PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN EARLY CARE AND EDUCATION CENTERS: IDENTIFYING OPPORTUNITIES AND TESTING STRATEGIES TO SUPPORT ACTIVE CLASSROOM ENVIRONMENTS

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ABSTRACT

Stephanie Lynn Mazzucca: Physical Activity and Sedentary Behavior in Early Care and Education Centers: Identifying Opportunities and Testing Strategies to Support Active Classroom Environments
(Under the direction of Dianne S. Ward)

Engaging in physical activity and limiting sedentary behavior are important to the optimal physical, psychosocial, and cognitive development in young children. The early care and education (ECE) setting is an important environment to support these behaviors, but few models exist to integrate intervention activities within a typical classroom schedule and support teachers' professional development on their role in fostering healthy physical activity and sedentary behaviors in preschoolers.

To identify opportunities within the classroom schedule that could be leveraged to improve children's behaviors, secondary data analyses were conducted using a sample of 50 ECE centers that were assessed using four full-day observations and 559 children 3-5 years old within centers who wore accelerometers during observation days. Children were differentially active and sedentary based on typically occurring classroom activities and more active outdoors than indoors.

Using self-reported teacher practices and perceptions within the same sample, we identified groupings of items using exploratory factor analysis related to teachers' 1) physical activity and sedentary practices, 2) self-efficacy, and 3) center-level support. Overall, these factors had inconsistent, weak relationships with children's MVPA and sedentary behavior.

However, two practices (withholding physical activity as punishment and making play equipment available to children) showed significant, positive associations with children's MVPA and significant, negative associations with children's sedentary behavior.

A 10-week intervention was developed and tested in a group-randomized controlled trial with 26 ECE teachers. Intervention teachers attended professional development workshops and were asked to modify pre-specified classroom activities and their practices. Children's total physical activity (non-sedentary time) was measured in 182 children via accelerometry. Children in intervention classrooms had a higher total volume of physical activity at follow-up compared to children in the control group (480.2 ± 9.3 vs. 459.7 ± 9.4 counts per minute), but this was not statistically significant. The overall approach was well-received by teachers and could be modified in future interventions.

This research provides novel information on patterns throughout the child care day and teacher practices that can support children's physical activity and reduce sedentary behavior, as well as promising intervention models that could be used to increase children's physical activity and reduce sedentary behavior.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

ANOVA	Analysis of variance
BCC	Behavior Change Consortium
BCT	Behavior change technique
BMI	Body mass index
CPM	Counts per minute
ECE	Early care and education
EFA	Exploratory factor analysis
EPAO	Environment and Policy Assessment and Observation
EPAO-SR	Environment and Policy Assessment and Observation – Self-Report
FL	Florida
Hr	Hour
ITT	Intent-to-treat
Min	Minutes
Min/hr	Minutes per hour
MPL	Move, Play, Learn!
MVPA	Moderate-to-vigorous physical activity
NC	North Carolina
NCDCDEE	NC Division of Child Development and Early Education
NAPSACC	Nutrition and Physical Activity Self-Assessment for Child Care
NASPE	National Association for Sport and Physical Education
NHANES	National Health and Nutrition Examination Survey

PA	Physical activity
PPE	Portable play equipment
QRIS	Quality Rating and Improvement System
SAS	Statistical Analysis Software
SB	Sedentary behavior
SCT	Social Cognitive Theory
SD	Standard deviation
SDT	Self-Determination Theory
SE	Standard error
TA	Technical assistance
TV	Television
US	United States

CHAPTER 1: INTRODUCTION

Background

Increasing physical activity and limiting sedentary time are important targets for many aspects of a young child's wellbeing, including gross motor skill development; healthy weight promotion; and improved self-esteem, self-regulation, and cognitive development.[1-13] However, young children's physical activity is often limited, and preschoolers (3-5 year olds) approximately 10 hours inactive each day.[14] More than 7 million United States (US) children younger than 5 attend early care and education (ECE) centers,[15] and this setting is important to focus efforts to promote physical activity and reduce sedentary behavior in young children. However, few ECE-based interventions exist, and those that do exist have had limited success.

Within the ECE setting, classroom teachers are influential gatekeepers to physical activity in ECE classrooms.[16] Their attitudes about physical activity and sedentary behavior, confidence in modifying children's physical activity, and their own physical abilities can influence the amount of activity they provide and how they interact with children to support physical activity and limit sedentary behavior.[16,17] Teachers often hesitate to implement physical activity in their classrooms for several reasons, including feeling poorly trained and unsupported to do so.[17] Few models exist to enhance teachers' skills to promote children's activity and limit sedentary behavior throughout the day, although such an approach could result in useful and, possibly, more sustainable outcomes. Instead, many interventions have focused on the implementation of standardized curricula to be used within a segment of the child care day to

promote physical activity. Few have focused specifically on the reduction of sedentary behavior. Also, little is known about how teachers use their classroom schedules and their behaviors to support physical activity and reduce excess sedentary behavior. Few interventions have engaged teachers in behavior change that is necessary for physical activity promotion and sedentary behavior reduction to become routinized within their classrooms. Innovative approaches to physical activity promotion and sedentary behavior reduction are needed, especially those that engage teachers through professional development (i.e., training) and ongoing technical assistance and leverage natural opportunities within their classrooms. Because of this research gap in how teachers can become agents of change for children's physical activity, a series of studies was undertaken.

The dissertation is divided into three studies. The overall goal of the project is to increase total physical activity in preschoolers (3-5 years old) enrolled in ECE programs through an intervention designed to alter the behavior of classroom teachers using a novel training and technical assistance approach. Aim 1 analyzed typical physical activity patterns of preschool children including patterns specific to classroom activities that occur within preschool classrooms. For example, teachers often allocate time for *circle time*, a period of formal learning that is generally done with children seated around in a circle; *center time*, a period of free play within various learning stations (centers) in the classroom; and *outdoor play time*. Aim 2 sought to identify teacher practices and perceptions that were supportive of or hindering to children's physical activity and sedentary behavior at child care. Using cross-sectional data from four-day observations of 50 ECE centers, we identified times of day and activities that were typically sedentary, as well as teacher practices and perceptions associated with children's physical activity.

Aims 1 and 2 informed the development of the Move, Play, Learn! intervention, designed to alter teacher behavior through professional development and technical assistance, and subsequently increase children's physical activity. The efficacy of the 10-week intervention was tested in Aim 3 with 26 ECE center classrooms randomly assigned to either the intervention group or a waitlist control group. Intervention teachers attended training workshops to learn to use natural opportunities across the child care day and to use their interactions with children to increase children's total physical activity. They were asked to modify typical classroom activities and their interactions with children to support physical activity, and they received technical assistance from research staff to support goal setting and self-monitoring to facilitate behavior change.

Specific aims

Aim 1: Quantify time spent in classroom activities (e.g., center time, circle time, outdoor time, teacher-led physical activity) and examine differences in child physical activity and sedentary behavior by classroom activity type.

- Hypothesis: Physical activity will be highest during outdoor time and physical activity during center time will be higher than circle time.

Aim 2: Identify groupings of teacher physical activity practices as well as demographic and psychosocial factors associated with children's physical activity at child care.

- Hypothesis: Better behavioral and environmental perceptions by teachers will be positively related to children's physical activity and negatively related to children's sedentary behavior.

Aim 3: Develop and test the efficacy of the Move, Play, Learn! intervention to increase children's total physical activity (i.e., non-sedentary time) at 10 weeks.

- Hypothesis: Children in ECE classrooms randomized to the Move, Play, Learn! intervention will have greater increases in accelerometer-measured total physical activity (i.e., nonsedentary time) at 10 weeks compared with children in ECE classrooms randomized to a waitlist control group.

CHAPTER 2: LITERATURE REVIEW

Importance of physical activity for young children

Participating in regular physical activity and avoiding excess sedentary behavior play important roles in many aspects of young children's short- and long-term health and development. Increases in physical activity are associated with improved markers of cardiovascular health, notably increases in high-density lipoproteins and decreases in total cholesterol, triglycerides, low-density lipoproteins, and blood pressure.[18-20] Conversely, excess sedentary time has been linked to an increase in children's blood pressure.[1] Additionally, physical activity is crucial for the development of children's gross motor skills and can enhance aerobic fitness and bone health.[21] Physical activity also has benefits beyond those related to physical health. Increases in physical activity have been shown to be associated with increases in children's self-esteem, self-regulation, and emotional health.[22-25] Last, emerging literature has demonstrated an association between physical activity and children's cognitive development and academic achievement.[26,27] The wide-ranging impact of physical activity on the development of young children underscores the importance of physical activity in early childhood.

While physical activity and sedentary behavior have been shown to impact children's health and development directly, an important indirect mechanism is through children's weight status. Physical activity is associated with a decreased risk of overweight or obesity during childhood[18,21,28-30] and into adulthood,[31-34] while excess sedentary time has been linked to an

increased risk of childhood obesity.[1] Maintaining a healthy weight is positively associated with children's educational attainment[26,27] and negatively associated with risk of adverse outcomes related to physical,[19,21,34-46] mental,[22-24,27,47] emotional,[22-25] and chronic health.[38-40] Given the burden of childhood obesity, with about 25% of children 2-5 years old in the United States (US) classified as overweight or obese (body mass index ≥85th percentile for age and sex),[48] physical activity promotion remains a crucial public health focus.

In spite of the importance of physical activity and the severity of the consequences of inactivity, young children's physical activity and sedentary behaviors are poor. Recent studies estimate that preschoolers (3-5 year olds) spend about 10 hours each day inactive[14] and that about half of preschool children fail to obtain the recommended amount of daily physical activity.[49-51] Preschool children are also spending an average of 4 hours/day in screen time, which is well above the 1-2 hours/day limit recommended.[52] Physical activity and sedentary behaviors established early in life track into adolescence and adulthood,[53,54] which reinforces the importance of helping children be active and avoid excess sedentary time early in life.

Based on the negative health consequences and the current inadequacy of children's physical activity and sedentary behaviors, experts in the US have called for physical activity promotion efforts in young children while they are beginning to develop life-long behaviors.[30,55] Currently, the Physical Activity Guidelines for Americans do not specify a recommendation for physical activity and sedentary behavior in children younger than six.[56] However, governmental authorities in the United Kingdom, Australia, and Canada have established national guidelines recommending ≥180 minutes of daily physical activity for preschoolers.[57-59] Also, the Canadian and Australian guidelines recommend no more than 1 hour of prolonged seated time, whereas the United Kingdom guidelines broadly recommend that periods of prolonged sitting be minimized.

The existence of these recommendations highlights that countries around the world understand the importance of young children's physical activity and support efforts to promote physical activity for young children.

Early care and education centers as an important setting for promoting children's physical activity

Early care and education (ECE) centers have been identified as an important setting for physical activity promotion and sedentary behavior reduction efforts.[60,61] Current estimates show that more than 7 million children under 5 years attend center-based child care in the US,[15] where the average enrolled child spends about 30 hours there each week.[62] The ECE setting is a major sphere of influence in the lives of children, and is sometimes the primary source of physical activity for children. There is growing recognition that child care centers have a significant role to play in shaping children's physical activity behaviors and should therefore be targeted as a setting to promote physical activity and reduce excess sedentary behavior.[60,61]

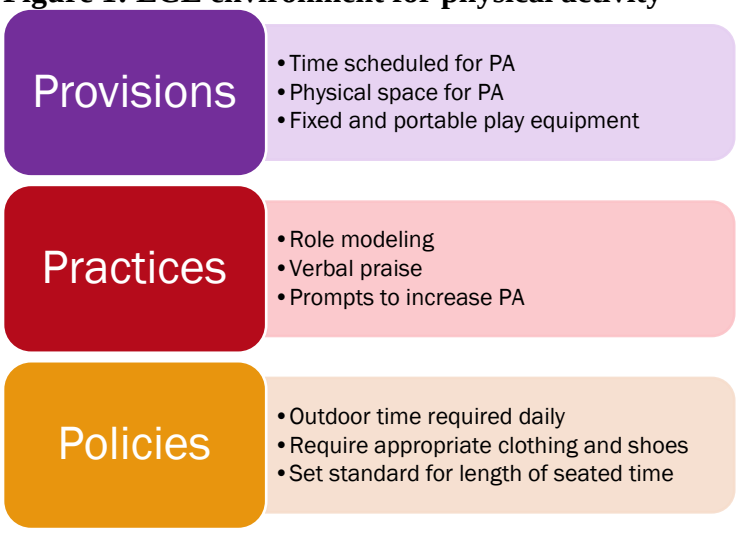
As such, several sets of standards exist around the amount of physical activity children should receive while in child care centers. The Institute of Medicine recommends that children accumulate 15 minutes of activity for every hour of child care attended, and that they experience no more than 30 minutes of continuous seated time.[30] Caring for Our Children, created by the American Public Association and the American Academy of Pediatrics, recommends that young children receive 90-120 minutes of moderate- to- vigorous physical activity (MVPA) per eight-hour day in child-care. [63] Not specifically designed for child care, but one set of recommendations that is often cited is from the National Association for Sport and Physical Education (NASPE), which recommends 120 minutes of physical activity each day, including 60

minutes of structured (i.e., adult-led) physical activity. The NASPE recommendations also state that time should be provided each day for outdoor physical activity.[64] Despite these recommendations, physical activity levels of children in child care are low,[49,65-69] and experts have called for the development of child care-based interventions to promote better physical activity behaviors.[60]

Leveraging early care and education environments to support children's physical activity

The child care center environment offers many potential opportunities to support children's physical activity, and research has demonstrated a link between the child care center and children's physical activity levels.[70-72] One study found that the child care center accounted for 27% of the variance in children's physical activity, more than other child-level factors such as gender, age or race.[73] The center environment is shaped by the child care providers, namely the center director and classroom teachers and can be divided into its provisions, practices, and policies (Figure 1). *Provisions* are those features of the environment that are offered or provided to children to support their physical activity behaviors. For example, time, equipment, and physical spaces to facilitate children's physical activity are important provisions within the physical activity environment of a child care center. The provision of time for physical activity can occur because teachers schedule time specifically for physical activity, indoors or outdoors, or because teachers integrate physical activity

Figure 1: ECE environment for physical activity



into other classroom activities. These classroom activities scheduled across the day are similar between centers, including circle time, a seated, formal learning period for the classroom, and center time, a period of free play within various learning stations (centers) in the classroom. *Practices* include the caregiver-child interactions that can either support or discourage children's physical activity and sedentary behavior, such as co-activity or verbal praise for children being active. *Policies* are the written rules to which the center ascribes, for example, some centers have policies stating that parents must send children dressed in shoes in which children can participate in physical activity or that no screen time is allowed within classrooms. These policies are derived from state and national regulations or are developed specifically by a center and serve to reinforce the provisions and practices within the center. The 3 "Ps" of ECE environments help describe the breadth of impact of a center's social and physical environments on children and facilitate identification of opportunities for intervention.

Previous research provides evidence of important features of a center's environment, defined within all of the 3 "Ps." Provisions such as portable play equipment (e.g., balls, tricycles),[70,72,74,75] open play spaces,[74] paths for wheeled toys,[72] and outdoor play environments with natural elements (e.g., trees, shrubs),[76] are positively associated with children's physical activity levels. Additionally, classroom teachers can encourage physical activity through the provision of time for active play and limiting time spent in sedentary activities (e.g., TV viewing, video games), which have been found to positively associate with children's physical activity.[70,75] However, little is known about how teachers allot time for physical activity throughout the day and how this supports children's physical activity and sedentary behaviors while in centers.

In addition to provisions, a teacher's own behaviors, or practices, around physical activity and sedentary behavior can support of hinder children's physical activity and sedentary behaviors. Important teacher practices include teachers joining in during active play (role modeling), verbally prompting children to be more active, and refraining from withholding physical activity as punishment for poor behavior,[77] and these social interactions with children are associated with increased child physical activity.[70] Also, teacher prompts to increase physical activity are positively associated with children's MVPA.[78,79] Teacher supervision and initiating structured physical activity sessions have shown mixed associations with children's physical activity,[74,80-82] likely due to inconsistent definitions of teacher supervision. In some studies, teacher supervision is defined simply as the presence of an adult in the immediate area while a child is engaging in physical activity. In this case, teachers may be a distraction to children rather than encouraging physical activity since they themselves are not participating in physical activity and curious or more social children, especially girls, naturally gravitate towards them.[80] This small body of research and inconsistent results indicate a clear need for more studies to clarify the role of teacher physical activity practices in physical activity promotion.

Last, policies are used to codify a center's provisions and practices into a set of standards followed by all staff within the center, which in turn should ensure the quality of provisions and practices within a center. Having a policy on the amount of physical activity offered is positively associated with the provision of time for physical activity.[83] Additionally, compliance with a policy to provide 60 minutes of daily physical activity is associated with increased child MVPA.[84,85] Also, there is a positive association between having a policy limiting screen time and the amount of screen time provided to children.[86] However, some studies have found mixed results on the association between a policy and the provision of time or children's MVPA,[84-86]

and there is considerable variability in the physical activity and sedentary behavior policies found across centers.[87] A center's physical activity and sedentary behavior environment appears to influence children's physical activity levels;[71,83,88] however, the inconsistent findings in some studies indicate that more studies are warranted. Overall, the provisions, practices, and policies can influence children's physical activity and offer multiple intervention points within the center to increase physical activity and decrease sedentary behavior; however, understanding the role of classroom teachers and the best strategies to enhance their skills to support physically active classroom environments is understudied.

Classroom teachers' perceptions on physical activity in ECE classrooms

In addition to quantitative studies on teacher practices and children's physical activity, qualitative studies reporting on in-depth interviews and focus groups can provide evidence of the role of teachers in physical activity promotion and sedentary behavior reduction within their classrooms. This qualitative literature also can help refine possible intervention approaches based on teachers' perceptions of barriers and facilitators to physical activity (Appendix 1).[16,17,87,89-99]

Within focus groups and interviews, teachers reported on their overall perceptions of children's physical activity within their classrooms. Teachers highlighted the importance of physical activity within ECE settings, as potentially the only opportunity some children may have to be active.[91] In one study, teachers reported thinking that children in their care are very active.[93] Based on evidence that most children are not meeting physical activity recommendations, this finding could indicate that teachers do not perceive a need to increase children's physical activity beyond the status quo. Also, teachers predominately focused on outdoor physical activity and do not often think about indoor spaces in terms of physical

activity.[16] Yet, weather challenges frequently result in limitations in outdoor time. One study asked about barriers to reducing sedentary behavior, which were largely the same as those for physical activity (e.g., space, equipment constraints).[94] Based on these results, opportunities exist for physical activity promotion indoors, as this is not a place teachers think of for physical activity on their own, and for educating teachers on what physical activity looks like in young children to clarify the misperception that most children are sufficiently active.

