ability to be successful in future academic settings and may be indicative of future ADHD development (218).

Evidence suggests that preschoolers who exhibit problematic classroom behaviors, and some to clinically significant levels, are likely to show similar problems in elementary school and later in adolescence (42). For example, in a study of 168 three-year-old preschoolers with behavioral problems, annual follow-up data indicated that 58% met criteria for ADHD diagnosis three years later (108). In a separate study, 46 three-year-old preschoolers with classroom behavior problems who were identified by either teachers or parents were followed and compared to 22 typically-developing control children (44). By age 6, 50% of children who had behavioral problems in preschool, met ADHD diagnostic criteria (44). Additionally, children who maintained problematic behavior at age 6 were more likely to meet diagnostic criteria at age 9 (43). Early manifestation of classroom behavior difficulties has also been linked to academic underachievement in elementary school (218), yet the mechanisms for this and the causal direction are not well understood. Research suggests that maladaptive classroom behavior in preschool can track into late childhood, but it is also possible that some classroom behavior problems will improve or dissipate over time (218), thus complicating this

relationship. There is limited research examining the effects of preschool inattention, hyperactivity, and impulsivity, and comparison across studies is often limited by various assessment measures.

Assessment of ADHD-Related Behaviors

Rating Scales

There is no single test to assess ADHD-related behaviors. In fact, clinicians recommend a multimethod approach to assessment (211). However, in research settings, this is not always possible due to financial and time constraints. Additionally, it is difficult to determine developmentally deviant levels of hyperactivity, impulsivity, and inattention in preschoolers as these behaviors are common (60, 62, 117, 182). There are numerous valid and reliable tests and scales to assess symptoms, yet most are validated in elementary school children (21). This lack of specificity in preschool assessment has led to a reluctance to diagnose and treat this population (39). Rating scales can be categorized as DSM-based which are based only on diagnostic criteria, or broad-based that evaluate a wide variety of behaviors (182). DSM-based rating scales are quick, easy to use, and cost effective. However, these scales lack the comprehensive ability of the broad-based scales to assess behavior (182). Another limitation of DSM-based scales is that discrepancies exist between parental and teacher ratings of ADHD-related behaviors in preschoolers (72, 211). Predictors of reporting discrepancies include ethnicity, prior diagnosis, parental depression, number of siblings, and children's academic achievement (106). Broad-based scales, such as the Behavior Assessment System for Children (BASC), provide a multidimensional approach to assessing a child's positive and

negative behaviors. The BASC contains both a parent and teacher rating scale in which a child's hyperactivity, aggression, conduct problems, anxiety, depression, somatization, atypicality, withdrawal, attention problems, and adaptive skills are rated over the course of the previous six months (195).

Direct Observation

Direct observation by a third party (i.e., someone other than the child's teacher or parent) of specific behaviors could be beneficial to limit rater bias of the child's behavior. Observation systems are viewed as the gold standard in behavioral research as they allow one to focus on specific behaviors (e.g., on-task time, impulsivity), but are limited by the need for extensive training and multiple ratings across days to acquire an accurate representation of behavior (182). One example of a direct observation system is the Behavioral Observation of Students in Schools (BOSS) system, which is a momentary and part-interval recording system (181). This system is advantageous because it is low burden for participants (118), and allows the researcher to observe the student in a classroom setting and efficiently record behaviors in real time without any hand calculations (181).

Cognitive Tasks

Additionally, cognitive tasks (e.g., inhibitory control, working memory, cognitive flexibility) may be used to assess executive functioning impairment, which is associated with ADHD-related behaviors. These tasks are advantageous because they provide an objective assessment of cognitive functions without the invasiveness of neuroimaging

tests (46, 75, 168, 187). These tasks are developmentally appropriate for preschool-age children and are available via the NIH toolbox application on an iPad (100). In a study by Brassell et al., researchers utilized the attentional network task (i.e., flanker task) in which 4-8 year old children were asked to select which direction the center fish was facing on a computer screen (31). Results indicated that children's performance on this task was positively associated with aerobic fitness, with the strongest relationship in younger children with ADHD risk (i.e., at or above the 90th percentile on the ADHD-IV Rating Scale) (31). This indicated that better inhibition scores on the task were associated with increased aerobic fitness in children with ADHD risk and that their inhibition scores were similar to typically developing children. Additionally, the authors noted that their selected cognitive task was lab-based and that replication using validated field-based tasks should be explored.

Physical Activity in Preschool-Age Children

It has been suggested that PA may be an effective way to improve ADHD-related behaviors (102), yet limited data exists in preschoolers. Currently, it is recommended that preschool-age children engage in 15 minutes of PA (i.e., light, moderate, or vigorous intensity) per hour (80). This recommendation would result in approximately 120 minutes of PA during an average 8-hour preschool day, or 180 minutes of PA during a 12-hour day (237). Within these guidelines, it is also suggested that PA be acquired in a mix of structured and unstructured activities, both indoors and outdoors, and integrated into activities that encourage cognitive and social development (80). Only one study has examined the compliance prevalence via objective measures in preschoolers in the United

States (178). In two separate samples of 286 and 337 children, researchers reported that 41.6 and 50.2% met the total day recommendation, respectively (178). Researchers also reported that more boys than girls met the current PA guideline (178). Among these samples, there were no differences in those meeting guidelines based on parent education, race/ethnicity, or weight status (178).

The type of preschool center that a child attends may also impact their likelihood to meet PA guidelines. For example, Montessori style preschools are different than traditional preschool settings in that they encourage children to engage in self-discovery and freely choose and move about different activities throughout the day (144). Studies have indicated that children attending Montessori style preschools engage in more MVPA and total PA as well as less sedentary time during the preschool day compared to those enrolled in traditionally structured preschools (40, 179). Additionally, children in these schools accumulated more MVPA outside of preschool and total day compared to children in traditional preschools (179). This suggests that children who attend this type of preschool did not compensate for their higher during preschool PA by being less active outside of preschool and that this type of learning environment could encourage more active habits beyond the classroom. However, it could also suggest that parents who value this type of education also value free play and physical activity in learning. In the United States, approximately 61% of preschool-age children attend some form of non-parental childcare setting (88). Therefore, both the childcare center and home environment may play a critical role in helping children meet PA recommendations and build healthy habits.

Physical Activity Assessment Methods

Objective measures of PA (i.e., accelerometry, direct observation) are considered the gold standard when assessing preschoolers in a free-living environment (180). Accelerometers are small devices that are worn on an elastic belt around the waist. As the child moves, the device records both the magnitude and frequency of accelerations (147). Internal microprocessors and transducers convert the acceleration into digital signals referred to as counts (212). These counts can then be summed into user-specified epochs (e.g., 15 seconds, 60 seconds) (147). Prediction equations with specific cut points can then be used to convert activity counts into activity intensities (147). Although accelerometers have been shown to be valid and reliable in preschoolers (174, 192, 212, 213, 229), they are not without limitations. Accelerometers provide only intensity and duration of activity (147), require 4-5 days of monitoring for reliable results (233), are inadequate in assessing movement when the torso is relatively stationary (212), and do not support a universal set of cut points which limits interpretation and translatability (25, 147). Additionally, accelerometer placement in this population is difficult as the device often does not stay in place. Direct observation (DO) is an assessment system which involves a trained individual observing and classifying children's PA for a set amount of time (147). This method is advantageous because it describes the intensity, type, and context (i.e., social factors) of activity (147), and is valid and reliable in children (153). Like accelerometer cut points, different DO systems limit translatability, and have the potential for reactivity in children (212). Another limiting factor of DO is the time intensive training and assessment. Studies should consider including both DO and accelerometry, as these assessment tools complement each other (180). The use of both

would allow researchers to better assess upper body movements, and understand the intensity, type, and context of PA.

Determinants of Physical Activity in Preschoolers

To develop successful interventions and increase the PA levels of preschoolers, it is imperative that factors influencing PA in preschoolers are understood and targeted (111). Several studies have been conducted to identify correlates and determinants of PA in preschoolers, and these factors have been categorized into demographic (e.g., socioeconomic status, parent education), biological (e.g., age, gender), psychological (e.g., personality, cognitive measures), environmental (e.g., neighborhood safety, PA resources), and social influences (e.g., parent and teacher PA practices) (70, 114, 115, 143, 159). Studies have shown that maternal role-modelling (59, 135, 166), parental monitoring (64, 65, 84, 166, 255), and childcare provider training (2, 10-12, 166, 231, 255) have consistently shown a positive association with increasing total PA and MVPA, specifically (111). This highlights the importance of including childcare providers in the intervention design to successfully change PA behavior in the preschool environment. Alternatively, no clear association has been identified between gender (15, 59, 193, 201, 226), parental goal-setting (84, 220), social support (84, 188), motor skill training (4, 10-12, 26, 28, 85, 127, 188, 255), or increased time for PA (2, 5, 22, 85, 91-94, 166, 188, 231, 255) and change in PA levels, so these factors may need to be examined further to understand why they are not critical to intervention design. Finally, child knowledge provided via educational materials (28, 64, 67, 69, 71, 91-94, 188, 220), parent knowledge (26, 28, 64, 67-69, 71, 84, 86, 91-94, 166, 188, 220, 255), curriculum

materials (2, 26, 28, 45, 68, 71, 86, 91-94, 105, 188, 222, 238), portable equipment (28, 45, 86, 105, 188), and parental motivation (68, 84), skills (67, 68, 127, 220), and self-efficacy (255) have consistently shown no association with change in PA in preschoolers (111). The lack of association of some of these factors could be attributed to varying degrees of intervention fidelity, which can drastically impact intervention success. While the proposed intervention utilized curriculum materials (shown in the literature to show no association with change in PA), it will be academically integrated which could lead to higher intervention fidelity. Currently, it is unknown if academically integrated PA interventions are better than non-academic PA interventions. Recent reviews have not examined academically integrated studies specifically, probably due to their recent addition to the literature resulting in limited data.

The success of intervention studies can also be determined by factors that are often excluded from traditional reviews. Some of these less-examined factors include who delivered the intervention, PA modality utilized during the intervention, and whether they were pragmatic (i.e., delivered under "real-world" conditions), all of which can impact the effect of the intervention (89). A recent systematic review on randomized controlled studies where PA was objectively assessed identified several factors that contributed to an intervention's ability to increase PA (214). Results indicated that preschool interventions were likely to increase PA when structured PA lessons were delivered (2, 4, 12, 26, 68, 71, 90, 94, 127, 166, 176, 194, 231), a parent component was not included (2, 4, 5, 12, 26, 28, 45, 85, 90, 127, 166), the intervention was delivered by experts or researchers (2, 68, 85, 166), the intervention was theory-based (12, 28, 68, 71, 90, 94, 166), and when it lasted less than six months (2, 4, 5, 12, 26, 45, 71, 85, 90, 94,

127, 166, 194, 231). While these findings are important to incorporate in designing new interventions, it is also critical to consider why these relationships contribute to increased PA in preschoolers. The lack of parent component finding may allude to the need for more interactive strategies, as these studies focused on involving the parent with informational newsletters (223). Another review suggested that more comprehensive parent strategies such as delivering a parent curriculum via websites and offering family activities resulted in increased PA in preschoolers (214). However, in studies that aim to increase PA levels in the home environment (i.e., after school), a parent component becomes important as they are not with their child during the preschool day. This review will not detail the role of the parent in intervention success, as the present study did not seek to alter the home environment. Because the present study was focused on increasing preschool-day PA, key determinants that were included were the inclusion of structured PA, delivery by a research staff member, and childcare provider training.

Pragmatic interventions (i.e., delivered under "real-world" conditions) have shown generally mixed results (214). One reason for this is the lack of intervention compliance by classroom teachers (214, 256). One way to combat this may be to incorporate structured PA into classroom lessons and provide adequate teacher training. However, before teachers can be trained to properly implement an intervention in the classroom setting, it is important to demonstrate initial efficacy in a more controlled environment with a researcher leading the intervention. For example, Alhassan et al., conducted a four-week PA intervention in preschoolers ($n = 67$, age = 4.1 ± 0.8 years) in which the intervention group participated in 30-minute researcher-led structured PA bouts (2). Results indicated that preschoolers in the intervention group engaged in

statistically significantly more vigorous PA during the intervention time ($F_{1,36} = 4.91$, $p = 0.04$) and greater MVPA during the overall preschool day ($F_{1,37} = 5.13$, $p = 0.03$; 5.5 minute increase) compared to the control group (2). This intervention was implemented by research staff, with training and assistance provided to the classroom teachers, to test the efficacy of the intervention which is similar to the goals of the present study.

Mechanisms Linking PA and ADHD-Related Behaviors

Physiological Mechanisms

Evidence for PA as a potentially beneficial treatment option for individuals with ADHD stems from animal studies examining the impact of exercise on neural function, data from healthy children examining cognitive benefits of PA, and limited preliminary data in children with ADHD (66, 102, 113, 251). Even though there is no conclusive evidence regarding the exact mechanism by which PA can alter ADHD-related behaviors, researchers have suggested possible hypotheses. Currently, the three leading potential physiologic mechanisms by which PA may reduce ADHD-related behaviors are: 1) via improvements in catecholamine neurotransmission (e.g., serotonin, norepinephrine, dopamine) (149, 158, 172), 2) via increasing brain blood flow and cerebral capillary growth (103, 137, 163, 186), and 3) via increasing nerve growth factors (i.e., brain-derived neurotrophic factor, BDNF) to increase plasticity (63, 103, 112, 149, 207). It is likely that behavior change is occurring because of a continuum of brain structure and function changes, not a single proposed mechanism acting alone.

It has been proposed that neurotransmitter dysregulation in the prefrontal cortex (PFC) may explain some of the cognitive deficits and symptoms associated with ADHD-

related behaviors (142, 209, 216, 242, 251). Following PA, there is an increase in serotonin, norepinephrine, and dopamine in the PFC and hippocampus which impacts mood and cognitive functioning (149, 158, 172). Serotonin increases may foster improvements in attention, mood, and may help control hyperactivity and aggression (112, 158, 172, 185). Additionally, increases in norepinephrine may improve executive functioning, decrease inattention, and boost working memory which can aid in learning (253, 254). PA-induced increases in dopamine may improve focus, attention, working memory, and hyperactivity (216, 251, 253, 254). In one study, norepinephrine and dopamine via plasma concentrations in blood samples were examined while young adults ($n = 12$; age = 22.2 ± 3.6 years) simultaneously exercised and performed cognitive tasks (156). Researchers concluded that PA improved catecholaminergic neurotransmission in young adults, which led to increases in executive function performance following PA (156). However, very few studies have examined the extent of catecholamine release in children with ADHD (252). The second hypothesis posits that increased blood flow to the PFC resulting from PA may alter cognitive processes to improve executive functioning skills such as response speed, decision-making, and information processing (112, 137, 251). This can occur because the increased blood flow improves metabolic function which supports neurogenesis (63). Finally, the third hypothesis proposes that PA causes an upregulation in BDNF which is crucial to synaptic plasticity, neurogenesis, hippocampal function, and long-term potentiation (i.e., increased strength of nerve impulses along previously used pathways) for memory and learning (63, 149, 207), as well as the differentiation and development of dopamine (125, 189, 190). Low hippocampal BDNF and dopamine deficiency is indicative of ADHD and has been

attributed to hyperactivity and cognitive deficits (102, 141, 234). It is hypothesized that PA-induced increases in BDNF could lead to improved mood, attention, inhibition, and learning (63, 112, 149, 234), yet few studies have examined exercise physiology specific to children with ADHD (251).

Each of the aforementioned influences of PA on the brain result in some degree of increased cell proliferation and neural plasticity. Furthermore, mice models have indicated that the period of greatest cell proliferation stemming from exercise occurs in the early developmental stages (132). Thus, it has been suggested that interventions involving PA may be most effective in the early childhood years, with positive effects also seen across the lifespan (101). Studies conducted in typically-developing elementary school-age children utilizing event-related potentials and functional magnetic resonance imaging have demonstrated that exercise can impact components of cognition that are vitally important in ADHD such as executive functioning and activation of the PFC (50). Therefore, if an intervention is initiated in the early developmental stages (i.e., preschool-age), it may be possible to influence brain growth in a way that could impact the trajectory of ADHD-related behaviors. Because assessment of physiological mechanisms is not feasible in the preschool classroom environment, additional behavioral mechanisms of change should be explored.

Theoretical Mechanisms

Two commonly utilized theoretical models in preschool PA interventions are the Social Ecological Model (SEM) and the Social Cognitive Theory (SCT). The SEM is a comprehensive framework that includes various health-impacting levels such as the

individual, interpersonal, organizational, community, and public policy levels, while acknowledging that each level has a complex interplay amongst each other (155, 202, 221). This model suggests that change must occur across multiple levels to create behavior change (202). It is possible to alter the PA environment in a preschool setting at the organizational level (e.g., preschool center policies, teacher training, knowledge, and implementation), the interpersonal level (e.g., modeling of PA by teachers and peers), and the individual level (e.g., exposure to active lesson plans) with a multicomponent intervention design. The community and public policy levels are more difficult to reach, but could be altered as a result of efficacious intervention trials.

Additionally, SCT is a model that can lead to behavior change following an intervention as it emphasizes both cognitive and environmental variables. According to SCT, behavior is learned, at least partially, through modeling and observation of peers and role models (17), and utilizes self-efficacy (i.e., one's belief in his/her ability to perform a given task) as the mediating variable of change (16, 74). It is possible that participating in a PA intervention will increase the PA self-efficacy of the preschool class, which can mediate a change in PA levels. However, this would be more likely to lead to changes in out of school PA, since the intervention is being delivered as a curriculum for the entire class. The major limitation of this model is our inability to measure self-efficacy in preschoolers. It is important to note that most research studies examining the impact of PA on classroom behavior have not integrated theoretical frameworks. Incorporating theoretical framework constructs into the design of a PA intervention may help us to understand how behavior change occurs. By altering the social PA environment of the preschool center and increasing opportunities to be active,

it is possible that we may change classroom behavior by the physiological mechanisms associated with increasing PA. By training the teachers to incorporate PA into early learning standards throughout their day, it was hypothesized that children's classroom behavior could improve.

Rationale for Early Intervention

Because the majority of preschool-age children attend some form of non-parental childcare (88), it should become easier to identify a child who is showing early signs of ADHD. Additionally, interventions in a preschool center can be beneficial for all children because it would target not only those exhibiting ADHD-related behaviors, but also typically developing children as a preventative measure. Potential interventions could then serve multiple purposes such as a prevention-based program and as a group level treatment. Early intervention in this age group is ideal due to prime brain development, neural plasticity, and the lack of comorbid disorder emergence (101).

Neuroimaging and executive functioning studies have confirmed that brain structure (e.g., lower cerebral volume, lower white matter volume) and function (e.g., inhibitory deficits, poor working memory) differences exist in preschoolers diagnosed with ADHD (49, 103, 206). There is also evidence to suggest executive functioning skills at age five, or lack thereof, are indicative of math and reading performance in fifth grade (198). Further, a preschool ADHD diagnosis remains stable after 6 years (199). The first five years of life are often viewed as a critical period regarding brain development. By age five, the child's brain will change only minimally in overall size and will be in a period where the overabundance of synapses is organized into dendritic trees (34, 161).

This allows the child to easily learn new skills and appear to have a more plastic brain, despite the inconclusive evidence surrounding this idea (9). Intervening in a child's life prior to age five also limits the likelihood of the need to address comorbid disorders and may reduce the likelihood of comorbid disorder development (101). Examples of disorders comorbid with ADHD are anxiety, depression, conduct disorder, oppositional defiant disorder, and mood disorders (82). Prevention and treatment options later in life would expectedly need to address both ADHD and the comorbid disorder(s), thus complicating mechanisms of change. Finally, the use of early intervention may reduce the severity of impairment later in life. Several impairments associated with ADHD such as poor academic outcomes, peer relations, self-esteem, and familial relations may be diminished or avoided completely with early intervention (102). Additionally, children who exhibit ADHD-related behaviors are more likely to be obese and physically inactive as adolescents (131). Therefore, intervening early in life with PA may be advantageous for both behavior problems and obesity risk.

Preschool PA Interventions

Evidence suggests that children are not active enough during the preschool day (27, 29, 76, 191). Due to the low percentage of preschoolers meeting PA guidelines (178), and a high percentage attending childcare centers (88), several interventions have been conducted in the preschool setting aimed at improving PA. The number of preschool interventions has been consistently growing over the last decade, as evidenced by several published reviews (32, 61, 89, 120, 214, 223, 227, 239, 246). Preschool PA interventions have shown equivocal results. Common limitations include few studies utilizing objective

PA assessment. A recent review indicated that for an intervention to be successful at increasing PA, it must include structured PA, have theoretical integration, and be led by external staff (89). When designing interventions, it is important to incorporate these aspects. However, utilizing external staff members to deliver the intervention is problematic. Although effective, PA interventions led by outside researchers or experts are often not sustainable because these external staff must leave at the end of the intervention. Once the intervention leader leaves the intervention site, there is no one to continue implementing the intervention, thus resulting in a lack of sustained intervention effect. Therefore, efficacy trials should aim to be implemented by a researcher to enhance program fidelity, but incorporate training and help from the classroom teacher to boost sustainability. Once initial feasibility is established, teachers can be trained to fully implement the intervention to achieve sustainability. Furthermore, to enhance preschool-day PA, it is essential that strategies are explored that highlight the ability of the teacher to implement the intervention. Preschool teachers and staff will remain at the school after research studies conclude, and thus could provide the link to creating a sustainable model. Further, administrator buy-in is crucial to incorporate the program into their center's standard practices. However, teachers are burdened by busy schedules and early education requirements, so it is important that interventions are incorporated into existing curricula.

Very few studies have incorporated PA into academic lessons within the preschool setting (133, 134, 176, 231), even though this may enhance teacher investment in the program and foster enhanced intervention compliance. Two of these studies improved classroom PA (176, 231), while two improved early literacy skills (133, 134).

Trost et al., were the first to test the feasibility and efficacy of a PA program integrated into preschool academic lessons (231). This study was conducted in one preschool center which had four classrooms (n = 48 children, 54.6% male, age = 4.1 ± 0.7 years) in half-day programs (231). Classrooms randomized to the intervention participated in a move and learn curriculum four days per week for eight weeks, while the control classrooms maintained their usual curriculum. The intervention integrated opportunities for PA into the existing preschool curriculum, including math, science, language arts, and nutrition. Teachers were encouraged to implement two 10-minute lessons each day. Physical activity was assessed utilizing Actigraph accelerometers and a direct observation system. Based on accelerometer data, children in the intervention classrooms exhibited significantly higher levels of classroom MVPA during the last four weeks of the intervention compared to children in control classrooms ($p < 0.05$) (231). Direct observation data indicated that children in intervention classrooms were more likely to engage in MVPA during circle time (OR = 2.6, 95% CI = 2.2, 3.0), free time outdoors (OR = 1.4, 95% CI = 1.2, 1.8), and free time indoors (OR = 1.2, 95% CI = 1.1, 1.3) (231). Results suggest that incorporating PA into existing curricula is feasible and efficacious in improving classroom PA levels in preschoolers. Additionally, process evaluation data indicated that teachers reported their students were attentive following the PA lessons (mean Likert score 4.4/5) (231). Strengths of this study included the use of two objective measures of PA, academic integration, and teacher implementation. There were also several limitations such as short study duration, the use of one preschool center, small sample size, half-day programs, lack of out-of-school PA assessment, and no direct assessment of children's classroom behavior. Despite these limitations, incorporating PA

into traditional learning experiences is a promising method to address common stand-alone PA intervention barriers.

In 2016, Pate et al., conducted a multisite RCT preschool PA intervention (16 preschool centers; n = 379 children; age = 4.5 ± 0.4 years) that was designed to be flexibly implemented by preschool teachers (176). The intervention design was innovative in its flexible approach, as it encouraged preschool teachers to use intervention components to modify their current practices to best fit their classroom needs (176). Teachers in the intervention schools were encouraged to incorporate structured PA opportunities into the classroom, incorporate both structured and unstructured PA during outdoor playtime, and integrate PA into their academic lessons while teachers in control schools maintained their typical practices. Physical activity was assessed using Actigraph accelerometers for five consecutive days at each data collection period. Results indicated that preschoolers in the intervention schools (n = 188, 48.9% male, age = 4.5 ± 0.4 years) engaged in an increase of 0.8 minutes of MVPA per hour compared to children in the control schools (n = 191, 51.8% male, age = 4.5 ± 0.4 years) (176). Over the course of an 8-hour preschool day, this would translate to an additional 6.4 minutes of MVPA. This result remained significant after controlling for parent education level and length of preschool day. This study demonstrated that a flexible intervention delivered by trained preschool teachers can improve MVPA during the school day. Strengths of this study include randomized design, objective PA assessment, academic lesson integration, and was led by preschool teachers. However, this study is not without limitations. This study did not assess which intervention component contributed to the increase in PA, nor did it examine the effects on classroom behavior of the children. The study sample consisted of

only 4-year-old children, which is a limiting factor for generalizability as preschool classrooms can have children ranging from 2.9 – 5 years of age.

Finally, two studies conducted by the same research group aimed to incorporate PA into academic lessons and examine the effects on academic outcomes. In 2014, Kirk et al., utilized a quasi-experimental teacher-led PA intervention in two Head Start centers. Participants included 72 preschoolers (age = 3.8 ± 0.1 years, 47% male, 100% African American) (134). Classroom teachers were instructed to incorporate two 15-minute PA lessons at any point during the day into their daily schedule. PA was observed via direct observation and early literacy assessments were conducted at baseline and following the six-month intervention. Results indicated that picture naming and alliteration scores increased, as well as increased PA during the lesson time (134). Researchers concluded that academically-integrated PA was feasible to increase early literacy skills in preschoolers. This study was limited by the lack of PA measurement outside of lesson time, a non-randomized design, and fidelity bias due to a researcher observing every PA session. In 2016, this research group sought to increase the dose of PA and encouraged teachers to implement two 30-minute academically-integrated PA lessons during the preschool day (133). Participants included 54 preschoolers (age = 4.1 ± 0.2 years, 31% male, 99% African American). Similar to their previous study, early literacy skills (i.e., rhyming and alliteration) improved after 8 months (133). It is unclear if either of these studies increased preschool day PA due to the lack of assessment. Therefore, to understand if increasing PA through academic integration is beneficial, more studies must examine the impact of the intervention on total day PA.

Relationships between PA and ADHD-Related Behaviors

Studies in School-Age Children

Interventions in elementary school-age children and adolescents have shown positive changes in ADHD symptoms and executive functions, yet these studies are limited by their various measures of PA and ADHD outcomes, as well as PA modality (1, 38, 52, 87, 95, 98, 110, 123, 126, 128, 129, 148, 154, 157, 173, 187, 197, 215, 225, 240, 252, 258). Lab-based studies have allowed researchers to examine the acute effects of PA on ADHD-related behaviors and cognition. Overall, findings support medium to large effects (Cohen's d = 0.5 – 0.8) on executive functioning, specifically attentional control (52, 77, 157, 164, 187). For example, one laboratory-based study examined the effect of an acute 20-minute bout of PA compared to a sedentary condition on inhibitory control (assessed via a flanker task) and stimulus-related processing (assessed via neuroelectric assessment using brain event-related potentials) in children with ADHD and matched controls (n = 40, 70% male, age = 9.5 ± 0.5 years) (187). Although children with ADHD started with lower response accuracy compared to controls (-7.0% ± 1.4%, $p = 0.026$), both groups improved response accuracy following exercise (87.1% ± 1.7%) compared to the sedentary condition (83.5 % ± 1.8%, $p = 0.011$) (187). Additionally, they also improved in academic performance measures of reading and mathematics. These improvements were also accompanied by neuroimaging changes, suggesting that acute exercise-induced changes in brain activity had occurred (187, 225). However, only one acute lab-based study demonstrated a reduction in behavioral outcomes, specifically disruptive behavior assessed via a 10-item IOWA Conners rating scale (95).

In contrast to acute PA studies, long-term effects of PA interventions seem to be stronger in the emotional and behavioral domain from parent and/or teacher reports (1, 38, 54, 110, 123, 126, 128, 148, 154, 215). Furthermore, objective executive functioning tests demonstrated medium to large effect sizes on attentional control, inhibition, and working memory in this population (38, 52, 54, 128, 240). However, these results should be interpreted with caution due to differing frequency, duration, intensity, and modality, as well as PA and ADHD-related behavior assessment methods. Additionally, most of these studies lack female participants, included a wide age range, and did not specify ADHD severity or medication status. The present study addressed these limitations by including female participants, narrowing the age range by including only 2.9-5-year-old children, and assessed whether children were taking any medication to alleviate common ADHD-related behaviors. It is also critical that the underlying mechanisms regarding acute and chronic effects of PA in this population are understood to better understand these outcomes.

Incorporating time for PA into the school day can be difficult with increasing demands for academic instruction. Because of this, researchers have attempted to incorporate PA into alternate times during the school day. For example, Verret et al., conducted a 10-week PA intervention for children with ADHD ($n = 21$, age = 9.1 ± 1.1 years) that was held three days per week during lunch time (240). These sessions included aerobic, muscular, and motor skill exercises targeting MVPA. Results indicated that children who participated in the lunch time PA intervention had improved parent- and teacher-reported behavior, specifically impulsivity ($t(8) = 2.53$, $p = 0.035$), as well as improved information processing ($F_{1,19} = 2.98$, $p < 0.05$) (240). In this study, only

program intensity and duration were assessed, so it is unknown if PA levels were altered over time. Unfortunately, both teachers and parents were not blinded to intervention group, so it is possible that bias influenced behavioral outcomes. Thus, objective measures of children's behavior, such as direct observation should be utilized in future studies. Similarly, Smith et al., conducted an 8-week PA intervention for children (n = 14, male = 42.3%, age = 6.7 ± 1.0 years) exhibiting elevated levels of ADHD-related behaviors in a before-school setting (215). This daily 30-minute intervention utilized a station-based small group game design to elicit MVPA. Results showed improved response inhibition ($t = 2.42$, $p < 0.05$) and improved parent- and teacher-reported behavior (215). This study was limited by its lack of control group and small sample size. Additionally, it did not assess PA which limits our understanding of the study results. However, it did provide preliminary data as one of the few studies specifically examining the effect of PA on a younger sample. Therefore, PA interventions have shown promising effects for improving ADHD-related behaviors in elementary school-age children and should be explored further. The lack of data in children less than six years old also emphasizes the need to explore this relationship in younger children. A major limitation of the reviewed studies is the lack of objective PA assessment both during the intervention sessions and during the total day. The present study sought to address these limitations by objectively assessing PA during the intervention and total day in preschoolers.

Studies in Preschool-Age Children

Among the few studies that increased preschool-day PA, none have examined these increases in regards to classroom behavior variables as an outcome (214). Therefore, there is a need for PA interventions specifically designed to improve ADHD-related classroom behavior in this age group. The knowledge in this area is limited by inconsistent assessment methods and lack of studies in preschool-age children. The current understanding of the relationship between PA and classroom hyperactive/impulsive and inattentive behavior is based on studies in typically-developing preschool children, or older children with ADHD. This forces extrapolation of study findings to preschoolers which is not beneficial due to the developmental differences that exist between age groups. Currently, little is known about the relationship between and the impact of PA on cognitive development in typically-developing preschoolers (46, 228).

Cross-sectional and quasi-experimental studies conducted in typically-developing preschoolers with elevated levels of ADHD-related behavior have shown benefits related to executive functioning, which is critical in ADHD development (24, 41, 104, 109, 134, 171, 248). For example, one study (n = 16, 81% male, age = 4.1 ± 0.4 years) utilized an acute 30-minute bout of PA or 30-minute sedentary bout during the preschool day and reported that preschoolers demonstrated significantly better ability to sustain attention following the PA condition (171). Another acute bout study conducted in the preschool setting tested the effects of a 10-minute teacher-led PA bout on time on-task. Preschoolers (n = 118, male = 47%, age = 3.8 ± 0.7 years) engaged in two 10-minute PA bouts and two 10-minute typical instruction periods over the course of four days (248).