Additionally, teachers reported benefits and barriers related to physical activity. Teachers understood the far-ranging benefits of physical activity, from physical, social, and emotional health to success in school.[16,91,92,95,96] Teachers noted using physical activity to teach and reinforce academic concepts, highlighting the potential synergy between physical activity and academics.[96] Teachers also identified center-level barriers of time, equipment, and space to implementing physical activity sessions.[89] Additionally, pressure to spend child care time focusing on traditional academic learning and kindergarten readiness instead of scheduling time for physical activity often deterred teachers from prioritizing physical activity.[91,93] Teacher-level barriers included teacher preferences for being outdoors, as well as their own physical conditions (e.g., allergies or asthma) that may affect their ability or desire to participate in physical activity with children. Last, child-level barriers were concern for child safety,[16,91,93] children's preference for physical activity[95] and the fear that children could get sick during physically actively play, especially outdoors.[16]

This literature demonstrates that teachers generally have a clear understanding of the benefits as well as the barriers related to physical activity at child care. While it is important to know these benefits and barriers, this does not directly translate to knowing how to leverage the benefits and face the barriers within behavioral interventions. Additional research is needed on

how to overcome these barriers within the context of physical activity promotion interventions. Only one study asked teachers what intervention strategies would be useful in light of identified barriers.[89] Without knowledge of teacher perceptions on how to overcome barriers, interventions may be ineffective at engaging teachers to change their behaviors around physical activity in their classrooms. Future research should focus on the perspective of teachers to understand what barriers are most challenging and acceptable strategies to overcome them within intervention.

Teachers also discussed opinions on their role in promoting physical activity with children in their care beyond time, space, and equipment considerations. Teachers stated that they feel increasing pressure to take responsibility for children's health, including physical activity.[97] However, they often feel ill equipped and lack confidence to make positive impact on children's physical activity given the barriers mentioned earlier.[97] Very few reported using a formal physical activity curriculum or having participated in training on children's physical activity,[89] despite the association between teacher education and children's physical activity.[75] Teachers did identify role modeling as important for facilitating children's physical activity, and some noted their potential to impact children's physical activity levels.[93,96] Furthermore, teachers identified different roles during outdoor playtime- either facilitators of physical activity, chaperones (supervising but not affecting physical activity), or being distracted/disengaged.[16] These data indicate that teachers understand their potential to impact children's physical activity but lack the confidence, knowledge, and resources to easily implement physical activity in their classrooms.

Last, in one study, teachers shared their recommendations for characteristics of intervention programs that would enhance physical activity opportunities within classrooms. Teachers noted that the intervention materials (e.g., physically active lesson plans) should be

turnkey, i.e., require little preparation from teachers, and align with the academic goals of early childhood education.[89] This enables teachers to meet academic standards while also integrating physical activity into their classrooms, thereby addressing multiple developmental objectives with one activity. As part of process evaluation of one intervention, directors reported that it was important for activities to be hands-on and to engage with children in order for children to like the intervention activities.[17] These recommendations are important to consider for the development of future interventions. However, no research has investigated teacher perceptions on the training and resources teachers think are needed to implement physical activity with preschoolers, and only one study sought to understand physical activity promotion from the director's perspective.[17]

Classroom-based interventions to increase children's physical activity in centers

Several interventions have been designed to improve children's physical activity outcomes by modifying the classroom environment through teacher-delivered interventions; however, most have had limited success. Evaluating prior studies can inform development of future interventions, and published reviews indicate that these interventions are promising but leave room for additional research to determine efficacious strategies to enhance teachers' skills around physical activity.[72,100-102] Currently, 20 published interventions have targeted classrooms within ECE centers, described across 38 papers (Appendix 2).[3,6,103-138] Three of these papers reported only trial protocols with results forthcoming. Of the remaining 17 interventions, only five have had positive impacts on children's physical activity,[105,109,123,126,132] while six others showed positive improvements in children's gross motor skills.[3,6,112,134,137,138] Inconsistencies in the results of these studies could stem from a number of reasons, including insufficient sample

size, inadequate teacher training and technical assistance, failure to focus on changing teacher behaviors, and limited integration into the existing child care day. In spite of these inconsistent results, it is important to take lessons learned from these studies when developing classroom-based interventions for physical activity.

Characteristics of these studies show considerable variation. Many of these studies are based in the United States,[105,106,108,112,113,123,126,132,133] with others from Australia,[6,119,124,128,130,134] the United Kingdom,[3,125] Canada,[139] Germany,[129] and Belgium.[115] This diverse representation highlights that interest in improving children's physical activity levels at ECE centers spans the globe. Intervention durations also varied, but clustered around 8-16 weeks,[112,118,121-123,125,128,132,133,139] 6 months,[3,6,105,106,108,124,130] or 1-3 years.[113,114,126,129,134] There were several strengths common across studies. For example, all studies except one used a group randomized study design, allowing for rigorous evaluation of the intervention.[133] Also, most used accelerometers to measure physical activity outcomes, while some used pedometers,[118] parent recall of child physical activity,[130,134] or did not measure physical activity directly.[124,128,133] Regardless of the different intervention approaches used, these common methodological strengths indicate consensus in the field on design features and should continue to be used.

Several approaches to improving physical activity are found within these interventions, including 1) the implementation of a standard curriculum developed by the researchers;[3,6,105,124,129,130,132,133] 2) the implementation a curriculum along with modifying the social environment;[118] 3) professional development focused on curriculum development;[124] and 4) increasing children's knowledge of physical activity.[130] Interventions that focused on a standard curriculum typically required teachers to implement these activities, usually between 10 and 30 minutes each, usually separate from the normal classroom activities for the day. In these

cases, teachers have to build in extra time for intervention activities and may perceive them as burdensome and be less likely to prioritize intervention efforts. Instead, some studies use an integrated approach, where intervention activities are implemented within the context of the typical classroom structure and can reinforce other learning objectives while providing time for physical activity.[118,126,132] Also, the structured curricula used often focus on improving children's gross motor skills, in a fashion more similar to physical education in elementary or secondary school. This approach may not be appropriate given teachers' insufficient training and/or lack of confidence for physical activity found in the qualitative literature. Also, physical activity lessons in these interventions focused on gross motor skills may not facilitate physical activity on their own, thereby not increasing overall physical activity levels of children. Last, only three studies specifically targeted sedentary behavior within their conceptualization of the intervention approach or evaluation.[118,126,136] A multi-component approach, which integrates physical activity into the existing child care day and facilitates changes to the social environment, seems a promising approach to instill long-lasting changes in a classroom.

Additionally, the thoughtful use of a theoretical framework guiding intervention development is important for intervention success and for understanding the mechanism by which the intervention acts on outcomes. Overall, there is a lack of theory used within these interventions. Only nine trials named a theory, and the utilization of constructs within those theories was poorly described. Social Cognitive Theory was mentioned in two interventions and[112,115] was implicit in another,[125] and while one used a Social Cognitive Theory-derived theory (Meta-Volitional Theory).[106] The Transtheoretical Model was cited in one set of studies[121-123] and used along with the Health Belief Model and Social Cognitive Theory in another.[115] Also, capacity building was used as a theoretical strategy to sustain behavior change

in one intervention.[134] While these varied theories were mentioned in several studies, only one explained how theoretical constructs linked to intervention components.[108] Five studies articulated a framework for development, Socio-Ecological Model or PRECEDE-PROCEDE, which was used to plan the intervention.[113,118,125,126,139] In order for environmental interventions to have success in the long-term, they require behavior change on the part of classroom teachers to make modifications to the physical and social environments in centers; thus, the use of behavior change theories is crucial to the efficacy and sustainability of interventions. The lack of theory robustly applied within in these interventions may represent a failure to adequately engage with teachers in a behavior change process. Future interventions should clearly articulate not only *which* theory is used, but also *how* that theory is used to guide intervention development, implementation, and evaluation.

Another possibility for the limited, inconsistent success within these interventions is related to the dose of teacher training and availability of ongoing technical assistance. The training teachers receive within these interventions often only included about a 3-hour overview of importance of physical activity, study protocols, and intervention activities provided. All studies included an initial training that includes these topics. Training within four studies went beyond those and included more general professional development for teachers around integrating physical activity within their classrooms.[6,108,126,139] Several offered supplemental training sessions for teachers throughout the duration of the intervention to reinforce intervention goals.[3,6,114,123,124,126,129,132,139] Along with training workshops, technical assistance to teachers, commonly in the form of on-site visits or telephone calls, can enhance intervention implementation. Five interventions offered technical assistance to help teacher solve challenges during the intervention period.[3,118,123,124,126] Only two studies used both training and ongoing

technical assistance to support teachers implementing intervention activities, both of which had a positive impact on child outcomes.[3,126] Based on the use of training and technical assistance in these studies, it seems most promising to use both strategies together to support teachers within physical activity interventions.

Taken together, approaches and results from prior interventions demonstrate a need for additional research on opportunities for promoting physical activity and reducing sedentary behavior across the day, a better understanding of teacher practices and perception, and effective intervention strategies that are integrated, multi-component, and theoretically-driven to improve physical activity outcomes for children in ECE centers.

CHAPTER 3: METHODS

We used several methodological approaches to identify opportunities for physical activity promotion and sedentary behavior reduction within early care and education (ECE) centers, teacher practices and perceptions that were associated with child behaviors, and strategies to modify children's physical activity and sedentary behavior.

Study population and protocols

Aims 1 and 2

Data for Aims 1 and 2 were collected as part of an effort to develop and test the Environment and Policy Assessment and Observation – Self-Report (EPAO-SR), a comprehensive measure of the ECE nutrition and physical activity environment completed by center directors and teachers.[140] The self-report format was developed as a low-cost alternative to the observer-implemented EPAO, which is a frequently used assessment of the center environment.[70,78,141-146] To develop and establish reliability and validity evidence for the EPAO-SR, a convenience sample of 50 ECE centers participated in a 4-day assessment of the physical activity environment including: observations of classrooms conducted by researchers, completion of the self-report surveys by directors and teachers, and measurement of child physical activity and sedentary behavior with accelerometry.

Observation days were designed to capture the entire formal child care day for the majority of the children in the class. This began with the first meal or the time when the teacher designated the formal start of the child care day, whichever came first. Observation days ended when the majority of children left the center for the day. Three research staff members were trained and certified against a gold standard observer to conduct the observation. At least one teacher per completed the EPAO-SR instrument. If there were multiple teachers per classroom or multiple observation classrooms per center, additional teachers were recruited to complete the EPAO-SR. Teachers completed two sets of surveys: (1) the *teacher daily survey* on four consecutive days and (2) the *teacher general survey* on two nonconsecutive days.

ECE centers were recruited from the Piedmont region of North Carolina (NC) from Wake, Durham, Orange, Chatham, Alamance, and Guilford counties. Contact information for centers was obtained from the NC Division of Child Development and Early Education database (http://ncchildcaresearch.dhhs.state.nc.us/search.asp?lang=English), and centers were invited to participate through mailed letters and telephone calls. Centers were eligible if they had at least a 2-star rating on North Carolina's quality rating and improvement system (lowest 1- to highest 5-star scale), which is based on the quality of the physical spaces, programming, and staff education for early child education. This rating is not specific to physical activity but instead is a general indicator of center quality. Parents of all children in observation classrooms were invited to allow child participation. Data were collected between August 2008 and April 2009. All methods were reviewed and approved by the University of North Carolina Institutional Review Board. Center directors and parents of children wearing accelerometers provided written informed consent prior to data collection.

Aim 3

Recruitment and data collection protocols

A convenience sample of 26 ECE programs was recruited through the NCDCDEE online database of ECE programs. Centers were recruited from Orange, Durham, Alamance, and Guilford counties in two waves: 1) July to August 2016 and 2) November 2016 to January 2017. Research staff contacted center directors to assess eligibility and interest in the program. Eligible centers had at least a 2-star rating on NC's quality rating and improvement system[147] and at least one preschool classroom with at least 10 preschool children. Centers were ineligible if directors reported providing the recommended 120 minutes of physical activity (outdoors and indoors) to children.

Once eligibility and interest were confirmed, research staff and the center director worked to identify one preschool classroom teacher per ECE program to participate. Teachers were eligible to participate if they had not completed a program to improve physical activity within the preceding six months and were willing to attend two in-person group workshops. Consent of the participating teacher was obtained through an in-person meeting with the teacher. Research staff worked with teachers via telephone calls to recruit children that would still be in attendance at follow-up. Teachers distributed and collected consent forms to parents of children to obtain parent consent for child accelerometer measurement.

After obtaining parent and teacher consent, baseline data collection was conducted. Data collected were: accelerometer-measured teacher and child physical activity; child and teacher demographics; physical activity and sedentary behavior provisions, practices; and teacher perceived self-efficacy for implementing physical activity and reducing sedentary behavior.

Accelerometers were fit on participating children and worn for five days during times children were in the center, with additional details provided below.

After baseline data collection, the 26 centers were randomly assigned to either the 10-week intervention or a wait-list control group. The intervention participants then began the Move, Play Learn! intervention, while control group participants were asked to proceed continue their normal practices. Follow-up measures included all baseline measures except demographic characteristics. Gift cards were offered to teachers for completing each measurement period: $25 for baseline and $35 for follow-up.

Once follow-up data collection was complete, in-depth interviews with seven randomly selected intervention teachers were conducted to assess participant satisfaction and opportunities to improve the program. The intervention was offered to those programs randomized to the waitlist control group after completion of follow-up data collection. All methods were approved by the University of North Carolina at Chapel Hill Institutional Review Board, and the trial was prospectively registered with clinicaltrials.gov (NCT02851030).

Intervention components

The intervention lasted 10 weeks, with two weeks for training and four modules of two weeks each. Modules focused on specific segments of the child care day schedule. Workshops were held at the beginning and at the midpoint of the intervention period (5 weeks). Teachers were asked to implement intervention activities during pre-specified times of day and to focus on key teacher practices. Implementation was supported by weekly technical assistance (e.g., phone calls, emails, text messages).

Teacher training: Teachers attended two in-person, half-day workshop, which presented an overview of child physical activity and sedentary behavior at ECE centers grounded in information from prior research studies.[148,149] Group discussions focused on modifying teachers' outcome expectations, outcome expectancies, autonomy, and relatedness (to the interventionist and teachers). Group discussion topics included the role of child care in supporting these behaviors in children; how to integrate physical activity and reduce sedentary behavior in their daily schedule; and what motivates teachers to facilitate physical activity with children. Behavior change techniques relevant to teachers and the ECE setting, e.g., information about health consequences, were incorporated into presentations and discussions (Appendix 4).

Teachers received intervention materials: MPL! activity lesson plans, activity cards corresponding to each MPL! activity, and portable play equipment during the workshops (Appendix 5). The interventionist led demonstrations of activities to targeted observational learning, and hands-on practice with intervention materials was intended to increase behavioral capacity and competence. Participants received contact hours (continuing education credit) for attendance.

Classroom-based modules: Teachers continued with the classroom-based portion of the intervention after the workshops, which were broken into four two-week modules. Each module centered on one pre-specified time of day and one teacher physical activity or sedentary behavior practice. Times of the day matched classroom activities that typically occur in preschool classrooms, and teacher practices were informed by previous literature.[78,126,148]

At the beginning of a module, teachers received an email newsletter with information on the module's time of day and teacher practice, and solutions to commonly reported barriers. Teachers were asked to set goals for the amount of time they would implement intervention activities, which could be met by implementing new activities or extending the amount of time in activities they would have already been doing with children without the intervention. Teachers used logs to self-monitor the frequency they implemented an intervention activity or engaged in a teacher practice. Progress was reported to the interventionist each week. Goal setting and self-monitoring were intended to increase teachers' self-efficacy for implementing physical activity and reducing sedentary behavior, and appropriate behavior change techniques (e.g., restructuring the physical and social environments) matched these activities.

Measures

Child physical activity and sedentary behavior

Child physical activity and sedentary behavior during the child care day was measured each day during the 4-day assessment period using ActiGraph GT1M accelerometers (Aims 1 and 2) and the 5-day assessment period using ActiGraph GT3X accelerometers (Aim 3). In Aims 1 and 2, data were collected in 15-second epochs to account for the sporadic nature of young children's physical activity and at a sample acceleration of 30 Hz. For Aim 3, accelerometers were programmed to a 5-second epoch length and to sample acceleration at 30 Hz. The ActiLife software was used to obtain epoch-level data files for processing in Statistical Analysis Software v9.2 (SAS, Cary, NC). Wear and nonwear periods were identified using dates and times logged by research staff members and by applying the NHANES nonwear algorithm.[150] Nonwear

periods were defined as intervals of at least 60 consecutive minutes of zero activity intensity counts, allowing for 1-2 minutes of counts between 0 and 100.

Data was classified into sedentary behavior (<25 counts per 15 seconds),[151] light physical activity (25 – 419 counts per 15 seconds), moderate physical activity (420 – 841 counts per 15 seconds), vigorous physical activity (≥842 counts per 15 seconds), and moderate-to-vigorous physical activity (MVPA, ≥420 counts per 15 seconds)[152] using child-specific accelerometer cutpoints. Total physical activity was defined as nonsedentary time (i.e., light, moderate and physical activity, ≥25 counts per 15 seconds). Data were summarized at the day level for total minutes of sedentary behavior and physical activity; minutes per hour of sedentary behavior and physical activity to account for differences in total wear time; and average counts per minute (cpm) to provide an intensity-weighted overall physical activity outcome. In sensitivity analyses, cutpoints developed by Evenson and colleagues were used to calculate an alternate estimate of MVPA.[151]

Teacher physical activity

In Aim 3, teacher physical activity outcomes were measured also using accelerometry. Similar to child physical activity measures, minutes of MVPA and sedentary behavior were measured with the GT3X model accelerometer. Data collection procedures were the same, with five child care days of wear collected at each time point. For teachers, accelerometers were programmed using a sampling frequency of 30 Hz and a 1-minute epoch length. The same NHANES nonwear algorithm to identify nonwear time in child accelerometry was used for teacher accelerometry.[140] Cutpoints were used to classify data into sedentary behavior (<100 counts per minute) and MVPA (>2020 counts per minute).[153]

Observations of ECE center environment

The physical activity and sedentary behavior environment was measured in Aims 1 and 2 using the EPAO, which is divided into a day-long observation of a classroom's provisions and practices and a document review of the center's physical activity policies. The observation documents six commonly occurring classroom activities according to start and end times: outdoor play time, center time, circle time, TV time, meals, and nap. Other activities (e.g., teacher-led physical activity and seated time) that could overlap into one of the other six categories were documented as minutes per occasion.

Within the EPAO protocol, data collectors noted weather- and environment-related factor, including temperature, precipitation, and humidity were observed with portable weather stations. Observers also completed a checklist of the variety and use of portable play equipment (indoor or outdoor), fixed outdoor play equipment, and natural environment features (e.g., trees providing shade, open, grassy areas). Fixed play equipment variety was a sum of 16 types of non-movable equipment, such as climbing structures, swings, and paved paths for tricycles. Portable play equipment variety was a sum of 14 types of active play equipment including balls, twirling play equipment (e.g., rhythm scarves), and push/pull toys (e.g., scooters).

ECE center physical activity and sedentary behavior environment

The physical activity environment within centers was assessed in Aim 3 using the EPAO-SR, a validated, comprehensive measure of both the nutrition and physical activity environments of child care centers reported by center directors and classroom teachers.[46] Only physical activity and sedentary behavior items were included this study (149 items). Teachers completed the

EPAO-SR on two days at each data collection time point to obtain a stable estimate of usual behavior.[140] EPAO-SR data was used to calculate total minutes of typically occurring activities (circle time, center time, outdoor play time, teacher-led physical activity indoors and outdoors) by summing across teacher reports of morning and afternoon teacher-led physical activity indoors and outdoors separately. Teachers reported the activity level of children during circle time on a scale of 1 (mostly seated) to 7 (mostly running) to obtain an estimate of activity levels within that classroom activity.