Both PA and time on-task were assessed objectively, with accelerometers and direct observation, respectively. Results indicated that participating in the PA bout led to improved time on-task ($F_{1,117} = 18.86$, $p < 0.001$) immediately following the activity bout (248). Importantly, children who were the most off-task before the PA bout (i.e., those who may be demonstrating maladaptive classroom behavior) showed the greatest improvement in time on-task, improving by 30% (49.8% before PA, 80.8% post PA; $F_{1,116} = 72.96$, $p < 0.001$) (248). This finding was critical as it emphasized the benefit of a small dose of PA to impact children exhibiting maladaptive classroom behavior and assessed on-task behavior directly which results from several executive functions. However, the short study duration suggested that the novelty effect could contribute to the positive result. Another key limitation was that total day PA was not assessed. While the study aimed to examine acute responses to PA, it is possible that total day PA impacted the results. Two studies targeted preschoolers with an ADHD diagnosis with a game-based approach and reported improvements in parent-reported hyperactivity assessed via the ADHD-IV rating scale and BASC-2, respectively (104, 109). However, neither study assessed the intensity or duration of these physically active games. They were also delivered by parents, which led to inconsistent doses of PA among participants.

The only randomized controlled trial examining the effect of a PA intervention on classroom behavior in preschool-age children was a secondary data analysis stemming from a larger intervention study (4). Seventy-one preschoolers (age = 4.3 ± 0.7 years, male = 49%) in eight classrooms (two preschool centers) participated in a locomotor skill-based PA intervention. Children randomized to the intervention group participated in a teacher-led 30-minute locomotor skill-based session while the control group

participated in a 30-minute unstructured free play session (4). Each group participated in their assigned session for 30 minutes per day, five days per week, for six months (4). Classroom behavior was assessed using the teacher rating scale of the BASC-2 questionnaire at baseline, 3-months, and 6-months, while PA was assessed with an accelerometer at baseline and 6-months. Results indicated that there was a statistically significant decrease in classroom hyperactivity (INT = -2.58 points, $p = 0.001$; CON = 2.33 points, $p = 0.03$), aggression (INT = -2.87 points, $p = 0.01$; CON = 0.97 points, $p = 0.38$), and inattention (INT = 1.59 points, $p < 0.001$; CON = 3.91 points, $p < 0.001$) (35). Interestingly, this study did not significantly alter preschoolers' PA levels, but reduced percent time spent in sedentary time and improved leaping motor skills (4). Despite the lack of change in PA, this intervention provided initial support for PA as a potential alleviate tool for disruptive classroom behaviors. The non-significant PA finding could be due to several reasons, specifically the use of accelerometers to assess locomotor-based PA. One of the major limitations of this intervention was that teachers did not implement each session with high fidelity (4). In a post-intervention survey, teachers indicated that they often did not implement the lessons because the lesson plans were too long, and this was exacerbated by the need to set up their classroom for activity prior to the lesson beginning (4). Therefore, it is possible that the intervention became burdensome during their daily schedules, which could have led to a lack of change in PA. Therefore, including PA during the teachers' daily routines may enhance intervention fidelity. Several review authors have suggested areas to consider in future research including incorporating an intervention into the preschool-day, objective PA measures, multimethod assessment of classroom behavior, long-term follow up to understand

lasting effects, and the need to quantify the characteristics of an effective PA dose. Therefore, the present study utilized a PA program integrated into early learning standards, objective assessment of PA, and both objective and subjective assessment of classroom behavior.

Summary

In preschool, children are taught to adjust to an academic classroom setting, interact with teachers and peers, and focus their attention on teacher-directed tasks. Poor classroom behavior (i.e., inattention, hyperactivity, impulsivity) are disruptive in the preschool environment. These behaviors expressed at a young age are associated with academic underachievement, behavioral problems, and the potential development of ADHD. Studies have shown positive changes in ADHD-related behaviors as a result of PA interventions in school-age children. However, limited data exists in preschoolers, where symptom onset begins. Physical activity interventions in the preschool setting have shown mixed results, but integration into academic lessons may lead to greater compliance and positive results. Despite the growing research surrounding PA as a potential treatment method in school-age children, very little is understood about its ability to improve classroom behavior in preschoolers. The present study sought to address several key limitations in the literature. Some of the major limitations included objective measurement of PA, lack of theory-driven design, lack of multimethod classroom behavior assessment, and lack of academic integration. This area of research is still in the preliminary stages of exploration. The present study allowed us to begin to understand the complex relationship between PA and classroom behaviors in a young, understudied population.

CHAPTER III

METHODS

Introduction

The purpose of this study was to examine the feasibility, acceptability, and efficacy of a 12-week academically-integrated PA intervention on classroom behavior in preschoolers. In this randomized controlled trial, participants were recruited from two preschool centers in the Greater Springfield, MA, area. The preschool centers were randomized to either the Preschoolers Actively Learning intervention (PAL) or health tracking control (CON) group. Participants in the PAL group received the PA program integrated into early learning standards for 10-15 minutes per day, four days per week for 12 weeks in Fall 2018 (Figure 1). The CON group was asked to maintain their normal curriculum for 12 weeks and received the intervention following post-intervention data collection. While the unit of randomization was the preschool, children were individually recruited for assessments and used as the unit of analysis in this study. Prior to data collection, parents completed both an informed consent for their participation and permission for their child to participate in the study. Baseline data collection occurred at the preschool centers over the course of two weeks. Baseline measures included physical measures, habitual PA, parent surveys, classroom behavior, and a brief cognitive task. Primary outcome variables (i.e., feasibility, acceptability, fidelity) were assessed daily, weekly, and post-intervention. Secondary outcome variables (i.e., classroom behavior, PA) were assessed at baseline, midpoint, and post-intervention.

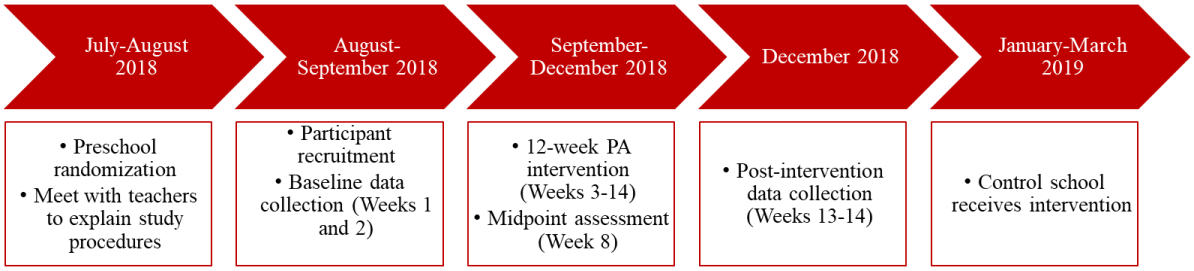

Figure 1. Study design for the PAL pilot study.

Preschools and Participants

Preschool Randomization

This study was conducted at two preschool centers in the Greater Springfield, MA, area. Preschools were eligible if they had at least three full-day preschool classrooms with approximately 12-20 students per classroom. Children's House and the Scantic Valley YMCA Learning Center agreed to participate in this study. These centers were selected because they are similar in terms of enrollment, program offerings, and curriculum. At baseline, both centers underwent a PA policy and environment evaluation observation using a modified version of the Environment and Policy Assessment and Observation Audit Tool. The preschool center was the unit of randomization rather than the classroom or individual child to limit intervention contamination. This design was selected as it is possible that randomizing classrooms within the preschool center may have led to bleeding of the intervention protocols across classrooms. For example, if one classroom was randomized to the intervention and the teacher had a positive experience with the PA lessons, it is possible that he or she spoke to another teacher who was randomized to the control group. The control group teacher may have implemented some of the intervention activities based off the recommendation and may have unknowingly compromised the integrity of the study. Preschool centers were randomized to either the

PAL or CON group using a random list generator. Because the preschool was the unit of randomization, all children enrolled in the preschool program were allowed to participate in their assigned condition. The PAL preschool participated in a 10-15-minute PA lesson during their morning circle time. Morning circle time was chosen as this part of the preschool day as it typically consists of sedentary activities such as sitting while reciting the date, weather, and classroom tasks. The CON preschool maintained their normally scheduled curriculum activities for the duration of the study. Following post-intervention data collection, the CON preschool was offered all intervention activities for 12 weeks. No data was collected at this time.

Participant Recruitment

Children attending the two participating preschool centers were individually recruited for the assessment portion of this study utilizing methods that have previously been successful in our lab (2-5). Children were individually recruited due to the PA assessment protocol (i.e., seven consecutive days of accelerometer wear). Before children were recruited, research staff met with preschool teachers to thoroughly explain study details and answer any questions they had regarding the study. Flyers describing the study were placed in all preschool children's cubbies and were sent home to their parents/guardians (Appendix A). Flyers were also be distributed at recruitment events such as afterschool or parent events. If interested, an envelope containing informed consent and parent permission was sent home with the child (Appendix B). Researchers were also present at pick up times and preschool events, if a parent/guardian preferred to fill out the paperwork at that time. We also utilized the preschool parent newsletters to

inform families of the study. Because classroom teachers were asked to provide specific information about each study participants' classroom behavior, they were individually recruited to participate in the study. Teacher recruitment occurred during teacher meetings at the beginning of the study. If teachers were interested in participating, they were asked to complete an informed consent document (Appendix C). Teachers were informed that the data they provided for each participant was confidential and not shared with parents.

Participant Inclusion & Exclusion Criteria

Children were eligible to participate in this study if they were between the ages of 2.9 and 5 years old at the time of baseline assessments and attended one of the two participating preschool centers. All children within each preschool center were allowed to participate in their preschool assigned intervention. However, in both groups, children were excluded from the assessment portion of the study if their parent/guardian did not complete the parent permission and informed consent documents. Additionally, children were excluded from specific analyses if they did not complete those measures. For example, if a child did not wear the accelerometer for the designated minimal amount of time, he/she was excluded from PA analyses. Because the literature has provided preliminary evidence that PA may impact the most off-task children (e.g., those who may exhibit ADHD-related behaviors) (123, 248), children were not excluded if they had any developmental disorder diagnosis or individualized education plan that impacted classroom behavior. Children were not excluded if they were taking medication to alleviate ADHD-related behaviors. It is likely that even if they were using medication, it

would not fully treat the symptomology. Change in medication was the greatest concern in this study, and this was reported by parents at baseline and post-intervention. Medication use was not prevalent in this sample, so it was not included as a covariate in analyses.

In the present study, classroom teachers participated in the assessment portion of the study by completing classroom behavior questionnaires for children who were participating in the assessment portion of the study. Teachers were eligible to participate if they were the primary or secondary teacher in the preschool classrooms in one of the two preschool centers. Because assistant teachers and temporary staff often spend short amounts of time in multiple classrooms, they were excluded from participation. For this study, we were interested in the teacher-reported classroom behavior completed by the teacher who spent the majority of the day with the child.

Experimental Intervention

Intervention Theoretical Framework

The proposed study sought to alter PA and classroom behavior by utilizing the Social Ecological Model (SEM), which is a comprehensive framework that includes various levels of health-impacting settings such as individual, interpersonal, organizational, community, and public policy levels while acknowledging that each level has a complex interplay amongst each other (202, 221). Use of this model suggests that change must occur across multiple levels to lead to behavior change. In this study, we aimed to alter the organizational level (e.g., preschool center PA policies, teacher training

and knowledge), the interpersonal level (e.g., modeling of PA program by research staff, teachers, and peers), and the individual level (e.g., exposure to active lesson plans).

Intervention Development

Previous preschool PA interventions have shown minimal changes in PA (223, 246), and may have been limited by lack of teacher compliance. In preschool classrooms, lack of time and the burden of meeting early learning standards are common challenges faced by teachers (7, 73). Due to this, researchers have begun to incorporate PA into academic curricula in an effort to increase implementation rates by teachers, children's PA levels, and academic outcomes (133, 134, 176, 231). Physical activity lessons utilized in the present study were adapted from intervention activities and lessons from the lab's Preschool Activity, Diet, and Sleep Study (6). In this study, 10-15 minute PA lessons were implemented three days per week and PA was assessed with accelerometers for seven consecutive days at baseline, 6 weeks, and 12 weeks. Results indicated that there was a significant increase in minutes spent in MVPA during the preschool day at 6 weeks compared to baseline (mean difference (MD) = 11.1 ± 3.7, $p = 0.01$) and at 12 weeks compared to baseline (MD = 16.7 ± 4.3, $p < 0.001$) (6). However, this study was not designed to assess classroom behavior. Despite the success of limited studies integrating PA into early learning standards, none have examined the effect of this type of PA intervention on classroom behavior in preschoolers.

Experimental PA Intervention

The PA intervention was integrated into Massachusetts early learning standards (Table 1) and was implemented four days per week for 12 weeks. Each intervention

session was conducted for 10-15 minutes during morning circle time at the preschool randomized to the PAL group. The intervention dose of 15 minutes aimed to be short, so it could be easily integrated into the daily preschool schedule without altering other activities. The PA intervention sessions were designed to be conducted indoors in small classroom spaces and were led by trained research staff members from the Pediatric Physical Activity Laboratory. Because the teachers are the primary role models for their students, teachers were asked to participate in the PA sessions as well. To demonstrate initial feasibility, it was important that researchers led the intervention sessions before teachers were trained to do so. Teachers assisted research staff and were encouraged to join the children during the PA lessons. Prior to the beginning of the intervention, a meeting took place with the teachers to explain study protocols and the lesson manual. Lesson plans were grouped by targeted learning standard and included suggestions for extension activities and modifications (Table 1). A member of the research staff checked in with teachers weekly to ensure the PA lessons aligned with the targeted early learning standards. Each PA lesson began with a brief (1-2 minutes) warm-up consisting of dynamic movements. The main component of the lesson plan (11-13 minutes) integrated PA into early learning standards through fun, age-appropriate activities. Finally, the PA lesson ended with a brief (1-2 minutes) cool-down consisting of low intensity movements and stretching. Due to the various ages of children enrolled in preschool classrooms, age-appropriate modifications were included with each lesson plan (Appendix D).

Table 1. Examples of PAL Lesson Plans and Early Learning Standard Integration.

Sample Lesson	Learning Standard Integration	Description	Example Movements	Extension Options
Treasure Hunt	-Mathematics: Counting, Cardinality -Social/Emotional: Social and Emotional Approaches to Play/Learning	A researcher will lead students on a treasure hunt. A number card will be presented. Students will say the number out loud and count along with their actions. Children will end with "10" to signify finding the treasure.	If a "3" card is chosen, students will belly crawl under a fishing net 3 times and count aloud. If a "4" is chosen, children jump high to grab a coconut 4 times.	Ask the students for other activities that may occur on a treasure hunt and have them choose a number for each action. Examples include hoist the flag, walk the plank.
Alphabet Pond	-English, Language Arts, and Literacy: Reading Foundational Skills	Alphabet cards will be laid on the floor throughout the space (only letters A, B, C). The researcher will tell the students to move like frogs and either jump or swim around the lily pads when the music is on. When the music stops, the student will stop on the nearest lily pad and perform the designated action.	If a child stops on an "A" lily pad, he/she puts their belly on the lily pad. If a child stops on an "B" lily pad, he/she puts their bottom on the lily pad. If a child stops on an "C" lily pad, he/she stands tall on tippy toes.	The researcher can alter the directions to make this a memory style game. For example, children must flip the lily pads over to hide the letters, they will then be instructed to recall where the letter "A" lily pads were and find one.
Copy Cat	-Mathematics: Measurement and Data	A researcher will provide a brief demonstration of small/big, light/heavy, narrow/wide movements. The students will copy the movements of the research like "Simon Says."	The researcher (Cat) will take wide steps around the space. Students will copy that movement unless the Copy Cat didn't say to do it.	Students may take turns being the Cat and choosing a movement for their peers to copy.
Crazy Traffic Lights	-English, Language Arts, and Literacy: Recognizing Environmental Print, Speaking and Listening, Vocabulary	Just like cars, we will follow the rules of the traffic light. In part 1, children will be shown green and "Go" will be said to begin. Children will be shown red and "Stop" will be said for movement to stop. In part 2, these will be reversed.	Children will perform small jumps around the space while the green light is being shown. They will freeze when the red light is shown. Other examples of movements include hopping, walking, running in place.	Introduce the yellow light as a third color option. Children will now need to move in slow motion when the yellow light is shown.
Moving Like Animals	-Theater Arts: Create characters through movement -Life Sciences: Identify characteristics of animals -Mathematics: Measurement and Data	The researcher will show the students a letter flashcard using 6-8 letters. They will identify the letter and think of an animal that starts with that letter. Students will move around like that animal for ~30 seconds before moving on to the next letter.	If a "K" card is chosen, students will identify the letter and suggest that a kangaroo starts with K. Children will then take big jumps around the space until a new letter is drawn.	Additional letters can be introduced to this lesson.

Health-Tracking Control Group

During the 14-week study, the preschool randomized to the health-tracking control group maintained their usual curriculum. The health-tracking control preschool was critical in identifying the effect of the intervention on the efficacy outcome variables as opposed to the effect of a typical preschool curriculum. All measures were collected at the health-tracking control preschool during the 14-week study in the fall of 2018. After the completion of data collection, this preschool was offered the PA intervention and all resources. No data was collected during this time.

Measurements

All assessments were conducted at the participating preschool centers. Trained members of the research staff completed all data collection. Baseline data collection took place at the end of September 2018. Midpoint data collection took place during week 8 of the study (Week 6 of the intervention, November 2018), and post-intervention data collection occurred during week 14 (Week 12 of the intervention, December 2018). Primary outcome variables (i.e., feasibility, acceptability, and fidelity) were assessed at various times throughout the study (Table 2). Secondary outcome variables (i.e., classroom behavior, PA) and covariates were assessed at baseline, midpoint (except teacher-reported classroom behavior), and post-intervention (Table 2).

Table 2. Assessment schedule for the PAL pilot study.

	Baseline	6 Weeks	12 Weeks
Primary Outcomes			
- Feasibility	X	X	X
- Acceptability	X	X	X
- Fidelity	X	X	X
Secondary Outcomes			
- Classroom behavior (BASC-3, teacher report)	X		X
- Classroom behavior (direct observation, research staff)	X	X	X
- MVPA percent time (accelerometer)	X	X	X
- Sedentary percent time (accelerometer)	X	X	X
Covariates			
- Demographics & socioeconomic status (PR)	X		
- Child's age	X		X
- Child's anthropometrics	X		X
- Child's medication use (PR)	X		X

BASC-3 = Behavior Assessment System for Children Version 3, MVPA = moderate-to-vigorous physical activity, PR = parent report.

Primary Outcome Measures

Because the present study was a pilot feasibility study, the primary outcome variables included several process evaluation measures. These variables were assessed via semi-structured questionnaires and were completed by trained members of the research staff and classroom teachers (Table 3).

Table 3. Primary outcome process evaluation measures and assessment schedule.

Variable	**Example**	**Assessment**	**Time Point**	**Assessed By:**
Fidelity: Did implemented program match the originally intended program?	Adherence, integrity, replication Compliance	Questionnaire Accelerometers	Daily Weekly	Research staff Accelerometer
Dosage: How much of original program was delivered?	Quantity	Questionnaire Teacher logs	Daily	Research staff Teacher
Quality: Were all components of the program delivered clearly and correctly?	Delivery	Questionnaire Direct observation of intervention	Daily	Research staff
Participant Responsiveness: Did children enjoy the program?	Attentiveness, interest of children	Questionnaire	Daily	Research staff
Monitoring of Control	INT contamination, usual practices	Questionnaire	Weekly	Research staff
Program Reach	Participation rates	Center attendance records	Daily	Teacher
Adaptation	Program modification	Questionnaire Teacher logs	Weekly	Research staff Teacher

Process Evaluation Measures

The feasibility of this intervention was assessed by meeting pre-determined recruitment (n = 42) and retention (80% at 12-week data collection) goals as well as through various fidelity measures. Fidelity, or the extent to which the implemented

intervention matched the originally designed program, contained several variables including intervention adherence, compliance, integrity, and replication (79). Intervention fidelity was measured following a direct observation of the intervention session by a research staff member. This individual completed a semi-structured questionnaire (Appendix E) to provide information regarding participation rates (compliance), how long children participated (adherence), if the intervention was implemented as originally designed (integrity), and if all components (i.e., warm-up, lesson, cool-down) of the intervention were implemented (replication).

The dosage of the intervention was assessed via semi-structured questionnaire (Appendix E) which was completed on a daily basis. For this measure, the start and stop times of the PA lessons were recorded by a trained member of the research staff. The quality of the intervention was assessed with direct observation of the intervention sessions using semi-structured questionnaire. A trained research staff member described if the intervention session was delivered clearly and correctly daily. Intensity of the intervention session was assessed with Actigraph accelerometers on one randomly selected day per week. On this day, enrolled participants wore their accelerometers around their waist and positioned on their lower back for the duration of the intervention PA lesson only. The intensity goal for the intervention was 50% of the time spent in MVPA, so this measure allowed us to quantify participants' compliance to the target intensity level. The intensity goal of 50% was selected due to results from a previous study in our lab in which participants spent 47% of the intervention time in MVPA (6). We hypothesized that the MVPA goal would be higher than our previous study as we have modified some lesson plans with teacher feedback to make them more active.

Because one goal of the PA intervention was to elicit MVPA among participants, this assessment provided insight into the actual intensity levels of the activities. Program reach was assessed by recording classroom attendance and participation rates of both enrolled and unenrolled children participating in the intervention. Teachers aided the research team and provided classroom attendance information. Finally, intervention adaptation was recorded daily after each intervention session by a trained research staff member. In addition to recording if an adaptation occurred, the researcher also recorded detailed notes describing what adaptations occurred and why they may have occurred. Teachers also had the opportunity to record any recommended adaptations specific to their classroom in their weekly teacher log. This information was crucial in understanding the feasibility of the originally designed intervention.

Acceptability of the intervention was determined by both teachers and children from their responsiveness to the intervention. Researchers assessed children's participation rates and enjoyment levels during each intervention session using the semi-structured questionnaire. Teachers also completed weekly logs in which they were able to express their satisfaction levels with each PA lesson, recommend adaptations, and the likelihood of implementing this lesson again. Following the completion of the 14-week study, teachers in the PAL preschool were given a post-intervention survey (Appendix F) to anonymously rate their overall satisfaction with the intervention via Likert-type questions and open-ended questions.

Finally, the preschool that was randomized to the health tracking control group was observed one day per week by a trained member of the research staff. The researcher directly observed morning circle time, which was the same time period that the

intervention preschool was participating in the PA lessons. Enrolled children were asked to wear the accelerometers during this time. The researcher utilized a semi-structured questionnaire for control school monitoring and also had the opportunity to record notes about the PA opportunities that may or may not have been offered during that time frame (Appendix G). Additionally, teachers were asked to record any additional PA or gross motor time that was planned for later in the day after the observation had ended. This weekly direct observation was crucial to ensure that no intervention contamination or implementation of other forms of PA confounded the study outcomes. Additionally, an environmental observation of the preschool center took place at baseline and post-intervention to assess any changes in the preschool PA environment.

Secondary Outcome Measures

Classroom Behavior

Direct Observation

Children's classroom behavior was directly observed by trained research staff members utilizing a modified version of the Behavioral Observation of Students in Schools (BOSS; Pearson, San Antonio, TX) software (208). The BOSS system was chosen because it targets positive behaviors such as academic engagement measured via time on-task, as well as maladaptive behaviors in the classroom (243). The BOSS software was utilized on an iPad application that allowed the observer to collect data without interrupting or distracting classroom activities. This measure has high inter-rater reliability with total agreement of repeated observations ranging from 90-100% (169), and kappa coefficients ranging from 0.93 - 0.98 (0.95 ± 0.02) (78). In a sample of 136

children exhibiting ADHD-related behaviors and 53 typically developing children, researchers reported 91.5 - 99.3% agreement across behavioral categories and two difference subject areas (i.e., math and reading class). Additionally, this study demonstrated the ability of BOSS to discriminate between children demonstrating ADHD-related behaviors in the classroom and their typically developing peers. There is limited data supporting treatment sensitivity, but results have indicated that the BOSS may be sensitive to changes after intervention. For example, in a small intervention study in children with ADHD (n = 3), active engaged time (effect size -2.91, -13.01) and a composite off-task score (effect size 1.8, 3.06) were shown to be sensitive to children's exposure to different intervention conditions (169). Despite the limited psychometric property data, researchers suggested that the BOSS system has enough evidence to be used as part of a multimethod assessment system (243), which is how it was utilized in the present study.

Trained research staff members performing the direct observation of classroom behavior were blinded to the preschool's intervention assignment. Six observers were recruited to conduct BOSS observations at baseline, 6-weeks, and 12-weeks. These individuals were blinded to the study purpose, hypotheses, and randomization. They did not attend research staff meetings and therefore only had contact with the PI. Separate meetings between the PI and BOSS observers took place for training purposes. By recruiting observers outside of the initial research team, we aimed to maintain blinding and minimize bias during observations. These observers underwent a rigorous training (i.e., approximately 15 - 20 hours) consisting of video observation and coding to ensure at least 80% agreement with the expert observer, which is recommended for BOSS

proficiency (243). Once this was achieved, observers were able to observe in the classrooms for data collection. To calculate inter-rater reliability, observers practiced video coding of preschool classroom lessons and activities prior to each data collection week and also double coded a subsample of participants at baseline. Observers entered the preschool classroom following morning circle time activities and aimed to not overlap with intervention leaders at the intervention school. Observations were conducted following morning circle time at both the PAL and CON preschools. Children were observed for 5 minutes following morning circle time on four separate days during the assessment period. These observations were averaged together for each assessment period. Each observer was assigned up to 12 children, and they were observed one at a time resulting in observations taking place immediately after and up to one hour following the intervention session. Observers were instructed to not enter a classroom until another member of the research staff had indicated that they may do so. Teachers were also be informed that observers did not know their group assignment to uphold blindness. It was possible that children were talking about the activity they just participated in while the observer entered the classroom, and this could not be controlled for.

Observers were trained to enter the classroom quietly and to not engage with children. While this did not rule out the chance of an observer seeing another staff member implementing the intervention in a separate classroom or overhearing a child or teacher talk about the intervention, every effort was made to ensure the classroom observers remained blind to the preschools' random assignment. Because the research question aimed to examine classroom behavior, children were only observed if the class

was engaged in indoor activities (e.g., large group activity, small group activity, learning centers) in the classroom. If the class went outdoors for free play immediately following the intervention, children scheduled for observation were not observed on that day. Instead, children were observed on the next available intervention day when the class returned to their normal indoor activities following the intervention time. As part of the observation, research staff indicated the setting of the observation (e.g., large group instruction, small group instruction, small group without teacher present) and the task (e.g., circle time, small learning centers). Every attempt was made to observe children in two different classroom tasks over the course of the assessment period to account for differences in behavior based on the task in which the child was engaged. The time that each child was observed varied amongst the observation days. For example, if a child was observed early in the session (i.e., in the first five minutes of the 60-minute observation period), he or she was observed towards the middle and end of the observation session on other days.

Classroom behavior was observed in 15-second intervals during the 5-minute observation period. The BOSS system utilized a combined momentary and part-interval recording system (Figure 2). On-task time was assessed with momentary time sampling, which means that the behavior was only recorded if it was present at the beginning of the 15-second interval (118). On-task behavior was categorized into either active engaged time (AET) or passive engaged time (PET). Examples of AET included actively engaging in teacher-directed activities such as singing aloud, writing, coloring, raising a hand, and talking to the teacher about assigned material (181). AET was not coded if the child was talking about unrelated topics, calling out, or aimlessly flipping through a book.

Examples of PET included listening to the teacher talk, looking at a worksheet, silently looking through a book, and listening to a classmate answer a question (181). PET was not coded if the child was looking around the classroom, silently reading unassigned material, or simultaneously engaging in other forms of off-task behavior. Conversely, off-task behavior was recorded using part-interval sampling, which means that the behavior was recorded if it occurred for at least three seconds at any point during the 15-second interval (118). Because the expected behavior in a classroom is on-task behavior, the two were coded differently to avoid over-reporting of on-task time and to highlight the frequency of maladaptive behaviors. Off-task behavior was defined as any behavior not directly related to a teacher's direction and was categorized as off-task motor (OFT-M), off-task verbal (OFT-V), or off-task passive (OFT-P) (181). Examples of OFT-M behavior included out of seat behavior, playing with unrelated objects, touching another child, drawing in an unrelated task, or fidgeting. OFT-M was not coded if the child was fidgeting while working on assigned material or while following the teacher's directions as this was considered on-task behavior. Examples of OFT-V behavior included making audible sounds, talking to other students or teachers about unrelated topics, and calling out answers when not permitted. OFT-V was not coded if the child was talking to a peer as part of a learning group. Examples of OFT-P included looking around the room, staring out the window, and sitting quietly in an unassigned activity. OFT-P was not coded if a child was sitting quietly performing an assigned task. From these behavior categorizations, outcome data was expressed as percent of the observed intervals (i.e., 5 minutes per observation) a child engaged in AET, PET, OFT-M, OFT-V, and OFT-P.

Finally, the researcher observed the behavior of one randomly selected peer to compare behavior to the target child.

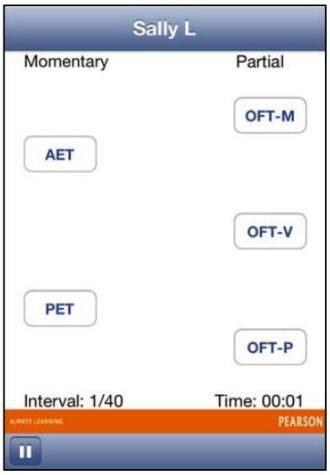

Figure 2. Behavior Observation of Students in Schools (BOSS) user interface during a classroom direct observation. Note: While a student's name is listed at the top as the identifier, only study ID number was used in the present study.

Teacher-Report

Children's classroom behavior was assessed at baseline and 12-weeks via teacher report using the preschool form (ages 2 – 5) of the Behavior Assessment System for Children, Version 3 (BASC-3) (196). Because teachers were unfamiliar with this questionnaire, a member of the research staff trained them on how to complete it appropriately during their initial meeting. The BASC-3 Teacher Rating Scale (TRS) is a comprehensive measure that included assessment of both positive and maladaptive behaviors in the preschool setting (196). Both the inattention and hyperactive subscales were assessed at baseline and at 12-weeks of the intervention. The TRS contained 105 items and took approximately 10-20 minutes to complete per child. Because of the length of time to complete each questionnaire for each child enrolled in the study, teachers were

compensated ($10 per child per time point, total of $20 per child). Questionnaire items encompassed a variety of behaviors that a child exhibited throughout the preschool day and included items such as, “Has trouble concentrating” and “Acts without thinking.” The rating scale used a 4-point response ranging from “Never” to “Almost Always.” Each answer was then assigned a numerical value to yield a raw score, from which *t*-scores (mean = 50, standard deviation = 10) were calculated to estimate the difference from normative data. To calculate a valid subscale score, three or more items must not be omitted. For the subscale calculations, higher scores indicated greater concern, with a score ranging from 60-69 meaning “At-risk” and a score greater than 70 meaning “Clinically significant.”