Teacher practices and perceptions on physical activity and sedentary behavior

Within the EPAO-SR protocol, teachers reported their practices for addressing physical activity and sedentary behavior of children in their classrooms; their self-efficacy specific to implementing physical activity and avoiding sedentary behavior in their classrooms; the degree to which they value being physically active and teaching children to be physically active; their perceptions of the physical environment for physical activity (e.g., presence of sufficient active play equipment); and their perceptions of support from the center director. These were assessed using 28 items, with three appearing on the teacher daily survey and 25 on the teacher general survey (Appendix 3). Some items were modified from a previously validated questionnaire,[154] most were newly developed. Items were tested in cognitive interviews with 35 ECE staff before field testing to ensure items were relevant and could be understood by teachers.[140]

Responses for most items were a 6-point Likert-type scale, from strongly disagree (1) to strongly agree (6). Responses for three items (e.g., frequency of joining in active play with children) ranged from 0-2 times per day. One item asked teachers to compare how much they encourage children to be active to other teachers in their center from "much less than other

teachers" (1) to "much more than other teachers" (5). Another item asking teachers how much they use their behavior to model physical activity had a 4-point response ranging from "I don't use my own behavior…" (1) to "I constantly use my own behavior…" (4). Six items were reverse coded so that higher scores were indicative of more favorable practices. Item-level averages across the four days of the teacher daily survey and the two days of the teacher general survey were calculated to get an overall average for each item (Aim 2).

Social Cognitive Theory constructs

As part of the evaluation of the Move, Play, Learn! Intervention (Aim 3), teachers reported their self-efficacy, outcome expectations, and outcome expectancies for physical activity promotion and sedentary behavior reduction at baseline, intervention midpoint, and follow-up. Items were taken from previous surveys to assess self-efficacy (28 items)[148,155,156] and outcome expectations and expectancies (16 items each).[155,157] Twenty-eight items measured self-efficacy, and sixteen measured outcome expectations and expectancies each. Teachers responding to self-efficacy and outcome expectations items with how much they agreed with each statement on a 6-point Likert scale and how important they perceived each outcome expectancies item with a 4-point scale (Appendix 6).

Sample demographics

Center directors reported center-level demographics, including the number of children attending the center and monthly tuition fees in the sample used in Aims 1 and 2. Star rating (≥2) was reported by directors in both study populations (all Aims).

Teachers reported demographic and health-related characteristics: highest education attained, years as an ECE teacher, prior training around physical activity (never, ≥1 year ago, <1 year ago) age in years, race (Black, Non-Hispanic White, other). Teachers also reported height (feet and inches) and weight (pounds), which were used to calculate body mass index (BMI) in kg/m^2. Categories of BMI were created as under-weight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2).

Parents of children wearing accelerometers reported: child sex (male/female), age (years), and race (Black, Non-Hispanic White, other).

Move, Play, Learn! process evaluation and program satisfaction

Process evaluation was collected in Aim 3 to assess implementation of the intervention according to the National Institutes of Health's Behavior Change Consortium framework.[158] Additional process evaluation measures were assessed to understand reach and acceptability.

Monitoring of fidelity to study design was conducted via interventionist self-report, in which all interactions with participants (date and time, length, content, mode) were recorded. Consistency of treatment delivery was maximized through the use of standardized intervention materials. The interventionist records were used to determine if treatment was delivered per protocol and consistently across teachers. Information on treatment receipt and enacted was collected by teacher self-report, in which teachers reported whether or not they received intervention materials (newsletters, contact from interventionist) at the end of the intervention. Last, teachers' goal setting and self-monitoring forms were used to determine whether they implemented (enacted) the classroom activities and teacher practices within each module.

Beyond the BCC framework, all recruitment efforts were tracked to determine the number of centers, teachers, and parents that were approached, the number eligible for participation, and the number enrolled. Surveys at the end of the intervention assessed how well the intervention was received by participants. Last, exit interviews were conducted with seven randomly selected intervention participants to understand their perception of the intervention (Appendix 7).

Statistical analyses

Aim 1

Linking EPAO observation and accelerometer data

EPAO observation and accelerometer data summarized each day were used to calculate means and standard deviations for time engaged in different classroom activities, sedentary behavior, and physical activity (light physical activity and MVPA). SAS v9.4 programs were used to link EPAO observation and 5-minute level accelerometer data. Overall start and stop times for the observation day were used to restrict accelerometer data to that matching EPAO data. Time stamps from the observation were used to code each 5-minute block of accelerometer data into one of the six major observation categories or missing.

Estimating physical activity and sedentary behavior across the ECE center day

Total minutes of sedentary behavior and physical activity (light and MVPA) and average counts per minute within each EPAO classroom activity category were calculated. The total time spent within each category was used to calculate a minute per hour estimate of sedentary behavior and physical activity to account for differences in the amount of time spent in each

EPAO category. Additionally, the total daily wear time was used to obtain an overall minute per hour estimate of sedentary behavior and physical activity by dividing total minutes of sedentary behavior or physical activity by total wear time. Center-level estimates were calculated as an average of all children and observation days within a center. Differences in sedentary and physical activity estimates by classroom activity category (i.e., outdoors, center time, circle time, and TV time) were assessed using ANOVAs. Four one-way ANOVAs tested differences in minutes per hour of each sedentary or physical activity outcome (i.e., sedentary behavior, light physical activity, and MVPA minutes per hour, and counts per minute) by classroom activity type.

Identifying correlates of sedentary behavior and MVPA within classroom activities

Correlates of MVPA and sedentary time from existing literature were examined separately for each classroom activity type. Child age, child gender, monthly tuition (proxy for family income), center star rating, size of center, teacher BMI, years of teacher experience, and teacher training on physical activity were included as potential demographic correlates. Possible weather-related covariates were temperature, precipitation, and humidity for the observation day. Physical environment correlates included portable play equipment variety and use, calculated from the EPAO as the sum of equipment types available and used. Only for outdoor time, summary scores for natural elements and fixed portable play equipment variety and use were included as correlates.

A backwards elimination strategy was used to identify correlates that were significantly associated with either sedentary behavior or MVPA. All potential correlates were included in initial models, from which correlates associated with sedentary behavior or MVPA with a p-

value of 0.2 or lower were retained in subsequent models. Correlates not significantly correlated with sedentary behavior or physical activity outcomes at the $p<0.05$ level were removed individually until remaining correlates were statistically significantly associated with accelerometer outcomes.

Depicting physical activity across the ECE center day

As a visual illustration of physical activity variations across the childcare day, counts per minute estimates were plotted temporally, and labeled with the corresponding EPAO categories for three observation days. All observation days were divided into quintiles of total minutes per day of MVPA, and three days were randomly chosen. To avoid excessively low and high days but capture days with different amounts of MVPA, two days were chosen from the 4th quintile for MVPA minutes and one from the 2nd quintile. These illustrations show different ways children accumulate physical activity and sedentary behavior in ECE centers.

Aim 2

Exploratory factor analysis (EFA)

EFA was used to identify constructs of teacher physical activity practices and perceptions. Before items were entered into the EFA, Spearman's rank-order correlations between items were examined to identify pairs of items that were highly correlated ($r > 0.80$). Three pairs of items fit this criterion, and one item from each pair was randomly chosen to be entered into the factor analysis. The EFA was conducted in SAS v9.4 using an oblique promax rotation to allowing for correlations between the resulting factors. The number of factors was based on visual inspection of the scree plot and eigenvalues. Eigenvalues >1 were considered

plausible factor structures. Items that did not load on any factor initially (loading < 0.20) were removed, and the EFA was repeated. The 0.20 criterion was set so that multiple items could be eliminated at one time and so that items with lower loadings could be retained in the case that their loadings were artificially lowered by those items with <0.20 loadings. The process was repeated until all retained items had factor loadings of at least 0.40. No items cross-loaded onto multiple factors (≥ 0.40 on multiple factors).

Once the factor structure was finalized, items within a factor were summed to calculate a total factor score. An alternate factor score was calculated as a weighted sum of the item responses using the factor loadings as weights. The weighted factor score allows items contributing the largest amount of variance to the factor to be more represented in the total factor score, which may better represent the underlying construct the items are measuring. Descriptive statistics and Cronbach's alphas for individual factors and pairwise correlations among factors were examined. Finally, differences in factor scores by teacher demographics (e.g., education, weight status, years as ECE teacher) were assessed.

Associations of teacher practices with child physical activity and sedentary behavior

Mixed-effect models were used to examine associations between factor scores and child physical activity using accelerometer-measured sedentary and MVPA minutes per child care hour. The analytic sample was restricted to children who had at least 2 days of accelerometry so that a more stable estimate of physical activity and sedentary behavior was obtained. Random intercepts were used to account for center and classroom level differences. Factor scores and continuous covariates were dichotomized into high and low categories using a median split. Child, teacher, and center level, covariates were added to the models in sequence. First, child

level covariates were added, and backward elimination used to obtain the final set of child level covariates. Teacher and center level covariates were added in the same manner, one level at a time.[159] Sensitivity analyses using the same model specification were conducted using outcomes calculated using alternative cutpoints.[151]

Teacher and child race were collapsed into two categories (Black versus all other races) due to a low representation by race/ethnicities other than Black and Non-Hispanic White. Teacher BMI was entered as a two-level variable (overweight or obese versus normal weight). Center level covariates were taken from corresponding EPAO observation data and included fixed play equipment, portable play equipment, star rating, and tuition. Fixed and portable play equipment were considered covariates to isolate the association of teacher perceptions and practices with child accelerometry independent of what the center can afford and of the quality of its physical environment. Center quality star rating was reported by directors. Tuition costs were reported by the center director as a continuous variable.

Aim 3

Primary outcome

The primary outcome of the Move, Play, Learn! intervention was change in total physical activity (i.e., light, moderate and physical activity) between baseline and post-intervention was assessed with accelerometer-measured minutes of non-sedentary time, expressed as average counts per minute within childcare. Counts per minute allowed the detection of intervention activities that could move children from sedentary to light physical activity and from light to moderate or vigorous physical activity. Three days of wear for ≥4 hours (excluding nap time) were required to be included in the analytic sample.[160]

An *a priori* power analysis estimated that 182 child participants were needed to detect an 0.55 effect size based on prior studies,[109,123,132] assuming an ICC of 0.12,[149] an alpha of 0.05, 80% power, and average cluster size of 7 children per classroom. Recruitment was planned to account for 15% attrition of teachers; however, the short duration of the study and good retention in wave 1 indicated that no additional teachers and children needed to be recruited.

The intent-to-treat (ITT) principle was used to assess differences in total physical activity at follow-up by treatment arm. Longitudinal, mixed effects models were fit and included a random effect to account for the correlation of child physical activity by ECE center and controlling for baseline total physical activity (SAS v9.4, Cary NC). Subsequent models were fit to adjust for child sex and teacher education (college degree vs. no college degree), which were distributed differently between study arms. Missing data were minimal and a result of children leaving the classroom to move into school or another child care program (n=7 children missing at follow-up, n=9 with insufficient accelerometer data). Multiple imputation was used to impute missing physical activity values based on child sex, age, and race.[161,162] PROC MI was used to develop five datasets with data imputed for missing physical activity values at follow-up using the Markov chain Monte Carlo procedure.

Secondary outcomes

Generalized linear regression models were fit to test differences in secondary outcomes by treatment arms. These outcomes included variables related to the physical environment from the EPAO-SR: activity rating during circle time, seated time (min/day), teacher-led PA outdoors (min/day), and teacher-led PA indoors (min/day). Differences in teacher physical activity (MVPA min/day) and sedentary behavior (min/day) were also assessed. The effect of the

intervention on teacher practices and perceptions was evaluated, including an overall teacher practice score and center-wide environmental support. Differences in the four teacher practices targeted in the intervention were also assessed: joining in active play with children, withholding physical activity as punishment, encouraging children to be more active or less sedentary, and making portable play equipment available. Last, changes in constructs from Social Cognitive Theory were examined, namely self-efficacy for promoting physical activity and reducing sedentary behavior, outcome expectancies, and outcome expectations.

CHAPTER 4: PHYSICAL ACTIVITY OPPORTUNITIES WITHIN THE SCHEDULE OF EARLY CARE AND EDUCATION CENTERS

Overview

Physical activity has many benefits for young children's health and overall development, but few studies have investigated how early care and education (ECE) centers allot time for physical activity, along with measured individual physical activity levels for indoor/outdoor activities during a typical day.

Fifty ECE centers in central North Carolina participated in four full-day observations, and 559 children 3-5 years old within centers wore accelerometers assessing physical activity during observation days. Observation and physical activity data were linked and analyzed for associations between child activity and type of classroom activity.

Children averaged 51 ± 13 minutes/day of moderate-to-vigorous physical activity and 99 ± 18 minutes/day of light physical activity while in child care. Children averaged 6 ± 10 and 10 ± 13 minutes/day of observed outdoor and indoor daily teacher-led physical activity, respectively. Outdoor time averaged 67 ± 49 minutes/day, and physical activity levels were higher during outdoor time than during common indoor activities (center time, circle time, and TV time).

Physical activity levels varied between indoor and outdoor class activities. Policy and program-related efforts to increase physical activity in preschoolers should consider these patterns to leverage opportunities to optimize physical activity within ECE centers.

Introduction

Regular participation in physical activity and reducing sedentary time are important for young children's short- and long-term health and development, including cardiovascular health,[1,18-20] aerobic fitness,[21] healthy weight development,[18,21,28-30] gross motor skills,[50,163-165] and bone health.[12,53,166,167] Benefits of physical activity extend to children's emotional health[22-24,168] and cognitive development, including academic achievement.[26,27,169] Early care and education (ECE) centers are an important setting for promoting physical activity during early childhood when life-long habits are being formed.[60,61,170] ECE centers are crucial for physical activity promotion, as more than 7 million United States (US) children under 5 years attend center-based child care,[15] where the average child attending center-based care spends about 30 hours each week.[62]

With the importance of the ECE setting in promoting physical activity, national organizations have recommended amounts of physical activity (light, moderate, and vigorous) 3 to 5-year old children should receive during center-based care.[30,64,171] The National Association for Sport and Physical Education (NASPE) recommends that preschoolers attending centers full-time receive at least 120 minutes of physical activity, accumulated across the entire day. NASPE recommendations also state that 60 minutes should be structured (i.e., teacher-led), at least 60 minutes should be unstructured, and daily outdoor physical activity should be provided.[64] The Institute of Medicine recommends children be provided 15 minutes of physical activity per hour of time in child care and to be seated continuously for no more than 30 minutes.[30] Despite these recommendations, physical activity levels of children in center-based care are low,[49,65-69] and experts have called for the development of child care-based interventions to improve physical activity behaviors.[60]

ECE centers can promote physical activity by allocating time in their schedules for active play and limiting time spent in sedentary activities (e.g., sitting between activities), which are positively associated with children's physical activity at centers.[70,75] Most classroom schedules are similar across the US and include *circle time*, a class-wide, formal learning period; *center time*, a period of play within stations ("centers") in the classroom; and *outdoor play time.* To develop sustainable physical activity interventions for child care centers, it is important to understand how ECE teachers allocate time for these classroom activities and children's physical activity levels during these activities. For example, increasing time spent outdoors is a potential strategy based on previous studies reporting higher levels of physical activity outdoors as compared with indoors.[81,172,173] However, no studies have quantified physical activity levels during different indoor classroom activities where children spend the majority of the day. This information can identify periods of the day where children are most and least active across the day, which can be used to inform interventions, recommendations, and policies to increase physical activity of children in ECE centers.

This paper will describe physical activity patterns across the day among preschoolers attending center-based care, as well as physical activity levels associated with commonly occurring classroom activities. We hypothesize that physical activity will be highest outdoors and that physical activity during center time will be higher than circle time. Additionally, time spent in other classroom activities, such as teacher-led physical activity, meals, and nap time, will be quantified to provide context for how children spend their child care day. Last, potential correlates of physical activity within classroom activities will be examined, to identify modifiable factors that can be addressed within interventions or non-modifiable factors that could facilitate targeting or tailoring of interventions.

Methods

Data collection procedures

Data for this study were collected within an effort to develop the Environment and Policy Assessment and Observation – Self-Report (EPAO-SR), a comprehensive measure of the ECE nutrition and physical activity environment completed by center staff,[140] based on the observer-implemented EPAO.[141] Data collection protocols for this study have been described elsewhere.[140] Briefly, a convenience sample of 50 ECE centers participated in a 4-day assessment of the physical activity environment of preschool classrooms (children 3-5 years old) and the physical activity and sedentary behaviors of children in those classrooms. Observation days captured the entire day for most children in the class – beginning with the first meal or when the child care day formally began, whichever came first, and ending when the majority of children left the center. Centers were recruited from Wake, Durham, Orange, Chatham, Alamance, and Guilford counties in North Carolina (NC). Centers were identified through the NC Division of Child Development and Early Education database (http://ncchildcaresearch.dhhs.state.nc.us/search.asp?lang=English) and were invited through letters and telephone calls. Eligible centers had at least a 2-star rating on North Carolina's quality rating and improvement system (lowest 1- to highest 5-star scale). This system rates the quality of the physical spaces, programming, and staff education across all domains of early child education (i.e., not specific to physical activity) and serves as a global indicator of center quality. Data were collected between August 2008 and April 2009. All methods were reviewed and approved by the University of North Carolina Institutional Review Board. Center directors and

parents of children wearing accelerometers provided written informed consent prior to data collection.

ECE center physical activity environment

The physical activity environment of ECE centers was measured using the EPAO, which is divided into (1) a day-long observation evaluating provisions and practices occurring during the observed day and (2) a document review of the center's physical activity policies. Outcomes from the EPAO provide a measure of physical activity environmental characteristics of a child care center, and the instrument has been used widely to assess physical activity environments in ECE settings.[70,78,142-146]

The observation uses a time-use diary method, documenting activities chronologically. Six classroom activities representing the major groupings of classroom activities in ECE centers (i.e., outdoor play time, center time, circle time, TV time, meals, and nap) were observed according to the time that the activity started and ended. Center time typically consisted of stations around the classroom through which children rotate, such as blocks/manipulative play, dramatic play where children dress up and engage in imaginative play, and arts and crafts projects. Circle time activities included good morning and welcome songs, discussion of the calendar, and sometimes a book read by the teacher. Other activities (e.g., teacher-led physical activity and seated time) that were either less frequent or were not mutually exclusive from the six major categories were documented as minutes per occasion. The EPAO also documents weather- and environment-related factors used as potential correlates in this study. Temperature, precipitation, and humidity were observed with portable weather stations. Observers completed an audit of variety and use of portable play equipment (indoor or outdoor), fixed outdoor play

equipment, and natural environment features (e.g., trees providing shade, open, grassy areas). Three research staff members were trained and certified against a gold standard observer to conduct the observation.

Measurement of correlates

Center directors (N=50) reported center-level demographics including star rating (2-5), monthly tuition fees, and number of children attending the center. Teachers (N=124) reported demographic and health-related characteristics, including years of ECE teacher experience, prior training on physical activity (within 1 year prior, >1 year ago, never), weight (pounds), and height (feet, inches). Weight and height were converted to kilograms (kg) and meters (m), respectively, and used to calculate body mass index (BMI in kg/m^2). Parents of children wearing accelerometers reported child age (years) and gender.