This questionnaire was administered via paper and pencil format at baseline and post-intervention, and item responses were entered in the online scoring sheet. In order to be scored and compared appropriately, data such as the child’s identification number, birth date, test date, and gender were utilized in the scoring sheet. The BASC-3 also provided validity measures to identify a teacher’s tendency to be excessively negative or flags items that did not match the consistency of items answered. The BASC-3 has demonstrated high internal consistency for composite scales in 2 - 3 year old children ($\alpha = 0.89 - 0.96$) and 4 - 5 year old children ($\alpha = 0.92 - 0.97$) and for clinical scales in 2 - 3 year old children ($\alpha = 0.77 - 0.89$) and 4 - 5 year old children ($\alpha = 0.81 - 0.93$) (196). Test-retest reliability coefficients ranged from 0.71 - 0.93, indicating acceptable to good reliability (196). The BASC-3 scales were strongly correlated with those of the BASC-2, which would be expected (correlations ≥ 0.90). When compared to the teacher version of the Child Behavior Checklist for ages 1.5 - 5 years, moderate correlations were

demonstrated for both composite and clinical scales, with those measuring externalizing behaviors (e.g., hyperactivity) slightly higher. For example, correlations comparing hyperactivity on both scales were 0.67 and those for inattention ranged from 0.58 - 0.61 (196).

Physical Activity

Physical activity levels were assessed objectively with Actigraph accelerometers (Actigraph, LLC, Pensacola, FL). Accelerometers were worn on an adjustable elastic belt around the waist of the participant, and were placed on the lower back to remain unobtrusive (232). Participants were asked to wear the accelerometer for seven consecutive days both during and outside of preschool. Data was stored in 15 second epochs to account for the sporadic nature of children's PA. Wear time was determined by a modified Troiano et al., (2007) algorithm to categorize non-wear time as twenty or more consecutive minutes of recorded zeros (230). Valid wear time criteria were defined as 8 hours per day for a minimum of three days. Pate et al., cut points for preschool-age children were used to convert unitless counts into PA intensity categories [sedentary time (ST); 0 - 199 counts per 15 seconds, light PA (LPA; 200 - 419 counts per 15 seconds), moderate PA (MPA; 420 - 841 counts per 15 seconds), vigorous PA (VPA $\geq$ 842 counts per 15 seconds)] (174). Accelerometers were initialized, downloaded, and data was reduced using Actilife software (Version 6.13.3).

Because accelerometers are limited in the type of activities they can detect (i.e., they have difficulty detecting upper body movements), direct observation was utilized to better understand the movement occurring during the intervention sessions. On the

randomly selected day per week in which the children wore the accelerometers for the lesson only, one member of the research staff directly observed the session using a modified Observational System for Recording Physical Activity in Children – Preschool (OSRAC-P) (33). The OSRAC-P was designed to assess children's PA in preschool classrooms. Within the observed classroom, participating children were randomly selected to be observed. Children were observed in 15-second intervals for approximately 3-4 minutes. Children's PA was coded as stationary (sedentary), upper limb movement (light intensity-upper limb), easy-slow (light), or moderate-to-fast (moderate-to-vigorous). According to the OSRAC-P scoring system, the stationary and upper limb movements are combined into the sedentary intensity category. However, for this study, we chose to keep upper limb movement as its own category to help distinguish movements that are light intensity but may be classified as sedentary due to the waist placement of the accelerometers.

Covariate Variables

Height & Weight

Height and weight were assessed at baseline and post-intervention (Appendix H). For both measurements, children were asked to remove their shoes and excess clothing (e.g. sweatshirts, jackets). Children were asked to stand as still as possible during the measurements. Height was measured twice to the nearest 0.1 cm using a portable stadiometer (Shorr Height Measuring Board, Olney, MD). A third measurement was only taken if the first two measurements differed by >0.5 cm. Weight was assessed using a portable scale (Scaletronix 5125, White Plains, NY) and was recorded twice to the

nearest 0.1 kg. If the two measures differed by >0.3 kg, a third measurement was taken. Averages of measurements for both height and weight were calculated. From these measurements, children's BMI percentile was calculated using the CDC age and gender predicted BMI percentile calculator (167). BMI percentile was the variable utilized in analyses.

Demographic Variables

A parent/guardian completed an online demographic survey at baseline (Appendix I). If preferred, a parent/guardian could request a paper copy of this survey that was sent home in a sealed envelope with their child. Through this survey, the parent/guardian provided information describing the child's race and ethnicity, sleep habits, presence of behavioral disorder diagnosis, behavioral medication status, and intention to change medication status over the next three months. The parent/guardian also provided information about his or her family's socioeconomic status which was a composite variable comprised of questions asking about income, highest level of education attained by the parent/guardian completing the questionnaire, and the highest level of education attained by another adult in the household. This composite SES variable was formed using a Principle Components Analysis. During the 12-week assessment, parents/guardians were asked to complete a shorter questionnaire that again asked about their child's behavioral diagnoses, medication use, and if any medication use changed over the course of the study. Parents/guardians were asked to remind the children to wear the accelerometers at home after preschool and on the weekends. At the end of the assessment week, they were reminded to send the accelerometer back to preschool with their child to be collected by research staff members. Due to the time

required to complete baseline and post-intervention questionnaires as well as assisting with their child's out of school accelerometer wear, parents/guardians were compensated $25 at the end of the study.

Preschool Environment

It was possible that classroom behavior could change without a change in PA levels measured via accelerometry. This change could be due to the altered PA policy and practices of the preschool center (e.g. increasing PA opportunities, improving PA policy). To assess the effect of the intervention on preschool center PA environment, the Environment & Policy Assessment and Observation (EPAO) survey was used at baseline and post-intervention (245) (Appendix J). The EPAO tool examined the preschool center's policies and practices related to PA, nutrition, and screen time usage. For this study, only the PA policy and practices subsection of the EPAO was utilized.

Exploratory Variable

Flanker Inhibitory Control and Attention Test

The Flanker Inhibitory Control and Attention Test Ages 3-7 version 2.0 via the National Institutes of Health (NIH) Toolbox for Assessment of Neurological and Behavioral Function on an iPad was used to assess inhibition and attention (162). Before the researcher began the task with the child, a participant profile was selected. Each participant had their own profile containing the study ID number as well as necessary demographic data. A trained member of the research staff administered the test to one child at a time in a quiet environment. Directions for explaining the task appeared on the

iPad screen and were read aloud to the child by the research staff. For this test, the child was instructed to pay attention to the direction of the arrow on the fish in the center of the screen and ignore the flanking fish to the left and right. The child selected the arrow at the bottom of the screen that matched the direction of the arrow on the center fish. This test included both congruent (i.e., all fish pointing in the same direction, Figure 3) and incongruent trials (i.e., the direction of the middle fish does not match the flanking fish, Figure 4). Prior to the test trials, the child completed four practice trials and had to get at least three correct to move on. If the child did not get three out of four practice trials correct, he or she was given two more opportunities to complete the practice trials. The test included 20 trials of mixed congruent and incongruent trials. In a sample of 52 children between the ages of 3 and 15 years, researchers indicated that this test had an intraclass correlation of 0.95 (95% CI = 0.92, 0.97) (249).

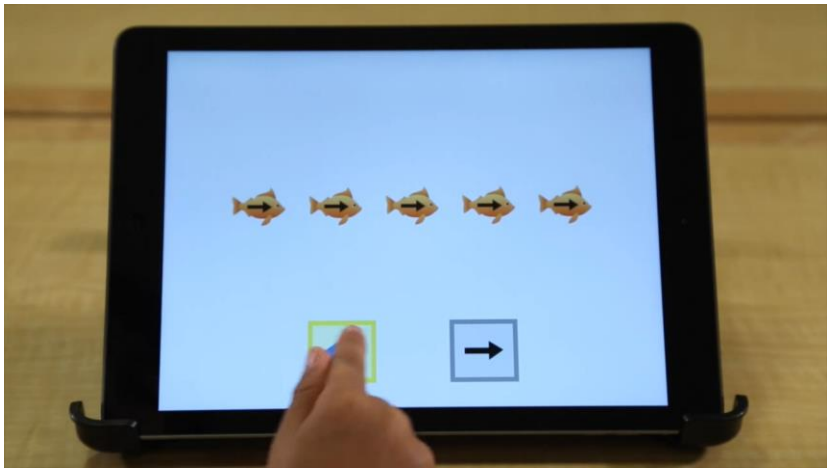

Figure 3. Example of a congruent trial in the Flanker Inhibitory Control and Attention Test.

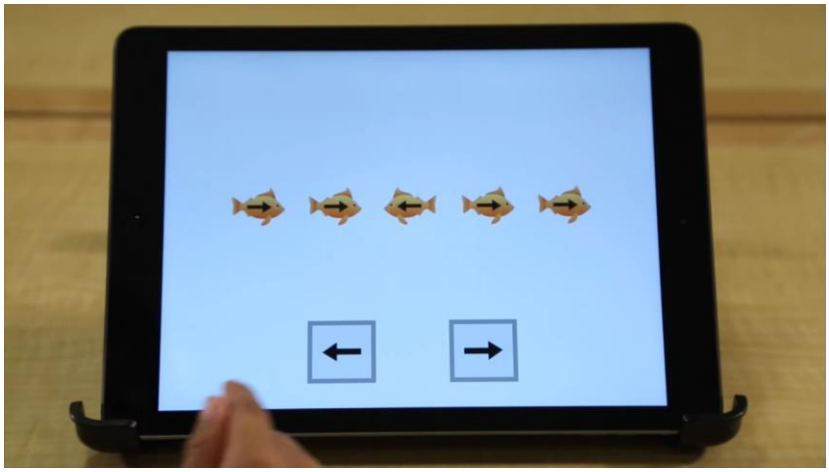

Figure 4. Example of an incongruent trial in the Flanker Inhibitory Control and Attention Test.

Sample Size Calculation

The primary aim of this study was to examine the feasibility and acceptability of a PA intervention integrated into early learning standards on classroom behavior. Therefore, a sample size calculation was not needed to address this aim. However, a sample size calculation was used to estimate the number of participants needed in each group to see a meaningful change in directly observed classroom behavior. Based on the size of the observed effect, sample size varied (Table 4). Using a repeated measures ANOVA model and assuming a 0.6 correlation between measures, a sample size of 578 children would provide 95% confidence and 80% power to detect a small effect (f = 0.1). This sample size estimation was heavily constrained by the number of preschool centers that participated in this study and the number of children enrolled at each preschool center. It was not possible to recruit 578 children. Therefore, we aimed to recruit 19 children per preschool based on the large effect as this fell within the enrollment for each preschool. Additionally, Palmer et al., were able to detect a large effect when comparing

children's attention following PA compared to a sedentary condition (171). Previous preschool PA interventions conducted by the Pediatric Physical Activity Lab have indicated approximately 10% attrition during a 12-week study (6). Due to this, we planned to recruit five additional children for a total sample size of 42 (n = 21 per preschool). Because it was not feasible to recruit enough children to see a small effect, post hoc power estimations were conducted to understand the actual power based on the sample recruited. The sample size calculation was performed using G Power (Version 3.1.9.2, Brunsbuttel, Germany).

Table 4. Sample size and power estimations.

Alpha	Power	Effect Size (f)	N	Group 1 (n)	Group 2 (n)
0.05	0.8	0.4	38	19	19
0.05	0.8	0.3	66	33	33
0.05	0.8	0.25	96	48	48
0.05	0.8	0.1	578	289	289

Statistical Analyses

The purpose of this study was to examine the feasibility, acceptability, fidelity and initial efficacy of a 12-week PA intervention integrated into early learning standards on classroom behavior in preschoolers. The primary outcomes included process evaluation measures designed to inform the feasibility and acceptability of this intervention. Secondary outcomes included preliminary efficacy outcomes such as classroom behavior and PA levels of preschoolers. Normality of data was assessed with

appropriate statistical tests. Descriptive statistics were calculated for each variable at baseline and included means and standard deviations for continuous variables and frequencies for categorical variables. Baseline differences between groups were examined using *t*-tests for continuous variables and chi square tests for categorical variables. Additionally, correlation coefficients and 95% confidence intervals were calculated to examine relationships between variables at baseline. A two-sided alpha < 0.05 was used to determine statistical significance for between groups baseline characteristic differences. All analyses were run using Stata (Version 15.1, StataCorp, College Station, TX).

Research Aims & Hypotheses

The following statistical tests were used to assess each research aim and corresponding hypotheses.

Aim 1: To examine the feasibility, acceptability, and fidelity of a 12-week PA intervention integrated into early learning standards on classroom behavior in preschoolers.

H_{1a}: Feasibility would be achieved if recruitment (n = 42) and retention (80% at 12-week data collection) goals are met.

Analysis Plan: Frequencies were calculated to determine if recruitment and retention goals were met. Additionally, *t*-tests and chi square tests were used to assess if there were any differences in the children who withdrew from the study compared to those who remained in the study

until completion. If a child withdrew from the study, researchers attempted to collect qualitative information as to why that occurred.

H_{1b}: For acceptability, children and teachers would demonstrate enjoyment and satisfaction, respectively, with the intervention program. It was hypothesized that children would demonstrate high participation rates and enjoyment of the PA intervention as assessed by semi-structured questionnaires completed daily by researchers. It was hypothesized that teachers would demonstrate high levels of satisfaction with the PA intervention as assessed weekly and post-intervention with teacher logs and surveys.

Analysis Plan: Means and standard deviations were calculated for continuous variables and frequencies were calculated for categorical variables. Additionally, representative quotes from teacher surveys were presented for qualitative variables.

H_{1c}: Fidelity of the PA intervention was determined by participant adherence and intervention implementation compliance. It was hypothesized that children would engage in MVPA for at least 50% of the PA intervention session as measured by accelerometer. It was also hypothesized that interventionists would deliver the intervention as originally intended 80% of the time.

Analysis Plan: Means and standard deviations were calculated for continuous variables and frequencies were calculated for categorical variables. Additionally, representative quotes were presented for qualitative variables.

Aim 2: To examine the preliminary efficacy of a 12-week PA intervention integrated into early learning standards on classroom behavior and physical activity levels in preschoolers.

H_{2a}: Children randomized to the intervention group would demonstrate a healthier movement profile (i.e., less sedentary time, greater light PA and MVPA minutes per hour) as measured by accelerometer during preschool hours compared to those randomized to the health-tracking control group.

Analysis Plan: To assess the changes in PA levels (i.e., sedentary, light PA, MVPA) across three time points (i.e., baseline, 6 weeks, and 12 weeks), a repeated measures ANOVA was utilized with main effects of group, time, and group*time interaction for each dependent variable. This was selected over a mixed model due to the small sample size and many participants who were missing 6-week PA data were also missing 12-week PA data. Bonferroni adjustments were utilized to assess multiple comparisons when appropriate.

H_{2b}: Children randomized to the intervention group would exhibit improvements in directly observed classroom behavior compared to those in the control group.

Analysis Plan: Direct observation data was categorized as percent of interval spent in AET, PET, OFT-M, OFT-V, and OFT-P. Due to baseline differences between directly observed classroom behavior variables, ANCOVAs were used to assess differences in directly observed classroom behavior between groups while controlling for baseline values.

H_{2c}: Children randomized to the intervention group would exhibit improvements in teacher-reported classroom behavior (hyperactivity/impulsivity and inattention) compared to those randomized to the health tracking control group.

Analysis Plan: To assess the changes in teacher-reported classroom hyperactivity/impulsivity and inattention, change scores were calculated and paired *t*-tests were used for each dependent variable across two time points (i.e., baseline and 12 weeks).

Exploratory Aim 3: To examine the relationships between directly observed off-task time, teacher-reported inattention, and an objective cognitive task of inattention in preschoolers.

H_3: Based on limited data in elementary school children, it was hypothesized that there would be a relationship between directly observed off-task time, teacher-reported inattention, and an objective task of inattention in preschoolers.

Analysis Plan: Data was examined for normality. Correlations and 95% confidence intervals were calculated to examine relationships between directly observed off-task time, teacher-reported inattention, and an objective task of inattention in preschoolers.

CHAPTER IV

MANUSCRIPTS

Aim 1: Feasibility and Acceptability of an Academically-Integrated Physical Activity Program on Preschoolers' Classroom Behavior

Abstract

Academically-integrated physical activity (PA) has the potential to alter health- and academic-related outcomes. However, process evaluation data describing the implementation of academically-integrated preschool PA interventions designed to alter academic-related outcomes such as classroom behavior are sparse within the literature. **PURPOSE:** To evaluate the feasibility, acceptability, and fidelity of a 12-week academically-integrated preschool PA program on classroom behavior in preschoolers. **METHODS:** Two preschools (N = 58 children, n = 6 classrooms) were randomized to either the Preschoolers Actively Learning (PAL, n = 32) or the health tracking control (CON; n = 26) group. The PAL PA lessons were implemented for 10-15 minutes during the morning four days per week for 12 weeks by research staff. Feasibility, acceptability, and fidelity data were collected daily (research staff questionnaire), weekly (teacher questionnaire, accelerometer), and post-intervention (teacher questionnaire). **RESULTS:** The PAL intervention lessons were implemented as intended 93% of the time and were approximately 12.3 minutes in duration. Children spent 40.5% of that time in moderate-to-vigorous PA. Modifications were made to 34.5% of the lessons. While teachers participated in only 68% of the lessons, 100% reported interest in future use. **DISCUSSION:** Results contribute to the limited data supporting academically-integrated

PA during the preschool day. This area of research is promising as programs with high feasibility, acceptability, and fidelity may be adopted by preschool centers to improve health- and academic-related outcomes in preschoolers. Future studies should increase teacher involvement and explore adding multiple PAL lessons throughout the day to increase the dose received by children.

Introduction

Evidence suggests that children are not active enough during the preschool day (27, 29, 76, 191). Due to the low percentage of preschoolers meeting physical activity (PA) guidelines (178, 235), and a high percentage attending childcare centers (88), several interventions have been conducted in the preschool setting designed to improve PA. However, teachers struggle with barriers to implement PA including limited to no equipment, inadequate space, increased demand to meet early learning standards, and inadequate PA-related professional development opportunities (99, 124). Very few studies have incorporated PA into academic lessons within the preschool setting (6, 133, 134, 176, 231), even though this may boost teacher investment in the program and foster enhanced intervention compliance. Further, there is emerging evidence to suggest that physical activity can be an effective way to improve classroom behavior (i.e., hyperactivity, impulsivity, and inattention) in elementary school children (247), yet limited research exists in preschoolers. Teachers estimate that developmentally-deviant levels (i.e., exceeding that of age- and gender-matched peers) of classroom behavior impact 18% of preschoolers (165). Further, when asked about factors that are detrimental to their classroom and student progress, teachers list classroom behavior as a major

contributor (184). Thus, incorporating PA in academic learning standards in preschool may serve a twofold benefit of enhancing both health-related and academic-related outcomes. Altering the preschool learning environment through exposure to increased opportunities for PA and teacher role-modeling of PA may be beneficial for enhancing PA and classroom behavior in preschoolers. Therefore, the Preschoolers Actively Learning (PAL) pilot study was designed to incorporate short bouts of PA into early learning standards that could be done with minimal equipment in small classroom spaces with the aim of potentially improving classroom behavior.

The outcomes of intervention studies (e.g., change in PA) are often influenced by process evaluation measures such as program implementation and fidelity (79). However, few studies report these process evaluation data, which limit our understanding of findings and pose a challenge for replication. Further, it is crucial to explore process evaluation data before researchers progress to assessing a program's effectiveness, due to the variability in program implementation that has been well-established in school-based studies (151, 204). It is also important to consider a program's feasibility and acceptability within the target population before modifying and disseminating this type of program. Because the incorporation of PA into academic settings is growing, it is important for researchers to report implementation data for these types of interventions, so we can better understand which aspects of the program may impact health-and academic-related outcomes. Therefore, the purpose of this paper was to evaluate the feasibility, acceptability, and fidelity of a 12-week academically-integrated preschool PA program designed to influence classroom behavior.

Methods

Participants

Two preschool centers (n = 6 classrooms) in the Greater Springfield, MA, area with similar PA environments, enrollment, and curricula were recruited and agreed to participate in this pilot study. Preschools were randomly assigned to either the PAL intervention (n = 1 preschool; 3 classrooms) or the health tracking control group (CON, n = 1 preschool; 3 classrooms). All children who were enrolled in preschool classes participated in their assigned intervention activities. However, children and their parents were individually recruited to participate in study assessments. Children were eligible for the assessment portion of the study if they were between the ages of 2.9 - 5 years old, were enrolled in a preschool classroom, and had a parent/guardian willing to complete study related materials (i.e., informed consent document and baseline demographics). Teachers were also individually recruited for this study and were eligible if they were the primary or secondary teacher in the preschool classroom.

Intervention

The PAL intervention was a 12-week classroom-based PA program that was designed to incorporate the Massachusetts early learning standards into short bouts of PA. It sought to be easily integrated into the preschool curriculum with minimal resources (i.e., space, equipment, set up time) in the fall of 2018. The intervention aimed to alter PA and classroom behavior by utilizing the Social Ecological Model (SEM) at the organizational (e.g., PA policies, teacher training), interpersonal (e.g., modeling of PA by research staff, teachers, peers), and individual (e.g., exposure to active lesson plans) levels (202, 221). The intervention sessions took place for 10-15 minutes during the

morning preschool circle time four days per week and were led by research staff with aid from classroom teachers. Weekly lesson plans were modified from the Preschool Activity, Diet, and Sleep study previously conducted by our lab (6). Lesson plans contained specific instructions for implementation, learning standard connection, suggested equipment/music, and options modification/extension. Prior to the study beginning, research staff met with all teachers and center directors to review the lesson plans and explain assessment protocols. The CON preschool was asked to maintain their usual curriculum during the 12-week intervention and received the PAL intervention following the 12-week data collection. Each preschool was given all necessary intervention equipment at the completion of the study. The study protocol was approved by the University of Massachusetts Amherst Institutional Review Board.

Assessments

While all children participated in the intervention activities, only children whose parent/guardian completed an informed consent document participated in the assessments. Demographic information was collected via an online questionnaire completed by the parent/guardian. Children's height and weight were recorded using a portable stadiometer and scale, respectively. Children's PA levels were assessed weekly during the intervention sessions on one randomly selected day with Actigraph accelerometers (Actigraph LLC, Pensacola, FL) worn on an elastic belt around the waist positioned on the back to be unobtrusive (232). Direct observation via a modified Observation System for Recording Physical Activity in Children, Preschool Version (OSRAC-P) was also utilized on one randomly selected day per week as accelerometers may not be able to detect upper limb body movements included in intervention lessons

(33). Each intensity level was summed and averaged over the total number of observed intervals to estimate percent of time spent in each PA intensity category [i.e., stationary (i.e., sedentary), upper limb movement (i.e., light intensity-upper limb), slow-easy (i.e., light intensity), moderate-to-fast (i.e., moderate-to-vigorous intensity)]. Upper limb movement was not combined with stationary activity in the sedentary intensity category because the purpose of the direct observation of PA was to identify movements (i.e. upper limb movement) that may not be captured by the accelerometer. Classroom behavior was assessed by teachers using the Behavior Assessment System for Children, 3rd edition (196) and by research staff using the Behavior Observation of Students in Schools system (208).

Process evaluation data were recorded daily via a semi-structured questionnaire by a research staff member who quietly observed the intervention session from the back of the classroom. All research staff were trained on observing sessions and recording process evaluation data prior to the study. Process evaluation measures included fidelity (i.e., intervention adherence and compliance), dosage (i.e., quantity delivered and received), quality (i.e., accurate intervention delivery), participant responsiveness (i.e., interest, attentiveness, enjoyment), reach (i.e., participation rates), program adaptation (i.e., any modification), and CON monitoring (i.e., intervention contamination) (79). Teachers were also asked to complete weekly logs examining their perception of lesson effectiveness, future lesson use, and suggested modifications. Finally, teachers completed a post-intervention survey to assess perceptions of program satisfaction (i.e., timing, duration, content, facilitation of lessons), acceptability (i.e., by teachers, families, students), impact (i.e., on classroom behavior, nap habits), and any additional feedback.

Statistical Analyses

Descriptive statistics were calculated to analyze demographic and process evaluation data. For continuous variables, means and standard deviations were calculated. For categorical variables, frequency distributions were calculated. T-tests and chi square tests were used as appropriate to determine differences in demographic variables between groups at baseline. Exemplary quotations were extracted to describe qualitative variables. Statistical analyses were conducted in Stata (Version 15.1, College Station, TX) and α of 0.05 was used to determine statistical significance.

Results

Participants in the PAL study included 58 children (PAL n = 32, CON n = 26) and eight teachers (PAL n = 4, CON n = 4). Children (age = 4.0 ± 0.8 years) generally fell into the healthy BMI percentile category for their age and sex and came from households with ≥ $80,000 annual income (Table 5). Approximately 48.3% were female and 73.1% identified as white, 17.3% identified as Hispanic, and 9.6% identified as Black or African American. At baseline, children spent approximately 74.3 ± 5.7% of their time in sedentary activity and 12.5 ± 3.8% of time in MVPA during the week. Fifteen children met the recommended PA guidelines of 180 minutes of PA per day. Teachers reported that children were in the 58th percentile and the 54th percentile for hyperactivity and inattention, respectively. Baseline classroom observations indicated that during the observed intervals, children spent 38.3 ± 8.1% of intervals in on-task time and 49.8 ± 33.2% in off-task time.

Feasibility & Fidelity

Enrolled children represented 64% of the eligible population in the PAL preschool and 36% in the CON preschool, which is 50% assessment reach (i.e., 50% of eligible preschoolers enrolled in the assessment portion of the study) in the overall preschool population in both schools. In each preschool, one child withdrew from the study due to leaving the preschool center before the 6-week assessment for a final sample size of 56 children. This resulted in 96.6% retention across both preschools. Process evaluation outcomes related to feasibility and fidelity are presented in Table 6. The PAL intervention was implemented 93.7% of the possible intervention days. A high percentage of children participated in the daily intervention lessons and continued to participate for at least half of the lesson. During some lessons, a few children would lose interest and stop participating, but when this occurred it was typically after the halfway point of the lesson. Further, the intervention lessons were implemented as intended over 93% of the time, suggesting high fidelity. Every intervention lesson was implemented clearly and correctly. All lesson components were implemented 94% of the time. The main reasons for not implementing certain components included adaptations needed to control classroom behavior and to regain lost interest. Finally, modifications were made in approximately one-third of the intervention lessons. Of these modifications, approximately 38% were implemented in weeks 1-3, 31% were implemented in weeks 4-6, 15% were implemented in weeks 7-9, and 15% were implemented in weeks 10-12. Therefore, approximately 70% of modifications made were implemented in the first six weeks of the intervention.

Each PAL intervention lesson was 12.3 ± 2.3 minutes in duration, which was consistent with the planned 10-15-minute intervention duration range. The CON preschool also wore accelerometers during their morning circle time (i.e., the same time as the intervention was offered to the PAL preschool) on a weekly basis to identify any potential contamination and were observed for 15.6 ± 1.3 minutes each week. The targeted 50% MVPA during intervention sessions was not achieved, as the PAL preschool engaged in an average of 40.5 ± 18.2% of MVPA as assessed by accelerometer during the lessons. However, this was greater than the CON preschool in which children engaged in only 18.6 ± 18.6% of MVPA during their 15-minute circle time ($t = -7.12$, $p < 0.0001$). This translated to approximately 5.0 ± 2.3 minutes of MVPA during the PAL lesson compared to 2.8 ± 2.8 minutes in the CON preschool. Children in the PAL preschool also engaged in greater light PA (19.1 ± 8.9% of time) and less sedentary activity (40.4 ± 19.4% of time) during the intervention time compared to the CON preschool children (light PA: 14.3 ± 8.1% of time, sedentary activity: 67.1 ± 23.7% of time). Direct observation of the PA lessons indicated that 10.8% of observed intervals were stationary (e.g., sedentary), 24.9% of observed intervals were categorized as upper limb movement (e.g., light to moderate intensity), 31.1% as slow or easy movement (e.g., light intensity), and 33.2% as moderate-to-fast (e.g., moderate to vigorous intensity).

During the same morning circle time observation at the CON preschool, observed activities included both unstructured and structured activities, and were frequently led by the classroom teacher. Activities typically were sedentary to light intensity and involved sitting at tables while coloring/writing, singing songs, dancing, building with blocks, and reciting the day's date and weather.

Acceptability

Intervention lessons were offered separately to each of the three preschool classrooms. On nine intervention days, two classrooms were combined due to low attendance and teacher to student ratio requirements. On average, 16, 13, and 8 children were in attendance during the intervention lessons in each of the three classrooms, respectively. Of this, an average of 13, 9, and 4 children were enrolled in the study. Participation rates were higher in one classroom at 94% compared to the other two, with classroom participation ranging from 74-78% of children in attendance. The majority of children participated in approximately 95% of the intervention lessons. Individual attendance data indicated that children enrolled in the study attended approximately 82% of intervention lessons, with attendance ranging from 39-95%. Individual attendance data was not collected for children who were not enrolled in the study. Observations of intervention sessions suggested that children enjoyed and were interested in almost every intervention lesson (Table 6).

Weekly lesson evaluations completed by teachers demonstrated that they felt that 100% of the lessons were effective for targeting specific learning standards and would be utilized in the future. Recommended modifications during the early weeks (i.e., weeks 1-3) of the study included using research staff to encourage some of the shy children who were less likely to participate and reducing the amount of repetitive movements to avoid children losing focus. These recommendations were incorporated into the remaining weeks of the intervention. Verbal encouragement was provided 9.8 ± 4.4 times per intervention lesson. It was clear that teachers valued this aspect of the program in the post-intervention evaluation in which one teacher remarked, "*The intervention leaders'*

interactions with the children were good. They had a lot of enthusiasm and heart. Children loved them and couldn't wait for them to arrive. I liked the compliments they gave the children."

In the post-intervention survey (Table 7), teachers expressed satisfaction with nearly every intervention component including timing, length, content, and facilitation. Further, they identified that the PAL pilot study was well-received by all involved groups. All teachers stated that they would continue implementing PAL lessons, with one teacher more likely to use them at other times during the preschool day as opposed to the planned intervention morning circle time. One teacher commented, "*The intervention activities were easily done with minimal materials, making them great for transition time*," while another noted, "*The intervention sessions had lots of new ideas, were structured, yet fun for the children*." This demonstrated high levels of teacher acceptability and a strong willingness to continue the program even after the study had ended.

Discussion

Despite the growing number of preschool PA interventions, few report comprehensive process evaluation data. The purpose of this study was to evaluate the feasibility, acceptability, and fidelity of a 12-week academically-integrated preschool PA program on preschoolers' classroom behavior. The PAL pilot study had high levels of feasibility, fidelity, and acceptability. Recruitment goals were exceeded with 58 children enrolled, but the program reach was lower in the CON preschool (36% vs. 64% of eligible students). This could be due to preschool randomization before recruitment. In the CON group, it is possible that parents felt less inclined to sign up because their school

was not receiving the program until after the completion of the 12-week data collection time point. Retention in both preschools was high, with only two students withdrawing from the study due to enrolling in new preschools outside of the area.

The PAL PA lessons were implemented with high fidelity as 94% of possible intervention lessons were implemented. Only three PA lessons were not implemented due to a holiday party (n=1), a field trip (n=1), and University break which limited research staff availability (n=1). This high implementation has been demonstrated in other studies as well (133, 134, 219, 231). Trost et al., reported 93% of possible intervention lessons were implemented with field trips and other preschool events as main contributors to missed intervention lessons (231). However, the Trost et al., study was conducted in half-day preschool classrooms which contrasts with the present study that targeted full-day preschool programs. Although most sessions were implemented, individual student dose received varied. The wide range of intervention attendance (39-95% for enrolled participants) indicated that not every student received the intended dose of the intervention. However, it was difficult to attain a greater dose with only one brief morning PA lesson during the preschool day. It is also important to note that absences due to illness and late arrivals (i.e., after the PA lesson had ended) were common. When PA lessons were implemented, all components were included, and the lesson was led as intended over 93% of the time. Reasons for not implementing all lesson components included music malfunction, the need to eliminate some equipment used to enhance classroom behavior management, and running out of time. Of the PA lessons implemented, 84% of the sessions went as planned. When this was not the case, it was often due to uncontrollable factors such as fire drills and the need to combine two classes

into one room to meet required teacher to child ratios. These situations altered the delivery of the intervention as children tended to be less engaged. While modifications were made nearly one-third of the time, these modifications tended to encourage additional movement. For example, in an animal movement lesson, children were encouraged to suggest their own favorite animals and demonstrate to the class how that animal would move. The rest of the class would join in moving like that animal until it was another child's turn.

During the 10-15-minute lessons, children engaged in MVPA only 40% of the time, which translates to about five minutes of MVPA per lesson. The lower than intended PA intensity (which was at least 50%) may be due to classroom management concerns. Intervention leaders sometimes needed to pause the lesson to ensure children were moving safely and stop children from arguing over equipment. Because the intervention used minimal equipment, days that did include equipment (~25% of PAL lessons) occasionally served as a distraction to the children and they were more concerned with exploring the equipment (e.g., hula hoops and bean bags) than using them as part of the movement activity. Low MVPA accumulation during structured PA lessons was also reported by Palmer et al., who implemented a 30-minute structured PA session and found that children only engaged in seven minutes of MVPA during the session (170). Palmer et al., utilized a PA lesson that was double the duration of the present study, which may have led to difficulties in sustaining the preschoolers' attention for that time. Further, St. Laurent et al., reported that children engaged in MVPA 48% of the time during 10-minute academically-integrated PA lessons in the Preschool Activity, Diet, and Sleep Study and cited children's shyness around intervention leaders as a potential reason

for the lack of MVPA engagement (219). This is a similar issue to what researchers in the present study experienced. For example, younger children (especially those who had recently moved up from toddler classrooms) were often shy around research staff which limited their engagement in the PA lessons and ensuing PA intensity. Both the present study and those by Palmer et al. and St. Laurent et al., provide evidence that multiple bouts of shorter high intensity PA may be needed throughout the preschool day to have more favorable impacts on PA intensity minute accumulation.

Participation rates varied among classrooms. One classroom with mostly older children (i.e., 4-5 years old) had an average participation rate of 94%. This contrasts with two classrooms that included younger children (i.e., 2.9-4 years old) and had between 74-78% of children participating. These classrooms had children who recently moved up from toddler classrooms and were still learning the rules of the preschool classroom. These children often struggled to follow directions and thus needed one-on-one attention from the teacher to aid participation. Because of this, more modifications were made in the younger classrooms to bolster participation. Teachers participated in 68% of the lessons, which was lower than the targeted 100% participation. This lower participation rate among teachers could be linked to the lower participation in the younger classrooms as teachers often had to work with students one-on-one or pull children aside from the intervention to deal with behavioral issues. A previous research staff-led academically-integrated PA intervention conducted by our lab resulted in only 55% teacher participation (219), which indicates that providing greater teacher training opportunities may be beneficial. Both this and the present study utilized a single teaching training session. Perhaps providing booster sessions throughout the study would enhance teacher

participation. These sessions could focus on upcoming lessons to ensure that teachers are comfortable participating and modeling the movements for the children. Preschool teachers can impact children's PA habits (81), and it has been suggested that teachers take an active role in improving children's PA through encouraging and modeling PA (134). Higher teacher participation has been reported in other studies (133, 134, 176, 231), but these programs were mainly teacher-led, with assistance from research staff. Therefore, it is difficult to compare the PAL study results with the findings of other studies as most implemented by researchers don't report teachers' participation rates.

Both children and teachers found the PAL pilot study to be enjoyable. Over 99% of lessons had at least half of the children participating, which suggests that the lessons were enjoyable and held their attention. Further, teachers reported that the lessons were effective for targeting early learning standards and that they would use them again in the future which is consistent with similar academically-integrated PA studies (133, 134, 231).

This study has several strengths within implementation assessment. First, direct observation by a research staff member was utilized to assess implementation during every PA lesson at the intervention preschool. This allowed the research team to not only identify participation rates and modifications, but also provided insight into specific classroom trends such as lower participation among certain classrooms. Further, the control school was directly observed during morning circle time each week to enhance comparisons in PA between the two groups. Evaluation data was also collected from teachers on a weekly basis in addition to the post-intervention survey. This allowed the research team to make timely adjustments to better fit the program into the class' routine.

For example, one teacher emphasized the importance of breaking the class into smaller groups to maximize engagement, and that suggestion was immediately incorporated to the rest of the program. Finally, intensity of activities during morning circle time was assessed weekly in both schools with accelerometers, which provided important fidelity information.

However, accelerometer use could also be viewed as a limitation because waist-worn accelerometers are unable to capture upper limb movements, which were often used as part of the PA lessons due to small classroom spaces. To combat this, one researcher directly observed the PA lesson and coded PA using a modified Observational System for Recording Physical Activity in Children, preschool version (33). Results indicated that upper limb movement occurred in approximately 25% of the observed intervals, which may have not been picked up by the accelerometer. However, completing this additional direct observation proved to be burdensome on staff during the lesson, so this was only conducted during five of the twelve weeks. Future studies should add a regular weekly direct observation system to better understand PA intensity. Another limitation was the short duration of the PA lessons. Because the PA lessons aimed to be short bouts of activity, it may be possible that including these lessons more frequently throughout the preschool day would provide a better dose of PA. Finally, only one research staff member observed the PA lessons and recorded process evaluation. It is possible that some degree of bias was introduced as there was no double checking of the data in real time. Future studies should utilize two observers to minimize this risk.

Overall, process evaluation data indicated that the PAL pilot study was feasible and acceptable by both children and teachers. We exceeded recruitment and retention

goals, which may indicate that parents valued this type of program as part of their preschool curriculum. The PA lessons were implemented with high fidelity, yet intensity of the sessions failed to meet percent time spent in MVPA goals. Future studies should examine ways to increase the intensity of academically-integrated PA lessons. Another aspect of implementation that should be targeted for improvement is teacher participation in the lessons. With sustainability as a long-term goal, specific strategies are needed to engage teachers in the PA lessons, so they will eventually feel comfortable implementing the lessons themselves. However, it was promising that teachers reported a desire to implement the lessons at other times during the preschool day after the study had ended. Future studies should explore more comprehensive teacher training techniques to take the next step of advancing this preliminary feasibility and acceptability study.

Table 5. Baseline characteristics for the PAL pilot study sample.

Variable	**Children (n = 58)**
Age	4.0 ± 0.8 years
Sex	51.7% male
BMI Percentile	65.9 ± 23.3
BMI Category	
Underweight	2%
Healthy Weight	80%
Overweight	12%
Obese	6%
Race/Ethnicity	
White	73.1%
Hispanic	17.3%
Black/African American	9.6%
Annual Income	
< $40,000	11.5%
$40,000 – 59,999	17.3%
$60,000 – 79,999	11.5%
≥ $80,000	59.6%
Diagnosed Developmental Disorder	1.9%
Individualized Education Plan	3.9%

Values are presented as mean ± standard deviation or frequency percentage.

Table 6. Semi-structured questionnaire responses from direct observation of PAL lessons.

Implementation Question	Yes (%)	No (%)
Feasibility & Fidelity		
Did at least 50% of the students present participate?	99.2	0.8
Did the majority of students participate in at least half of the intervention lesson?	96.7	3.3
Was the intervention lesson implemented as intended?	93.4	6.6
Did the intervention leader implement the intervention session clearly?	100.0	0.0
Did the intervention leader implement the intervention session correctly?	100.0	0.0
Did the intervention leader implement all of the planned lesson components?	94.2	5.8
Were modifications made from the original intervention lesson plan?	34.5	65.5
Did the intervention leader recommend modification for the future?	22.6	77.4
Did the lesson observation go as expected?	84.0	16.0
Acceptability		
Did the majority of students seem to enjoy the intervention lesson (e.g., smiling, actively engaged, having fun)?	99.2	0.8
Did the intervention lesson appear to hold the interest/attention of the majority of students participating?	93.4	6.6
Did the classroom teacher(s) participate in lesson facilitation?	68.0	32.0
Did the classroom teacher(s) seem to enjoy participating in the lesson?	85.4	14.6

Table 7. Post-intervention teacher questionnaire responses for the PAL study.

How satisfied are you with each of the following components of the PAL study?	**Extremely Satisfied**	**Slightly Satisfied**	**Slightly Dissatisfied**	**Extremely Dissatisfied**
Timing of the lessons	100%	0%	0%	0%
Length of the lessons	100%	0%	0%	0%
Duration of the program	100%	0%	0%	0%
Content of the lessons	100%	0%	0%	0%
Facilitation of the lessons	100%	0%	0%	0%
Initial PAL teaching meeting	100%	0%	0%	0%
Communication between PAL team and teachers	100%	0%	0%	0%
How well do you think the PAL pilot study was received by each of the following groups?	**Extremely Well**	**Moderately Well**	**Slightly well**	**Not well at all**
Other preschool teachers/staff	100%	0%	0%	0%
Children	100%	0%	0%	0%
Families	100%	0%	0%	0%
How likely are you to continue using these lesson plans?	**Extremely Likely**	**Somewhat Likely**	**Somewhat Unlikely**	**Extremely Unlikely**
During morning circle time	66%	33%	0%	0%
During other periods of the day	100%	0%	0%	0%

Aim 2: Preliminary Efficacy of an Academically-Integrated Preschool Physical Activity Program on Classroom Behavior in Preschoolers

Abstract

It has been reported that physical activity (PA) can influence classroom behavior (i.e., hyperactivity, inattention, on-task time) in elementary school children, yet little is understood regarding this relationship in preschoolers. Preschool PA interventions have shown mixed effects, potentially due to low intervention compliance. One way to combat low compliance is to integrate PA into early learning standards. Therefore, academically-integrated PA may be a viable method to improve PA levels and classroom behavior in preschoolers. **PURPOSE:** To evaluate the preliminary efficacy of a 12-week academically-integrated PA intervention on preschoolers' PA and classroom behavior. **METHODS:** Children (n = 58, age = 4.0 ± 0.8 years, 51.7% male) from two preschool centers were randomized to either the Preschoolers Actively Learning (PAL) or the health-tracking control (CON) group. The PAL intervention consisted of 10-15-minute PA lesson integrated into academic learning standards offered during morning circle time four days per week for 12 weeks. Physical activity was assessed with accelerometers for seven consecutive days at baseline, 6-weeks, and 12-weeks. Classroom behavior was assessed via direct observation using the Behavioral Observation of Students in Schools application at three time points and via teacher report using the Behavior Assessment System for Children, Preschool Version at baseline and 12-weeks. Repeated measures ANOVAs were used to examine changes in PA by group across three time points. ANCOVAs were used to assess directly observed classroom behavior and an independent sample *t*-test was used to examine differences in teacher-reported classroom behavior. **RESULTS:** Children in the PAL group spent greater amount of time in moderate-to-vigorous PA during the intervention time compared to the CON group's typical morning

circle time (PAL: 5.0 ± 2.3 minutes, CON: 2.8 ± 2.8 minutes; $p < 0.0001$). However, this did not translate to any other significant differences in preschool-day PA or classroom behavior at 6-weeks or 12-weeks. **DISCUSSION:** Preliminary efficacy for this academically-integrated PA intervention to impact preschoolers' classroom behavior or PA levels was not established. This may be due to poor accelerometer compliance, differences in classroom environment, and intensity and duration of intervention lessons. Future studies should explore alternate measures to boost compliance and examine greater intervention doses of daily PA on these outcomes.

Introduction

Maladaptive classroom behaviors such as inattention, hyperactivity, and impulsivity, may present as difficulty sustaining attention, fidgeting, and interrupting frequently (8). These problematic behaviors can manifest in the preschool classroom and can lead to poor academic achievement, cognitive challenges, and maladjustment to the school environment (23, 116, 218). Preschoolers typically exhibit hyperactive, impulsive, and inattentive behaviors, yet elevated levels of these behaviors can be a risk factor for later development of attention-deficit/hyperactivity disorder (ADHD) (108). When asked about factors that are detrimental to their classroom and student progress, teachers list classroom behavior as a major contributing factor (184). While teachers recognize maladaptive classroom behavior as a problem, there is limited data to support evidence-based strategies and solutions. Physical activity (PA) can be an effective way to improve maladaptive classroom behaviors in elementary school-aged children (103, 150), yet limited research exists in preschoolers. The current evidence suggests that acute bouts of

PA can improve attention and on-task time in preschoolers (146, 171, 244, 248), but less is understood about long-term effects of PA. One study utilized daily 30-minute locomotor lessons for six months and demonstrated improvements in teacher-reported hyperactivity, inattention, and aggression (35). However, this study was limited by varying levels of intervention fidelity across classrooms, because teachers felt burdened by finding time in their day for PA (4).

Currently, it is recommended that preschoolers engage in 15 minutes of PA (i.e., light, moderate, or vigorous intensity) per waking hour (80). This amounts to approximately 120 minutes of PA over the course of an 8-hour preschool day and 180 minutes for a typical 12-hour day. However, nearly half of all preschoolers are not meeting PA guidelines (178, 235). Due to this, several preschool interventions aimed at increasing PA have been conducted, yet a common limiting factor is the lack of intervention compliance by teachers (32, 61, 89, 120, 214, 223, 227, 239, 246). Therefore, it is critical that effective behavioral interventions are designed in a way that is easily implemented by teachers in a preschool classroom setting. One way to combat low teacher compliance is by reducing the burden of added activities and incorporating PA into preschool learning standards. This is an emerging area of research, with limited studies showing positive changes in PA (6, 176, 231) and academic-related outcomes (133, 134). Despite the reported benefits, it is unknown if academically-integrated PA programs can alter classroom behavior in the preschool setting. Academically-integrated PA that bolsters teacher compliance poses a unique opportunity to not only improve academic- and health-related outcomes, but potentially to influence classroom behavior. Therefore, the purpose of this study was to examine the preliminary efficacy of a 12-

week academically-integrated PA intervention on preschoolers' physical activity levels and classroom behavior.

Methods

Participants

In this randomized controlled pilot study, two preschool centers (n = 6 classrooms) in the Greater Springfield, MA, area were randomized to either the PAL intervention (n = 1 preschool, n = 3 classrooms) or the health tracking control group (CON, n = 1 preschool, n = 3 classrooms). These preschools were approached for participation because they had similar student enrollment, curriculum offerings, and PA environments and policies. All children who attended the preschool participated in their assigned intervention. Children were individually recruited via flyers and in-person at preschool pick up times. Only children whose parents expressed interest and signed consent forms were eligible to participate in the assessment portion of this study. Children were excluded from the assessments if their parent did not provide permission for participation. Additionally, primary and secondary preschool teachers were recruited for participation in the assessment portion of this study and completed informed consent documents. This study was approved by the University of Massachusetts Amherst Institutional Review Board.

Intervention

Prior to the study beginning, research staff met with teachers at both schools to explain the PAL intervention and all study assessments. The intervention was implemented four days per week for 12 weeks. The PAL intervention was designed to integrate PA into early education learning standards through short bouts of activity

offered during the morning circle time, a typically sedentary part of the day. PAL was designed to alter PA and classroom behavior by incorporating elements of the Social Ecological Model in the organizational (e.g., PA policies, teacher training), interpersonal (e.g., modeling of PA by teachers, peers, and research staff), and individual (e.g., exposure to active lessons) levels (202, 221). To demonstrate initial feasibility, it was important that researchers led the intervention sessions before teachers were trained to do so. Teachers assisted research staff and were encouraged to join the children during the PA lessons. PAL lessons were led by trained research staff for 10-15 minutes and were adapted from the Preschool Activity, Diet, and Sleep study (6). Each lesson plan was integrated into various early learning standards and contained instructions for implementation as well as equipment needs. PA lessons began with a brief 1-2-minute warm-up, a fun age-appropriate 8-10-minute game or activity, and a 1-2-minute low intensity cool down. Because teachers are the primary role model for their students, teachers were encouraged to join the children during PA lessons. Throughout the study period, the CON preschool was asked to maintain their typical curriculum and not participate in any other PA program. The CON preschool received the PAL intervention at the completion of the 12-week data collection timepoint. No data was collected at this time.

Assessments

Data was collected only for children whose parent/guardian completed an informed consent document and parent permission. Parents completed a demographic questionnaire at baseline and a follow-up questionnaire at 12-weeks online via Qualtrics or via paper if requested. Parents were compensated $25 for completing the questionnaire

as well as assisting with their child's accelerometer wear in the home environment. Children's assessments (i.e., physical measures, preschool-day PA, and classroom behavior) were all conducted at the preschool centers during the preschool day. Research staff measured children's height and weight using a portable stadiometer and scale, respectively. From this, children's BMI percentile was calculated using the CDC's age- and gender-specific BMI calculator (167). Children wore Actigraph accelerometers (Actigraph LLC, Pensacola, FL) on an elastic belt around their waist positioned on their lower back (232) for seven consecutive days at baseline, 6-weeks, and 12-weeks to assess preschool-day and habitual PA. Children were asked to wear the accelerometers during all waking hours and to only remove it if the unit would get completely wet (e.g., bathing, swimming). Classroom teachers and parents were informed of accelerometer wear instructions and were asked to ensure correct repositioning of the monitor whenever removed. Children also wore accelerometers during the PA lessons on one randomly selected day each week to provide insight into the intensity of the PAL lessons. Accelerometers were initialized to store data in 15-second epochs. A modified Troiano et al., wear time algorithm of 20 minutes or more consecutive zeros was used to determine non-wear time (230). For this analysis, valid wear time was defined as eight hours per day for at least three days. Pate et al., preschool cut points were used to reduce activity counts into PA intensity categories (sedentary, light, MVPA) (174). Accelerometers were initialized, downloaded, and data were reduced in Actilife software (version 6.13.3). Because accelerometers worn around the waist are limited in detecting upper body movements, direct observation via a modified Observation System for Recording Physical Activity in Children, Preschool Version (OSRAC-P) was utilized on one

randomly selected day per week to better understand PA intensity during the lessons (33).Within the observed classroom, participating children were randomly selected to be observed. Children were observed in 15-second intervals for approximately 3-4 minutes. Children's PA was coded as stationary (i.e., sedentary), upper limb movement (i.e., light intensity), slow-easy (i.e., light intensity), or moderate-to-fast (i.e., moderate-to-vigorous intensity). For analysis, data were reduced and expressed as percent of intervals spent stationary, upper limb movement, slow-easy, or moderate-to-fast.

Children's classroom behavior was assessed by direct observation of research staff members and by teacher-report. Research staff members who conducted classroom direct observations (i.e., separate from the intervention implementation staff) were blinded to the study aims and group randomization, and completed at least fifteen hours of training prior to the start of the study as well as weekly booster sessions throughout the study. Classroom observations were conducted at baseline, 6-weeks, and 12-weeks, immediately following the regularly scheduled morning circle time (and PA lesson in PAL preschool) using the Behavioral Observation of Students in Schools (BOSS, Pearson, San Antonio, TX) on an iPad application (208). The BOSS software has high inter-rater reliability with total agreement of repeated observations ranging from 90-100% (169), and kappa coefficients ranging from 0.93 - 0.98 (0.95 ± 0.02) (78). Children were observed for five minutes up to four different days during the assessment week and the observations were averaged for that week. Each research staff member observed one child at a time and were able to observe up to 12 students each day, with observations ranging from immediately following circle time to one-hour post-circle time. Children were rotated through the observation order, so if one child was observed at the beginning

of the session then he or she was observed towards the middle and end of the session on subsequent days. Due to the aim of the study (to examine the impact of PAL intervention on classroom behavior), observations were not conducted if the class went outside to play immediately following circle time. On-task time was measured with momentary time sampling and was categorized as active engaged time (AET; e.g., answering a teacher's question) or passive engaged time (PET; e.g., listening to a teacher talk) (118, 181). Off-task time was measured with part-interval sampling and was categorized as off-task motor (OFT-M; e.g., out of seat), off-task verbal (OFT-V; e.g., calling out), or off-task passive (OFT-P; e.g., staring out the window) (118, 181). From these categorizations, outcome data were expressed as percent of time during the observed interval that a child engaged in each behavior.

Teachers reported children's classroom behavior at baseline and 12-weeks using the preschool form of the Behavior Assessment System for Children, Version 3 (BASC-3) (196). This was completed on paper and later entered into the Q-Global online scoring system. The BASC-3 is a comprehensive rating scale of positive and maladaptive classroom behaviors and takes approximately 10-20 minutes to complete per child. The rating scale consisted of a 4-point scale ranging from "Never" to "Almost Always," from which numbers were assigned and used to calculate the raw score, t-score, and normative percentile. The BASC-3 has demonstrated high internal consistency for composite scales in 2 - 3 year old children ($\alpha = 0.89 - 0.96$) and 4 - 5 year old children ($\alpha = 0.92 - 0.97$) and for clinical scales in 2 - 3 year old children ($\alpha = 0.77 - 0.89$) and 4 - 5 year old children ($\alpha = 0.81 - 0.93$) (196). Test-retest reliability coefficients ranged from 0.71 -

0.93, indicating acceptable to good reliability (196). Due to the time to complete each child's questionnaire, teachers were compensated $10 per questionnaire completed.

As the primary aim of the PAL pilot study was to examine the feasibility and acceptability of a 12-week academically-integrated PA program on preschoolers' classroom behavior, process evaluation data were collected on a daily, weekly, and post-intervention basis. These data are reported in depth elsewhere. Briefly, trained research staff members observed every PA lesson and recorded feasibility, acceptability, and fidelity data. Teachers completed weekly lesson evaluations as well as a post-intervention questionnaire.

Statistical Analyses

Normality of data was assessed with the Shapiro-Wilk test. Data that was not normally distributed was log transformed for analyses. Descriptive statistics were calculated for each variable at baseline and included means and standard deviations for continuous variables and frequencies for categorical variables. Between group differences were examined using independent samples *t*-tests for continuous variables and chi square tests for categorical variables with a two-sided α level set to 0.05. Correlation coefficients and 95% confidence intervals were calculated to examine baseline relationships between PA and classroom behavior. Repeated measures ANOVAs were run to assess change in PA levels (i.e., sedentary, light, MVPA minutes per preschool hour) between two groups across three time points and Bonferroni adjustments were used as necessary. Inter-rater reliability between classroom observers was calculated based on video coding at each timepoint prior to entering the classroom. In addition, a subsample of the participants was double coded at baseline to ensure acceptable levels of inter-rater reliability translated

from video coding to coding live in the classroom. ANCOVAs were used to assess differences in directly observed classroom behavior (i.e., AET, PET, OFT-M, OFT-V, OFT-P) between groups across three time points. Change scores were calculated and paired *t*-tests were used to examine change in teacher-reported classroom behavior across two time points between schools. A one-sided α set to 0.05 was used to determine statistical significance for PA and classroom behavior analyses. All analyses were conducted in Stata (Version 15.1; Stata Corp, College Station, TX).

Results

In total, 58 children (PAL; n = 32, CON: n = 26) and eight teachers (PAL; n = 4, CON: n = 4) enrolled in the PAL study. Two children (PAL; n = 1, CON: n = 1) withdrew from the study prior to 6-week data collection due to enrolling in a new preschool center for a final sample size of 56 children. At baseline, two children in each group did not have parent completed demographic information. Participants baseline characteristics are presented in Table 8. In the total sample, children were 4.0 ± 0.8 years of age with an average BMI percentile in the normal weight category for their age and sex. Approximately half the sample was male. There was a statistically significant difference in parent-identified race/ethnicity between groups for the participants that consented for the assessment portion of the study. In the CON preschool, 100% of the participants were white whereas the PAL preschool was more diverse. The two groups were similar in their habitual PA over the course of the baseline week, with most spending a significant portion of their day in sedentary time. Seven children in the PAL group and eight children in the CON group met the recommended PA guideline of 180

minutes of daily PA at baseline. One parent in the CON group reported that a child had a diagnosed developmental disorder (i.e., autism) and each group contained one child with an individualized education plan.

Baseline correlations (Table 9) indicated that teacher-reported inattention was positively related to preschool-day light PA minutes per day (r = 0.34, p = 0.03; 95% CI = 0.03, 0.59) and preschool-day MVPA minutes per day (r = 0.32, p = 0.048; CI = 0.01, 0.58). Directly observed OFT-M behavior was positively related with preschool-day light PA minutes per day (r = 0.45, p = 0.002; 95% CI = 0.18, 0.66) and preschool-day MVPA minutes per day (r = 0.45, p = 0.003; 95% CI = 0.17, 0.68). OFT-V behavior was also positively associated with preschool-day light PA minutes per day (r = 0.46, p = 0.002; 95% CI = 0.10, 0.64) and preschool-day MVPA minutes per day (r = 0.39, p = 0.01; 95% CI = 0.19, 0.67). Finally, OFT-P behavior was positively associated with preschool-day light PA minutes per day (r = 0.32, p = 0.03; 95% CI = 0.03, 0.57). There were no relationships between PA and on-task time.

Physical Activity

At baseline, six children in the PAL group and five children in the CON group were excluded due to lack of accelerometer wear time. There were no differences in baseline wear days between groups (PAL: 4.0 ± 1.4 days, CON: 4.2 ± 1.0 days; p = 0.73). At the 6-week assessment time point, 14 children in the PAL group and six children in the CON group were excluded from the analyses due to insufficient wear time. Two additional children were excluded from the PAL group due to lost monitors. At the 6-week time point, 52% of PAL group and 32% of the CON group were excluded from PA analyses. At the 12-week assessment timepoint, eight children in the PAL group and

three children in the CON group were excluded due to insufficient wear time. In the PAL group, four additional children were excluded due to injury/inability to wear the monitor (n = 1), device malfunction (n = 1), and lost monitors (n = 3). In the CON group, four additional children were excluded due to travel during the assessment period (n = 1) and lost monitors (n = 3). At the 12-week time point, 39% of PAL group and 28% of the CON group were excluded from PA analyses. At each time point, there were no differences in age, BMI percentile, sex, race, or preschool between those who had sufficient wear time and those who did not.

Physical activity data were examined during the intervention time (i.e., circle time when the PAL lessons were implemented), the preschool day (i.e., 9:00 am – 4:00 pm), and the total day (i.e., 7:00 am – 10:00 pm). There were no between group differences in preschool-day sedentary, light, or MVPA minutes per hour (all $p > 0.36$). The PAL PA lessons lasted approximately 12.3 ± 2.3 minutes. During the PAL intervention time (i.e., circle time), the PAL preschool engaged in 5.0 ± 2.3 minutes of MVPA while the control school engaged in only 2.8 ± 2.8 minutes of MVPA ($t = -7.12$, $p < 0.0001$). During the intervention time (i.e., circle time), the PAL group also engaged in less percent time spent sedentary and greater percent time spent in light activity (Figure 5). Changes in sedentary minutes per hour ($F_{2,62} = 0.61$, $p = 0.45$), light PA minutes per hour ($F_{2,62} = 1.6$, $p = 0.79$), and MVPA minutes per hour ($F_{2,62} = 0.22$, $p = 0.19$; Figure 6) were not statistically significant. A secondary analysis was conducted to examine changes in preschool morning PA as the PAL intervention was offered during the morning hours. There were no changes over time by intervention group in sedentary minutes per hour ($F_{4,62} = 0.26$, $p = 0.90$), light PA minutes per hour ($F_{4,62} = 1.43$, $p = 0.77$), or MVPA minutes per hour

($F_{4,62} = 5.45$, $p = 0.99$). Both groups increased their MVPA at 6-weeks but decreased back to or below their baseline levels. Despite the lack of intervention effect on PA, both children and teachers seemed to enjoy participating in the PAL lessons 99% and 85% of the time, respectively, and 100% of teachers reported that they would continue implementing these lessons after the study had ended.

Direct Observation of Classroom Behavior

Prior to the start of the intervention, research staff (blinded to intervention assignment) demonstrated 87% agreement for on-task behaviors and 65% agreement for off-task behaviors. A subsample of participants was double coded at baseline, which resulted in 90% agreement for on task behaviors and 81% for off-task behaviors amongst observers. While researchers aimed to observe each child four times over the course of each assessment week, several factors limited the total number of observations conducted (e.g., absences, changing regular schedules, vacations, observer availability). Children were observed 2.4 ± 1.0 times at baseline, 1.6 ± 0.8 times at 6-weeks, and 1.6 ± 0.6 times at 12-weeks. The number of times children were observed at each time point is depicted in Figure 7. Baseline differences between groups were present for AET ($t = 4.7$, $p < 0.0001$), OFT-M ($t = -3.5$, $p = 0.001$), OFT-V ($t = -4.1$, $p = 0.0002$), and OFT-P ($t = -2.9$, $p = 0.0058$) with the CON group demonstrating a more favorable classroom behavior pattern. Because of the baseline differences between groups, ANCOVA models were adjusted for baseline classroom behavior. There were no significant differences between groups at the 6-week assessments in AET ($F_{1,43} = 13.8$, $p = 0.99$), PET ($F_{1,43} = 1.96$, $p = 0.17$), OFT-M ($F_{1,43} = 7.68$, $p = 0.99$), OFT-V ($F_{1,43} = 1.09$, $p = 0.30$), or OFT-P ($F_{1,43} = 1.16$, $p = 0.71$) after controlling for baseline scores. In addition, there were no significant

differences between groups at the 12-week assessments in AET ($F_{1,46} = 0.14$, $p = 0.71$), PET ($F_{1,46} = 5.33$, $p = 0.71$), OFT-M ($F_{1,46} = 1.91$, $p = 0.97$), OFT-V ($F_{1,46} = 1.00$, $p = 0.68$), or OFT-P ($F_{1,46} = 5.13$, $p = 0.97$), after controlling for baseline scores. Adjusted means and contrasts are presented in Table 10.

Teacher-Reported Classroom Behavior

At baseline, 100% of classroom behavior questionnaires were completed by teachers. There was no statistically significant difference between teacher-reported inattention in the PAL (n = 32, 54.63 ± 21.78 percentile) and CON (n = 26, 52.38 ± 25.88 percentile) groups at baseline (t = -0.36, $p = 0.72$). However, the groups were statistically different in teacher-reported hyperactivity with the PAL group exhibiting greater hyperactive behaviors (70.94 ± 22.80 vs. 40.64 ± 29.91 percentile; t = -4.34, $p = 0.0001$) at baseline. During the 12-week assessment, one preschool teacher went on leave and was unable to complete questionnaires for her class and one student had an incomplete questionnaire, so a hyperactivity score could not be calculated. Therefore, the CON 12-week sample size was 14 for hyperactivity and 15 for inattention. There were no statistically significant changes in teacher-reported hyperactivity (t = 0.74, $p = 0.23$) or inattention (t = 0.93, $p = 0.18$) in response to the PAL intervention (Table 11).

Discussion

It has been well established that physically active preschoolers experience health benefits (228). However, most preschoolers are not reaching recommended levels of PA (178, 235). Many interventions have been conducted to improve preschoolers' PA, yet results are mixed. One reason for this is the lack of PA intervention compliance demonstrated by many pragmatic interventions. There is also evidence to suggest that PA

during the preschool day can favorably impact classroom behavior (121, 171). Because children with maladaptive classroom behavior in preschool are at an increased risk for later academic challenges and potential ADHD development, it is imperative that we explore opportunities to alter this trajectory. An emerging area of research, academically-integrated classroom PA, may help combat low intervention compliance while providing health- and academic-related benefits. Therefore, the purpose of this study was to examine the preliminary efficacy of a 12-week academically-integrated PA intervention on preschoolers' PA levels and classroom behavior. The PAL intervention did increase time spent in MVPA during morning circle time compared to the control school. However, we did not observe any changes in total preschool-day PA, directly observed classroom behavior, or teacher-reported classroom behavior. Despite lack of intervention effects on these outcome measures, both teachers and children enjoyed participating in the PAL lessons which may lead to greater sustainability of this program.