Child physical activity and sedentary behavior

Child physical activity during child care was assessed during the 4-day assessment period using ActiGraph GT1M accelerometers. Parents of all children in observation classrooms were invited to allow child participation. Data were collected in 15-second epochs to account for the sporadic nature of young children's physical activity. The ActiLife software was used to obtain epoch-level data files for processing in SAS v9.2 (Cary, NC). Wear and nonwear periods were identified using dates and times logged by research staff members and by applying the NHANES nonwear algorithm.[150] Nonwear periods were defined as intervals of at least 60 consecutive minutes of zero activity intensity counts, allowing for 1-2 minutes of counts between 0 and 100.

SAS v9.3 macros were used to classify data into sedentary behavior (<25 counts per 15 seconds), light physical activity (25 – 419 counts per 15 seconds), and moderate-to-vigorous physical activity (MVPA, ≥420 counts per 15 seconds) using accelerometer cutpoints developed by Pate and colleagues.[152] Data were summarized at the day level for total minutes of sedentary behavior and physical activity as well as minutes per hour to account for differences in total observation hours. Average counts per minute (cpm) was also computed to provide an intensity-weighted overall physical activity outcome. In sensitivity analyses, cutpoints developed by Evenson and colleagues were used to calculate alternate estimates of children's physical activity.[151]

Data analysis

EPAO observation and accelerometer data summarized at the day level were used to calculate means and standard deviations for overall time spent in different classroom activities and for time spent across the day in sedentary behavior and physical activity (light and MVPA). SAS v9.3 macros were used to link EPAO observation and 5-minute level accelerometer data. Overall start and stop times for the observation day were used to restrict accelerometer data to that matching EPAO data. Accelerometer data summarized in 5-minute increments was coded as occurring within one of the six major observation categories or coded as uncategorized time based on the time stamps for each category.

Five minute increments were used to match EPAO and accelerometer data for two reasons. First, 5-minute blocks were considered appropriate given the level of precision we were able to collect. Data collectors used clocks (e.g., watches, clocks in centers, mobile phones) that were not synchronized perfectly with the accelerometers, so the exact times on the EPAO may

not represent the exact same times from the accelerometers. As such, the use of a finer gradation of time would most likely not increase the precision of categorization. Also, the misclassification by using 5-minute increments was balanced across the observation days and fairly random, i.e., there would not be systematically over- or underestimating physical activity or sedentary behavior for one classroom activity type.

Total minutes of sedentary behavior and physical activity (light and MVPA) and average counts per minute within each EPAO classroom activity category were computed to obtain a category-specific sedentary or physical activity estimate. Minute per hour estimates of sedentary behavior and physical activity were calculated specific to each category using the total time observed within the EPAO, to account for differences in the amount of time spent in each EPAO category. Center-level estimates were calculated as the average of all children and observation days within a center. Differences in sedentary and physical activity estimates by classroom activity category (i.e., outdoors, center time, circle time, and TV time) were assessed using ANOVAs in SAS v9.4. Four one-way ANOVAs were used to test differences in each sedentary or physical activity outcome (i.e., sedentary behavior, light physical activity, and MVPA minutes per hour, and counts per minute), accounting for the amount of time spent in each classroom activity.

Potential correlates of MVPA and sedentary time were examined separately for each classroom activity type. Based on existing literature, sociodemographic and health-related correlates included child age, child gender, monthly tuition (proxy for family income), center star rating, size of center, teacher BMI, years of teacher experience, and teacher training on physical activity. Weather-related covariates included temperature, precipitation, and humidity for the observation day. Physical environment correlates included portable play equipment variety and

use, calculated from the EPAO as the sum of equipment types available and used. For outdoor time, summary scores for natural elements and fixed portable play equipment variety and use were examined. A backwards elimination strategy was used to identify correlates that were significantly associated with either sedentary behavior or MVPA. All potential correlates were included in initial models, from which correlates associated with sedentary behavior or MVPA with a p-value of 0.2 or lower were retained in subsequent models. Correlates not significantly correlated with sedentary behavior or physical activity outcomes at the $p<0.05$ level were removed individually until remaining correlates were statistically significantly associated with accelerometer outcomes.

To provide a visual illustration of the physical activity variations across the childcare day, counts/minute estimates were plotted and overlaid with corresponding EPAO categories for three days. The days were randomly chosen based on total minutes/day of MVPA. To avoid excessively low and high days but capture days with distinctly different amounts of MVPA, two days were chosen from the 4th quintile for MVPA minutes and 1 from the 2nd quintile. The temporal plots of physical activity by time show different ways children accumulate physical activity in ECE centers.

Results

Sample characteristics

From the original 50 centers, 49 were used for this study; one was excluded because only one child wore an accelerometer. An average of 11 ± 6 children per center wore accelerometers, for a total of 559 children. Of the 3-5 year olds attending participating centers, about half (57%) were Non-Hispanic White, a third (31%) were Non-Hispanic Black, and 8% were Hispanic

(Table 1). Classroom teachers were on average 37 years old and had been a teacher for about 10 years. Half of teachers had at least a college degree, and nearly half had participated in physical activity training within the preceding year.

Time spent in classroom activities

Forty-eight centers were observed for four days, and one center was observed for three days, for a total of 195 observation days. Classrooms were observed for about 8½ hours each day (Figure 2). Children spent on average 67 ± 49 minutes each day in outdoor play, with about 7 ± 10 minutes of that as teacher-led physical activity. Children spent an average of 188 ± 13 minutes indoors each day. During this time, children spent about 10 ± 13 minutes in teacher-led physical activity. About 98 ± 59 minutes were allotted for center time, usually as two sessions, morning and afternoon. Children spent about 30 ± 19 minutes in circle time each day, usually once per day. Seated time, defined as time outside of the other pre-specified categories (e.g., circle time, meals, naps) when the majority of children were required to be seated for at least two minutes, averaged 53 ± 36 minutes each day. Television time was observed for an average of 7 ± 20 minutes but was only observed on 16% of observation days (8/195 observation days).

Table 1: Characteristics of participating centers, teachers, and children

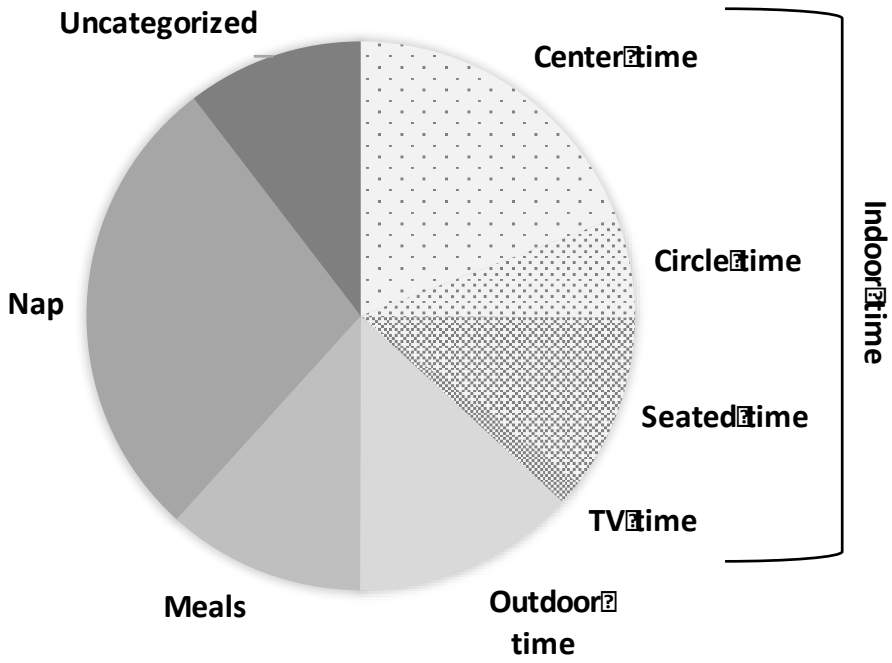
	Centers (n=49)
Race/ethnicity of all 3-5 year olds (%)	
Non-Hispanic White	57%
Non-Hispanic Black	31%
Hispanic	8%
Other	4%
Mean weekly tuition fees (SD)	163 (30)
Star rating (%)[a]	
2	6%
3	35%
4	29%
5	31%
	Teachers (n=123)
Mean years as a teacher (SD)	10 (8)
Mean age in years (SD)	37 (12)
Percent female	100%
Highest level of education	
High school or lower	10%
Some college	39%
College degree	47%
Graduate degree	3%
Missing	1%
Prior training on physical activity[b]	
Never	36%
>1 year ago	20%
1 year ago or less	44%
BMI Category	
Underweight or normal (<25)	42%
Overweight or obese (≥25)	58%
Race/ethnicity	
Non-Hispanic White	53%
Non-Hispanic Black	39%
Hispanic	2%
Other	6%
	Children[c] (n=558)
Percent female	50%

[a] Star rating refers to the NC Quality Rating System, a 1- to 5-star rating system encompassing the program's standards and education of ECE staff. Only centers with a star rating of at least 2 were included in this study. Percentages sum to 101% due to rounding.

[b] Teachers reported whether they had received training on physical activity with the following question: "Have you ever received training in physical activity for young children (e.g., continuing education workshop or college class for credit) or training on a specific physical activity curriculum?" with response options of yes, within the past 12 months; yes, more than 12 months ago; no, but I'm attending a training in the next 6 months; or no. The validity of this question, comparing teacher-report to researcher observation of training certificates was 90%.

[c] Only children who wore accelerometers during the assessment visit.

Figure 2: Mean time spent in classroom activities in the childcare setting.



	Minutes per day Mean (SD)
Total observed time	509.4 (52.4)
Outdoor time	67.2 (49.2)
Outdoor teacher-led PA	6.5 (9.9)
Indoor time	187.6 (62.5)
Center time	97.7 (58.7)
Circle time	30.2 (18.6)
Seated time	52.6 (35.6)
TV time	7.2 (19.8)
Indoor teacher-led PA[a]	9.8 (13.2)
Meals	59.5 (16.6)
Nap	142.0 (28.1)
Uncategorized[b]	53.1 (35.8)

Average time/day spent in each observed classroom activity category are shown together in the pie chart on the left. On the right, means and standard deviations for classroom activities are presented.

[a] Indoor teacher-led physical activity is not mutually exclusive of the other indoor time categories and does not contribute to the indoor time total.

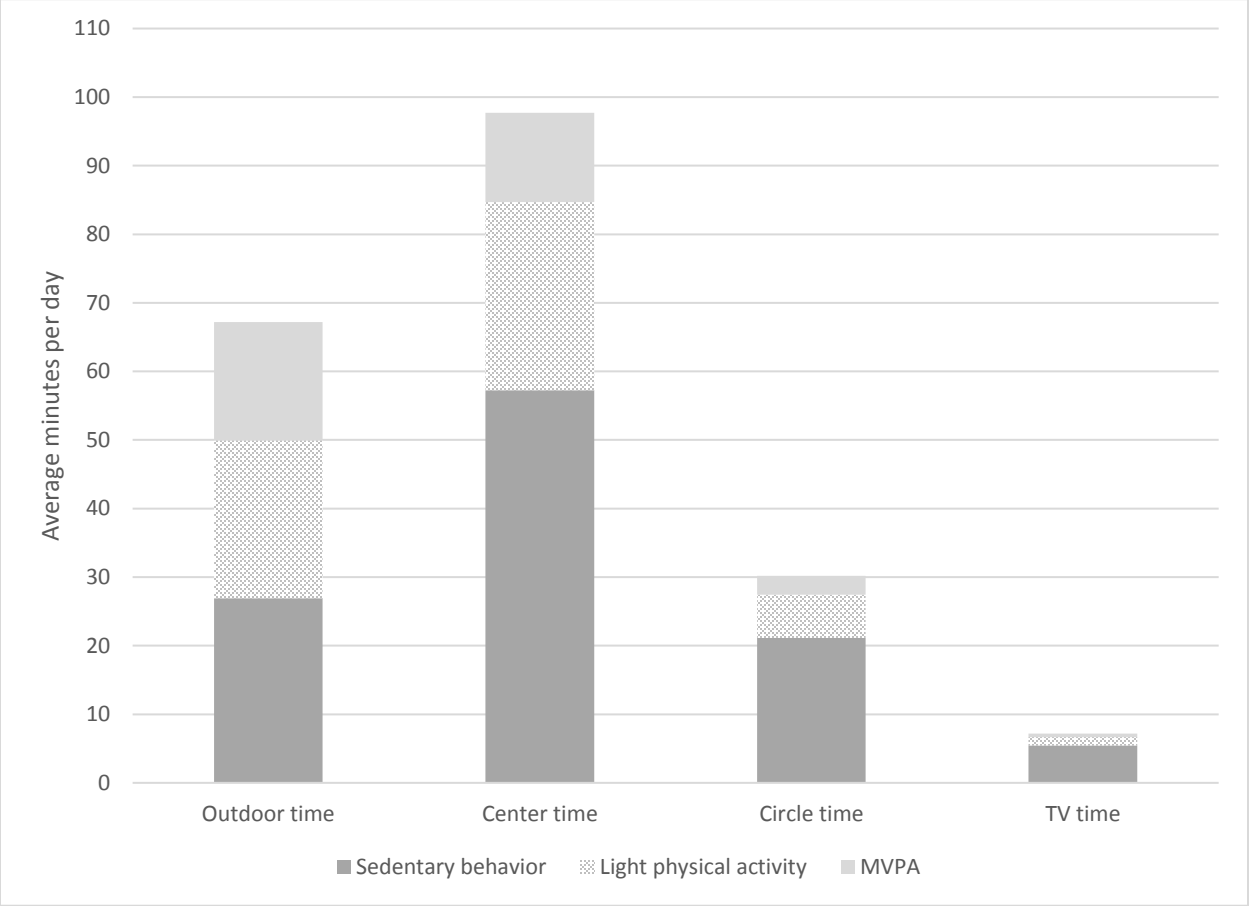
[b] Uncategorized time did not fall within one of the pre-specified observation categories, mainly including transitions between classroom activities.

Physical activity by classroom activity type

Children accumulated an average of 51 ± 13 minutes of MVPA, 99 ± 18 minutes of light physical activity, and 296 ± 62 minutes of sedentary behavior daily. Children accumulated the most MVPA during outdoor time (21 ± 12 minutes) versus other classroom activities, with circle time and TV time each averaging about 3 ± 2 minutes of MVPA each (Figure 3). Minute per hour (min/hr) estimates of sedentary behavior and physical activity by classroom activity indicate that the relative amount of time in sedentary behavior was lower for outdoor time (24 min/hr) and center time (35 min/hr) as compared with circle time and TV time (41 and 47 min/hr, respectively) (Table 2). The time spent in MVPA was also higher for outdoor time and center time (16 and 8 min/hr, respectively) than other classroom activity categories.

ANOVAs showed significant differences in all sedentary behavior and physical activity outcomes by classroom activity types (Table 2; all p-values <0.0001). Pairwise comparisons adjusted for multiple comparisons indicated that estimates during circle time and TV time were not statistically different from each other. All other pairwise comparisons between minutes per hour of sedentary behavior, light physical activity, and MVPA for the four classroom activities were significant ($p<0.0001$, data not shown).

Figure 3: Time in physical activity intensity by classroom activity type during the child care day



Time spent (minutes per day) at different accelerometer-measured sedentary behavior, light physical activity and moderate-to-vigorous physical activity (MVPA) are plotted for the four commonly occurring classroom activities.

Table 2: Physical activity and sedentary behavior estimates by classroom activity type during the child care day

	Overall[a] Mean (SD)		Outdoor time Mean (SD)	Center time Mean (SD)	Circle time Mean (SD)	TV time Mean (SD)	p-value[b]
Average Counts Per Minute	568.8 (104.7)		1204.8 (361.3)	656.8 (175.0)	499.6 (197.9)	352.7 (218.2)	<0.0001
Minutes/hour							
Sedentary behavior	38.1 (33.2)		23.5 (6.1)	34.7 (4.2)	41.4 (4.9)	46.7 (6.2)	<0.0001
Light physical activity	11.4 (1.5)		20.9 (2.8)	17.2 (2.3)	12.8 (2.9)	9.1 (4.0)	<0.0001
MVPA	10.5 (1.5)		15.7 (4.7)	8.1 (2.3)	5.8 (2.5)	4.3 (2.6)	<0.0001

[a] excluding nap time

[b] p-values from ANOVAs testing group mean differences in sedentary behavior or physical activity levels (average counts per minute, sedentary minutes per hour, light PA minutes per hour, or MVPA minutes per hour) by the four classroom activity type.

Correlates of physical activity

Eight models were fit for the four classroom activity types and included final sets of correlate exposures and either sedentary behavior or MVPA min/hr as the outcome. Several factors were associated with sedentary behavior and physical activity levels during observed classroom activities (data not shown). During outside time, average child age (ß=3.2, p=0.04) and teachers having 10+ years of experience (ß=3.0, p=0.03) were positively associated with MVPA (min/hr). For center time, center star rating was negatively associated with MVPA (min/hr) (ß=-0.7, p=0.01), perhaps because centers with a higher rating focus center time on more traditional, less active educational objectives. Weather-related factors, such as percent humidity (ß=0.2, p=0.03), precipitation (ß=-5.4, p=0.01), and average temperatures above 60 degrees (ß=-3.8, p=0.03) were associated with sedentary behavior (min/hr) during circle time. No correlates were identified for outdoor time or center time sedentary behavior, or for circle time MVPA. Similar associations were found in the sensitivity analysis using the alternative accelerometer cutpoints from Evenson et al.[151]

Physical activity levels across the day

To understand variations in physical activity across the entire child care day, physical activity throughout the day was plotted temporally for three days from different centers, using average cpm plotted by time (Figure 4). Graphs were overlaid with the observation data on classroom activity type. These were chosen to be representative of the sample, i.e., not on the extremes of the distribution, but distinct enough to illustrate differences in "more" and "less" active days at child care. Center A (Figure 4a, average 305 cpm) represents a less active day,

while Center B (Figure 4b, average 782 cpm) and Center C (Figure 4c, average 647 cpm) represent different patterns of more active days.

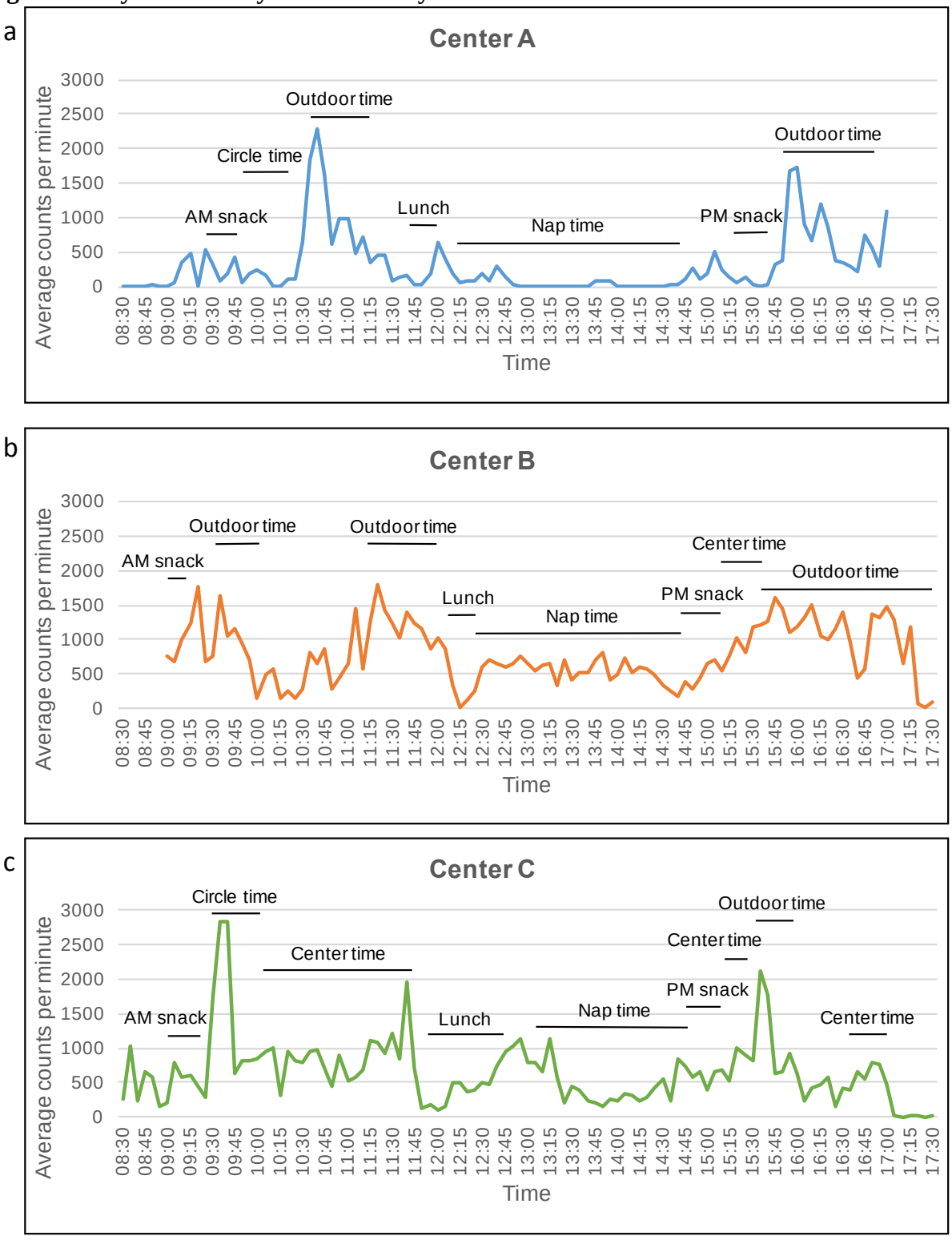
From these graphs, several physical activity patterns are noted. Across the three days, mornings are generally more active than afternoons. The highest peaks of physical activity most often occur during outdoor time, except in Center C, which may have replaced outdoor time that day with indoor circle time in the morning. This classroom did not go outside that morning despite good weather; however, this teacher was still able to integrate intense physical activity indoors. The sharp peaks for outdoor time in Centers A and C and morning circle time in Center C also demonstrate that children are most active at the beginning of these activities, then becoming less active as the activity progresses. Overall, these graphs show the temporal sequence of physical activity and how children accumulate physical activity across the child care day.

Discussion

This study examined time allocated to classroom activities and physical activity across the day of preschoolers attending center-based care, including physical activity levels during commonly occurring classroom activities. Key findings from this study are significantly higher levels of MVPA and lower levels of sedentary behavior during outdoor play, as in other studies, and during center time, a novel finding, as compared with other indoor activities. This highlights important differences in the way classroom teachers use their schedules and opportunities for increasing physical activity across the day in ECE centers.

Within this sample, teachers allocated an average of 67 minutes/day of time for outdoor play, notably higher than a recent study by Tandon et al., who observed 33 minutes of outdoor

Figure 4: Physical activity across the day in three centers



These graphs depict the time course of accelerometer-measured physical activity across the day at three centers, overlaid with data from observations conducted by research staff indicating the classroom activity taking place at the corresponding time.

time in child care centers in Seattle, Washington, US[41] The teacher-led physical activity estimates (10 minutes indoors and 6 minutes outdoors) from our study are also higher than those in the Tandon study (8.4 and 0.4 minutes, respectively) but lower than those found by LaRowe et al.[174] These differences could be due to sampling differences, geographical differences, or characteristics of the teachers. Similar amounts of total MVPA were observed in this study (51 minutes/day, 11 minutes/hour) compared with estimates of 55 minutes[41] and 7 minutes/hour[39,40] from other studies.

Several correlates were found that were specific to outdoor MVPA or center MVPA time, but no correlates were identified for MVPA during circle time. Within center time, the finding that center star rating was negatively associated with MVPA could be because centers with a higher rating focus center time on more traditional, less active educational objectives. The North Carolina star rating system does not have a specific component related to physical activity, but instead is more of a global indicator of the quality of the center. Correlates for only one of the four classroom activity periods (circle time) were identified for sedentary behavior. Other studies have identified important child- and center-level correlates of overall physical activity, including natural features,[76,175] fixed play equipment,[143] portable play equipment,[70,143] and playground density.[80] The present sample may have been too homogenous in both correlates and sedentary and physical activity levels within each classroom activity; future work is needed to expand upon this.

Of these 49 centers, 32 (65%) met the Institute of Medicine recommendation for 15 minutes of non-sedentary time per hour, compared with 42-50% of children in a study by Pate et al.[68] Children accumulated an average of 99 minutes of light physical activity and 51 minutes of MVPA, but were only offered an average of 16 minutes of observed teacher-led physical

activity. Most centers (N=41) met the NASPE recommendation for 120 minutes of total physical activity for all observation days, but no center met the recommendation for offering 60 minutes of teacher-led physical activity on all observation days.

The results from this study can inform intervention development, specifically the times of day where there is most potential for adding in physical activity or reducing sedentary behavior based on time spent in different classroom activities and sedentary behavior and physical activity levels of children during those classroom activities. Opportunities exist for increasing physical activity both indoors and outdoors. Since children accumulate most of their MVPA from outdoor play, it is important to optimize outdoor time to be as active as possible. Children may need additional prompts to be active, as their physical activity levels decrease over time during outdoor play.[176] Teachers could prompt increases in physical activity after children have been outdoors for a prolonged time either with active toys or teacher-led physical activity, which has been found to be a successful strategy.[174] Indoors, there should be a continued focus on bridging educational and physical activity objectives, as done in some interventions.[126,132] This is not intended to compete with other educational objectives but instead can facilitate a child's ability to learn.[177,178] Additionally, these data show that small increases in the amount of physical activity in each classroom activity type could result in a large accumulation of daily MVPA. If an intervention increased MVPA in outdoor play, center time, and circle time by 10%, there would be a practically significant increase in MVPA by 3.7 minutes daily, or about 75 minutes monthly. Within the present sample, this increase would result in result in all except three centers meeting recommendations. Similarly, a 10% increase in average counts per minute translates to an increase in daily caloric expenditure by 63, which accumulates to more than 1,250 per month,

for a 4-year old female at the 50th percentile of BMI (16 kg).[179] This increased caloric expenditure has been shown to be large enough to achieve the Healthy People 2020 goals.[180]

Future studies should work towards a more complete understanding of the role of physical activity within center-based care. Teacher-led physical activity is known to be an important contributor to children's overall physical activity levels and gross motor development,[64,174] but more work is needed to understand how to support teachers in integrating structured physical activity into their schedules. Also, more research is needed on limiting seated time without hindering learning and developmental objectives. Currently, there is little understanding of how seated time is used within ECE settings and its impact on a child's overall physical activity levels and children's development. Our results show that children are required to be seated for nearly an hour each day, which may be detrimental to children's development and is important for future work to consider. Strengths of this study include the use of multiple, full-day, researcher-implemented observations in 49 centers and accelerometer-measured physical activity and sedentary behavior among 559 children.

Despite many strengths, several limitations of this study must be considered. One limitation is that some observation time could not be matched with accelerometer data. An average of 53 minutes/day were not categorized in the EPAO (Figure 2). This likely includes transitions between activities and infrequent activities such as field trips (occurring on 3 observation days), but future research should aim to capture this information more formally. Also, activities not observed with a time stamp could not be matched with accelerometer data (e.g., seated time, teacher-led physical activity). We have modified the observation to capture these activities with specific times so that the entire child care day is better captured and can be fully linked with accelerometer data. The cross-sectional design of the study precludes the ability

to draw causal inferences about the relationship between correlates and sedentary behavior or MVPA. Also, the data were collected in 2008 and 2009 and thus may not represent current practice; however, no major policy shifts have occurred at the state level around physical activity in ECE settings. Last, this study is limited in its representatives, as participating centers may be different than other North Carolina centers. However, more than half accepted tuition subsidies, i.e., served lower-income children, indicating representation from different socioeconomic groups. Centers in North Carolina may also be different from other places with different child care regulations, geography, weather, and urbanization.

Conclusions

This study used objectively collected data from observations and accelerometry to understand the patterns of physical activity and sedentary behavior across the child care day, and the types of classroom activities that facilitated child physical activity. Children were observed as being more active outdoors and center time than other indoor activities (circle time, TV time). Results from this study reaffirm the tenants of organizations highlighting the importance of physical activity in ECE settings[170] and highlight potential opportunities for interventions focused on increasing physical activity and reducing sedentary behavior in preschoolers attending ECE centers.

CHAPTER 5: EARLY CARE AND EDUCATION TEACHER PRACTICES AND PERCEPTIONS ASSOCIATED WITH PRESCHOOLER PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR

Overview

Early care and education (ECE) teachers shape behaviors of preschool-aged children, yet efforts to identify teacher practices and perceptions that could drive teacher-child interactions and support children's physical activity or minimize excess sedentary behavior are limited. The purpose of this study was to identify teacher practices and perceptions that could influence child physical activity and sedentary behavior and observe how they are related to children's moderate-to-vigorous physical activity (MVPA) and sedentary behavior.

Teachers (N=113) completed questionnaires on their physical activity and sedentary practices and beliefs. MVPA and sedentary behavior of 3-5 year-olds in the same child care centers (N=508) was measured via accelerometry. Exploratory factor analysis was used to determine groupings of questionnaire items, and mixed-effect models were used to assess associations of factor scales with child MVPA or sedentary behavior.

A 3-factor solution was the best fit for the teacher survey data, with factors aggregating around 1) teacher physical activity practices to support child physical activity, 2) teacher self-efficacy (confidence) for implementing physical activity, and 3) perceived center level environmental support for physical activity. In general, teachers rated themselves highly confident to provide support for children's activity and reducing inactivity and as having strong teacher practices and center level supports. Perceived environmental support was negatively

associated with minutes per hour of sedentary behavior (ß= -1.2, p-value= 0.04), adjusted for child and teacher level covariates. The teacher physical activity practices factor was inversely associated with child MVPA, significant in the crude model but attenuated in the fully adjusted model (ß= -0.8, p-value= 0.08). Teacher self-efficacy showed weak, non-significant associations with MVPA and sedentary behavior.

Three factors were identified from a survey on that could be associated with increased child MVPA, but mixed associations were found between these factors teacher practices and perceptions around physical activity and sedentary practices and children's MVPA and their sedentary behavior. Possibly teachers' lack of knowledge related to their role in supporting children's activity and/or limiting inactivity may have affected these outcomes. Because of the potential for teachers to affect children's activity level, more work is needed to understand how these factors independently or collectively influence children's behaviors.

Introduction

Promoting health behaviors during early childhood, such as engaging in physical activity and minimizing time being sedentary, is important given that behaviors learned during the early years track with children into adolescence and adulthood.[53,54] Engaging in regular physical activity and avoiding excess sedentary time during childhood have benefits for physical[1,18-21] and emotional health,[22-25] as well as cognitive development and academic achievement.[26,27] However, recent studies estimate that preschool-aged children (3-5 years old) in the United States (US) spend about 10 hours each day inactive,[14] and about half of preschool children fail to obtain the recommended 60 minutes of daily physical activity.[49-51,181] Therefore, encouraging young children to participate in physical activity and to limit sedentary behavior during this early

childhood period may maximize these benefits across a child's life.[182] A key environment for the promotion of these behaviors is the early care and education (ECE) setting. More than 7 million children under five years of age attend center-based child care in the US,[15] and those who attend centers spend on average 30 hours there each week.[62] Because of the importance of ECE settings in the promotion and reduction of sedentary behavior,[60,61] it is crucial to understand how these settings support child behaviors.

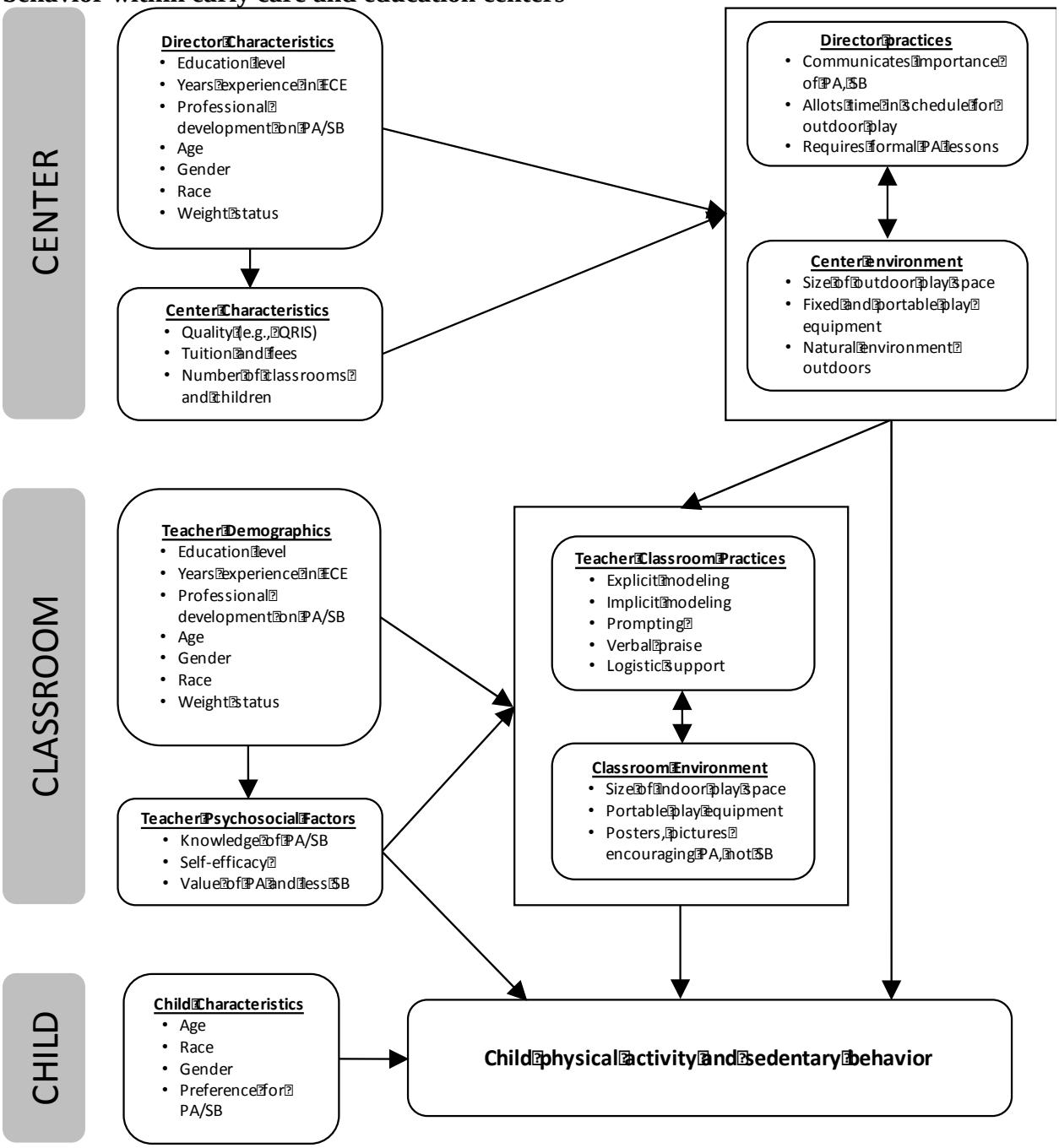
Caregivers, including parents and ECE teachers, are recognized as important adults who shape the environments and behaviors of preschool-aged children. Understanding and leveraging this influence is central to physical activity promotion and reduction of sedentary behavior for preschool-aged children since caregivers control much of the young child's environment and opportunities. One way these caregivers impact child behavior is through the use of practices, such as role modeling or prompting, to encourage children to be active or reduce sedentary time. Beyond practices, other psychosocial constructs such as caregiver self-efficacy, or confidence, for providing active opportunities or their knowledge related to physical activity and sedentary behavior can impact children's behaviors. Previous work has identified frameworks for understanding parent physical activity practices,[183] developed measurement tools to assess these practices and psychosocial constructs,[184-188] and established relationships between parent practices and children's physical activity and sedentary behavior.[189-192] In comparison, there has been much less work done to understand ECE teacher practices and psychosocial constructs related to physical activity and sedentary behavior.

To understand the role of teacher physical activity practices and potentially mediating psychosocial constructs one could extrapolate from the parenting literature. However, the influence of an ECE center teacher is likely distinct from that of parents because of the inherent

differences in the home versus child care settings. For example, the ratio of children to caregivers in a classroom is higher than within a home, changing the way a teacher can interact with any one individual child at a given time. Furthermore, ECE centers have a more complex organizational structure, where multiple levels (center, classroom, and child levels) and gatekeepers (teachers and directors) influence children's physical activity and sedentary behaviors (Figure 5). The impact of these various influences on teachers' ability to provide physical activity for children and help them avoid excess sedentary behavior is important to consider in regards to their health promotion efforts, as teachers are the most proximal influence on children within the ECE setting.

Most prior studies on the role of the teacher have identified a few teacher physical activity practices that are positively associated with children's physical activity, including teachers joining children in active play (co-participation) or prompting children to be less sedentary (e.g., "Why don't you get up and play tag with us?").[70,74,77-79] These studies are important for understanding the unique way ECE teachers act to promote physical activity and minimize sedentary behavior, but little work has examined the role of the teacher beyond individual practices. To our knowledge, only one study has examined psychosocial constructs (i.e., self-efficacy),[193] and none have examined other constructs or teacher perceptions of center level influences. This broader understanding of how teachers influence children's physical activity and sedentary behavior can improve center-based interventions, many of which are implemented through teachers, and can in turn improve child physical activity and sedentary behaviors.

Figure 5: Description of multi-level influences of children's physical activity and sedentary behavior within early care and education centers



ECE, early care and education. PA, physical activity. SB, sedentary behavior. QRIS, quality improvement rating systems (i.e., those used to evaluate the quality of a center's program and environment)

This paper aims to determine underlying factors related to teacher practices and perceptions that may influence child physical activity and sedentary behaviors using exploratory factor analysis. These factors will then be used to assess the relationship between teacher practices and perceptions and children's accelerometer-measured physical activity and sedentary behavior, considering child, classroom, and center level covariates. We hypothesize that better behavioral and environmental perceptions will be positively related to children's physical activity and negatively related to children's sedentary behavior. Because of the potential importance that ECE teachers may have on children's health promoting behaviors, a comprehensive understanding of these relationships is needed to inform the development, implementation, and evaluation of appropriately targeted and tailored interventions delivered by teachers in support of children's physical activity and reduced sedentary behavior.