Physical activity was improved during morning circle time, but not during total preschool morning hours or total preschool day. One factor that could have impacted our null finding in preschool-day PA could be related to the timing of PA assessment. Baseline measurements took place in late September (i.e., average temperature 69º F), 6-week assessments in early November (i.e., average temperature 52º F), and 12-week assessments in December (i.e., average temperature 36º F). As the weather got colder over the course of the study, outdoor play time was often limited in both schools. This was similar to what Sharma et al., encountered when pilot testing a nutrition and PA intervention in two Head Start preschools (n = 75 children). Authors reported a decrease in preschool-day PA over the course of the six-week study which was conducted during

the fall (i.e., October through December) and attributed this decrease to fewer PA opportunities offered during colder weather (210). Few studies have longitudinally examined the effect of seasonality on preschoolers' PA levels, but there is preliminary evidence to suggest that weather can influence PA levels. Two recent reviews examining determinants of preschoolers' PA concluded that preschoolers tend to be less active during the colder winter weather (143, 236). This was attributed to the correlation between preschoolers' PA and outdoor play time (19), which is reduced during the winter. For example, McKee et al., compared the activity of 85 preschoolers who wore pedometers for one week in winter and spring (152). Researchers reported that children had a 20% reduction in steps per day in the winter compared to the spring (152). Additionally, Carson et al., assessed preschoolers' PA during each season and found that children were most likely to be active during the summer and least active during the winter months (OR = 2.41; 95% CI = 1.70, 3.42) (47). However, the study by Carson et al., assessed children's PA via parental self-report, which is likely to include some inaccuracies as parents are not with their children during the preschool day to accurately report on their PA during that time. Despite different PA assessment methods in the literature compared to the present study, the trend is consistent with our study findings. In addition, the 12-week assessments coincided with holiday events such as caroling practice, a field trip, pajama day, and holiday parties which occurred on more days in the PAL preschool compared to the CON preschool during the 12-week assessment. These events were atypical for the children and resulted in interruptions to their usual schedule, including PA. Further, it is possible that teachers in the intervention preschool may have

compensated for the intervention by using PAL lessons as designated time for PA during the colder months rather than incorporating additional time for PA in the classroom.

The classroom behavior null findings in response to PA are in contrast to previous studies in the literature which have demonstrated improvements in various classroom behavior variables with within-subjects designs (171, 244, 248). For example, Palmer et al., utilized an acute 30-minute bout of PA or 30-minute sedentary bout during the preschool day and reported that preschoolers (n = 16, 81% male, age = 4.1 ± 0.4 years) demonstrated significantly better ability to sustain attention following the PA condition (171). Similarly, Webster et al., tested the effects of a 10-minute teacher-led PA bout on time on-task during preschool mornings. Preschoolers (n = 118, male = 47%, age = 3.8 ± 0.7 years) engaged in two 10-minute PA bouts and two 10-minute typical instruction periods over the course of four days (248). Both PA and time on-task were assessed similarly to the present study, with accelerometers and direct observation, respectively. Results indicated that participating in the PA bouts led to improved time on-task ($F_{1,117} = 18.86$, $p < 0.001$) immediately following the intervention (248). Each of these studies saw positive impacts of PA on classroom behavior, but this was in response to acute (i.e., one day or one week) study durations. Because of this, it is possible that the novelty effect of these PA interventions contributed to their findings. Both Palmer et al., and Webster et al., assessed classroom behavior immediately before and after PA. The present study did not assess classroom behavior immediately before the PA lesson began but instead used a full week (without intervention) as the baseline comparative measure, which could explain the observed lack of effect. There may have been acute impacts of the PAL

lessons at each time point, but this is unclear as our research team did not measure classroom behavior immediately prior to PA to assess within participant change.

Finally, Logan et al., utilized a similar intervention design with two days of 10-minute PA bouts and two days of typical instruction in preschoolers (n = 21, age = 4.6 years) (146). Like the present study, researchers observed an improvement in morning PA ($p < 0.01$), but no statistically significant change in on-task time (146). Researchers cited small sample size, lack of total day PA assessment, and different preschool center environments as potential causes. Even though the study durations varied (1 week vs. 12 weeks) the limitations of small sample size and different preschool center environments reported by Logan et al., are consistent with that of the present study. While the participating preschools were matched on PA-related policies and practices, both the PAL and CON preschools had different classroom environments which may explain the observed baseline differences in classroom behavior as well as the null findings. Behavioral expectations in the classroom varied by teacher and preschool, with classrooms in the PAL group demonstrating a higher off-task normative environment compared to the CON group.

The only randomized controlled trial examining the effect of a PA intervention on classroom behavior in preschool-age children was a secondary data analysis stemming from an intervention study, Project PLAY (4). Seventy-one preschoolers (age = 4.3 ± 0.7 years, male = 49%) in eight classrooms (two preschool centers) participated in a locomotor skill-based PA intervention. Children randomized to the intervention group participated in a teacher-led 30-minute locomotor skill-based session while the control group participated in a 30-minute unstructured free play session (4). Each group

participated in their assigned session for 30 minutes per day, five days per week, for six months (4). Classroom behavior was assessed by teachers at baseline, 3-months, and 6-months, while PA was assessed with an accelerometer at baseline and 6-months. Results indicated that there was a statistically significant decrease in classroom hyperactivity (INT = -2.58 points, $p = 0.001$; CON = 2.33 points, $p = 0.03$), aggression (INT = -2.87 points, $p = 0.01$; CON = 0.97 points, $p = 0.38$), and inattention (INT = 1.59 points, $p < 0.001$; CON = 3.91 points, $p < 0.001$) (35). Interestingly, this study did not significantly alter preschoolers' PA levels, but reduced percent time spent in sedentary time and improved leaping motor skills (4). One of the major limitations of the locomotor skill-based intervention was that teachers did not implement each session with high fidelity (4). In a post-intervention survey, teachers indicated that they often did not implement the lessons fully because the lesson plans were too long, and this was exacerbated by the need to set up their classroom for activity prior to the lesson beginning (4). Therefore, it is possible that the intervention became burdensome during their daily schedules, which could have led to a lack of change in PA. When comparing these results to the present findings, the type of PA should be considered. The PA intervention differed with Project PLAY utilizing 30-minute bouts of locomotor skill-based PA and the present study utilizing shorter academically-integrated PA. Both studies observed no change in PA, but Project PLAY resulted in improvements in motor skills as well as a reduction in sedentary time. It is possible that these improvements in locomotor skills and sedentary time contributed to their teacher-reported improvements in classroom behavior. Locomotor movements are more complex, and may result in greater neurological changes which can impact behavior.

The present study was hindered by measurement concerns (e.g., accelerometer compliance, insufficient classroom observations, and missing teacher questionnaires) which impacted our ability to understand potential impacts on PA and classroom behavior. Physical activity outcomes were limited by accelerometer non-compliance as wear time criteria proved to be a challenge for children in this study. Many children did not wear the monitor sufficiently and were excluded from data analysis. This was most noticeable during the 6-week assessment when 22 children did not have enough data to be analyzed. Due to this, our analytic sample size was reduced. Some teachers commented that children often took monitors off during nap time and did not want to put them back on after nap. Further, among the children who did wear the accelerometers, there were often 3-4 children who were shy around intervention leaders and refused to participate in the PA lessons. While accelerometer non-compliance can result from a multitude of factors, it is important to note that this trend is common in youth activity studies which measured PA with accelerometers. In a recent review, Howie & Straker reported that average non-compliance was between 22 and 30% for baseline and follow-up assessments, with a range of 2-70% (122). More importantly, youth-based activity studies tend to not report the non-compliance data. Of the studies reviewed, studies with young children and those conducted in school settings had some of the highest rates of missing PA data when compared to studies in elementary school age children (122). It is evident that the present study is not the first to encounter non-compliance issues, and strategies to reduce this should be explored (e.g., incentive after each time point, researcher presence throughout the day to ensure wear after nap and when children are picked up by parents).

The present study aimed to use a multimethod approach to evaluate classroom behavior by including both direct observation by research staff and teacher-reported classroom behavior. It proved difficult to attain sufficient direct observations following morning circle time due to unplanned schedule changes, children's absences, and observer availability. During assessment weeks, we encountered schedule changes in the preschool classrooms that prohibited the research team from completing the required observations. For example, if the weather was appropriate for outdoor play in the morning, teachers would alter the daily schedule by taking the children outside immediately following circle time (instead of later in the morning), which meant we were unable to observe classroom behavior that day. Further, children's absences and late arrivals limited our ability to conduct observations. For example, if a child was dropped off after the PA lesson had ended, we were unable to observe their classroom behavior following PA, because they were not present to participate in the lesson. The majority of children were observed three times at baseline and only one to two times at 6-weeks and 12-weeks. Because each child was not observed four times at each time point as originally intended, it is possible that we did not observe an accurate representation of each child's classroom behavior. Finally, one research staff member withdrew from the study prior to 6-week assessments which greatly impacted our team's ability to conduct the necessary amount of observations in a short period of time. Teacher completion of classroom behavior questionnaires was 100% at baseline, but one teacher was unable to complete questionnaires at 12-weeks due to medical leave. This classroom accounted for 44% of the CON group, which drastically limits our findings. We also observed significant differences between the PAL and CON groups in classroom behavior at

baseline. While we made every attempt to match preschool centers on PA policies and practices, it would have been beneficial to identify classroom management styles. The classroom behavior differences observed at baseline may be due to differences in preschool policies and classroom management styles of teachers. For example, after baseline assessments it became clear that levels of acceptable off-task behavior varied by preschool. For example, the PAL preschool tended to be more off-task during all activities observed, and this seemed to be normative behavior for the classroom whereas the CON preschool teachers seemed to address maladaptive behaviors more quickly and therefore children understood how to behave in academic situations. These differences likely impacted our results as altering classroom behavior is difficult when the classroom management style allows for off-task behaviors to occur. Further, it is possible that the teachers in the two preschools viewed children's behaviors differently and one may have classified behavior as "maladaptive" while the other would not have made that distinction. For example, one item on the BASC asked teachers to note how often a child "speaks out of turn." One teacher in the CON preschool may have viewed speaking out of turn as problematic and could have been more likely to notice and record that information about children in the study. Another teacher in the PAL preschool may not have seen a problem with children speaking out of turn in class and therefore may not recognize it as a maladaptive behavior. In that classroom, speaking out of turn seemed to be typical behavior for the children. If classroom behavior was not viewed as problematic or maladaptive, teachers may have been less likely to report it or attempt to alter it in the classroom.

Strengths of this study include the integration of PA into early learning standards which has potential to boost sustainability and dissemination across various preschools. Previous studies utilizing academically-integrated PA have shown that academically-integrated PA can have positive impacts on preschool-day PA and academic-related outcomes (i.e., early literacy skills) (6, 133, 134, 231). The present study improved upon previous literature by using both direct observation and teacher-reported classroom behavior, which limits potential teacher bias. With only teacher-reported classroom behavior, it is possible that teachers may over-report maladaptive behaviors for some children. Conducting the classroom observation in addition to teacher-report limited this potential bias by including information from blinded research staff. In addition, several measures of process evaluation were collected during the PAL pilot study. Process evaluation data indicated that both teachers and children found the PAL lessons enjoyable and that teachers would continue to implement them during the preschool day. One teacher reported that she would be extremely likely to include these activities in the future to help children transition from one activity to another. High rates of acceptability are promising as the long-term goal of the PAL program is to increase sustainability of academically-integrated PA during the preschool day. Finally, another strength of this study is the objective assessment of PA both during and outside of preschool as previous studies have failed to account for PA outside of the preschool day.

Overall, implementing short bouts of academically-integrated PA improved activity levels during morning circle time, but that change did not translate to an impact on total preschool day activity level. Furthermore, there were no statistically significant changes in classroom behavior as assessed by direct observation or teacher report.

Several factors may have contributed to these null findings such as measurement concerns, classroom environment, and study duration. It will be important for future studies to improve upon the measurement aspect of this work by employing strategies to boost accelerometer compliance and more accurately capture children's classroom behavior via direct observation. It is possible that even with this PA exposure, measurement issues did not allow us to accurately quantify initial efficacy of the program. While the PAL pilot study was acceptable and enjoyable for teachers and children, greater emphasis should be placed on increasing the intensity of the lessons and potentially altering individual session duration as well as overall study duration. It is possible that 12 weeks was too short to observe behavioral changes in response to chronic PA. To improve upon this study design, future research should 1) find ways to accurately assess outcome variables, 2) increase teacher participation as a way to enhance children's PA through modeling, 3) improve research team capacity by hiring and training additional classroom observers, and 4) explore opportunities for additional PAL lessons throughout the day.

Table 8. Between group differences in baseline characteristics in PAL study sample.

Variable	**PAL (n = 32)**	**CON (n = 26)**	***p*-value**
Age (years)	4.0 ± 0.2	4.0 ± 0.2	0.94
Sex (% male)	17 (53.1%)	13 (50.00%)	0.81
BMI percentile	67.2 ± 4.5	63.65 ± 4.86	0.61
BMI Category			
Underweight	1 (3.3%)	0 (0.0%)	0.82
Healthy Weight	23 (76.7%)	17 (85.0%)	
Overweight	4 (13.3%)	2 (10.0%)	
Obese	2 (6.7%)	1 (5.0%)	
Race/Ethnicity			
White	15 (51.7%)	23 (100.0%)	0.001*
Hispanic	9 (31.0%)	0 (0.0%)	
Black/African American	5 (17.2%)	0 (0.0%)	
Sleep (hours/night)			
8-10 hours	24 (82.8%)	16 (69.6%)	0.26
11-13 hours	5 (17.2%)	7 (30.4%)	
TD Physical Activity			
Sedentary (% time)	74.5 ± 6.2	74.1 ± 5.3	0.79
Light PA (% time)	13.2 ± 0.5	13.3 ± 0.4	0.84
MVPA (% time)	12.3 ± 0.8	12.6 ± 0.8	0.79
Diagnosed Developmental Disorder	0 (0.0%)	1 (4.34%)	0.44
Individualized Education Plan	1 (3.6%)	1 (4.0%)	1.00
Family Income			
< $40,000	4 (13.8%)	2 (8.7%)	0.12
$40,000 – 59,999	8 (27.6%)	1 (4.4%)	
$60,000 – 79,999	3 (10.3%)	3 (13.0%)	
≥ $80,000	14 (48.3%)	17 (73.9%)	

BMI = body mass index, TD = total daily.

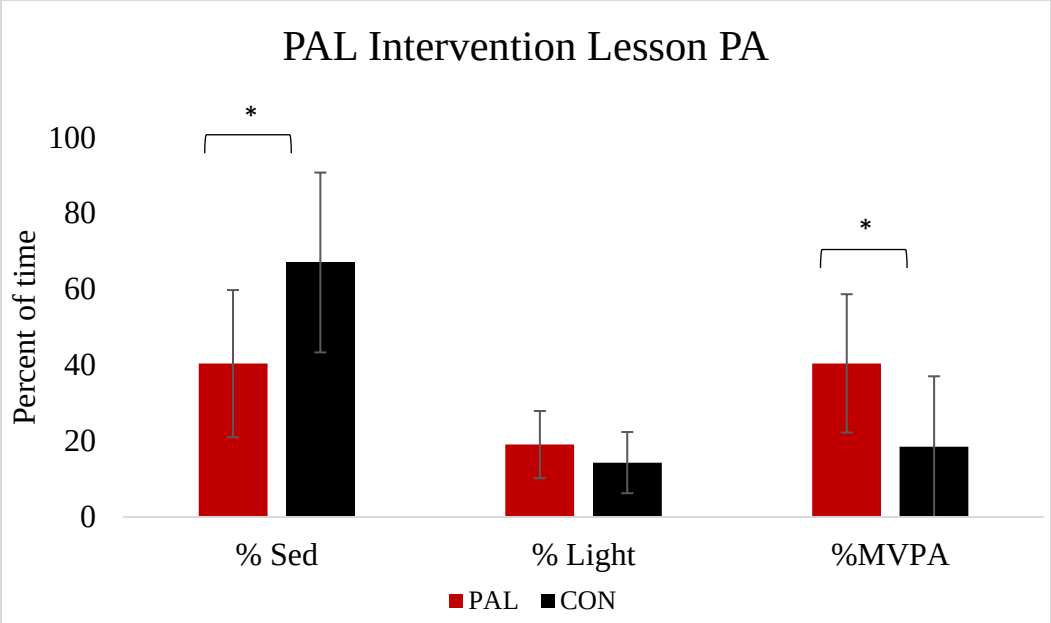

Figure 5. Percent time spent in each PA intensity by intervention group during the intervention time period.

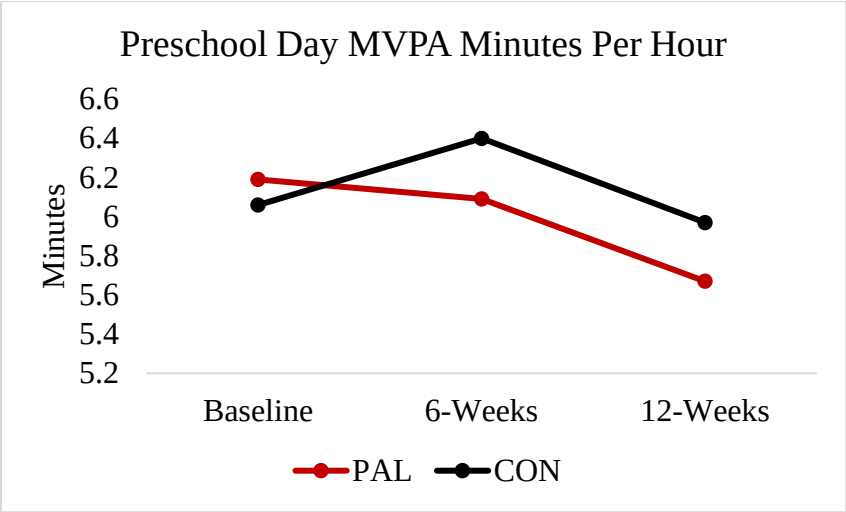

Figure 6. Change in preschool day MVPA minutes per hour by intervention group.

Table 9. Baseline relationships between physical activity and classroom behavior variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Sex	1											
2. Age	-0.10	1										
3. PD Sed	0.12	-0.03	1									
4. PD LPA	0.02	0.05	-0.17	1								
5. PD MVPA	-0.01	-0.07	-0.54***	0.63***	1							
6. TR HYP	-0.02	-0.03	-0.23	0.13	0.25	1						
7. TR INATT	-0.27	0.11	-0.11	0.34*	0.32*	0.64***	1					
8. AET	-0.11	0.17	-0.05	-0.17	-0.04	-0.17	-0.11	1				
9. PET	0.11	-0.16	0.28	-0.16	-0.28	0.13	0.05	-0.78***	1			
10. OFT-M	0.07	-0.14	-0.15	0.45**	0.45**	0.12	0.15	-0.70***	0.28*	1		
11. OFT-V	-0.08	-0.10	-0.08	0.39*	0.46**	-0.08	0.09	-0.38**	0.04	0.64***	1	
12. OFT-P	-0.00	-0.12	0.14	0.32*	-0.02	-0.10	-0.11	-0.46**	0.13	0.41**	0.15	1

PD Sed = preschool day average sedentary minutes per day, PD LPA = preschool day light physical activity minutes per day, PD MVPA = preschool day moderate to vigorous physical activity minutes per day, TR HYP = teacher-reported hyperactivity percentile, TR INATT = teacher-reported inattention percentile, AET = active engaged time, PET = passive engaged time, OFT-M = off-task motor time, OFT-V = off-task verbal time, OFT-P = off-task passive time. * denotes $p < 0.05$, ** denotes $p < 0.01$, *** denotes $p < 0.0001$.

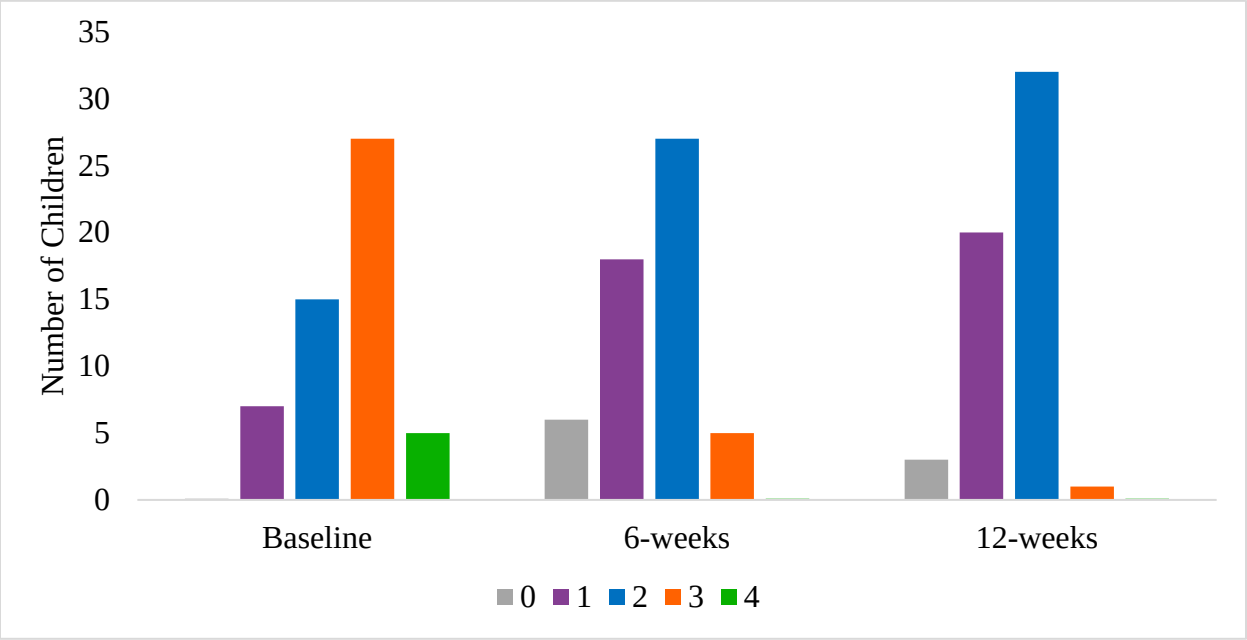

Figure 7. Number of classroom behavior observations for each child at each time point in the PAL pilot study. 0 = number of children observed 0 times, 1 = number of children observed once, 2 = number of children observed twice, 3 = number of children observed 3 times, 4 = number of children observed 4 times.

Table 10. Baseline and adjusted 6-week and 12-week direct observation classroom behavior data by intervention group from ANCOVA analyses.

	PAL			CON				
	Baseline	6-Weeks (Adjusted)	12-Weeks (Adjusted)	Baseline	6-Weeks (Adjusted)	12-Weeks (Adjusted)	Baseline 6-Weeks Contrast (95% CI) n = 46	Baseline to 12-Weeks Contrast (95% CI) n = 49
AET	42.2 (3.7)	13.7 (4.4)	33.9 (6.4)	69.5 (4.7)	39.5 (4.7)	30.0 (6.9)	-25.8 (7.0) (-39.8, -11.8)	3.9 (10.3) (-16.7, 24.5)
PET	25.4 (3.3)	52.1 (41.6)	34.4 (4.9)	18.2 (3.0)	41.6 (5.4)	51.3 (5.3)	10.5 (7.5) (-4.6, 25.6)	-16.9 (7.3) (-31.6, -2.2)
OFT-M	31.3 (3.1)	41.9 (5.3)	26.5 (3.9)	15.4 (3.3)	19.5 (5.6)	19.2 (4.2)	22.4 (8.1) (6.1, 38.8)	7.3 (6.0) (-4.8, 6.0)
OFT-V	13.4 (2.2)	10.2 (2.6)	10.7 (2.3)	3.0 (0.7)	14.5 (2.8)	14.5 (2.8)	-4.3 (4.1) (-12.5, 4.0)	3.6 (3.6) (-3.6, 10.8)
OFT-P	21.2 (11.5)	18.6 (3.4)	16.9 (7.7)	11.5 (2.4)	13.1 (3.6)	9.2 (4.0)	5.5 (5.1) (-4.8, 15.8)	9.2 (4.0) (1.0, 17.3)

Data are reported as the mean (standard error) of the percent of observed intervals that participants engaged in each behavior. 6-week and 12-week values are adjusted for baseline values. Contrast indicated a comparison of change scores between groups. PAL = Preschoolers Actively Learning group, CON = health tracking control group, CI = confidence interval, AET = active engaged time, PET = passive engaged time, OFT-M = off-task motor, OFT-V = off-task verbal, OFT-P = off-task passive.

Table 11. Teacher-reported hyperactivity and inattention in the study sample.

	PAL Preschool			CON Preschool			
	Baseline	12-Weeks	Change Score	Baseline	12-Weeks	Change Score	p-value
HYP	70.9 ± 22.8	68.4 ± 25.1	-1.9 ±17.8	28.8 ± 26.4	34.1 ± 32.7	2.1 ± 15.1	0.23
ATT	54.6 ± 21.8	50.4 ± 26.6	-3.5 ±15.6	50.0 ± 30.1	51.1 ±31.4	1.1 ±15.6	0.18

PAL = Preschoolers Actively Learning, CON = health tracking control group, HYP = hyperactivity expressed as percentile, ATT = inattention expressed as percentile.

CHAPTER V

CONCLUSION

Overall Summary

The purpose of this study was to examine the feasibility, acceptability, and preliminary efficacy of a 12-week PA intervention integrated into early learning standards on classroom behavior in preschoolers. In this study, two preschool centers were randomized to either the PAL group or CON group. The PAL preschool participated in 10-15 minute academically-integrated PA lessons during morning circle time four days per week for 12 weeks while the CON preschool maintained their usual curriculum. The primary aim of this study was to examine the feasibility, acceptability, and fidelity of an academically-integrated PA intervention on classroom behavior in preschoolers. Recruitment and retention goals were met with 58 children enrolled in the study and 96.6% retention at 12-weeks. Over the course of 12 weeks, 94% of PAL PA lessons were implemented. Modifications were made in approximately one-third of the intervention lessons, and 70% of those modifications occurred in the first six weeks of the study. Overall, the intervention was acceptable to both teachers and children who appeared to enjoy the intervention 85% and 99%, respectively. In their post-intervention survey, all teachers reported that the PAL lessons were effective for meeting learning standards and that they would implement them in the future. However, some fidelity outcomes were not achieved. The intervention intensity goal for preschoolers of 50% MVPA was not met, with only 40.5 ± 18.2% of the lessons spent in MVPA. Attendance of participating children ranged from 74-94%, with greater participation among older children.

Intervention feasibility and acceptability was high, but some aspects of fidelity such as intervention intensity adherence and teacher participation need modification.

The secondary aim of this study was to examine the preliminary efficacy of an academically-integrated PA intervention on preschoolers' PA and classroom behavior. During the morning circle time when the PAL intervention took place, the PAL group engaged in approximately 5.0 ± 2.3 minutes of MVPA during the PAL lesson compared to 2.8 ± 2.8 minutes in the CON preschool. No other changes in preschool day or total day PA was observed. Classroom behavior was assessed via teacher-report and direct observation. No statistically significant changes were observed for either measure. Missing data limited our ability to assess change in these variables.

The study exploratory aim sought to examine the relationship between an objective task of attention, teacher-reported inattention, and directly observed off-task time. The objective task of attention was measured with the NIH Toolbox Flanker Task for preschool-age children. At baseline, there was no significant difference between the PAL preschool and CON preschool in terms of performance on the task (PAL: 21.2 ± 2.3, CON: 19.8 ± 2.5; t = -0.41, p = 0.69). There were no within-group changes from baseline to 12-weeks. At baseline, teacher-reported inattention was positively associated with directly observed off-task motor behavior (r = 0.37, p = 0.006; 95% CI = 0.12, 0.58). No other significant relationships were observed.

Significance of Findings

The primary aim which was to examine feasibility and acceptability of the PAL intervention was supported by both quantitative and qualitative data. Teachers reported that the lessons were effective and enjoyable on a weekly basis and were extremely likely

to implement these lessons during other periods of the day. The program was well received by teachers, children, and families, which is important for future implementation. Despite high levels of feasibility and acceptability, some aspects of fidelity need to be improved upon for future studies. For example, strategies to alter the intensity level of the PA lessons as well as variable participation rate among children and teachers will be necessary in future studies. We also experienced assessment challenges, which may have impacted our lack of preliminary efficacy findings. These challenges included insufficient accelerometer wear and classroom observations. With more accurate measures, we may better understand the potential impact of the PAL intervention on secondary outcome variables.

Limitations & Future Directions

This study had several limitations impacting both implementation and assessment outcomes. From an implementation perspective, children's participation varied amongst the different classrooms. One contributing factor to this may be the age ranges within a preschool classroom. For example, two of the three classrooms had students who were transitioning from toddler classrooms and were therefore less familiar with the rules and expectations of the preschool classroom. In these classrooms, some children either would not participate due to feeling shy around intervention leaders or have to be pulled aside by the teacher due to unsafe movement behaviors. This was also linked to lower than anticipated teacher participation. Because teachers were needed to manage the behaviors of children during the intervention lesson, they were unable to participate and act as a role model for the children. One strategy that the research team incorporated during the study was to have one team member solely responsible for encouraging some of the shy

non-participating children. This worked for some children more than others. Future studies should explore the possibility of the research team visiting the classroom prior to the intervention to help the younger children get more comfortable with outside individuals entering their classroom.

Teachers viewed the PAL intervention favorably, which was evident in their weekly log and post-intervention survey. The teachers chose to participate in the assessment portion of the study, which may have introduced some bias into their responses. One explanation for high teacher ratings could be due to the modifications made early in the study. When teachers had suggestions to better implement the program in their classroom, the research team was receptive and made the suggested modifications. Teachers could have provided high ratings on the post-intervention survey because they viewed the research team as receptive and respectful of their needs. The weekly logs were administered by research staff and the post-intervention survey was given to the teachers in a sealed envelope so it could remain anonymous. It is possible that social desirability bias contributed to some of the high ratings received from teachers. This could also have contributed to their overall satisfaction with the program despite the lack of change in children's classroom behavior. Teachers liked the new ideas for incorporating PA into their classroom, but not necessarily the effects of the intervention. Furthermore, our lab has worked with this preschool center in the past and had developed good relationships with the teachers. In previous studies, the teachers had been honest about components of programs that they did not like and what needed to be altered for them to continue implementing the program. Because of these previous

experiences, we feel confident that the teachers were very honest with us in terms of program evaluation.

PAL lessons did not reach the intended intensity goal of at least 50% of time spent in MVPA as measured by accelerometer. This could be due to a multitude of reasons including classroom management, distractions, and research team training. As previously mentioned, classroom management of unsafe movement behaviors impacted multiple areas of the intervention. In this case, intervention leaders sometimes had to pause the lesson to stop children from arguing or moving in unsafe ways (i.e., crawling on top of other children, throwing bean bags across the room). This took away from the intervention delivery as the intensity had to be decreased or stopped briefly. Further, it was difficult to incorporate equipment into some PAL lessons. Minimal equipment (e.g., bean bags, small hula hoops) was intended to supplement the PA lessons, but some children would inappropriately use the equipment (e.g., throwing bean bags at another student, kicking the hula hoops around the floor) which caused the lesson to be stopped or modified. It was difficult to retain the attention of the class when a few children found alternate uses for the equipment. One strategy that the research team adopted midway through the study was to hold the equipment until it was ready for use by the children, then immediately collect it after a given movement pattern. This attempted to limit the opportunities to pick up and inappropriately use the equipment during the lesson. The small classroom spaces also could have contributed to low PA intensity. Despite lower than intended intensity among other fidelity limitations, research staff reported 100% of the lessons were implemented clearly and correctly. There may have been some bias in the responses to these items on the questionnaire as they were completed by research

staff. For example, it is conceivable that a researcher completing those questions may have been less likely to say the intervention was "incorrect" because they felt it would reflect poorly on the research team. It is also possible that the lessons were implemented "correctly" according to the intervention plan, but that did not necessarily mean the lesson worked. A lesson may have been implemented correctly, but then modified or extended to maintain the children's interest. In this case, a lesson could have begun as being implemented correctly (and coded this way) but was modified afterwards to hold interest or adjust to the needs of the class. This would help explain the fidelity limitations despite high ratings of correct implementation. While the PAL lessons were designed to be conducted indoors in small classrooms, some teachers placed additional restrictions on where the children could move (i.e., staying on the circle time carpet) which further limited movement abilities. To maximize potential efficacy of the PAL intervention with some of these limitations, it may be beneficial for future studies to incorporate these 10-15-minute PA lessons at least twice per day or during times outside of circle time. By adding more opportunities for PA, it is possible that MVPA accumulation will reach the intended dose. It is also possible that the best time for the intervention may vary by classroom. It may be beneficial to observe when children are the most off-task during the day, and then plan to implement the intervention prior to those times. Future studies should consider the individual needs of classrooms as it pertains to off-task behavior.

Measurement compliance and timing also impacted the findings of this pilot study. Physical activity outcome variables assessed by accelerometry may be underestimated as waist-worn devices have difficulty collecting data on upper body movements. Because the classroom spaces were small, the PAL lessons did utilize

several upper body movements in an attempt to increase intensity without gross motor movements such as running or skipping. We anticipated this issue prior to the study beginning and planned to directly observe one PAL lesson each week. However, due to research staff member's limited availability, direct observations were only obtained for five out of the twelve weeks. A strategy to overcome this in the future would be to designate two or three staff members to serve as observers and provide specific training for that purpose. Further, accelerometer wear time compliance was low, particularly at the 6-week timepoint. The novelty of wearing the monitors seemed to have worn off by that point and teachers reported that children would forget to put them back on after nap time. In the future, it may be beneficial for the research team to be more proactive in reminding children and parents to wear the monitors during assessment time points. It may also be worth exploring direct observation during the assessment weeks at the preschool center to gather more qualitative data about PA patterns and reasons for noncompliance.

While classroom observation combined with teacher-reported classroom behavior was a novel measurement approach, conducting classroom observations proved to be difficult for our research team. The classroom observers were recruited specifically for this role and were blinded to the study aims. During training prior to baseline observations, two observers withdrew from the study for academic reasons. Following baseline observations, one additional observer withdrew from the study, and subsequently from the university. Observations during the 12-week assessment were also limited due to observer availability related to university final exams. Therefore, the team was short staffed during 6-week and 12-week assessments, which is directly related to the low

number of observations obtained at those time points. Further, some children were regularly dropped off late, unfortunately after the intervention time so we were unable to observe their response to the PA lessons. Initially, we had planned to observe children for up to one hour following the PA lesson, but teachers frequently shifted their schedules (e.g., to go outside in warmer weather or to practice for a preschool concert). This shortened the observation window as well. Future studies should recruit a larger classroom observation team and allow for two weeks of assessments to account for some of the challenges we faced. Further, teacher-reported classroom behavior assessments were limited by missing data during the 12-week assessment due to a teacher out on medical leave. There were also large standard deviations in teacher-reported classroom behavior, which suggested that there was high between participant variability in these measures. Future studies may wish to explore alternate teacher-reported assessment methods (e.g., shorter questionnaires or rating scales, weekly behavior charts) or utilize a larger sample size to overcome this challenge. It is also possible that teacher-reported classroom behavior may have been affected by baseline assessments conducted in September. The questionnaire recommends that teachers respond to the questions based on the child's behavior over the last six months. If a teacher had a new student in their class that had just started a few weeks prior to baseline assessment, it is possible that the teacher did not have an accurate view of the child's behavior. Moving forward, it may be important to consider utilizing this questionnaire after teachers had a certain amount of time with children in their classroom.

In this study, the timing of the assessment weeks was not ideal. The original schedule was confined by the university's semester to maintain research staff availability.

However, this 12-week study schedule may have negatively affected the outcomes. Baseline measurements took place during late September, when the average outdoor temperature was 69º F. At this time, children were outdoors usually twice per day. At 6-weeks in early November, the average outdoor temperature was 52º F and that decreased to 36º F by mid-December for 12-week assessments. As the temperature got cooler, children were less likely to play outside or had their outdoor time shortened. This was coupled with the 12-week time point occurring just before the holidays. At this time, children had a pajama day when they stayed inside and watched a movie, had a holiday party, and had a field trip for a holiday concert. These activities were important for their preschool curricula, but may have negatively impacted our assessments. For example, it is likely that children were less active at 12-weeks partly because they were not outside for free play and were participating in structured sedentary activities during the preschool day. While schedule constraints are challenging to avoid, future studies should aim to better align assessment periods with both preschoolers' and research teams' schedules.

Finally, this study was underpowered to accurately detect intervention effects on classroom behavior. A sample size estimate was conducted based on secondary aim outcome variables. We chose to power based off a large effect due to practical recruitment goals in the two participating preschools. We were underpowered to observe either a small or medium effect in this sample due to limited number of preschoolers enrolled at the two participating centers. It was not feasible for us to recruit 578 participants to detect a small effect when the PAL preschool enrolled a maximum of 50 children and the CON preschool enrolled a maximum of 72 children. Post-hoc calculations were conducted to determine the achieved power. Based on our final sample

size of 49 and a 0.25 correlation between repeated measures, we had 97% power to detect a large effect (f = 0.4), 68% power to detect a medium effect (f = 0.25) and 16% power to detect a small effect (f = 0.01) in classroom behavior outcomes. Future studies should include additional preschool centers to be adequately powered to see potential effects of the intervention on classroom behavior.

Although this pilot study had several limitations, outcome data provided preliminary evidence for the feasibility and acceptability of this type of program. The next steps for this pilot intervention include modification based on the aforementioned limitations. Before drawing conclusions about the preliminary efficacy of academically-integrated PA on classroom behavior in preschoolers, teacher involvement needs to be improved. As teachers act as primary role models for the children, their enthusiasm and participation in the program could directly impact children's participation and intensity. Teacher training should be emphasized, and implementation could be split fifty-fifty between the teacher and research staff rather than the approach taken in the present study where the research team led the lesson and the teacher participated minimally. While the present model of having researchers implement the intervention was chosen to make sure it worked before training teachers, it is possible that teachers were not as invested in the program because they did not have a direct role. On some occasions, teachers used the lesson time as a break to catch up on other classroom activities. If greater training and implementation was emphasized early on, it is possible that teacher involvement would be increased. It is also possible that offering research staff to assist with other unrelated tasks may provide teachers with the feeling that they have time to more fully participate in the intervention protocol. A further extension of this model would be training the

teachers to implement the PAL lessons on their own with minimal support from research staff. This would be the ultimate goal in creating a sustainable intervention program.

Finally, future work should conduct sensitivity analyses to examine if the intervention had greater effects in some groups compared to others. Variables to consider for future analyses include age, gender, race, levels of off-task behavior, and teacher engagement. While the present study was not powered to conduct these analyses, we conducted an exploratory analysis to determine if older children (i.e., 4-5 years of age) responded to the intervention while excluding younger children (i.e., 2.9-3 years of age). There were 16 and 10 older children in the PAL and CON group, respectively, but only 18 children had complete PA data. There was no intervention by time effect on mean sedentary minutes per preschool day ($F_{2,26} = 0.01$, $p = 0.99$), mean light PA minutes per preschool day ($F_{2,26} = 0.83$, $p = 0.45$), or mean MVPA minutes per preschool day ($F_{2,26} = 0.01$, $p = 0.99$). For directly observed classroom behavior, 25 children had complete data and were included in the analyses. There was a significant effect of the intervention on OFT-V behavior ($F_{1,19} = 4.67$, $p = 0.04$) at 6-weeks (contrast = -13.54, 95% CI = -26.72, -0.35). We were unable to assess changes in teacher-reported classroom behavior in older children because only 1 older child in the CON group had complete data. While many of these findings remained insignificant in this sample, it is possible that differences would be seen in studies with larger sample sizes.

Conclusions

The PAL pilot study provided initial evidence to support the feasibility and acceptability of an academically-integrated PA program from rich process evaluation data collected at various times throughout the 12-week study. This is promising for future

studies as it demonstrated that preschool center directors, teachers, parents, and students were receptive to this type of program added to their typical curriculum. However, preliminary efficacy of this program to impact classroom behavior was not established. Both quantitative and qualitative data will be used to modify the present study and improve upon limitations. This study also highlighted some important measurement issues that must be improved upon before future studies can examine the efficacy of the PAL program.

APPENDIX A

STUDY FLYER

Preschoolers Actively Learning (PAL) Study

Pediatric Physical Activity Laboratory

What we are doing:

- The Pediatric Physical Activity Laboratory at UMass Amherst is studying academically-integrated physical activity and classroom behavior in preschoolers

Who we are looking for:

- Preschoolers (ages 2.9 – 5 years) to participate in a 12-week program
- All children will participate in the physical activity program during preschool, but we are recruiting children to participate in the measurement portion of the study

What you and your child will do:

- You will be asked to complete questionnaires about demographic information and your child's behavior (15-20 min)
- At the beginning and end of the study, your child will be asked to participate in some measures (e.g., height and weight, a brief matching task on an iPad, and classroom behavior observation)
- Your child will be asked to wear a small monitor to measure how much they move at the beginning, middle, and end of the program
- Depending on your child's preschool, your child will either:
  - Participate in an in-school physical activity program (Fall 2018)

    OR
  - Participate in a health tracking program (this preschool will participate in the physical activity program in Spring 2019)

Parent/Guardian – ***Informed Consent/Parent Permission forms will be sent home next week.*** *If you are interested in your child participating in the measurement portion of this study, please complete this form and return to your child's teacher in the provided sealed envelope. Contact our study staff with any questions by phone (413-545-6104) or email (kinpedlab@umass.edu).*

APPENDIX B

PARENT INFOMED CONSENT & PERMISSION FORM

University of Massachusetts Amherst

PARENT INFORMED CONSENT & PERMISSION FOR MINOR TO PARTICIPATE IN RESEARCH FORM

Preschoolers Actively Learning (PAL) Pilot Study

FOR QUESTIONS ABOUT THIS STUDY, CONTACT:

Sarah Burkart, M.S.
University of Massachusetts Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104
kinpedlab@umass.edu

WHAT IS THIS FORM?

This form will provide you with the information you will need to understand why this study is being done and explain the involvement of you as the parent or guardian and what your child will need to do to participate. It will also describe any known risks, inconveniences, or discomforts that you or your child may have while participating. We encourage you to take some time to think this over and ask any questions now, and at any other time. If you decide to participate in this study, you will be asked to sign this form and you will be given a copy for your records.

PURPOSE OF THE RESEARCH PROJECT

You and your child are invited to participate in a study designed to examine the feasibility, acceptability, and efficacy of a classroom physical activity program offered during the preschool day on the classroom behavior and physical activity levels of preschool children. We hope to learn if a physical activity program can be successfully implemented during the preschool day and if it will be well received by preschoolers. We also hope to learn if this type of program can impact preschoolers' classroom behavior. All children at your child's preschool will participate in the program. However, we are individually recruiting children and their parent/guardian to participate in the assessment portion of the study.

ELIGIBILITY

For your child to participate in the assessment portion of this study, he or she must be enrolled in a preschool classroom at either Children's House or Scantic Valley YMCA Learning Center and willing to comply with the study conditions included in the project procedures described below. To participate in the parent/guardian portion of this study,

Participant Initials: _____

you must be the parent or guardian of a preschool student who is eligible to participate in the assessment portion of this study. As part of this study, two preschool centers will be randomly assigned to either the physical activity intervention or be asked to keep their normal curriculum. If your child is in the preschool that will participate in the physical activity intervention in Fall 2018, he or she will participate in 10-15 minutes of physically active academic lessons four days per week. All children in your child's preschool classroom will participate in the physical activity program as part of their normal classroom activities. If your child attends the health-tracking preschool center, they will continue to participate in their usual classroom curriculum. However, in Spring 2019, the physical activity program will be offered to their preschool and they will be able to participate in the physically active academic lessons at that time.

Only children whose parents have completed this consent and permission form are eligible to participate in the measurement portion of this study. By participating in the assessment portion of the study, you will help us to understand if integrating physical activity into early learning standards can have an impact on the health and classroom behavior of preschoolers.

STUDY LOCATION AND DURATION OF INVOLVEMENT

Your child will participate in this study at their preschool center during their regularly scheduled preschool day. Your child's involvement in this study will last for 14 weeks. The first two weeks will be a baseline data collection and will be followed by the 12-week physical activity intervention. Your child will be asked to wear a small activity monitor on his or her waist for seven days during the beginning, middle, and end of the study. If your child attends the preschool that receives the physical activity intervention, your child's participation in the program is expected to last 40-60 minutes per week (10-15 minutes following morning circle time, four days per week).

The parent/guardian portion of this study will involve the completion of two questionnaires (one at the beginning of the study and one at the end). Each questionnaire will take approximately 15-20 minutes to complete (total of 30-40 minutes for both). At baseline, we will also ask you to complete a brief demographic questionnaire (5-10 minutes) about your child and your family. The questionnaires will be available online and can be completed remotely. If you prefer not to complete the questionnaire online, we can provide you a paper copy of the questionnaires for you to complete and return in a sealed envelope.

WHAT WILL I BE ASKED TO DO?

If you decide to participate in the study, you will be asked to complete a brief online questionnaire to provide some basic demographic and background information about your child and your family. In addition, you will complete a questionnaire about your child's behavior at the beginning and end of the study.

Participant Initials: _____

WHAT WILL MY CHILD BE ASKED TO DO?

Randomization

Two preschool centers are participating in this study. Prior to the start of the study, one preschool will be randomly assigned (like flipping a coin) to participate in the physical activity program and one preschool will be randomly assigned to the health tracking program (see "Programs" section for more information about these programs).

Baseline Measurements:

If you decide to have your child participate in this study, your child will be asked to complete the following steps. The first thing your child will do is complete baseline measurements in the two weeks prior to the start of his or her preschool's assigned program. These measures will be conducted during the morning (at his or her preschool center) and will include the following:

1. Physical measures – A research staff member will measure your child's height and weight. This will take approximately five minutes to complete.

2. Physical activity levels – Your child will be asked to wear a small activity monitor on a belt around his or her waist to measure physical activity for one week (at school and at home).

3. Classroom behavior – A research staff member will observe the classroom behavior of students in your child's preschool classroom (on four separate days) following morning meeting/circle time to observe on- and off-task behavior. The researcher will quietly observe several children in the classroom. Therefore, your child will only be observed for a few minutes (5 minutes). The researcher will observe normal classroom activities and no other information will be collected. Your child's teacher will also complete a questionnaire about your child's classroom behavior. In this questionnaire, teachers will rate whether certain behaviors occur never, sometimes, often, or always. Examples include, "Shares toys or possessions with other students," and "Is easily distracted." If you wish to review the questionnaire that teachers will be completing, please contact the research team and we can provide you a copy of the form.

4. Cognitive task – Your child will complete one task on an iPad application to assess attention/inhibition using a Flanker task. For each trial, a series of five goldfish with arrows on their belly are presented and your child will be asked to choose the arrow that matches the middle fish. This will take approximately 3-4 minutes to complete.

Programs:

Depending on your child's preschool, he or she will either participate in the physical activity program or the health tracking program for 12 weeks.

Participant Initials: _____

1. If your child is in the PAL physical activity intervention group, he or she will be asked to participate in a brief physical activity program that is integrated into the Massachusetts Early Learning Standards, which is part of their usual preschool curriculum. This will take place for 10-15 minutes following morning meeting/circle time Mondays through Thursdays for 12 weeks. Members of our research team will lead these sessions with the help of your child's preschool classroom teacher. The program will include age-appropriate group-based games and activities. For example, in "Treasure Hunt," children will be lead through a treasure hunt where they will perform specific movements that correspond to number cards that are held up. If number 1 is shown to the children, they will identify the number and perform one broad jump to demonstrate jumping off the ship to start their hunt. These sessions aim to increase physical activity during the preschool day while incorporating academic concepts. All children in the preschool classroom will participate in the daily physical activity program. Only children who have a parent/guardian who has provided consent will participate in the assessment portion of the study.

2. If your child is in the health tracking group, he or she will continue to participate in their usual preschool curriculum for 12 weeks. The preschool center assigned to the health tracking group will receive the PAL physical activity program (described above) in the Spring of 2019. No additional information will be collected at this time.

3. Children in both programs will be asked to wear activity monitors for 15 minutes one day per week.

Midpoint measurements:

Halfway through the study (week 6 of the program), your child will again be asked to wear the activity monitor at preschool and at home for one week. Classroom behavior will also be observed by a member of the research staff (same as baseline).

Post-program measurements:

During the last week of the study, your child will be asked to repeat all the baseline measurements.

BENEFITS OF PARTICIPATING IN THIS STUDY

There are no anticipated benefits to you as a parent/guardian for your participation in this study. We cannot and do not guarantee or promise that your child will receive any benefits from this study. However, potential benefits of participating for your child include the potentially improved physical activity levels during the preschool day, having fun engaging in the physical activity sessions, and potential improvements in their classroom behavior.

Participant Initials: _____

RISKS OF PARTICIPATING IN THIS STUDY

No risks are expected for parent/guardian participation in this study. The elastic belts and rubber wrist bands used to secure the activity monitor in place may rub on your child's skin and become uncomfortable. No skin damage should result from this and the discomfort level is minimal.

Your child may be at risk for injury related to physical activity program used in this study. This risk is no greater than the risk your child experiences during usual preschool play time. The intensity of these sessions will be no greater than his/her regular school physical activity.

ALTERNATIVES

The only alternative to being a part of this study is not to participate. If you and your child choose not to participate in the measurement portion of the study, your child may still participate in the physical activity sessions when it is offered as his or her preschool.

PROTECTION OF PERSONAL INFORMATION

The following procedures will be used to protect the confidentiality of your study information. The information obtained from this study will be treated as privileged and confidential. Participants right to privacy will be maintained in any ensuing analysis and presentation of the data. They will be assigned a numerical ID number at the beginning of the study and all individual data will be identified by ID number only. Each subject will be identified by an ID number and personal information will be kept separately on the University secured Box cloud service for 10 years after which they will be destroyed. This list is stored separately from study data on the Box cloud system. Only the investigators of the study will have access to the personal data. Data collected on the iPad (e.g. direct observation classroom behavior data and cognitive task) will be directly exported to secure University-supported Box cloud system folders. This will be done with a unique email address that only study investigators will have access to and used to upload files to Box. Computer files containing data are password protected and stripped of all identifiers. In addition, all files (e.g. informed consent form and parental permission form) containing identifying information will be stored separately from the study data. Only the investigators of the study will have access to the personal data, which will be kept in a folder, locked in a file cabinet in locked office (Pediatric Physical Activity Laboratory). Any information linking your name to your ID number will be destroyed at the completion of the study data analysis. There could be a possibility of data breach. However, the research team will make every effort to maintain the confidentiality of all data. **There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues. For more information on this policy visit**

Participant Initials: _____

http://www.umass.edu/research/guidance/mandatory-reporting.

MEDICAL TREATMENT

The University of Massachusetts Amherst does not have a program for compensating subjects for injury or complications related to human subjects research. In the unlikely event of injury resulting directly from participating in this study, researchers will assist you and your child in every way to make sure your child get proper medical attention.

COMPENSATION

For your time and effort in participating in the measurement portion of this study, your family will receive up to $25 for participating in this study. You will receive:

1. $10 for participating in the baseline measurements ($5 for returning the activity monitor after one week of wear and $5 for questionnaire completion)
2. $5 for participating in the midpoint measurements (for returning the activity monitor after one week of wear)
3. $10 for participating in the post-program measurements ($5 for returning the activity monitor after one week of wear and $5 for questionnaire completion)

There is no cost to participate in this study.

WHAT IF I HAVE QUESTIONS?

We encourage you to take as long as you like before you make a decision about your participation in this study. If you have further questions about this project or you have a research related problem, you may contact the faculty sponsor, Dr. Sofiya Alhassan at 413-545-3475 or alhassan@kin.umass.edu. If you have questions regarding your rights as a research participant, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at 413-545-3428 or humansubjects@ora.umass.edu.

CAN I WITHDRAW FROM THE STUDY?

You do not have to be in this study if you not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide not to participate. The research staff may also withdraw you from the study without your permission for one or more of the following reasons:

- Not being able to comply with the instructions of the research staff
- The study is canceled, other administrative reasons or unanticipated circumstances

If you wish to withdraw your data following the completion of the study, you may contact the research team in writing to do so.

Participant Initials: _____

PARTICIPANT STATEMENT OF VOLUNTARY CONSENT

When signing this form, I am agreeing to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language which I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw myself and my child at any time. A copy of this form has been given to me.

_____

Parent/Legal Guardian Name (Print)

_____ _____

Parent/Legal Guardian Signature Date

_____

Child's Name (Print)

_____

Child's Classroom

For demographic questionnaire, please either provide your email or select paper copy to be sent home with your child in a sealed envelope.

_____ ☐

Parent/Guardian Email Address Paper copy

By signing below, I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

_____

Study Representative's Name (Print)

_____ _____

Study Representative's Signature Date

University of Massachusetts Amherst-IRB
(413) 545-3428
Approval Date: 08/06/2018 **Protocol #:** 2018-4918
Valid Through: 08/05/2019
IRB Signature: Nancy C. Hewitt

Participant Initials: _____

APPEDNIX C

TEACHER INFORMED CONSENT

University of Massachusetts Amherst

TEACHER INFORMED CONSENT FORM

Preschoolers Actively Learning (PAL) Pilot Study

FOR QUESTIONS ABOUT THIS STUDY, CONTACT:

Sarah Burkart, M.S.
University of Massachusetts Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104

WHAT IS THIS FORM?

The Informed Consent form will provide you with the information you will need to understand why this study is being done and explains your involvement in this study as the teacher associated with students participating in this study. It will also describe what you will need to do to participate, as well as any known risks, inconveniences, or discomforts that you may have while participating in this study. We encourage you to take some time to think this over and ask any questions now, and at any time. If you decide to participate in this study, you will be asked to sign this form and you will be given a copy for your records.

PURPOSE OF THE RESEARCH PROJECT

You are invited to participate in a study designed to examine the feasibility, acceptability, and efficacy of a classroom physical activity program offered during the preschool day on the classroom behavior and physical activity levels of preschool children. We hope to learn if a physical activity program can be successfully implemented during the preschool day and if it will be well received by students. We also hope to learn if this type of program can impact classroom behavior in preschoolers.

ELIGIBILITY

To participate in the teacher portion of this study, you must be either the primary or secondary classroom teacher working with preschoolers at either Children's House or Scantic Valley YMCA Learning Center.

STUDY LOCATION AND DURATION OF INVOLVEMENT

The teacher portion of this study will involve the completion of one questionnaire per participating child at the beginning of the study and one questionnaire per participating

Participant Initials: _____

child after 12 weeks. Questionnaires will only be completed for children whose parent/guardian has given consent to participate in the measurement component of this study. This questionnaire will take approximately 15-20 minutes to complete per child. Teachers will be compensated for their time for completing these questionnaires.

WHAT WILL I BE ASKED TO DO?

If you decide to participate in the study, you will be asked to complete a questionnaire for each child participating in the measurement portion of this study to describe his/her classroom behavior habits at the beginning and end of the study. This questionnaire will take approximately 15-20 minutes per child to complete. If your preschool is selected to participate in the physical activity program in Fall 2018, you will also be asked to provide some feedback at the end of the 12-week program on how well you think the students received the physical activity program and to share any suggestions you may have about the program with our research team (5-10 minutes). If your preschool is selected to participate in the health tracking group in Fall 2018, you will have the opportunity to participate in the classroom physical activity program in Spring 2019.

BENEFITS OF PARTICIPATING IN THIS STUDY

There are no anticipated benefits to you as the teacher for participating in this study.

RISKS OF PARTICIPATING IN THIS STUDY

No risks are expected for your participation in this study.

ALTERNATIVES

The only alternative to being a part of this study is not to participate.

PROTECTION OF PERSONAL INFORMATION

The following procedures will be used to protect the confidentiality of your study information. The information obtained from this study will be treated as privileged and confidential. Participants right to privacy will be maintained in any ensuing analysis and presentation of the data. They will be assigned a numerical ID number at the beginning of the study and all individual data will be identified by ID number only. Each subject will be identified by an ID number and personal information will be kept separately on the University secured Box cloud service for 10 years after which they will be destroyed. This list is stored separately from study data on the Box cloud system. Only the investigators of the study will have access to the personal data. Computer files containing data are password protected and stripped of all identifiers. In addition, all files (e.g. informed consent form) containing identifying information will be stored separately from the study data. Only the investigators of the study will have access to the personal data, which will be kept in a folder, locked in a file cabinet in locked office (Pediatric Physical Activity Laboratory). Any information linking your name to your ID number will be destroyed at the completion of the study data analysis. There could be a possibility of data breach.

Participant Initials: _____

However, the research team will make every effort to maintain the confidentiality of all data. **There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues. For more information on this policy visit http://www.umass.edu/research/guidance/mandatory-reporting**.

MEDICAL TREATMENT

The University of Massachusetts Amherst does not have a program for compensating subjects for injury or complications related to human subjects research. In the unlikely event of injury resulting directly from participating in this study, researchers will assist you in every way to make sure you get proper medical attention.

COMPENSATION

As the consented classroom teacher, you will receive $10 per questionnaire (two questionnaires, one at the beginning and one at the end of the study) completed for each child enrolled in the study. The maximum compensation for each child enrolled in the study when both questionnaires are completed is $20. For example, if 10 children in your classroom enroll in the study and you complete both questionnaires (at baseline and week 12) for each child, you will earn $200. Compensation will be prorated for partially completed questionnaires. For example, if a questionnaire is partially completed at baseline, you will receive $5 instead of $10 for a fully completed questionnaire.

WHAT IF I HAVE QUESTIONS?

We encourage you to take as long as you like before you make a decision about your participation in this study. If you have further questions about this project or you have a research related problem, you may contact the faculty sponsor, Dr. Sofiya Alhassan at 413-545-3475 or alhassan@kin.umass.edu. If you have questions regarding your rights as a research participant, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at 413-545-3428 or humansubjects@ora.umass.edu.

CAN I WITHDRAW FROM THE STUDY?

You do not have to be in this study if you not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide not to participate. The research staff may also withdraw you from the study without your permission for one or more of the following reasons:

- Inability to comply with the necessary study instructions of the research staff

Participant Initials: _____

- The study is canceled, other administrative reasons or unanticipated circumstances

If you wish to withdraw your data following the completion of the study, you may contact the research team in writing to do so.

PARTICIPANT STATEMENT OF VOLUNTARY CONSENT

When signing this form, I am agreeing to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language which I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw myself and my child at any time. A copy of this Informed Consent form has been given to me.

_____

Teacher Name (Print)

_____ _____

Teacher Signature Date

For post-study feedback survey, please either provide your email or select paper copy.

☐

_____

Teacher Email Address Paper copy

By signing below, I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

_____

Study Representative's Name (Print)

_____ _____

Study Representative's Signature Date

University of Massachusetts Amherst-IRB
(413) 545-3428
Approval Date: 08/06/2018 **Protocol #:** 2018-4918
Valid Through: 08/05/2019
IRB Signature: Nancy C. Hewitt

Participant Initials: _____

APPENDIX D

SAMPLE PHYSICAL ACTIVITY LESSON

MA Curriculum Framework Links: Mathematics - Counting and Cardinality

- MA.1. Listen to and say the names of numbers in meaningful contexts.
- MA.2. Recognize and name written numerals 0–10.

Duration: 10-15 minutes
Materials: Number flash cards (1 through 10)

Directions: The students will line up behind the teacher and follow directions as they are lead through a "treasure hunt". The intervention leader will hold up number cards as they start each action. The intervention leader will ask, "What number is this?" The students respond with "2." The teacher will respond "Great job. This is number 2. I see a fort ahead on our treasure hunt. We will need to roll under it! Can you show me how you roll under the fort wall 2 times? Let's count out loud together." The intervention leader will repeat this process for each number.

1. Off the ship (1 broad jump)
2. Log roll under the fort wall (2 rolls)
3. Belly crawl under the fishing nets (3 low crawls)
4. Hop across the hot sand (4 hops)
5. Jump high to grab a coconut (5 jumps)
6. Swim across the stream (6 swim strokes on belly)
7. Duck under the jungle branches (7 squatting walks)
8. March with high knees through the mud (8 marches)
9. Run 9 paces around the quicksand (jog in place 9x)
10. Jump for joy - found the treasure (10 star jumps)

Extension: Ask the children for other activities that may happen on a treasure hunt. Some additional examples include jump aboard a ship, island hopping, eyes ahead (lookout), X marks the spot, dig for treasure, hoist the flag, walk the plank. You can ask the students to pick a number for each action and perform that number of movements.

Age Modification: For younger classrooms, identify the number first and have them repeat after you rather than have them identify the number on their own. "This is number 2. Can you repeat after me?"

APPENDIX E

PAL STUDY: IMPLEMENTATION FORM

Classroom:_____

Session Title/#:_____

Intervention Week: _____ Day of the Week: M T W Th

Intervention start time: _____:_____ am

Intervention end time: _____:_____ am

1. Among those with consent/assent, record participants that are in attendance (see attached sheet). Number of participants in attendance: _____

2. How many students participated in the intervention session? _____

Question:	Yes	No
3. Did at least 50% of the students participate? If no, why?		
4. Did the majority of students participate in at least half of the intervention session? If not, approximately how many minutes did the majority of the students participate in? _____		
5. Did the majority of the students seem to enjoy the intervention session?		
6. Did the intervention session appear to be hold the interest/attention of the majority of the students participating? If not, explain.		
7. Did the intervention leader(s) provide encouragement during the intervention session?		
8. Was the intervention session implemented as intended? If no, why not?		
9. Did the classroom teacher(s) participate in lesson facilitation?		

	Yes	**No**
10. Did the intervention leader implement the intervention session clearly and correctly?		
11. Did the intervention leader implement all of the planned session components? If no, which components were not implemented and why?		
12. Were modifications/adaptations made from the original intervention session plan? If yes, what modifications were made?		
13. Did the intervention leaders recommend modifications or changes for the future? If yes, explain.		
14. Did this observation session go as expected? If no, please use this space to indicate why.		

APPENDIX F

PRESCHOOL TEACHER POST INTERVENTION SURVEY

UMass Amherst

Preschool Post-Survey

We thank you for your assistance and accommodations with the Preschool Physical Activity and Classroom Behavior Pilot Study. Now that the study has concluded, we would appreciate your feedback and thoughts on the overall program.

This survey should only take a few minutes. If you wish to share any additional feedback, or have any questions for the UMass Pediatric Physical Activity Laboratory team, feel free to contact us at kinpedlab@umass.edu.

Please select ONE response for each of the following questions.

	Extremely likely	Slightly likely	Slightly unlikely	Extremely unlikely
1. How likely are you to continue using any of the session plans after morning circle time?	○	○	○	○
2. How like likely are you to continue using any of the session plans during other periods of the school day?	○	○	○	○

How satisfied are you with each of the following components of the Preschool Physical Activity and Classroom Behavior pilot study?