Methods

Data collection procedures

Data were taken from a study to develop and establish reliability and validity evidence for the Environment and Policy Assessment and Observation – Self-Report (EPAO-SR), a measure of the nutrition and physical activity environment for 3-5 year-old children completed by center directors and teachers.[140] This instrument was adapted from the EPAO conducted by research staff.[141] A convenience sample of directors and teachers from 50 ECE centers in North Carolina (NC) was recruited to complete the self-report instrument and to allow research staff to conduct the EPAO in parallel. Eligible centers were required to have at least a 2-star rating on the NC quality rating and improvement system (1 to 5-star scale, 5 indicating highest quality). This quality rating and improvement system is mandatory for all licensed ECE facilities and rates

facilities on staff education and program standards, related to early childhood education broadly (i.e., not specific to physical activity). Centers were identified through the NC Division of Child Development and Early Education database and invited to participate using mailed letters and telephone calls.

At least one teacher per center was recruited to complete the EPAO-SR instrument. Additional teachers completed the EPAO-SR if there were multiple teachers per classroom or multiple 3-5-year-old classrooms in a center. Teachers completed two sets of surveys: (1) the *teacher daily survey*, on four consecutive days, and (2) the *teacher general survey* on two nonconsecutive days. Teachers also reported demographic information along with the first teacher daily survey. Center directors reported center level demographics. Trained research staff conducted full-day observations of 3-5-year-old classrooms for the four days corresponding to the teacher daily survey days, and physical activity behaviors of children in observation classrooms were assessed via accelerometry. All methods were reviewed and approved by the University of NC Institutional Review Board. Center directors, teachers, and parents of children wearing accelerometers provided written informed consent before data collection. Data were collected between August 2008 and April 2009.

Measures

Teacher survey items

Within the teacher daily and general surveys, classroom teachers were asked to respond to items which described their practices for addressing physical activity and sedentary behavior of children in their classrooms; their self-efficacy specific to implementing physical activity and avoiding sedentary behavior in their classrooms; the degree to which they value being physically

active and teaching children to be physically active; their perceptions of the physical environment for physical activity (e.g., presence of sufficient active play equipment); and their perceptions of support from the center director. These were assessed using 28 items, with three appearing on the teacher daily survey and 25 on the teacher general survey (Appendix 3). Items that asked teachers about discrete, quantifiable behaviors were included on the teacher daily survey, while their perceptions of the center environment and their self-efficacy were found on the teacher general survey. Some items were modified from a previously validated questionnaire,[154] most were newly developed. Items were tested in cognitive interviews with 35 ECE staff before field testing to ensure items were relevant and could be understood by teachers.[140]

Responses for most items were a 6-point likert-type scale, from strongly disagree (1) to strongly agree (6). The three items on the teacher daily survey asked teachers whether a practice (e.g., joining in active play with children) never occurred, occurred in the morning, or occurred in the afternoon (range of 0-2 times per day for each item). One item asking teachers to compare how much they encourage children to be active to other teachers in their center had a 5-point response ranging from "much less than other teachers" (1) to "much more than other teachers" (5). Another item asking teachers how much they use their behavior to model physical activity had a 4-point response ranging from "I don't use my own behavior…" (1) to "I constantly use my own behavior…" (4). Six items were reverse coded such that a higher score indicated a more favorable practice. For each item, averages across the four days of the teacher daily survey and the two days of the teacher general survey were calculated for each item to get an overall estimate of that item for each teacher.

Child physical activity

Children's physical activity during child care day was measured across the four observation days on consecutive weekdays using ActiGraph GT1M accelerometers to obtain an estimate of usual physical activity and sedentary behaviors that can vary by day of the week. Two days of wear for ≥4 hours were required to be included in the analysis. Accelerometer data were collected in 15-second epochs to better capture the sporadic nature of young children's physical activity. Epoch-level files were obtained using the ActiLife software. Data processing was done in SAS v9.2 (Cary, NC), using dates and times logged by research staff members and the National Health and Nutrition Examination Survey (NHANES) nonwear algorithm.[150] Within this algorithm, nonwear periods are intervals of at least 60 consecutive minutes of zero counts, allowing for 1-2 minutes of counts between 0 and 100. Child-specific cutpoints were used to classify data into sedentary behavior (<25 counts per 15 seconds)[151] and moderate-to-vigorous physical activity (MVPA, ≥420 counts per 15 seconds).[152]

Day-level sedentary and MVPA estimates were calculated as a sum total of epoch-level data. Minutes per child care hour of sedentary behavior and MVPA were then calculated to account for differences in total wear time. A minute per child care hour unit was chosen for comparability with other studies in chid care.[126] An additional estimate of MVPA was calculated using alternate child-specific cutpoints.[151]

Child, teacher and center level covariates

Covariates were assessed at the child, teacher, and center level. Child level covariates reported by parents included sex (male/female), age (years), and race (Black, Non-Hispanic White, other).

Self-reported teacher level covariates included highest education attained, years as an ECE teacher, prior training around physical activity (never, ≥1 year ago, <1 year ago) age in years, race (Black, Non-Hispanic White, other). Teachers also reported height (feet and inches) and weight (pounds), which were used to calculate body mass index (BMI) in kg/m^2. Categories of BMI were created as under weight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (≥30 kg/m^2).

Center level covariates were taken from corresponding EPAO observation data and included fixed play equipment, portable play equipment, star rating, and tuition. Fixed play equipment variety was a sum of 16 types of non-movable equipment, such as climbing structures, swings, and paved paths for tricycles. Portable play equipment variety was a sum of 14 types of active play equipment that can be easily moved, such as balls, twirling play equipment (e.g., rhythm scarves), and push/pull toys (e.g., scooters). Fixed and portable play equipment were considered covariates to be able to isolate the association of teacher perceptions and practices with child accelerometry independent of what the center can afford and of the quality of its physical environment. Center quality star rating and tuition costs were reported by the center director.

Statistical analysis

Factor analysis

Exploratory factor analysis (EFA) was used to identify constructs of teacher physical activity practices and perceptions. Before entering items into the factor analysis, Spearman's rank-order correlations between items were examined. Three pairs of items asking about very

similar practices were highly correlated ($r > 0.80$), from which one was randomly chosen to be entered into the factor analysis. The EFA was conducted in SAS v9.4 using an oblique promax rotation, which allows the resulting factors to be correlated with each other. The number of factors was based on visual inspection of the scree plot and eigenvalues (eigenvalues >1 were considered plausible factor structures). Items that did not load on any factor initially (loading < 0.20) were removed, and the EFA was repeated. The 0.20 criterion was set so that multiple items could be eliminated at one time, while also allowing items with lower loadings to be retained in case their loadings were artificially lower due to retention of items with very low factor loadings in the model. The process was repeated until all retained items had factor loadings of at least 0.40. No items cross-loaded onto multiple factors (≥ 0.40 on multiple factors).

Once the factor structure was finalized, factor scores were created as a sum of the item responses per factor. An alternate factor score was calculated as a weighted sum of the item responses using the factor loadings as weights. The weighted factor score allows items contributing the largest amount of variance to the factor to be more represented in the total factor score, which may better represent the underlying construct the items are measuring. Descriptive statistics and Cronbach's alphas for individual factors and pairwise correlations among factors were examined. Finally, differences in factor scores were assessed by teacher demographics (e.g., education, weight status, years as ECE teacher).

Associations of teacher practices with child physical activity and sedentary behavior

Mixed-effect models were used to examine associations between factor scores and daily child outcomes using accelerometer-measured sedentary behavior and MVPA minutes per child care hour as outcomes. Random intercepts were used to account for center and classroom level

differences. To account for possible confounding by child, teacher, and center level, covariates were added to the models, one level at a time. First, child level covariates were added, and backward elimination used to obtain the final set of child level covariates. Teacher and center level covariates were added in the same manner, one level at a time.[159] Factor scores and continuous covariates were dichotomized into high and low categories using a median split. Both teacher and child race were collapsed into 2 categories (Black versus all other races) due to a low representation by race/ethnicities other than Black and Non-Hispanic White. Teacher BMI was entered as a two-level variable (overweight or obese versus normal weight). Sensitivity analyses using the same model specification were conducted using outcomes calculated using alternative cutpoints.[151]

Results

Sample characteristics

A total of 113 teachers were recruited to take part in the study, all of whom were female (Table 3). On average, participating teachers had been a teacher for ten years and were 37 years old. Most were highly educated, with about 46% having a college degree or higher. Parents of 558 children gave consent for children to wear accelerometers (average of 11 children per center), and 508 had sufficient accelerometer date to be included in the analytic sample. Children were on average 3.8 years old (Table 4). Of those children, 50% were female, and 26% were non-Hispanic Black. During child care hours, children accumulated 73 minutes of MVPA per day (18% of child care day) and engaged in 258 minutes of sedentary behavior per day (64% of child care day), including meal times but excluding nap time.

Notable differences were observed between certain teacher and child characteristics and child MVPA and sedentary behavior. Female children engaged in significantly less MVPA (ß= -1.1 minutes/hour, p-value= <0.001) and more sedentary behavior (ß= 0.9 minutes/hour, p-value= 0.02) compared to males. Non-Hispanic Black children engaged in significantly more MVPA compared to other race/ethnic groups (ß= 0.7 minutes/hour, p-value= 0.04). Children in classrooms with Non-Hispanic Black teachers engaged in more sedentary behavior compared to those in classrooms with teachers of other race/ethnicities (ß= 1.4 minutes/hour, p-value= 0.02).

Table 3: Characteristics of participating teachers

	Teachers (N=113)
Mean years as a teacher (SD)	10 (8)
Mean age in years (SD)	37 (12)
Female	100%
Race/ethnicity	
Non-Hispanic White	52%
Non-Hispanic Black	40%
Hispanic	2%
Other	6%
BMI Category	
Underweight or normal (<25)	44%
Overweight or obese (≥25)	56%
Highest level of education	
High school or lower	11%
Some college	42%
College degree or higher	46%
Missing	1%
Prior training on physical activity	
Never	42%
>1 year ago	38%
1 year ago or less	20%

Table 4: Characteristics of participating children

	Children (N=508)
Mean age (SD)	3.8 (0.7)
Percent female	50%
Race/ethnicity	
Non-Hispanic White	62%
Non-Hispanic Black	26%
Other	12%
Within-child care accelerometer estimates (minutes/day)[a]	
Sedentary behavior	258 (74)
Moderate-to-vigorous physical activity	73 (24)

[a] Within-child estimates are controlling for clustering of children within centers

Identification of constructs using exploratory factor analysis

After visual inspection of the scree plot and considering factor solutions with eigenvalues at least one, it appeared that a 2-, 3-, or 4-factor solution would be appropriate. The 3-factor solution, however, was retained because it captured a meaningful grouping of factors with items having at least a 0.4 factor loading and no cross-loading of items onto multiple factors (Table 5). Cross-loading was indicated by at least a 0.3 loading on more than one factor. A 2-factor structure did not distinguish between groupings of items, and no items within the 4-factor solution loaded at least 0.4 onto one of the factors. Factors derived included 1) *teacher physical activity practices* (11 items, Cronbach's alpha = 0.91), 2) *teacher self-efficacy for implementing physical activity* (3 items, Cronbach's alpha = 0.84), 3) *perceived environmental support for physical activity* (4 items, Cronbach's alpha = 0.69). On the whole, teacher responses were quite high and similar across the sample.

Table 5: Exploratory factor analysis 3-factor solution

Item	Factor Loading	Mean	SD
Factor 1: Teacher PA practices (11 items, Cronbach's alpha = 0.91)			
I am a role model for being physically active for the children in my class.	0.95	3.7	1.2
My behavior encourages children to be physically active.	0.85	3.9	1.0
I join children in physically active play.	0.70	3.9	1.0
I encourage children to be physically active.	0.68	4.4	0.9
I enjoy being physically active in my spare time.	0.67	4.3	1.0
I enjoy being physically active at work.	0.66	4.6	0.9
I make positive statements about being physically active.	0.62	4.1	1.1
How much do you use your own behavior (modeling) to encourage your class to be physically active?	0.61	3.0	0.6
It is my job to teach children in my class about being physically active.	0.60	4.4	1.2
I make comments to children that promote physical activity.	0.57	3.7	1.1
In comparison to other teachers at your child care center, how much do you feel you encourage your class to be physically active (e.g., run around with them, encourage them to move more, play indoor active games, etc.)?	0.47	3.5	0.7
Factor 2: Teacher self-efficacy for PA promotion (3 items, Cronbach's alpha = 0.84)			
I feel confident that I can help the children in my class to be physically active for at least one hour each day.	0.78	5.0	0.8
I feel confident that I can get children in my class to be physically active even when they aren't interested.	0.76	4.9	0.8
I feel confident that I can teach children in my class why being physically active is good for them.	0.71	5.1	0.6
Factor 3: Classroom and center supports for PA (4 items, Cronbach's alpha = 0.69)			
The center director communicates the importance of physical activity.	0.68	4.0	1.4
When outside, plenty of toys are available for children to use without waiting for a turn.	0.66	3.6	1.5
The center provides outside resource people that enhance the children's physical activity.	0.64	3.7	1.4
The posters and pictures in my classroom show children being physically active.	0.43	4.2	1.2

Associations of identified factors with child physical activity and sedentary behavior

Crude associations between classroom-level factor scores and child physical activity were calculated, clustered by center (Table 6).

Contrary to expectations, children in classrooms with higher teacher physical activity practice scores (factor 1) accumulated less MVPA compared to children in classrooms with lower teacher physical activity practice scores (ß= -1.1 minutes/child care hour, p-value= 0.007). This association was attenuated in the fully adjusted model (ß= -0.8 minutes/hour, p-value= 0.08) but the association remained inverse.

Children in classrooms with higher teacher physical activity self-efficacy (factor 2) appeared to accumulate slightly more MVPA and fewer sedentary minutes per hour in both crude and adjusted models, but the estimates were imprecise.

A positive relationship between teacher environmental support (factor 3) and child MVPA was observed. Teacher environmental support was negatively associated with sedentary behavior in both crude (ß= -1.2 minutes/hour, p-value= 0.045) and adjusted models (ß= -1.2 minutes/hour, p-value= 0.04). No differences were observed using the alternate accelerometer cutpoints or using the standardized regression coefficients to calculate factor scores for all three factors.

Table 6: Associations between teacher practices and child physical activity and sedentary behavior during child care

	Crude model			Fully adjusted model		
	ß	**SE**	**p-value**	**ß**	**SE**	**p-value**
Moderate-to-vigorous physical activity (min/hr) outcome						
Intercept	10.98	0.31		10.89	0.37	
Teacher PA practices (high vs. low)	-1.12	0.41	0.007	-0.76	0.44	0.083
Teacher self-efficacy (high vs. low)	0.19	0.40	0.630	0.13	0.42	0.759
Teacher environmental support (high vs. low)	0.69	0.39	0.077	0.57	0.40	0.149
Child gender (female vs. male)				-1.07	0.28	<0.001
Child race (black vs. other)				0.72	0.35	0.042
Fixed equipment (high variety vs. low)				0.86	0.42	0.042
Sedentary behavior (min/hr) outcome						
Intercept	37.65	0.47		36.79	0.51	
Teacher PA practices (high vs. low)	1.13	0.62	0.071	0.92	0.65	0.156
Teacher self-efficacy (high vs. low)	-0.14	0.59	0.813	-0.04	0.61	0.954
Teacher environmental support (high vs. low)	-1.16	0.58	0.045	-1.17	0.58	0.044
Child gender (female vs. male)				0.92	0.40	0.023
Teacher race (black vs. other)				1.36	0.58	0.020

Discussion

The objective of this study was to identify teacher level factors that were associated with children's physical activity and sedentary behavior. Using survey items that were derived from prior research and based on the literature, we identified three factors: teacher practices, teacher self-efficacy for influencing child activity, and perceived center level environmental supports for child activity. These factors had mixed results in their association with children's physical activity and sedentary behavior, but the teacher practices factor shows the most promise for future use as it seems to be internally consistent and associated with child outcomes. including the range and variation of teachers' responses to survey items and the other contextual factors that could influence the teacher-child relationship around these practices.

There are several reasons that could explain these results, one being that teachers rated themselves as having highly favorable profiles of these practices and high levels of self-efficacy, and perceived high levels of support for physical activity at their centers. Also, the variation among teachers was low and may have limited our ability to detect relationships with child outcomes. Social desirability bias could explain why teachers rated themselves so favorably, as there were differences between observer and teacher reports of these practices.[140] There is evidence that teachers are willing to report barriers to implementing physical activity in their classrooms, including environmental supports[89] and a lack of self-efficacy,[97] in qualitative studies. It may be the case that teachers in the present study were unwilling to report challenges to physical activity. While items were tested in cognitive interviews before use, refinements in the survey items (e.g., providing examples of practices) may be helpful in the future use of these items to allow teachers to better report their practices and perceptions.

Also, we did not collect information on how active these teachers perceived children in their classroom were. There is some evidence suggesting that teachers think children in their care are very active,[93] perhaps active enough to the point that teachers do not need to use their behavior to encourage activity and discourage an excess amount of sedentary behavior. The relationship of these practices and perceptions with child outcomes is likely bidirectional and contextual, as has been hypothesized for the relationship between parents and children.[194] It is possible teachers reserve the use of some practices only for when they feel that children need to be more active or less sedentary. However, if a teacher's estimation of a child being "active enough" is inaccurate, a missed opportunity may result for teachers to use their behavior to help children obtain sufficient activity within the ECE day. Future studies are needed to understand the dynamics of these relationships and whether professional development (training) can clarify

teachers' understanding of children's physical activity and their role in supporting children's behaviors.

The dynamics of these relationships may, in part, explain the inconsistencies found in the literature on teacher practices and perceptions around physical activity and sedentary behavior. Previous studies have demonstrated that teacher practices such as prompting children to be more active or joining in active play are infrequently observed,[74,77] which is distinct from the present study where teachers reported frequent use of these practices. Some studies have found a positive association of researcher-observed teacher prompting children to be active with higher quality physical activity environments[70] and child MVPA.[78] One study conducted by Henderson et al. found a positive relationship between encouragement of indoor play and children's MVPA at centers, but an inverse relationship between teachers joining in active play outside and children's MVPA at centers.[79] And yet, other studies have reported no association between teacher practices and child MVPA.[81,195] In light of these mixed findings, it is possible that the influence of the teacher on child physical activity via practices and perceptions is weaker compared to that of the physical environment (e.g., space, time allotted for active play) or social influences (e.g., peers). These discrepancies need to be resolved to create and deliver effective, parsimonious programs to child care providers.