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3a. Timing of the intervention sessions	○	○	○	○	○

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3b. Length of the intervention sessions	○	○	○	○	○
3c. Duration of the program	○	○	○	○	○
3d. Content of the intervention sessions	○	○	○	○	○

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3e. Facilitation of the intervention sessions	○	○	○	○	○
3f. Initial meeting(s) with teachers/staff	○	○	○	○	○
3h. Communication between the research team and teachers/ staff	○	○	○	○	○

Overall, how well do you think the Preschool Physical Activity and Classroom Behavior pilot program was received by each of the following group ?

	Extremely well	Moderately well	Not slightly well	Not well at all
4a. Other school teachers/staff?	○	○	○	○
4b. Students	○	○	○	○
4c. Families	○	○	○	○

Please share any specific opinions you have on any of the following components.

5a. The Preschool Physical Activity and Classroom Behavior research team:

5b. The physical activity intervention sessions:

5c. The study assessments/measurements:

5d. Program communication:

5e. Other:

6. If you witnessed some of the physical activity intervention sessions, what sessions or program components do you think were most effective?

7. If you witnessed some of the physical activity intervention sessions, what sessions or program components do you think were least effective?

6. Please share any additional feedback or suggestions for our physical activity and classroom behavior program.

APPENDIX G

PAL STUDY: CON MONITORING FORM

These items are to be recorded during each observation session.

Classroom:_____ Time Observed:_____ Indoor/Outdoor: _____

Temperature: _____ Precipitation: _____

1a. Accelerometer start time: _____:_____ am/pm

1b. Accelerometer end time: _____:_____ am/pm

2. Select the category of activities that were offered during the observation:

_____ Unstructured _____ Structured _____ Combination

2a. If structured or combination was selected, describe what activities were observed:

2b. If structured or combination was selected, approximately what percentage of the students participated in the structured activities?

3. Was physical activity incorporated into the observed classroom activities? If yes, describe.

4. Select the category of physical activity that describes the majority of the students during the observation.

_____ Sedentary _____ Light _____ Moderate-to-Vigorous

5. Are there any other planned PA sessions throughout the day? If so, describe the type of activity, approximate duration and intensity (ask the teacher).

6. Please note any additional observations:

APPENDIX H

PAL STUDY: PHYSICAL MEASURES

Today's Date: _____ / _____ / 20___

SID: _____

Order of measurements:

- Following protocol, measure first weight, first height (record interference)
- Repeat same order for 2nd measures.
- 3rd measurement(s) if needed (follow protocol).

Data should not be entered unless protocol was followed.
Box used to indicate measurement notes: R=refusal, X=margin notes regarding this measure.

	FIRST	**SECOND**	**THIRD**
Weight	□□□.□ **kg**	□□□.□ **kg**	□□□.□ **kg** (if >.3kg apart)
Measured Height (including any interference)	□□□.□ **cm**	□□□.□ **cm**	□□□.□ **cm** (if >.5cm apart)
Interference (0.0 if none) (15.8 if used)	- □□.□ **cm**	- □□.□ **cm**	-□□.□ **cm**
Net Height (Measured – interference)	=□□□.□ **cm**	=□□□.□ **cm**	= □□□.□ **cm**

APPENDIX I

PAL PARENT DEMOGRAPHIC INFO SURVEY

Thank you for signing up your child to participate in the assessment portion of the UMass Physical Activity and Classroom Behavior Study!

The purpose of this form is to provide us with some basic information about your child and your family. All information that you share with us is confidential. If you have any questions, please feel free to contact us at the number or email below. You can save your progress and completed information on the form as long as you use the same link and Internet browser to reopen the form. (Contact information will be available again at the end of the form.)

Contact Information

Sarah Burkart, MS, Doctoral Candidate
Pediatric Physical Activity Laboratory
University of Massachusetts, Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104
kinpedlab@umass.edu

Start of Block: Demographic Info

Child's first name:

_____

Child's last name:

_____

Parent/Guardian's first name:

_____

Parent/Guardian's last name:

_____

Email address:

_____

What is your current marital status?

- ○ Married
- ○ Divorced or separated
- ○ Widowed
- ○ Single - Never Married

Child's date of birth:

_____

Child's gender:

- ○ Male
- ○ Female

To which of the following races do you consider your child to belong? (You may choose all that apply.)

- ☐ Native American
- ☐ Asian
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Black or African American
- ☐ White
- ☐ Other _____

Additionally, do you consider your child to belong to any of the following ethnic groups? (You may choose all that apply.)

- ☐ Mexican, Mexican American, or Chicano
- ☐ Puerto Rican
- ☐ Cuban
- ☐ Central American (such as Guatemalan, El Salvadoran, Honduran, Nicaraguan, Panamanian, Costa Rican)
- ☐ South American
- ☐ African/African American
- ☐ West Indian or Caribbean
- ☐ Native American Indian
- ☐ Japanese/Japanese American
- ☐ Chinese/Chinese American
- ☐ Filipino
- ☐ Korean
- ☐ Laotian
- ☐ Cambodian
- ☐ Vietnamese

- [ ] Pacific Islander (such as Native Hawaiian, Guamanian, Tongan, Samoan)
- [ ] Asian Indian
- [ ] Middle Eastern
- [ ] European
- [ ] Other (please specify)

_____

What was the approximate **total** income, before taxes, of your **household** for the last year?

- ○ Less than $5,000
- ○ $5,000 - $9,999
- ○ $10,000 - $19,000
- ○ $20,000 - $29,999
- ○ $30,000 - $39,999
- ○ $40,000 - $49,999
- ○ $50,000 - $59,999
- ○ $60,000 - $69,999
- ○ $70,000 - $79,000
- ○ $80,000 - $89,999
- ○ $90,000 - $99,000
- ○ Over $100,000

What is the highest level of education that **you** have completed? (select only one response)

- ○ 6th grade or less
- ○ 8th grade or less
- ○ Attended some high school
- ○ High school graduate or GED
- ○ Technical school
- ○ Some college
- ○ College graduate
- ○ Post graduate degree

Not including you, what is the **highest** education level among all the people living in your child's home? (select only one response)

- ○ 6th grade or less
- ○ 8th grade or less
- ○ Attended some high school
- ○ High school graduate or GED
- ○ Technical school
- ○ Some college
- ○ College graduate
- ○ Post graduate degree

Approximately how many hours does your child sleep per night?

- ○ Less than 6 hours
- ○ 5-7 hours
- ○ 8-10 hours
- ○ 11-13 hours
- ○ 14-16 hours

Does your child nap during the day?

- ○ Often
- ○ Sometimes
- ○ Never

Display This Question:
If Does your child nap during the day? = Often
And Does your child nap during the day? = Sometimes

Approximately how long does your child nap during the day?

- ○ Less than 1 hour
- ○ 1-2 hours
- ○ 2-3 hours
- ○ More than 3 hours

Has your child ever been diagnosed with a developmental disorder such as attention-deficit hyperactivity disorder (ADHD) or other learning disabilities?

- ○ Yes
- ○ No

Skip To: End of Survey If Has your child ever been diagnosed with a developmental disorder such as attention-deficit hypera... = No

Has your child been prescribed with an Individualized Education Program (IEP)?

- ○ Yes
- ○ No

If yes, please share your child's diagnosis.

_____

Is your child currently taking any medication to alleviate disorder symptoms?

_____

Display This Question:
If Has your child ever been diagnosed with a developmental disorder such as attention-deficit hypera... = Yes

Do you plan to begin a new medication or change current medication status in the next 3 months?

_____

APPENDIX J

EPAO INSTRUMENT (PA ITEMS)

Date of Observation: ☐☐ / ☐☐ / ☐☐☐☐
month *day* *year*

Observer ID#:

Start time:

Number of children in classroom: ☐☐

Initials of Teacher Observed

Ages of children:
[Mark all that apply]

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ◎ 6

Eating Occasions Observed:
[Mark all that apply]

- ○ Breakfast
- ○ AM Snack
- ◎ Lunch
- ◎ PM Snack

Total Physical Activity occasions observed: ☐☐

End time: ☐☐ : ☐☐

Weather:

Physical Activity - Child Behaviors

1. How many minutes of total active play time was observed (includes indoor, outdoor, structured and unstructured)?

minutes

2. Was structured physical activity observed?

○ no

○ yes

35a. How many occasions? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other

35b. Total minutes of structured PA observed:

minutes

35c. Was the structured PA optional for children? ○ yes ○ no

3. Did you observe any outdoor active play?

○ yes ☐ 36a. How many times/day? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no ☐ 36b. Was it due to weather (too hot, too cold, rain/snow)?

○ yes ○ no ○ unsure

4. How many total minutes of outdoor active play (structured and unstructured) was observed?

☐☐☐

minutes

5. Was drinking water for children available outdoors?

○ no outdoor time observed ☐ a. Did you see a drinking fountain located in the outdoor play area? ○ yes ○ no

○ yes ○ no

6. While outdoors, did you witness teachers prompting children to drink water?

○ yes ○ no ○ no outdoor time observed

Sedentary Activities - Child

7. Did you observe children seated for more than 30 minutes at a time (excluding nap and mealtimes)?

○ yes ☐ a. How many ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

b. How many total minutes of seated activity (majority of the class seated) was observed?

41. Was a TV present in the room? ○ yes ○ no

42. Was TV viewing observed?

○ yes → 42a. Total minutes TV was on: ☐☐☐ *minutes*

○ no

42b. Was it on during meals? ○ yes → 42b_1. If yes, how many meals? ○ 1 ○ 2 ○ 3 or more

○ no

42c. Was the TV used only for viewing educational programs? ○ yes ○ no

43. Was a VCR/DVD present in the room? ○ yes ○ no

44. Was there a video game system present in the room? ○ yes ○ no

45. Was a computer present in the room for use by children? ○ yes ○ no

46. Was video game or computer game playing observed?

○ yes → 46a. Total number of minutes computer/video game playing was observed: ☐☐☐ *minutes*

○ no

46b. Was it being used for educational purposes only? ○ yes ○ no

46c. How many total children participated in computer/video game playing during the entire day? ☐☐ *# of children*

Physical Activity - Staff Behaviors

47. Did you observe restricting active play as punishment?

○ yes ☐ 47a. How many times/day? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

48. Did staff join in active play?

○ yes ☐ 48a. How many times/day? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

49. How many positive statements were made about physical activity (e.g., Good throw!, Running is fun!, I like the way you threw that ball!)?

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

50. Did staff provide prompts to **increase** physical activity (e.g., Can you jump higher?, Can you hop on one foot?)?

○ yes ☐ 50a. How many times/day? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

51. Did staff provide prompts to **decrease** physical activity (e.g., Slow down!, Give it a rest! Don't climb on the slide!)?

○ yes ☐ 51a. How many times/day? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

52. Were any **formal** physical education lessons for children observed? ○ yes ○ no

53. Were any extra-curricular (special) physical activity programs provided to children on a fee basis (e.g., Tumbling Tots, Tumble Bus)?

○ yes ☐ 53a. Were any active alternatives provided for those children that did not participate? ☐ ○ yes ○ no

○ no

Center Environment

Please indicate where these pieces of physical activity equipment (both fixed and portable) were located:

54. Fixed Play Equipment	***indoors only***	***outdoors only***	***both indoors & outdoors***	***not present***
a. balancing surfaces (balance beams, boards, etc.)	○	○	○	○
b. basketball hoop	○	○	○	○
c. climbing structures (jungle gyms, ladders, etc.)	○	○	○	○
d. merry-go-round	○	○	○	○
e. pool	○	○	○	○
f. sandbox	○	○	○	○
g. see-saw	○	○	○	○
h. slides	○	○	○	○
i. swinging equipment (swings, rope, etc.)	○	○	○	○
j. tricycle track	○	○	○	○
k. tunnels	○	○	○	○

55. Portable Play Equipment	***indoors only***	***outdoors only***	***both indoors & outdoors***	***not present***
a. ball play equipment	○	○	○	○
b. climbing structures (ladders, jumble gyms, etc.)	○	○	○	○
c. floor play equipment (tumbling mats, carpet squares, etc.)	○	○	○	○
d. jumping play equipment (jump ropes, hula hoops)	○	○	○	○
e. parachute	○	○	○	○
f. push/pull toys (wagon, scooters, etc.)	○	○	○	○
g. riding toys (tricycles, cars, etc.)	○	○	○	○
h. rocking & twisting toys (rocking horse, sit-n-spin, etc.)	○	○	○	○
i. sand/water play toys (buckets, scoops, shovels, etc.)	○	○	○	○
j. slides	○	○	○	○
k. twirling play equipment (ribbons, scarves, batons, etc.)	○	○	○	○

56. Was outdoor running space . . .

○ unobstructed with plenty of space for groups games (tag, red rover, etc.)

○ some obstruction, but space was adequate for individual play (running, skipping, etc.)

○ plenty of space for play, but obstructed with play equipment

○ little running space or completely obstructed

57. Did staff limit or restrict outdoor play area in a way that substantially affect active play (more than 1/3 of total play space or quipment)?

○ yes ☐ 57a. How many outdoor play occasions? ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ other ☐ ☐☐

○ no

58. Was indoor play space suitable for . . .

○ quiet play (classroom is small and not a lot of room for movement)

○ limited movement/some active play (able to translocate by walking, skipping, hopping, jumping, etc.)

○ all activities (easily able to perform all gross motor activities)

59. Were any posters, pictures or displayed books about **physical activity** present in the observation room?

○ yes ☐ 60a. How many were present? 1 2 3 4 5 other ___

○ no

REFERENCES

1. Ahmed G, Mohamed S. Effect of regular aerobic exercise on behavioral, cognitive and psychological response in patients with attention-deficit/hyperactivity disorder. *Life Sci J*. 2011;8(2).
2. Alhassan S, Nwaokelemeh O, Lyden K, Goldsby T, Mendoza A. A pilot study to examine the effect of additional structured outdoor playtime on preschoolers' physical activity levels. *Child Care Pract*. 2013;19(1):23-35.
3. Alhassan S, Nwaokelemeh O, Mendoza A et al. Feasibility and Effects of Short Activity Breaks for Increasing Preschool-Age Children's Physical Activity Levels. *J Sc Health*. 2016;86(7):526-33.
4. Alhassan S, Nwoakelemeh O, Ghazarian M, Roberts J, Mendoza A, Shitole S. Effects of locomotor skill program on minority preschoolers' physical activity levels. *Pediatr Exerc Sci*. 2012;24(3):435-9.
5. Alhassan S, Sirard JR, Robinson TN. The effects of increasing outdoor play time on physical activity in Latino preschool children. *Int J Pediatr Obes* 2007;2(3):153-8.
6. Alhassan S, St. Laurent CW, Burkart S, Greever CJ, Ahmadi MN. Feasibility of Integrating Physical Activity Into Early Education Learning Standards on Preschooler's Physical Activity Levels. *J Phys Act Health*. 2019;16(2):101-7.
7. Alhassan S, Whitt-Glover MC. Intervention fidelity in a teacher-led program to promote physical activity in preschool-age children. *J Prev Med*. 2014;69:S34-S6.
8. American Psychiatric A. *Diagnostic and statistical manual of mental disorders (DSM-5®)*. American Psychiatric Pub; 2013.
9. Andersen SL, Navalta CP. Annual Research Review: New frontiers in developmental neuropharmacology: can long-term therapeutic effects of drugs be optimized through carefully timed early intervention? *J Child Psychol Psychiatry*. 2011;52(4):476-503.
10. Annesi JJ, Smith AE, Tennant G. Cognitive-behavioural physical activity treatment in African-American pre-schoolers: Effects of age, sex, and BMI. *J Paediatric Child Health*. 2013;49(2):E128-E32.
11. Annesi JJ, Smith AE, Tennant GA. Effects of a cognitive–behaviorally based physical activity treatment for 4-and 5-year-old children attending US preschools. *Int J Behav Med*. 2013;20(4):562-6.
12. Annesi JJ, Smith AE, Tennant GA. Effects of the Start For Life treatment on physical activity in primarily African American preschool children of ages 3–5 years. *Psychol Health Med*. 2013;18(3):300-9.
13. Applegate B, Lahey BB, Hart EL et al. Validity of the age-of-onset criterion for ADHD: a report from the DSM-IV field trials. *J Am Acad Child Adolesc Psychiatry*. 1997;36(9):1211-21.
14. Arnett AB, Pennington BF, Willcutt EG, DeFries JC, Olson RK. Sex differences in ADHD symptom severity. *J Child Psychol Psychiatry*. 2015;56(6):632-9.
15. Ball K, Cleland VJ, Timperio AF, Salmon J, Crawford DA. Socioeconomic position and children's physical activity and sedentary behaviors: longitudinal findings from the CLAN study. *J Phys Act Health*. 2009;6(3):289-98.

16. Bandura A. *Self-efficacy*. Wiley Online Library; 1994.
17. Bandura A. Health promotion from the perspective of social cognitive theory. *Psychology and Health*. 1998;13(4):623-49.
18. Baranowski T, Anderson C, Carmack C. Mediating variable framework in physical activity interventions: How are we doing? How might we do better? *Am J Prev Med*. 1998;15(4):266-97.
19. Baranowski T, Thompson WO, Durant RH, Baranowski J, Puhl J. Observations on physical activity in physical locations: Ager gender, ethnicity, and month effects. *Res Q Exerc Sportt.* 1993;64(2):127-33.
20. Barbaresi WJ, Colligan RC, Weaver AL, Voigt RG, Killian JM, Katusic SK. Mortality, ADHD, and psychosocial adversity in adults with childhood ADHD: a prospective study. *Pediatr*. 2013;131(4):637-44.
21. Barkley RA. *Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment*. Guilford Publications; 2014.
22. Barkley RA, Fischer M, Smallish L, Fletcher K. Young adult follow-up of hyperactive children: antisocial activities and drug use. *J Child Psychol Psychiatry.* 2004;45(2):195-211.
23. Barry TD, Lyman RD, Klinger LG. Academic underachievement and attention-deficit/hyperactivity disorder: The negative impact of symptom severity on school performance. *J Sch Psychol*. 2002;40(3):259-83.
24. Becker DR, McClelland MM, Loprinzi P, Trost SG. Physical activity, self-regulation, and early academic achievement in preschool children. *Early Educ Devel* 2014;25(1):56-70.
25. Beets MW, Bornstein D, Dowda M, Pate RR. Compliance with national guidelines for physical activity in U.S. preschoolers: measurement and interpretation. *Pediatr*. 2011;127(4):658-64.
26. Bellows L, Anderson J. The Food Friends Get Movin'with Mighty Moves: A Physical Activity Program for Preschoolers. *J Nutr Educ Behav*. 2013;45(5):473-5.
27. Boldemann C, Blennow M, Dal H et al. Impact of preschool environment upon children's physical activity and sun exposure. *Prev Med*. 2006;42(4):301-8.
28. Bonvin A, Barral J, Kakebeeke TH et al. Effect of a governmentally-led physical activity program on motor skills in young children attending child care centers: a cluster randomized controlled trial. *I*nt J Behav Nutr Phys Act. 2013;10(1):90.
29. Bower JK, Hales DP, Tate DF, Rubin DA, Benjamin SE, Ward DS. The childcare environment and children's physical activity. *Am J Prev Med*. 2008;34(1):23-9.
30. Boyle CA, Boulet S, Schieve LA et al. Trends in the prevalence of developmental disabilities in US children, 1997-2008. *Pediatr*. 2011;127(6):1034-42.
31. Brassell AA, Shoulberg EK, Pontifex MB, Smith AL, Delli Paoli AG, Hoza B. Aerobic fitness and inhibition in young children: Moderating roles of ADHD status and age. J Clin Child Adolesc Psychol. 2017;46(5):646-52.
32. Brown HE, Atkin AJ, Panter J, Wong G, Chinapaw MJM, Sluijs EMF. Family-based interventions to increase physical activity in children: a systematic review, meta-analysis and realist synthesis. *Obes Rev*. 2016;17(4):345-60.
33. Brown WH, Pfeiffer KA, McIver KL, Dowda M, Almeida JM, Pate RR. Assessing preschool children's physical activity: the Observational System for

Recording Physical Activity in children-preschool version. *Res Q Exerc Sport*. 2006;77(2):167-76.
34. Bryck RL, Fisher PA. Training the brain: Practical applications of neural plasticity from the intersection of cognitive neuroscience, developmental psychology, and prevention science. *Am Psychol*. 2012;67(2):87.
35. Burkart S, Roberts J, Davidson MC, Alhassan S. Behavioral Effects of a Locomotor-Based Physical Activity Intervention in Preschoolers. *J Phys Act Health*. 2018;20(XX):1-7.
36. Bussing R, Mason DM, Bell L, Porter P, Garvan C. Adolescent outcomes of childhood attention-deficit/hyperactivity disorder in a diverse community sample. *J Am Acad Child Adolesc Psychiatry*. 2010;49(6):595-605.
37. Bussing R, Zima BT, Gary FA, Garvan CW. Barriers to detection, help-seeking, and service use for children with ADHD symptoms. J Behav Health Serv Res. 2003;30(2):176-89.
38. Bustamante EE, Davis CL, Frazier SL et al. Randomized Controlled Trial of Exercise for ADHD and Disruptive Behavior Disorders. *Med Sci Sports Exerc*. 2016;48(7):1397-407.
39. Byrne JM, Bawden HN, DeWolfe NA, Beattie TL. Clinical assessment of psychopharmacological treatment of preschoolers with ADHD. *J Clin Exp Neuropsychol*. 1998;20(5):613-27.
40. Byun W, Blair SN, Pate RR. Objectively measured sedentary behavior in preschool children: Comparison between Montessori and traditional preschools. *Int J Behav Nutr Phys Act*. 2013;10(1):2.
41. Campbell DW, Eaton WO, McKeen NA. Motor activity level and behavioural control in young children. *Int J Behav Dev*. 2002;26(4):289-96.
42. Campbell SB. Behavior problems in preschool children: A review of recent research. *J Child Clin Psychol Psychiatry* 1995;36(1):113-49.
43. Campbell SB, Ewing LJ. Follow-up of hard-to-manage preschoolers: adjustment at age 9 and predictors of continuing symptoms. *J Child Clin Psychol Psychiatry*. 1990;31(6):871-89.
44. Campbell SB, Ewing LJ, Breaux AM, Szumowski EK. Parent-referred problem three-year-olds: Follow-up at school entry. *J Child Clin Psychol Psychiatry*. 1986;27(4):473-88.
45. Cardon G, Van Cauwenberghe E, De Bourdeaudhuij I. Promoting physical activity at the preschool playground: The influence of lowering playground density. *J Sci Med Sport*. 2012;15:S255-S6.
46. Carson V, Hunter S, Kuzik N et al. Systematic review of physical activity and cognitive development in early childhood.*J Sci Med Sport*. 2016;19(7):573-8.
47. Carson V, Spence JC, Cutumisu N, Boule N, Edwards J. Seasonal variation in physical activity among preschool children in a northern Canadian city. *Res Q Exerc Sport*. 2010;81(4):392-9.
48. Castellanos FX. Neuroimaging studies of ADHD. *Stimulant drugs and ADHD: Basic and clinical neuroscience*. 2001:243-58.
49. Castellanos FX, Lee PP, Sharp W et al. Developmental trajectories of brain volume abnormalities in children and adolescents with attention-deficit/hyperactivity disorder. *JAMA*. 2002;288(14):1740-8.

50. Chaddock L, Erickson KI, Prakash RS et al. A neuroimaging investigation of the association between aerobic fitness, hippocampal volume, and memory performance in preadolescent children. *Brain Res*. 2010;1358:172-83.
51. Chaddock L, Pontifex MB, Hillman CH, Kramer AF. A review of the relation of aerobic fitness and physical activity to brain structure and function in children. *Journal of the International Neuropsychological Society*. 2011;17(6):975-85.
52. Chang YK, Liu S, Yu HH, Lee YH. Effect of acute exercise on executive function in children with attention deficit hyperactivity disorder. *Arch Clin Neuropsych*ol. 2012;27(2):225-37.
53. Charach A, Dashti B, Carson P et al. Attention deficit hyperactivity disorder. 2011.
54. Choi JW, Han DH, Kang KD, Jung HY, Renshaw PF. Aerobic exercise and attention deficit hyperactivity disorder: brain research. *Med Sci Sports Exerc*. 2015;47(1):33-9.
55. Chronis-Tuscano A, Lewis-Morrarty E, Woods KE, O'Brien KA, Mazursky-Horowitz H, Thomas SR. Parent–child interaction therapy with emotion coaching for preschoolers with attention-deficit/hyperactivity disorder. *Cogn Behav Pract* 2016;23(1):62-78.
56. Chronis-Tuscano A, Molina BS, Pelham WE et al. Very early predictors of adolescent depression and suicide attempts in children with attention-deficit/hyperactivity disorder. *Arc Gen Psychiatry*. 2010;67(10):1044-51.
57. Chronis AM, Fabiano GA, Gnagy EM et al. An evaluation of the summer treatment program for children with attention-deficit/hyperactivity disorder using a treatment withdrawal design. *Behav Ther*. 2004;35(3):561-85.
58. Chung J, Tchaconas A, Meryash D, Adesman A. Treatment of Attention-Deficit/Hyperactivity Disorder in Preschool-Age Children: Child and Adolescent Psychiatrists' Adherence to Clinical Practice Guidelines. *J Child Adolesc Psychopharmacol.* 2016;26(4):335-43.
59. Cleland V, Timperio A, Salmon J, Hume C, Telford A, Crawford D. A longitudinal study of the family physical activity environment and physical activity among youth. *Am J Health Promot*. 2011;25(3):159-67.
60. Collett BR, Ohan JL, Myers KM. Ten-year review of rating scales. V: scales assessing attention-deficit/hyperactivity disorder. *J Am Acad Child Adolesc Psychiatry*. 2003;42(9):1015-37.
61. Colquitt JL, Loveman E, O'Malley C et al. Diet, physical activity, and behavioural interventions for the treatment of overweight or obesity in preschool children up to the age of 6 years. *Cochrane Lib*. 2016.
62. Connor DF. Preschool attention deficit hyperactivity disorder: a review of prevalence, diagnosis, neurobiology, and stimulant treatment. *J Dev Behav Pediatr*. 2002;23:S1-S9.
63. Cotman CW, Berchtold NC, Christie L-A. Exercise builds brain health: key roles of growth factor cascades and inflammation. *Trends Neurosci.* 2007;30(9):464-72.
64. Cottrell L, Spangler-Murphy E, Minor V, Downes A, Nicholson P, Neal WA. A kindergarten cardiovascular risk surveillance study: CARDIAC-Kinder. *Am J Health Behav*. 2005;29(6):595-606.

65. Davis AM, Gallagher K, Taylor M et al. An in-home intervention to improve nutrition, physical activity, and knowledge among low-income teen mothers and their children: results from a pilot study. *J Dev Behav Pediatr*. 2013;34(8):609-15.
66. Davis CL, Tomporowski PD, McDowell JE et al. Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychol*. 2011;30(1):91.
67. Davison KK, Jurkowski JM, Li K, Kranz S, Lawson HA. A childhood obesity intervention developed by families for families: results from a pilot study. *Int J Behav Nutr Phys Act*. 2013;10(1):3.
68. De Bock F, Genser B, Raat H, Fischer JE, Renz-Polster H. A participatory physical activity intervention in preschools: a cluster randomized controlled trial. *Am J Prev Med*. 2013;45(1):64-74.
69. De Coen V, De Bourdeaudhuij I, Vereecken C et al. Effects of a 2-year healthy eating and physical activity intervention for 3–6-year-olds in communities of high and low socio-economic status: the POP (Prevention of Overweight among Pre-school and school children) project. *Public Health Nutr*. 2012;15(09):1737-45.
70. De Craemer M, De Decker E, De Bourdeaudhuij I et al. Correlates of energy balance-related behaviours in preschool children: a systematic review. *Obes Rev*. 2012;13(s1):13-28.
71. De Craemer M, De Decker E, Verloigne M, De Bourdeaudhuij I, Manios Y, Cardon G. The effect of a kindergarten-based, family-involved intervention on objectively measured physical activity in Belgian preschool boys and girls of high and low SES: the ToyBox-study. *Int J Behav Nutr Phys Act.* 2014;11(1):38.
72. De Los Reyes A. Introduction to the special section: More than measurement error: Discovering meaning behind informant discrepancies in clinical assessments of children and adolescents. *J Clin Child Adolesc Psychol*. 2011;40(1):1-9.
73. Dinkel D, Schaffer C, Snyder K, Lee JM. They just need to move: Teachers' perception of classroom physical activity breaks. *Teach Teach Educ*2017;63:186-95.
74. Dishman RK, Saunders RP, Motl RW, Dowda M, Pate RR. Self-efficacy moderates the relation between declines in physical activity and perceived social support in high school girls. *J Pediatr Psychol*. 2009;34(4):441-51.
75. Donnelly JE, Hillman CH, Castelli D et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc*. 2016;48(6):1197-222.
76. Dowda M, Brown WH, McIver KL et al. Policies and characteristics of the preschool environment and physical activity of young children. *Pediatr*. 2009;123(2):e261-6.
77. Drollette ES, Scudder MR, Raine LB et al. Acute exercise facilitates brain function and cognition in children who need it most: an ERP study of individual differences in inhibitory control capacity. *Dev Cogn Neurosci*. 2014;7:53-64.
78. DuPaul GJ, Volpe RJ, Jitendra AK, Lutz JG, Lorah KS, Gruber R. Elementary school students with AD/HD: Predictors of academic achievement. *J School Psychol*. 2004;42(4):285-301.

79. Durlak JA, DuPre EP. Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *Am J Comm Psychol*. 2008;41(3-4):327-50.
80. Early Childhood Obesity Prevention Policies Committee on Obesity Prevention Policies for Young C. *Early childhood obesity prevention policies*. Washington DC: National Academies Press; 2011.
81. Early DM, Maxwell KL, Burchinal M et al. Teachers' education, classroom quality, and young children's academic skills: Results from seven studies of preschool programs. *Child Dev*. 2007;78(2):558-80.
82. Efron D, Bryson H, Lycett K, Sciberras E. Children referred for evaluation for ADHD: comorbidity profiles and characteristics associated with a positive diagnosis. *Child Care Health Dev*. 2016;42(5):718-24.
83. Egger HL, Kondo D, Angold A. The Epidemiology and Diagnostic Issues in Preschool Attention-Deficit/Hyperactivity Disorder: A Review. *Infants Young Child* 2006;19(2):109-22.
84. Elder JP, Crespo NC, Corder K et al. Childhood obesity prevention and control in city recreation centres and family homes: the MOVE/me Muevo Project. *Pediatr Obes*. 2014;9(3):218-31.
85. Eliakim A, Nemet D, Balakirski Y, Epstein Y. The effects of nutritional-physical activity school-based intervention on fatness and fitness in preschool children. *J Pediatr Endocrinol Metab*. 2007;20(6):711-8.
86. Engelen L, Bundy AC, Naughton G et al. Increasing physical activity in young primary school children—it's child's play: A cluster randomised controlled trial. *J Prev Med*. 2013;56(5):319-25.
87. Faber Taylor A, Kuo FE. Children with attention deficits concentrate better after walk in the park. *J Atten Disord.* 2009;12(5):402-9.
88. Federal Interagency Forum on Child and Family Statistics. *America's Children: Key National Indicators of Well-Being*. Washington, DC: Government Printing Office. 2015. Available from: Government Printing Office.
89. Finch M, Jones J, Yoong S, Wiggers J, Wolfenden L. Effectiveness of centre-based childcare interventions in increasing child physical activity: a systematic review and meta-analysis for policymakers and practitioners. *Obes Rev*. 2016;17(5):412-28.
90. Finch M, Wolfenden L, Morgan PJ, Freund M, Jones J, Wiggers J. A cluster randomized trial of a multi-level intervention, delivered by service staff, to increase physical activity of children attending center-based childcare. *Prev Med*. 2014;58:9-16.
91. Fitzgibbon ML, Stolley MR, Schiffer L, Horn L, KauferChristoffel K, Dyer A. Hip-Hop to Health Jr. for Latino Preschool Children. *Obesity*. 2006;14(9):1616-25.
92. Fitzgibbon ML, Stolley MR, Schiffer L et al. Family-based hip-hop to health: Outcome results. *Obesity*. 2013;21(2):274-83.
93. Fitzgibbon ML, Stolley MR, Schiffer L, Van Horn L, KauferChristoffel K, Dyer A. Two-year follow-up results for Hip-Hop to Health Jr.: a randomized controlled trial for overweight prevention in preschool minority children. *J Pediatr*. 2005;146(5):618-25.

94. Fitzgibbon ML, Stolley MR, Schiffer LA et al. Hip-Hop to Health Jr. Obesity Prevention Effectiveness Trial: Postintervention Results. *Obesity*. 2011;19(5):994-1003.
95. Flohr JA, Saunders MJ, Evans SW, Raggi V. Effects of physical activity on academic performance and behavior in children with ADHD. *Med Sci Sport Exerc*. 2004;36(5):S145-S6.
96. Froehlich TE, Lanphear BP, Auinger P et al. Association of tobacco and lead exposures with attention-deficit/hyperactivity disorder. *Pediatr*. 2009;124(6):e1054-63.
97. Galéra C, Côté SM, Bouvard MP et al. Early risk factors for hyperactivity-impulsivity and inattention trajectories from age 17 months to 8 years. *Arch Gen Psychiatry*. 2011;68(12):1267-75.
98. Gawrilow C, Stadler G, Langguth N, Naumann A, Boeck A. Physical activity, affect, and cognition in children with symptoms of ADHD. *J Atten Disord*. 2016;20(2):151-62.
99. Gehris J, Gooze R, Whitaker R. Teachers' perceptions about children's movement and learning in early childhood education programmes. *Child Care Health Devel*. 2015;41(1):122-31.
100. Gershon RC, Wagster MV, Hendrie HC, Fox NA, Cook KF, Nowinski CJ. NIH toolbox for assessment of neurological and behavioral function. *Neurology*. 2013;80(11 Supplement 3):S2-S6.
101. Halperin JM, Bedard AC, Curchack-Lichtin JT. Preventive interventions for ADHD: a neurodevelopmental perspective. *Neurotherapeutics.* 2012;9(3):531-41.
102. Halperin JM, Berwid OG, O'Neill S. Healthy Body, Healthy Mind?: The Effectiveness of Physical Activity to Treat ADHD in Children. *Child Adolesc Psychiatr Clin N Am.* 2014;23(4):899-936.
103. Halperin JM, Healey DM. The influences of environmental enrichment, cognitive enhancement, and physical exercise on brain development: can we alter the developmental trajectory of ADHD? *Neurosci Biobehav Rev*. 2011;35(3):621-34.
104. Halperin JM, Marks DJ, Bedard AC et al. Training executive, attention, and motor skills: a proof-of-concept study in preschool children With ADHD. *J Atten Disord*. 2013;17(8):711-21.
105. Hannon JC, Brown BB. Increasing preschoolers' physical activity intensities: an activity-friendly preschool playground intervention. *Prev Med*. 2008;46(6):532-6.
106. Harvey EA, Fischer C, Weieneth JL, Hurwitz SD, Sayer AG. Predictors of discrepancies between informants' ratings of preschool-aged children's behavior: An examination of ethnicity, child characteristics, and family functioning. *Early Child Res Q*. 2013;28(4):668-82.
107. Harvey EA, Metcalfe LA, Herbert SD, Fanton JH. The role of family experiences and ADHD in the early development of oppositional defiant disorder. *J Consult Clin Psychol*. 2011;79(6):784.
108. Harvey EA, Youngwirth SD, Thakar DA, Errazuriz PA. Predicting attention-deficit/hyperactivity disorder and oppositional defiant disorder from preschool diagnostic assessments. *J Consult Clin Psychol*. 2009;77(2):349-54.
109. Healey DM, Halperin JM. Enhancing Neurobehavioral Gains with the Aid of Games and Exercise (ENGAGE): initial open trial of a novel early intervention

fostering the development of preschoolers' self-regulation. *Child Neuropsychology*. 2015;21(4):465-80.
110. Hernandez-Reif M, Field TM, Thimas E. Attention deficit hyperactivity disorder: Benefits from Tai Chi. *J Bodyw Mov Ther*. 2001;5(2):120-3.
111. Hesketh KR, O'Malley C, Paes VM et al. Determinants of Change in Physical Activity in Children 0–6 years of Age: A Systematic Review of Quantitative Literature. *Sports Med*. 2016:1-26.
112. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: exercise effects on brain and cognition. *Nat Rev Neurosci*. 2008;9(1):58-65.
113. Hillman CH, Pontifex MB, Raine LB, Castelli DM, Hall EE, Kramer AF. The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience*. 2009;159(3):1044-54.
114. Hinkley T, Crawford D, Salmon J, Okely AD, Hesketh K. Preschool children and physical activity: a review of correlates. *Am J Prev Med*. 2008;34(5):435-41. e7.
115. Hinkley T, Salmon J, Okely AD, Hesketh K, Crawford D. Correlates of preschool children's physical activity. *Am J Prev Med*. 2012;43(2):159-67.
116. Hinshaw SP. Externalizing behavior problems and academic underachievement in childhood and adolescence: causal relationships and underlying mechanisms. *Psychol Bull*. 1992;111(1):127.
117. Hinshaw SP, Nigg JT. Behavior rating scales in the assessment of disruptive behavior problems in childhood. 1999.
118. Hintze JM, Volpe RJ, Shapiro ES. Best practices in the systematic direct observation of student behavior. *Best Pract School Psychol*. 2002;4:993-1006.
119. Hjern A, Weitoft GR, Lindblad F. Social adversity predicts ADHD-medication in school children–a national cohort study. *Acta paediatrica*. 2010;99(6):920-4.
120. Hodges EA, Smith C, Tidwell S, Berry D. Promoting physical activity in preschoolers to prevent obesity: a review of the literature. *Journal of pediatric nursing*. 2013;28(1):3-19.
121. Howie EK, Schatz J, Pate RR. Acute effects of classroom exercise breaks on executive function and math performance: A dose–response study. *Res Q Exerc Sport*. 2015;86(3):217-24.
122. Howie EK, Straker LM. Rates of attrition, non-compliance and missingness in randomized controlled trials of child physical activity interventions using accelerometers: A brief methodological review. *J Sci Med Sport*. 2016;19(10):830-6.
123. Hoza B, Smith AL, Shoulberg EK et al. A Randomized Trial Examining the Effects of Aerobic Physical Activity on Attention-Deficit/Hyperactivity Disorder Symptoms in Young Children. *J Abnorm Child Psychol*. 2014:1-13.
124. Hughes CC, Gooze RA, Finkelstein DM, Whitaker RC. Barriers to obesity prevention in Head Start. *Health Aff*. 2010;29(3):454-62.
125. Hyman C, Hofer M, Barde Y-A et al. BDNF is a neurotrophic factor for dopaminergic neurons of the substantia nigra. *Nature*. 1991;350(6315):230-2.
126. Jensen PS, Kenny DT. The effects of yoga on the attention and behavior of boys with attention-deficit/hyperactivity disorder (ADHD). *J Atten Disord*. 2004;7(4):205-16.

127. Jones RA, Riethmuller A, Hesketh K, Trezise J, Batterham M, Okely AD. Promoting fundamental movement skill development and physical activity in early childhood settings: a cluster randomized controlled trial. *Pediatr Exerc Sci*. 2011;23(4):600-15.
128. Kang KD, Choi JW, Kang SG, Han DH. Sports therapy for attention, cognitions and sociality. *Int J Sports Med*. 2011;32(12):953-9.
129. Katz DL, Cushman D, Reynolds J et al. Putting physical activity where it fits in the school day: preliminary results of the ABC (Activity Bursts in the Classroom) for fitness program. *Prev Chronic Dis*. 2010;7(4):A82.
130. Kessler RC, Adler LA, Barkley R et al. Patterns and predictors of attention-deficit/hyperactivity disorder persistence into adulthood: results from the national comorbidity survey replication. *Biol Psychiatry*. 2005;57(11):1442-51.
131. Khalife N, Kantomaa M, Glover V et al. Childhood attention-deficit/hyperactivity disorder symptoms are risk factors for obesity and physical inactivity in adolescence. *J Am Acad Child Adolesc Psychiatry*. 2014;53(4):425-36.
132. Kim Y-P, Kim H, Shin M-S et al. Age-dependence of the effect of treadmill exercise on cell proliferation in the dentate gyrus of rats. *Neurosci Lett*. 2004;355(1):152-4.
133. Kirk SM, Kirk EP. Sixty minutes of physical activity per day included within preschool academic lessons improves early literacy. *J Sch Health*. 2016;86(3):155-63.
134. Kirk SM, Vizcarra CR, Looney EC, Kirk EP. Using physical activity to teach academic content: a study of the effects on literacy in head start preschoolers. *Early Child Educ J*. 2014;42(3):181-9.
135. Klohe-Lehman DM, Freeland-Graves J, Clarke KK et al. Low-income, overweight and obese mothers as agents of change to improve food choices, fat habits, and physical activity in their 1-to-3-year-old children. *J Am Coll Nutr*. 2007;26(3):196-208.
136. Koziol LF, Stevens MC. Neuropsychological assessment and the paradox of ADHD. *Appl Neuropsychol Child*. 2012;1(2):79-89.
137. Lambourne K, Tomporowski P. The effect of exercise-induced arousal on cognitive task performance: a meta-regression analysis. *Brain Res*. 2010;1341:12-24.
138. Lange A-M, Daley D, Frydenberg M, Rask CU, Sonuga-Barke E, Thomsen PH. The effectiveness of parent training as a treatment for preschool attention-deficit/hyperactivity disorder: study protocol for a randomized controlled, multicenter trial of the new forest parenting program in everyday clinical practice. *JMIR Res Protoc*. 2016;5(2).
139. Langley K, Holmans PA, van den Bree MBM, Thapar A. Effects of low birth weight, maternal smoking in pregnancy and social class on the phenotypic manifestation of Attention Deficit Hyperactivity Disorder and associated antisocial behaviour: investigation in a clinical sample. *BMC Psychiatry*. 2007;7(1):26.
140. Lavigne JV, LeBailly SA, Hopkins J, Gouze KR, Binns HJ. The prevalence of ADHD, ODD, depression, and anxiety in a community sample of 4-year-olds. *J Clin Chilf Adolesc Psychol* 2009;38(3):315-28.

141. Lee B-H, Kim H, Park S-H, Kim Y-K. Decreased plasma BDNF level in depressive patients. *J Affect Disord*. 2007;101(1):239-44.
142. Levy F. The dopamine theory of attention deficit hyperactivity disorder (ADHD). *Aust N Z J Psychiatry*. 1991;25(2):277-83.
143. Li Y-C, Kwan MY, King-Dowling S, Cairney J. Determinants of physical activity during early childhood: A systematic review. *Adv Phys Educ*. 2015;5(02):116.
144. Lillard AS. Preschool children's development in classic Montessori, supplemented Montessori, and conventional programs. *J Sch Psychol*. 2012;50(3):379-401.
145. Loe IM, Feldman HM. Academic and educational outcomes of children with ADHD. *J Pediatr Psychol* 2007;32(6):643-54.
146. Logan SW, Wadsworth DD, Robinson LE, Webster EK. Influence of classroom-based physical activity breaks on physical activity and on-task behavior in preschool children. *J Educ Human Dev*. 2016;4(4):39-46.
147. Loprinzi PD, Cardinal BJ. Measuring children's physical activity and sedentary behaviors. *J Exerc Sci Fit* 2011;9(1):15-23.
148. Lufi D, Parish-Plass J. Sport-based group therapy program for boys with ADHD or with other behavioral disorders. *Child Fam Behav Ther*. 2011;33(3):217-30.
149. Ma Q. Beneficial effects of moderate voluntary physical exercise and its biological mechanisms on brain health. *Neurosci Bull*. 2008;24(4):265-70.
150. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. *Med Sci Sport Exerc*. 2006;38(12):2086.
151. McGraw SA, Sellers D, Stone E et al. Measuring implementation of school programs and policies to promote healthy eating and physical activity among youth. *Prev Med*. 2000;31(2):S86-S97.
152. McKee DP, Murtagh EM, Boreham C, Nevill AM, Murphy MH. Seasonal and annual variation in young children's physical activity. *Med Sci Sport Exerc*. 2012;44(7):1318-24.
153. McKenzie TL. Use of direct observation to assess physical activity. *Physical activity assessments for health-related research.Champaign, IL: Human Kinetics*. 2002:179-95.
154. McKune AJ, Pautz J, Lomjbard J. Behavioural response to exercise in children with attention-deficit/hyperactivity disorder. *S Afr J Sports Med* 2004;15(3):17-21.
155. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Behav* 1988;15(4):351-77.
156. McMorris T, Collard K, Corbett J, Dicks M, Swain JP. A test of the catecholamines hypothesis for an acute exercise–cognition interaction. *Pharmacol Biochem Behav*. 2008;89(1):106-15.
157. Medina JA, Netto TLB, Muszkat M et al. Exercise impact on sustained attention of ADHD children, methylphenidate effects. *Atten Defic Hyperact Disord.* 2010;2(1):49-58.
158. Meeusen R, De Meirleir K. Exercise and brain neurotransmission. *Sports Med.* 1995;20(3):160-88.

159. Mitchell J, Skouteris H, McCabe M et al. Physical activity in young children: a systematic review of parental influences. *Early Child Devel Care*. 2012;182(11):1411-37.
160. Morgan PL, Staff J, Hillemeier MM, Farkas G, Maczuga S. Racial and ethnic disparities in ADHD diagnosis from kindergarten to eighth grade. *Pediatr*. 2013;132(1):85-93.
161. Mrzljak L, Uylings HBM, Van Eden GG, Judáš M. Neuronal development in human prefrontal cortex in prenatal and postnatal stages. *Prog Brain Res*. 1991;85:185-222.
162. National Institutes of Health, Northwestern. U. *NIH Toolbox for Assessment of Neurological and Behavioral Function: Administrator's Manual*. National Institutes of Health; 2006.
163. Nemet D, Oh Y, Kim HS, Hill M, Cooper DM. Effect of intense exercise on inflammatory cytokines and growth mediators in adolescent boys. *Pediatr*. 2002;110(4):681-9.
164. Neudecker C, Mewes N, Reimers AK, Woll A. Exercise interventions in children and adolescents with ADHD: a systematic review. *J Atten Disord*. 2015:1087054715584053.
165. Nolan EE, Gadow KD, Sprafkin J. Teacher reports of DSM-IV ADHD, ODD, and CD symptoms in schoolchildren. *J Am Acad Child Adolesc Psychiatry***.** 2001;40(2):241-9.
166. O'Dwyer MV, Fairclough SJ, Knowles Z, Stratton G. Effect of a family focused active play intervention on sedentary time and physical activity in preschool children. *Int J Behav Nutr Phys Act.* 2012;9(1):117.
167. Ogden CL, Kuczmarski RJ, Flegal KM et al. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. *Pediatr*. 2002;109(1):45-60.
168. Orban SA, Rapport MD, Friedman LM, Kofler MJ. Executive Function/Cognitive Training for Children with ADHD: Do Results Warrant the Hype and Cost? *ADHD Rep*. 2014;22(8):8-14.
169. Ota KR, DuPaul GJ. Task engagement and mathematics performance in children with attention-deficit hyperactivity disorder: Effects of supplemental computer instruction. *Sch PSychol Q*. 2002;17(3):242.
170. Palmer KK, Matsuyama AL, Robinson LE. Impact of structured movement time on preschoolers' physical activity engagement. *Early Child Educ J*. 2017;45(2):201-6.
171. Palmer KK, Miller MW, Robinson LE. Acute exercise enhances preschoolers' ability to sustain attention. *J Sport Exerc Psychol*. 2013;35(4):433-7.
172. Paluska SA, Schwenk TL. Physical activity and mental health. *Sports Med*. 2000;29(3):167-80.
173. Pan CY, Tsai CL, Chu CH, Sung MC, Huang CY, Ma WY. Effects of Physical Exercise Intervention on Motor Skills and Executive Functions in Children With ADHD: A Pilot Study. *J Atten Disord*. 2015.
174. Pate RR, Almeida MJ, McIver KL, Pfeiffer KA, Dowda M. Validation and calibration of an accelerometer in preschool children. *Obesity*. 2006;14(11):2000-6.

175. Pate RR, Baranowski T, Dowda M, Trost SG. Tracking of physical activity in young children. *Med Sci Sports Exerc*. 1996;28(1):92-6.
176. Pate RR, Brown WH, Pfeiffer KA et al. An Intervention to increase physical activity in children: a randomized controlled trial with 4-year-olds in preschools. *Am J Prev Med*. 2016;51(1):12-22.
177. Pate RR, Freedson PS, Sallis JF et al. Compliance with physical activity guidelines: prevalence in a population of children and youth. *AnnEpidemiol*. 2002;12(5):303-8.
178. Pate RR, O'Neill JR, Brown WH, Pfeiffer KA, Dowda M, Addy CL. Prevalence of compliance with a new physical activity guideline for preschool-age children. *Child Obes*. 2015;11(4):415-20.
179. Pate RR, O'Neill JR, Byun W, McIver KL, Dowda M, Brown WH. Physical activity in preschool children: comparison between Montessori and traditional preschools. *J Sch Health*. 2014;84(11):716-21.
180. Pate RR, O'Neill JR, Mitchell J. Measurement of physical activity in preschool children. *Med Sci Sports Exerc*. 2010;42(3):508-12.
181. Pearson. *BOSS User's Guide*. Bloomington, MN: Pearson; 2013.
182. Pelham JWE, Fabiano GA, Massetti GM. Evidence-based assessment of attention deficit hyperactivity disorder in children and adolescents. *J Clin Child Adolesc Psychol*. 2005;34(3):449-76.
183. Perwien AR, Hall J, Swensen A, Swindle R. Stimulant treatment patterns and compliance in children and adults with newly treated attention-deficit/hyperactivity disorder. *J Manag Care Pharm.* 2004;10(2):122-9.
184. Piotrkowski CS, Collins RC, Knitzer J, Robinson R. Strengthening mental health services in Head Start: A challenge for the 1990s. *American Psychologist*. 1994;49(2):133.
185. Pliszka SR. The neuropsychopharmacology of attention-deficit/hyperactivity disorder. *Biol Psychiatry*. 2005;57(11):1385-90.
186. Ploughman M. Exercise is brain food: the effects of physical activity on cognitive function. *Dev Neurorehabil*. 2008;11(3):236-40.
187. Pontifex MB, Saliba BJ, Raine LB, Picchietti DL, Hillman CH. Exercise improves behavioral, neurocognitive, and scholastic performance in children with attention-deficit/hyperactivity disorder. *J Pediatr*. 2013;162(3):543-51.
188. Puder JJ, Marques-Vidal P, Schindler C et al. Effect of multidimensional lifestyle intervention on fitness and adiposity in predominantly migrant preschool children (Ballabeina): cluster randomised controlled trial. *BMJ*. 2011;343:d6195.
189. Querido JS, Sheel AW. Regulation of cerebral blood flow during exercise. *Sports Med*. 2007;37(9):765-82.
190. Rasmussen P, Brassard P, Adser H et al. Evidence for a release of brain-derived neurotrophic factor from the brain during exercise. *Exp Physiol* 2009;94(10):1062-9.
191. Raustorp A, Pagels P, Boldemann C, Cosco N, Söderström M, Mårtensson F. Accelerometer measured level of physical activity indoors and outdoors during preschool time in Sweden and the United States. *J Phys Act Health*. 2012;9(6):801-8.

192. Reilly JJ, Coyle J, Kelly L, Burke G, Grant S, Paton JY. An objective method for measurement of sedentary behavior in 3-to 4-year olds. *Obes Res*. 2003;11(10):1155-8.
193. Reilly JJ, Jackson DM, Montgomery C et al. Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. *Lancet*. 2004;363(9404):211-2.
194. Reilly JJ, Kelly L, Montgomery C et al. Physical activity to prevent obesity in young children: cluster randomised controlled trial. *BMJ*. 2006;333(7577):1041.
195. Reynolds CR. *Behavior assessment system for children*. Wiley Online Library; 2004.
196. Reynolds CR, Kamphaus RW, Vannest KJ. *BASC3: Behavior Assessment System for Children*. PscyhCorp; 2015.
197. Reza AB, Hamid F. Biological Effects of cycling exercise on reducing symptoms of children's attention deficit hyperactivity disorder. *Ann Biol Res*. 2011;2(6).
198. Ribner AD, Willoughby MT, Blair CB, Investigators FLPK. Executive function buffers the association between early math and later academic skills. *Front Psychol* 2017;8:869.
199. Riddle MA, Yershova K, Lazzaretto D et al. The preschool attention-deficit/hyperactivity disorder treatment study (PATS) 6-year follow-up. *J Am Acad Child Adolesc Psychiatry* 2013;52(3):264-78. e2.
200. Rowland AS, Lesesne CA, Abramowitz AJ. The epidemiology of attention-deficit/hyperactivity disorder (ADHD): a public health view. *Ment Retard Dev Disabil Res Rev.* 2002;8(3):162-70.
201. Sääkslahti A, Numminen P, Varstala V et al. Physical activity as a preventive measure for coronary heart disease risk factors in early childhood. *Scand J Med Sci Sports*. 2004;14(3):143-9.
202. Sallis JF, Owen N, Fisher EB. Ecological models of health behavior. *Health behavior and health education: Theory, research, and practice*. 2008;4:465-86.
203. Sanchez RJ, Crismon ML, Barner JC, Bettinger T, Wilson JP. Assessment of adherence measures with different stimulants among children and adolescents. *Pharmacotherapy.* 2005;25(7):909-17.
204. Saunders RP, Evans MH, Joshi P. Developing a process-evaluation plan for assessing health promotion program implementation: a how-to guide. *Health Prom Pract*. 2005;6(2):134-47.
205. Sciberras E, Mulraney M, Silva D, Coghill D. Prenatal Risk Factors and the Etiology of ADHD—Review of Existing Evidence. *Current psychiatry reports*. 2017;19(1):1.
206. Seidman LJ. Neuropsychological functioning in people with ADHD across the lifespan. *Clin Psychol Rev*. 2006;26(4):466-85.
207. Seifert T, Brassard P, Wissenberg M et al. Endurance training enhances BDNF release from the human brain. *Am J Physiol Regul Integr Comp Physiol*. 2010;298(2):R372-7.
208. Shapiro ES. *Academic skills problems: Direct assessment and intervention*. Guilford Press; 2011.

209. Sharma A, Couture J. A review of the pathophysiology, etiology, and treatment of attention-deficit hyperactivity disorder (ADHD). *Ann Pharmacother*. 2014;48(2):209-25.
210. Sharma S, Chuang R-J, Hedberg AM. Pilot-testing CATCH early childhood: a preschool-based healthy nutrition and physical activity program. *Am J Health Educ.* 2011;42(1):12-23.
211. Sims DM, Lonigan CJ. Multi-method assessment of ADHD characteristics in preschool children: Relations between measures. *Early Child Res Q*. 2012;27(2):329-37.
212. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. *Sports Med*. 2001;31(6):439-54.
213. Sirard JR, Trost SG, Pfeiffer KA, Dowda M, Pate RR. Calibration and Evaluation of an Objective Measure of Physical Activity in Preschool Children. *J Phys Act Health*. 2005;2(3):345.
214. Sisson SB, Krampe M, Anundson K, Castle S. Obesity prevention and obesogenic behavior interventions in child care: A systematic review. *Prev Med*. 2016;87:57-69.
215. Smith AL, Hoza B, Linnea K et al. Pilot physical activity intervention reduces severity of ADHD symptoms in young children. *J Atten Disord* 2013;17(1):70-82.
216. Solanto MV. Dopamine dysfunction in AD/HD: integrating clinical and basic neuroscience research. *Behav Brain Res*. 2002;130(1):65-71.
217. Sonuga-Barke EJ, Daley D, Thompson M, Laver-Bradbury C, Weeks A. Parent-based therapies for preschool attention-deficit/hyperactivity disorder: a randomized, controlled trial with a community sample. *J Am Acad Child Adolesc Psychiatry*. 2001;40(4):402-8.
218. Spira EG, Fischel JE. The impact of preschool inattention, hyperactivity, and impulsivity on social and academic development: A review. *J Child Psychol Psychiatry*. 2005;46(7):755-73.
219. St. Laurent CW, Burkart S, Alhassan S. Evaluation of the Implementation of an Academically-Integrated Health Behavior Intervention in Preschool Children. *J Sch Health*. 2019:In Review.
220. Stark LJ, Spear S, Boles R et al. A pilot randomized controlled trial of a clinic and home-based behavioral intervention to decrease obesity in preschoolers. *Obesity*. 2011;19(1):134-41.
221. Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot*. 1996;10(4):282-98.
222. Stratton G, Mullan E. The effect of multicolor playground markings on children's physical activity level during recess. *Prev Med*. 2005;41(5):828-33.
223. Summerbell CD, Moore HJ, Vögele C et al. Evidence-based recommendations for the development of obesity prevention programs targeted at preschool children. *Obes Rev*. 2012;13(s1):129-32.
224. Tandon M, Pergjika A. Attention Deficit Hyperactivity Disorder in Preschool-Age Children. *Child Adolesc Psychiatr Clin N Am.* 2017;26(3):523-38.
225. Tantillo M, Kesick CM, Hynd GW, Dishman RK. The effects of exercise on children with attention-deficit hyperactivity disorder. *Med Sci Sports Exerc*. 2002.

226. Taylor RW, Murdoch L, Carter P, Gerrard DF, Williams SM, Taylor BJ. Longitudinal study of physical activity and inactivity in preschoolers: the FLAME study. *Med Scie Sports Exerc*. 2009;41(1):96-102.
227. Temple M, Robinson JC. A systematic review of interventions to promote physical activity in the preschool setting. *J Spec Peditr Nurs*. 2014;19(4):274-84.
228. Timmons BW, LeBlanc AG, Carson V et al. Systematic review of physical activity and health in the early years (aged 0–4 years). *Appl Physiol Nutr Metab*. 2012;37(4):773-92.
229. Toschke JA, von Kries R, Rosenfeld E, Toschke AM. Reliability of physical activity measures from accelerometry among preschoolers in free-living conditions. *Clin Nutr*. 2007;26(4):416-20.
230. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181.
231. Trost SG, Fees B, Dzewaltowski D. Feasibility and Efficacy of a "Move and Learn" Physical Activity Curriculum in Preschool Children. *J Phys Act Health*. 2008;5(1):88-103.
232. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc*. 2005;37(11):S531.
233. Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med Sci Sports Exerc*. 2000;32(2):426-31.
234. Tsai S-J. Attention-deficit hyperactivity disorder may be associated with decreased central brain-derived neurotrophic factor activity: clinical and therapeutic implications. *Med Hypotheses*. 2007;68(4):896-9.
235. Tucker P. The physical activity levels of preschool-aged children: A systematic review. *Early Child Res Q*. 2008;23(4):547-58.
236. Tucker P, Gilliland J. The effect of season and weather on physical activity: a systematic review. *Public health*. 2007;121(12):909-22.
237. USDHHS. *Physical Activity Guidelines for Americans*. Second ed. Washington, DC: US Department of Health and Human Services; 2018.
238. Van Cauwenberghe E, De Bourdeaudhuij I, Maes L, Cardon G. Efficacy and feasibility of lowering playground density to promote physical activity and to discourage sedentary time during recess at preschool: a pilot study. *Prev Med.* 2012;55(4):319-21.
239. Venetsanou F, Kambas A, Giannakidou D. Organized physical activity and health in preschool age: A review. *Cent Eur J Public Health.* 2015;23(3):200.
240. Verret C, Guay MC, Berthiaume C, Gardiner P, Beliveau L. A physical activity program improves behavior and cognitive functions in children with ADHD: an exploratory study. *J Atten Disord*. 2012;16(1):71-80.
241. Visser SN, Danielson ML, Bitsko RH et al. Trends in the Parent-Report of Health Care Provider-Diagnosed and Medicated Attention-Deficit/Hyperactivity Disorder: United States, 2003–2011. *J Am Acad Child Adolesc Psychiatry*. 2014;53(1):34-46.e2.

242. Volkow ND, Wang G-J, Newcorn JH et al. Motivation deficit in ADHD is associated with dysfunction of the dopamine reward pathway. *Mol Psychiatry*. 2011;16(11):1147-54.
243. Volpe RJ, DiPerna JC, Hintze JM, Shapiro ES. Observing students in classroom settings: A review of seven coding schemes. *School Psychol Rev*. 2005;34(4):454.
244. Wadsworth DD, Rudisill ME, Hastie PA, Boyd KL, Rodríguez-Hernández M. Preschoolers´ Physical Activity and Time on Task During a Mastery Motivational Climate and Free Play. *MH Salud*. 2014;11(1).
245. Ward D, Hales D, Haverly K et al. An instrument to assess the obesogenic environment of child care centers. *Am J Health Behav*. 2008;32(4):380-6.
246. Ward DS, Vaughn A, McWilliams C, Hales D. Interventions for increasing physical activity at child care. *Med Sci Sports Exerc*. 2010;42(3):526-34.
247. Watson A, Timperio A, Brown H, Best K, Hesketh KD. Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act.* 2017;14(1):114.
248. Webster EK, Wadsworth DD, Robinson LE. Preschoolers' time on-task and physical activity during a classroom activity break. *Pediatr Exerc Sci.* 2015;27(1):160-7.
249. Weintraub S, Dikmen SS, Heaton RK et al. Cognition assessment using the NIH Toolbox. *Neurology*. 2013;80(11 Supplement 3):S54-S64.
250. Wichstrøm L, Berg-Nielsen TS, Angold A, Egger HL, Solheim E, Sveen TH. Prevalence of psychiatric disorders in preschoolers. *J Child Psychol Psychiatry*. 2012;53(6):695-705.
251. Wigal SB, Emmerson N, Gehricke J-G, Galassetti P. Exercise: applications to childhood ADHD. *J Atten Disord*. 2013;17(4):279-90.
252. Wigal SB, Nemet D, Swanson JM et al. Catecholamine response to exercise in children with attention deficit hyperactivity disorder. *Pediatric research*. 2003;53(5):756-61.
253. Wilens TE, Dodson W. A clinical perspective of attention-deficit/hyperactivity disorder into adulthood. *J Clin Psychiatry*. 2004.
254. Winter B, Breitenstein C, Mooren FC et al. High impact running improves learning. *Neurobiol Learn Mem*. 2007;87(4):597-609.
255. Yin Z, Parra-Medina D, Cordova A et al. Miranos! Look at us, we are healthy! An environmental approach to early childhood obesity prevention. *Child Obes*. 2012;8(5):429-39.
256. Yoong SL, Wolfenden L, Clinton-McHarg T et al. Exploring the pragmatic and explanatory study design on outcomes of systematic reviews of public health interventions: a case study on obesity prevention trials. *J Public Health*. 2014;36(1):170-6.
257. Young S, Myanthi Amarasinghe J. Practitioner Review: Non-pharmacological treatments for ADHD: A lifespan approach. *J Child Psychol Psychiatry*. 2010;51(2):116-33.
258. Ziereis S, Jansen P. Effects of physical activity on executive function and motor performance in children with ADHD. *Res Dev Disabil.* 2015;38:181-91.