To our knowledge, only one other study has aimed to develop a broader understanding of ECE teacher practices and self-efficacy around physical activity and sedentary behavior.[193] Derscheid et al. developed a scale centered on knowledge of nutrition and physical activity and teacher self-efficacy around 1) implementing typical best practices around nutrition and physical activity, e.g., completing professional development on physical activity; 2) implementing nutrition and physical activity curricula, e.g., teaching locomotor skills, and 3) daily activities

related to nutrition and physical activity, e.g., having adult involvement in the recommended 60 minutes/day of physical activity. These self-efficacy items primarily relate to task self-efficacy, the degree to which teachers believe they can meet a specified goal. Teachers reported a high level of confidence, similar to the present study, and there was a significant, positive association between nutrition and physical activity knowledge and overall self-efficacy. The items in the daily activities category are most similar to the self-efficacy items developed for this study; however, we did not find a strong positive relationship as in that study. The purpose of this study was to assess not only teachers' self-efficacy for implementing physical activity or avoiding sedentary behavior but also how frequently teachers *use* these practices that can support children's behaviors.

The present study is the one of only a few to develop a broader understanding of teacher physical activity practices and how they relate to children's physical activity and sedentary behavior. We used strong, objective measures of physical activity and sedentary behavior from multiple days of accelerometry for each child. Also, the use of exploratory factor analysis allowed the characterization of three distinct constructs related to teacher practices, their self-efficacy, and perception of center environment support for physical activity.

Limitations include the use of cross-sectional data which precludes our ability to make inferences about the direction of the association between identified factors and child physical activity or sedentary behavior. Additionally, the small sample size may have limited our ability to detect meaningful relationships between teacher practices and perceptions and child outcomes. Also, these data were taken from an existing data set which was collected between 2008 and 2009. It is possible these data reflect teacher perceptions that are now outdated; however, no secular efforts around altering teacher physical activity and sedentary behavior practices have

occurred. Finally, this sample may not represent ECE centers in other demographic or cultural settings although the sample was representative of NC based on demographic characteristics. There may be differences in the way these practices are used and fit within the larger ECE context in other areas with different perspectives on children's physical activity and sedentary behavior and ECE standards.

This emerging area offers many opportunities for future research. More work is needed to understand the role of constructs such as self-efficacy to overcome barriers, as our items only assessed task self-efficacy (e.g., ability to implement physical activity) Information on barrier self-efficacy may relate more directly to what intervention efforts are needed to support teachers. Also, future work should investigate a wider range of teacher practices than those within our teacher practices factor, as there may be additional practices that are important. For example, we found significant associations between two practices that did not load onto the factor structure (withholding physical activity as punishment and and making portable play equipment available to children) and child outcomes (data not shown). A further distinction between practices related to the reduction of excess sedentary behavior from those focused on the promotion of physical activity is needed, as our knowledge of sedentary behavior within ECE settings deepens.[190]

Additionally, future studies are needed to understand mediators that should be considered in interventions should focus on to increase physical activity and decrease sedentary behavior in ECE settings. Knowledge of what constructs are best to target within interventions, what strategies are needed to modify those constructs, and if modifying them will change children's behaviors will increase the chances that interventions will be successful. For example, in light of the inverse association between teacher practices and children's physical activity, physical activity promotion efforts may need to start earlier than aiming to increase these practices and

teachers' confidence. It might be more efficacious, instead, to start by increasing the awareness of what these practices are, how they operate within the larger ECE setting, and their potential for improving children's activity levels and development.

Conclusions

This study identified three factors related to teacher physical activity and sedentary practices, including their self-efficacy for implementing physical activity and their perception of the center supports for physical activity. We found an inverse relationship between teacher perception of center supports for physical activity and accelerometer-measured sedentary behavior of children. While relationships with child outcomes were mixed, this work adds to the understanding of how teachers may use their behavior to support children's physical activity or discourage sedentary behavior within the larger context of ECE centers. Results from this study reinforce the need for continued efforts to understand the role of the classroom teacher in promoting healthy physical activity and sedentary behavior profiles in children. Additionally, results can be used to inform physical activity promotion and sedentary behavior reduction efforts in ECE centers that depend on teachers to implement intervention activities.

CHAPTER 6: EFFICACY OF A GROUP-RANDOMIZED TRIAL TO INCREASE PHYSICAL ACTIVITY AND DECREASE SEDENTARY BEHAVIOR IN PRESCHOOL CHILDREN IN EARLY CARE AND EDUCATION CENTERS: THE MOVE, PLAY, LEARN! INTERVENTION

Overview

Interventions to increase preschool children's physical activity and reduce sedentary behavior within early care and education settings have had modest success. Most previous interventions have focused on the implementation of standardized curricula separate from the classroom's usual activities and have not adequately engaged teachers to modify their interactions with children. The purpose of this study was to develop and test the 10-week Move, Play, Learn! intervention, a professional development intervention to support teachers in modifying their existing indoor and outdoor classroom activities to increase children's total physical activity during the child care day.

Twenty-six ECE centers were recruited and randomly allocated to the intervention or a wait-list control group. Intervention teachers attended two in-person workshops and were asked to modify one pre-specified classroom activity (e.g., circle time) and one teacher practice (e.g., joining in active play) for two weeks, followed by three other classroom activity and practice pairings. Children's total physical activity (non-sedentary time) was measured in 182 children for 5 child care days with accelerometers. Mixed effects models with center as a random variable were used to test the effects of the intervention on physical activity. Additionally, teachers

reported on the classroom and center environment, their practices, and Social Cognitive Theory constructs.

Children in the intervention arm had a higher total volume of physical activity at follow-up 480.2 ± 9.3 counts per minute) compared to children in the control group (459.7 ± 9.4 counts per minute), p=0.12. Although this was not a statistically significant difference, it appeared to be driven by an increase in vigorous activity in the intervention group at follow-up (5.6 ± 0.1 minutes/hour) compared to the control group (5.4 ± 0.1 minutes/hour), p=0.13. Teachers in the intervention arm reported a statistically significant increase in encouraging children to be active compared with control teachers.

The intervention did not produce meaningful improvements in child physical activity behaviors, but the overall professional development and technical assistance approach was well-received by teachers. Professional development and technical assistance is a promising strategy for future interventions, and additional research is needed to test strategies specifically to reduce sedentary behavior in children and that leverage natural opportunities within classrooms to integrate physical activity.

Background

The many benefits of participating in regular physical activity and avoiding excess sedentary time to young children's short- and long-term health and development have been well documented.[1,18-30] Despite these benefits, it is estimated that preschoolers (3-5 year olds) spend about 10 hours each day inactive.[14] Physical activity behaviors established early in life track into adolescence and adulthood,[53,54] and as, such experts have called for efforts to increase physical activity and reduce excess sedentary behavior focused on young children.[30,55]

Early care and education (ECE) centers are a key setting for these promotion efforts because many children spend large amounts of time there.[60,61] In the United States, more than 7 million children under 5 years attend center-based child care,[15] where the average enrolled child spends about 30 hours each week.[62] The ECE setting is a major influence on children's physical activity and sedentary behaviors.[70-72] and maybe the primary source of physical activity for many children. While the importance of the ECE setting is well known, physical activity levels of children in child care remain low, and levels of sedentary behavior are high.[49,65-69] Prior interventions have shown that these child behaviors can be improved when ECE centers change the physical activity and sedentary behavior provisions (i.e., time and spaces available to children) and practices (e.g., encouraging children to be active, co-participation with children).[100,196,197] However, additional research is needed to determine which changes are most effective and how they can be institutionalized within ECE classrooms.

While interventions to modify the provisions and practices within ECE centers have been tested, the impact on child behaviors has been inconsistent and few have been successful.[105,109,123,126,132] Three potential strategies for increasing child physical activity through child care programs have received inadequate attention. First, most interventions have relied on a standardized physical activity or gross motor development curriculum to provide activities in addition to their usual classroom schedule.[3,6,105,124,129,130,132,133] Using a physical activity curriculum required adding extra time in a prescribed daily schedule is often challenging for child care programs. A promising approach, but with limited application, is including intervention activities that are designed to meet other learning objectives (e.g., numeracy, literacy, emotional development) along with providing physical activity to children, allowing intervention activities to be integrated into a classroom's daily routine.[126,132] Second, few studies

have included a focus on teacher practices, despite an understanding that teachers' influence is broader than the allocation of time for physical activity or the implementation of curricular-based activities.[118,126] Finally, we are aware of only one study that specifically aimed to reduce sedentary behavior;[119] instead, studies typically focus on increasing total physical activity or moderate-to-vigorous physical activity (MVPA) with a reduction in sedentary behavior as a byproduct. Reducing the amount of time children spend seated (defined as sedentary) may help children accumulate additional physical activity time.

Theory-informed intervention studies are also missing in the child care physical activity literature that address barriers and facilitators of teachers' behavior which affect their ability to create more opportunities for children to be active. Many studies are either atheoretical or articulate a theoretical underpinning without information on which constructs were used or how constructs map onto intervention objectives.[106,112,115,121,125] For example, Social Cognitive Theory[198] is a commonly cited theory, since ECE interventions targeted within classrooms are inherently educational. Other theories such as Self-Determination Theory,[199] which leverages intrinsic motivation to sustain behavior change, may be useful for interventions that require teachers to change their instructional or personal behaviors. In addition to the absence of theory in many ECE intervention, few have articulated the use of behavior change techniques, the most basic components of an intervention intended to modify processes that regulate behavior, within classroom-based interventions.[200]

Across prior interventions, there has been a temporal shift from researcher-delivered interventions to those delivered by teachers, which allows these interventions to have a greater potential for dissemination. With this shift, there is a need to train teachers to implement intervention activities, delivered through in-person workshops and sometimes reinforced with

ongoing technical assistance (e.g., follow-up visits, phone calls, emails).[3,126] This training and technical assistance has focused narrowly on how to implement the standardized curricula and misses an opportunity for broader professional development that could benefit teachers beyond the intervention period. A more comprehensive professional development model would include information and discussion about how physical activity translates to better physical, psychosocial, and cognitive development and the spectrum of opportunities for physical activity promotion and sedentary behavior reduction and leave teachers with a skill set that is wider than required to implement a static, standardized curriculum.

The purpose of this study was to test a theoretically-driven intervention using professional development to facilitate changes to the physical and social environment to improve physical activity outcomes for children in ECE centers. The Move, Play, Learn! (MPL) intervention was designed to improve children's total physical activity (i.e., nonsedentary time) through a training model rooted in Social Cognitive and Self-Determination Theories with corresponding behavior change techniques to support teachers in integrating physical activity and physical activity-supportive teacher practices into their existing classroom schedules. We hypothesize that children in classrooms of teachers randomized to the 10-week intervention will have greater increases in total physical activity measured at baseline and immediately after the intervention than those randomized to the waitlist control arm. Secondary outcomes related to teachers' psychosocial factors and aspects of the classroom environment that could hypothetically be impacted by the intervention.

Methods

Study design

Twenty-six ECE center teachers (1 teacher per center) were randomized 1:1 into either the intervention or waitlist control arms to test the efficacy of the intervention on children's accelerometer-measured total physical activity and sedentary behavior during child care hours.

Sample description and recruitment

We used convenience sampling to recruit 26 ECE programs through North Carolina's (NC) Department of Child Development and Early Education (NCDCDEE) online database of ECE programs. Recruitment took place in Orange, Durham, Alamance, and Guilford counties in two waves: 1) July to August 2016 and 2) November 2016 to January 2017. Directors of these eligible centers were contacted by phone to assess eligibility and interest in the program. Eligible centers had at least a 2-star rating on NC's quality rating and improvement system.[147] All licensed ECE settings in NC are evaluated using this system based on physical spaces, program standards, and staff education and given a rating of 1 (lowest) to 5 (highest) stars. An additional eligibility criterion for this study was that centers had to have at least one preschool classroom with children between 3-5 years of age and at least 10 preschool children enrolled in that classroom to ensure our ability to recruit sufficient numbers of children. Centers were excluded if directors reported in the screening call that they were already providing the recommended 120 minutes of physical activity (outdoors and indoors) to children.

Once research staff confirmed that a center director was interested in the program and the center met eligibility criteria, the research staff and center director worked to identify one preschool classroom teacher per ECE program to participate. Only one teacher per center was

enrolled into the study to maximize statistical power and minimize budget in this small-scale study. Teachers were eligible for participation if they had not completed a program to improve physical activity within the preceding six months and were willing to attend both in-person group workshops. Consent of the participating teacher was obtained through an in-person meeting with the teacher. Research staff worked with teachers via telephone calls to recruit children who would remain in the classroom for the entire study period, from baseline data collection through follow-up data collection. Teachers distributed and collected consent forms to parents of children in their classroom to obtain consent for children to wear accelerometers. All methods were approved by the University of North Carolina at Chapel Hill Institutional Review Board, and the trial was prospectively registered with clinicaltrials.gov (NCT02851030).

Outcome assessments and randomization

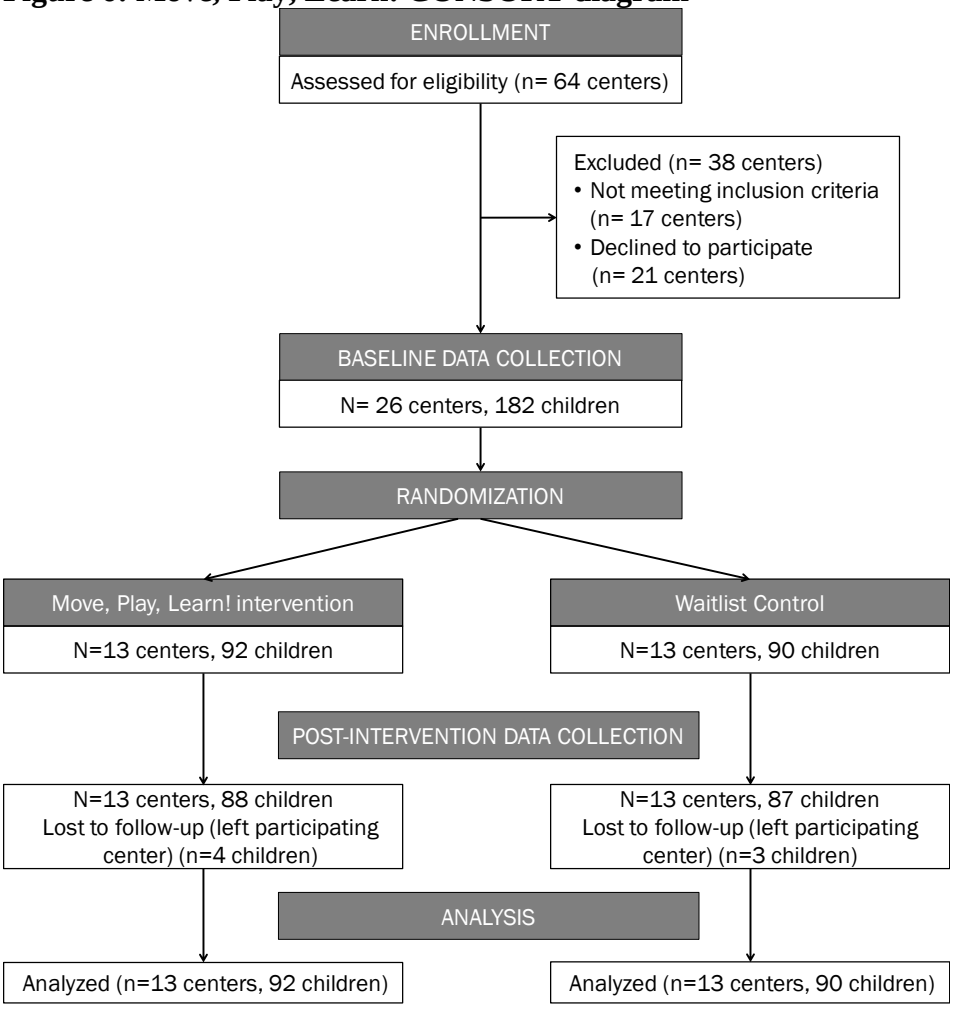
Following teacher and parent consent, baseline data collection was conducted, and randomization took place after completion of all baseline measures (Figure 6). Data collection consisted of accelerometer-measured teacher and child physical activity and teacher-reported demographics, physical activity- and sedentary behavior-related provisions, practices, and perceived self-efficacy for implementing physical activity and reducing sedentary behavior. Parents reported child age, sex, and race/ethnicity. Accelerometers were fit on participating children and worn for five days during times children were in the center.

After baseline data collection, classrooms were randomly assigned to either the 10-week intervention or a wait-list control group. The intervention participants then completed the intervention protocol, while control group participants were asked to proceed according to their normal practices. All measures except demographic characteristics were repeated at follow-up to

assess the impact of the intervention. Gift card incentives were offered to teachers for completing each measurement period: $25 for baseline and $35 for follow-up. After follow-up measures were completed, the control group received the intervention.

In-depth interviews with seven randomly selected intervention teachers were conducted once the initial intervention implementation was complete to understand the intervention from the perspective of a teacher and what modifications to the intervention format or content would be necessary. Once follow-up data collection was completed, the intervention was offered to those programs randomized to the waitlist control group.

Figure 6: Move, Play, Learn! CONSORT diagram



Intervention description

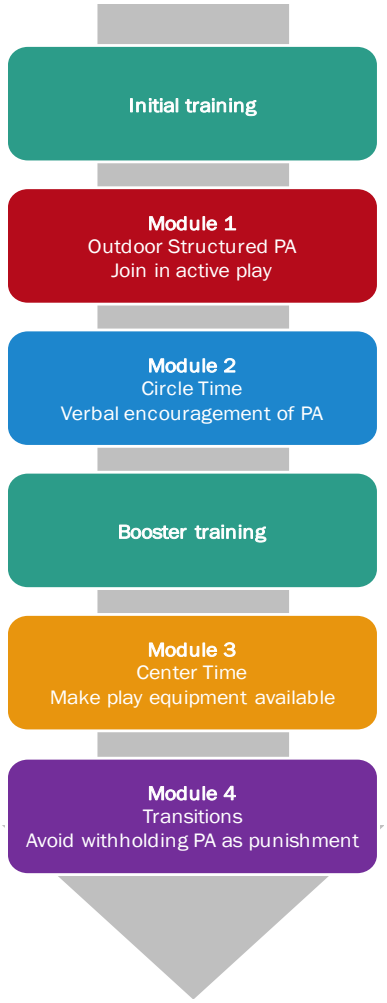
The intervention lasted 10 weeks, divided into two weeks for training workshops and four implementation modules of two weeks each that focused on specific segments or components of the child care day schedule (Figure 7). Workshops were held at the beginning and at the midpoint of the intervention period (5 weeks). Teachers were asked to implement intervention activities during specific times of day and to focus on key teacher practices. These classroom modifications were supported by weekly technical assistance from the interventionist. Segments of the day included outdoor time, circle time, center time, and transitions. Teacher practices were informed by the literature and included: joining in active play; verbal encouragement of physical activity and discouragement of sedentary behavior; making portable play equipment available; and not withholding physical activity as punishment.

Formative Research

Prior to the design and implementation of the Move, Play, Learn! Intervention, a 4-week feasibility pilot was conducted with 22 ECE teachers from 6 centers. Teachers participated in an in-person training workshop, where they were introduced to the project; gained knowledge of children's physical activity; built skills on implementing physical activity in their classrooms; and received active play toys and physical activity lesson plans to support their efforts. Following the workshop, teachers focused on one area of their child care day each week. Intervention activities were designed to be implemented within one of four focus areas (outdoor time, circle time, center time, transitions), to be short (~10 minutes each), and to integrate into

the classroom's existing structure. Weekly, project staff contacted the teachers by phone or text to provide technical assistance.

Figure 7: Intervention overview



Feedback from the participants was positive, and all teachers noted that children enjoyed participating in the activities and that they would participate in a similar program in the future. This small-scale feasibility pilot provided evidence that the overall approach was accepted by teachers and that they would be willing to implement classroom activities integrated into their existing classroom activities.

Intervention components

Teacher training: Teachers attended two in-person, half-day workshop, which presented information about children's physical activity and sedentary behavior at ECE centers based on prior research studies.[148,149] Teachers learned about the role of child care in supporting these behaviors in children; opportunities to integrate physical activity and reduce sedentary behavior in their daily schedule; and teacher practices that can support physical activity and discourage sedentary behavior. Afterwards, group discussions centered on how they could operationalize topics from the workshops into their classrooms and what motivated teachers to promote healthy physical activity and sedentary behaviors in children. These discussions were designed to modify teachers' outcome expectations and expectancies and to increase teachers' autonomy and feelings of relatedness

(Figure 8). Relevant behavior change techniques, e.g., instruction on how to perform a behavior, were incorporated into presentations and discussions (Appendix 4).

During both workshops, participants received intervention materials: MPL! activity lesson plans, activity cards corresponding to each MPL! activity, and $30 worth of portable play equipment (Appendix 5). Demonstrations of activities led by the interventionist targeted observational learning, and hands-on practice with intervention materials facilitated increases in behavioral capacity and competence. Participants received contact hours, a type of continuing education credit provided through the NCDCDEE for attendance at workshops.

Classroom-based modules: After teachers completed the first in-person training workshop, they implemented intervention activities during four two-week modules. Each module focused on one time of the day and one teacher physical activity practice (Figure 7). Times of the day reflected classroom activities typically occurring in preschool classrooms, and teacher practices were chosen based on previous literature.[78,126,148] Within each module, newsletters, goal setting and self-monitoring, weekly technical assistance, and text message reminders were used to support implementation of classroom activities and teacher practices (Table 7).

Newsletters sent at the beginning of each module reviewed information covered on that segment of the child care day in the training workshop (e.g., circle time) and gave them guidance on how to modify their behavior (e.g., verbally encouraging children to be active) to increase physical activity during that segment. They also included potential barriers to increasing physical activity and how to overcome these barriers (Appendix 5).

Teachers were reminded to set goals around the amount of time they would implement intervention activities and to share those with the interventionist. Teachers self-monitored

frequency of implemented intervention activities or engaged in teacher practices and reported progress to the interventionist each week. Goal setting and self-monitoring were intended to increase teachers' self-efficacy for implementing physical activity and reducing sedentary behavior, and appropriate behavior change techniques (e.g., restructuring the physical and social environments) matched these activities.

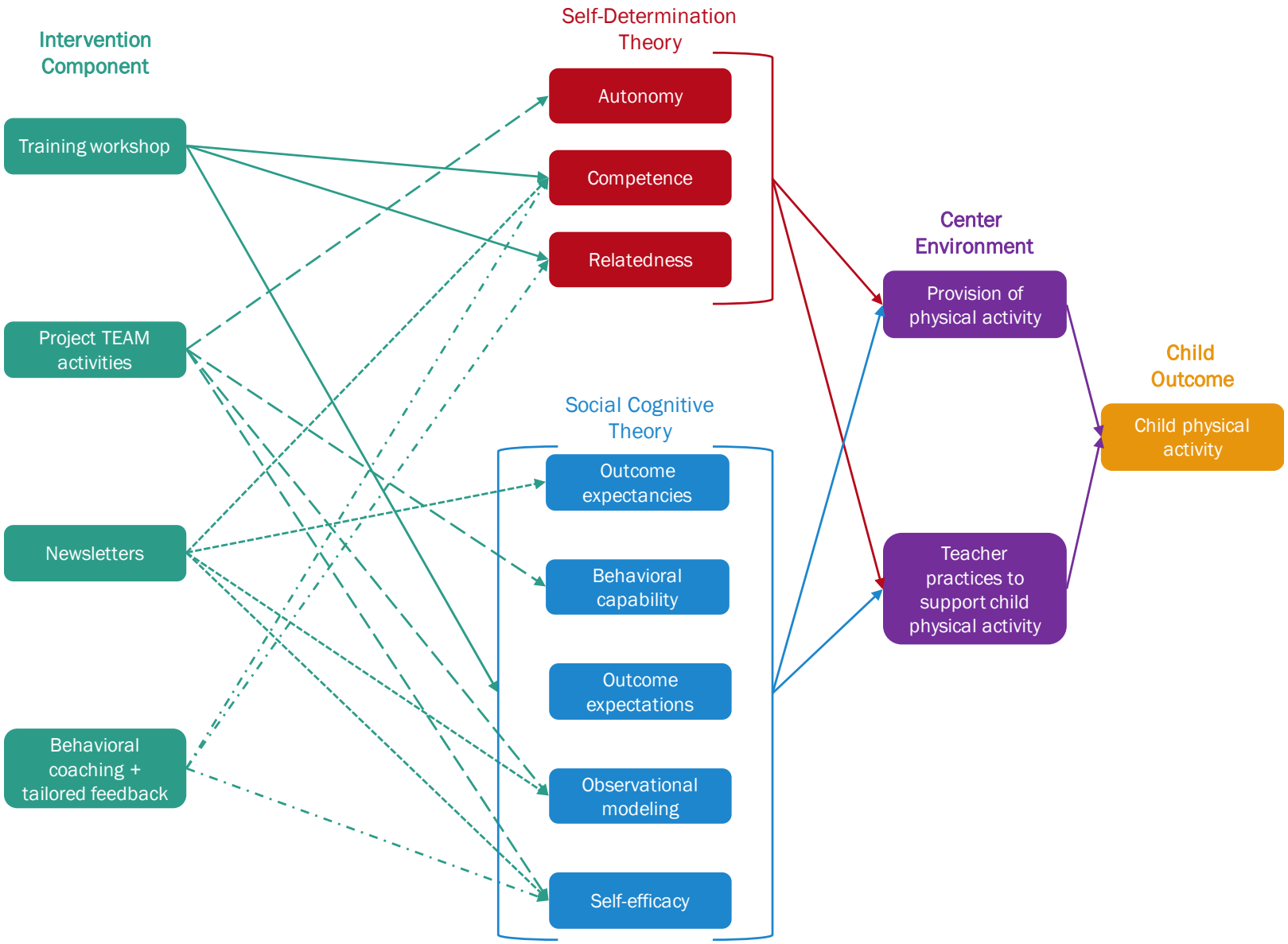
The interventionist provided technical assistance to each teacher through phone calls, emails, or text messages based on teacher preferences for communication to help teachers overcome challenges during implementation, increase their behavioral capacity and self-efficacy. Calls provided social support and fostered a sense of relatedness with the interventionist. For example, if a teacher had problems with classroom management (or feared behavior problems) as a result of a classroom activity, the interventionist worked with the teacher to identify ways to create a smooth transition between a physically active lesson and the next classroom activity.

Last, teachers were sent text message reminders about implementing intervention activities about 2 times/week at the start of their day or during children's nap time. These times of day were chosen because they are times that teachers are likely to check their phone.

Table 7: Description of intervention components of classroom modules

Classroom module component	Component description
Newsletters	• Review information presented in training workshop on each module's segment of the day and teacher practice • Address barriers to implementation
Goal setting and self-monitoring	• Teachers choose implementation frequency (e.g., add 2 activities per week) • Progress towards goal tracked weekly
Weekly technical assistance	• Review goal setting and implementation progress with interventionist
Text message reminders	• Sent twice a week to prompt implementation

Figure 8: Move, Play, Learn intervention conceptual model



Data collection procedures

Outcome data were collected within the child care center at two time points – baseline and at the end of the 10-week intervention (Table 8). Additional data on theoretical constructs were collected at the midpoint of the intervention (5 weeks) during the second training workshop. Because the study was small in size and budget, the interventionist also served as the data collector and was not blinded to treatment allocation during follow-up data collection. The interventionist was previously trained on data collection with accelerometers, and was experienced in other measures did not require training (i.e., self-report surveys).

Primary outcome measure

The primary outcome, change in total physical activity between baseline and post-intervention, was assessed with accelerometer-measured minutes of children's non-sedentary time using GT3X accelerometers (ActiGraph, Pensacola, FL). Children wore accelerometers during waking hours for five child care days at each data collection time point, which was used to estimate usual behavior at each measurement point. Accelerometers were worn only during child care hours, beginning when the child arrived for the day and ending when the child left. Teachers were instructed to remove the monitors during water-based activities and when children left the center each day. Monitors were worn on a belt and placed over the right hip. Accelerometers were programmed to 5-second epochs and to sample acceleration at 30 Hz.

Epoch-level files were obtained using the ActiLife software, and data processing was done in SAS v9.4 (Cary, NC) using dates and times logged by teachers. The National Health and Nutrition Examination Survey (NHANES) nonwear algorithm was used to identify nonwear periods, defined as intervals of at least 60 consecutive minutes of zero activity intensity counts,

allowing for 1-2 minutes of counts between 0 and 100.[150] Cutpoints developed for children were used to classify data into sedentary behavior (<25 counts per 15 seconds),[151] light physical activity (25 – 419 counts per 15 seconds), moderate physical activity (420 – 841 counts per 15 seconds), vigorous physical activity (≥842 counts per 15 seconds), total physical activity (≥25 counts per 15 seconds) and moderate-to-vigorous physical activity (MVPA, ≥420 counts per 15 seconds).[152] An additional estimate of MVPA was calculated using alternate cutpoints (≥574 counts per 15 seconds).[151]

Child care day-level summaries were calculated as a sum of epoch-level data for sedentary behavior and MVPA. Minutes per hour of sedentary behavior and different intensities of physical activity were then calculated to account for differences in total wear time. An average of epoch-level counts per minute was calculated as an intensity-weighted daily average of physical activity. Change in average counts per minute at childcare was used as the primary outcome variable to detect changes in total volume of physical activity, since intervention activities could have moved children from sedentary to light physical activity and from light to moderate or vigorous physical activity. Three days of wear for ≥4 hours (excluding nap time) were required to be included in the analytic sample.[160]

Secondary outcome measures

Sample demographics

Demographics were collected at baseline through teacher and parent surveys. Teacher reported age, race/ethnicity, height, weight, educational attainment, years of experience in the child care, and training on physical activity. Parents reported child sex, age in years, and race/ethnicity.

Teacher physical activity

Teacher physical activity outcomes were measured also using accelerometry on the same days as the children wore accelerometers. Change in minutes of MVPA and sedentary behavior between baseline and follow-up were measured with the GT3X model accelerometer. Data collection followed the same procedure as with child measures, with five child care days of wear collected at each time point using a sampling frequency of 30 Hz and a 1-minute epoch length. The same NHANES nonwear algorithm to identify nonwear time in child accelerometry was used for teacher accelerometry.[140] Cutpoints were used to classify data into sedentary behavior (<100 counts per minute) and MVPA (>2020 counts per minute),[153] and average counts per minute.

ECE center physical activity and sedentary behavior environment

The physical activity environment within centers was assessed using the Environment and Policy Assessment and Observation – Self-Report (EPAO-SR) instrument. The EPAO-SR is a validated, comprehensive measure of both the nutrition and physical activity environments of child care centers reported by center directors and classroom teachers.[46] Only items related to physical activity and sedentary behavior were included this study (149 items). Many items asked teachers to report time spent in various activities in the morning or afternoon or the presence of active play equipment and could be skipped if that activity did not take place. Teachers completed the EPAO-SR on two days at each data collection time point to obtain a stable estimate of usual behavior.[140]

Select constructs from the EPAO-SR that were relevant to the intervention were analyzed. Changes in the four teacher practices targeted within the intervention were calculated. Also, overall scores for teacher practices and perceived center environment support for physical activity and sedentary behavior were calculated based on a previous study.[148] EPAO-SR data were used to calculate total minutes of typically occurring activities, including circle time, center time, outdoor play time, teacher-led physical activity indoors and outdoors, and required seated time. Last, teachers were asked to report on the activity level of children during circle time on a scale of 1 (mostly seated) to 7 (mostly running) to estimate intensity of activity specific to circle time.

Behavior change theory constructs

Surveys measuring teachers' self-efficacy, outcome expectations, and outcome expectancies specific to physical activity promotion and sedentary behavior reduction within their classrooms were collected at baseline, intervention midpoint, and follow-up data collection. Self-efficacy items (28 items) were taken from previous studies.[148,155,156] The outcome expectations and expectancies measures (16 items each) were taken from previously validated questions.[155,157] Teachers responded to self-efficacy and outcome expectations items with how much they agreed with each statement on a 6-point Likert scale. Outcome expectancies items asked teachers to respond with how important they perceived each outcome expectancies item with a 4-point scale (Appendix 6).

Table 8: Move, Play, Learn! measures summary

Measure	Assessment method	Measured at		
		Baseline	Mid-point (5 weeks)	Follow-up (10 weeks)
Primary outcome				
Children's physical activity at child care	Accelerometry	X		X
Mediators				
ECE PA Environment	EPAO-SR	X		X
Teacher practices and perceived center environment support	Teacher survey	X		X
Teacher behavior change constructs • Self-efficacy • Outcome expectations • Outcome expectancies	Teacher survey	X	X	X
Moderators				
Teacher demographics (age, race/ethnicity, education, prior PA training	Teacher survey	X		
Teacher physical activity at child care	Accelerometry	X		X
Child demographics (age, sex, race/ethnicity)	Parent survey	X		

Process evaluation and program satisfaction

Process evaluation was collected to assess implementation of the intervention according to the framework provided by the National Institutes of Health's Behavior Change Consortium (Table 9).[158] Additionally, several process evaluation measures outside of the BCC framework were assessed to understand reach and acceptability (Appendix 7).

Table 9: Process evaluation measures

Process evaluation component	Data source
Behavior Change Consortium framework	
Fidelity to study design	• Interventionist report of participant contacts (date, time, length, content, mode)
Consistency of treatment delivery	• Use of standardized intervention materials • Interventionist report of participant contacts
Treatment receipt	• Teacher report of receiving intervention materials (newsletters, text messages, contact from interventionist) from surveys at end of the intervention
Treatment enactment	• Teacher goal setting and self-monitoring logs
Additional process measures	
Reach	• Recruitment tracking logs of numbers of centers contacted and screened
Acceptability of the intervention	• Teacher surveys at end of the intervention • Exit interviews with 7 randomly selected intervention participants

Power calculation

An *a priori* power analysis estimated that 182 child participants were needed to detect an 0.55 effect size in counts per minute based on changes in total physical activity and MVPA in prior studies,[109,123,132] assuming an ICC of 0.12,[149] an alpha of 0.05, 80% power, and average cluster size of 7 children per classroom. Initially, recruitment was planned to account for 15% attrition of teachers. However, based on the short duration of the study and acceptable retention in wave 1, no additional teachers and children were recruited.

Statistical analysis

Differences in total physical activity at follow-up by treatment arm were tested under the intent-to-treat principle (ITT) using longitudinal, mixed effects models that included a random effect to account for the correlation of child physical activity by ECE center and controlling for baseline total physical activity (SAS v9.4, Cary NC). Additional models were fit that adjusted for baseline covariates distributed differently between study arms: child sex and teacher education (college degree vs. no college degree). Missing data were minimal and mostly due to children leaving the classroom to move into school or another child care program (n=7 children total missing at follow-up). Multiple imputation was used to impute missing physical activity values based on child sex, age, and race.[161,162] PROC MI was used to develop five datasets with data imputed for missing physical activity values at follow-up using the Markov chain Monte Carlo procedure. Generalized linear models were fit to test differences by arm in secondary outcomes.

Results

Sample characteristics

ECE centers from which teachers and children were recruited were mostly 3- or 4-star centers (Table 10). The classroom teachers were all female and had been a teacher for about ten years. Most were Non-Hispanic White (38% overall) or Non-Hispanic Black (46% overall). The majority were highly educated, with 58% having a college degree or higher. Only about half had ever received training specific to children's physical activity or sedentary behavior. Children were on average 4 years old, and about half were female (Table 11), with the majority of children Non-Hispanic White (61% overall) or Non-Hispanic Black (28% overall).

Table 10: Move, Play, Learn! Intervention – center and teacher characteristics

	Intervention teachers (N=13)	Control teachers (N=13)
Center star rating		
2	2 (15%)	1 (8%)
3	4 (31%)	5 (38%)
4	4 (31%)	5 (38%)
5	3 (23%)	2 (15%)
Mean years as a teacher (SD)	10.4 (6.0)	10.5 (6.0)
Mean age in years (SD)	37.2 (12.1)	39.5 (10.6)
Females (%)	13 (100%)	13 (100%)
Race/ethnicity		
Non-Hispanic White	6 (46%)	4 (31%)
Non-Hispanic Black	6 (46%)	6 (46%)
Hispanic	0 (0%)	2 (15%)
Other	1 (8%)	1 (8%)
BMI Category		
Underweight or normal (<25 kg/m^2)	5 (38%)	3 (23%)
Overweight or obese (≥25 kg/m^2)	8 (62%)	10 (77%)
Highest level of education		
High school diploma or lower	0 (0%)	1 (8%)
Some college	4 (31%)	6 (46%)
College degree or higher	9 (69%)	6 (46%)
Prior training on physical activity		
Never	7 (54%)	6 (46%)
>1 year ago	4 (31%)	3 (23%)
6 months - 1 year ago	2 (15%)	4 (31%)

Table 11: Move, Play, Learn! Intervention - child characteristics

	Intervention children (N=92)	Control children (N=90)
Mean age (SD)	3.9 (0.7)	3.7 (0.7)
Females (%)	47 (51%)	41 (46%)
Race/ethnicity		
Non-Hispanic White	55 (60%)	56 (62%)
Non-Hispanic Black	3 (25%)	27 (30%)
Hispanic	12 (13%)	5 (6%)
Other	2 (2%)	2 (2%)

Changes in child physical activity

Seven children left the center during the intervention period, and nine had insufficient accelerometer data at follow-up (95% retention). At baseline, children accumulated an average of 118 minutes of total physical activity per child care day and 433 counts per minute, with no meaningful differences noted between groups. The primary outcome analysis indicated that children in the intervention arm averaged 480.2 ± 9.3 counts per minute at follow-up compared to 459.7 ± 9.4 counts per minute in the control group controlling for baseline (p-value = 0.12, Table 12). This difference was not statistically significant and corresponds to a small effect size (Cohen's d = 0.2).

There was an increase in vigorous physical activity in children in the intervention group compared to those in the control, (5.6 vs. 5.4 min/hr, respectively). This increase was not statistically significant (p=0.13) but equates to an increase in vigorous activity of 6 minutes per week in the intervention group compared to control group, which was the largest effect size change of the accelerometer outcomes (Cohen's d = 0.3). No other practical or statistically significant differences were noted in the amount of sedentary behavior, total physical activity, or MVPA by treatment arm in crude analyses, those adjusted for child sex and teacher education, or using alternate cutpoints for MVPA.

Table 12: Baseline and follow-up child accelerometer outcomes and comparisons between intervention and control centers

	Intervention				Control				
	Baseline		Follow-up		Baseline		Follow-up		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	p-value[a]
Counts per minute (mean)	441.2	9.9	480.7	9.3	424.9	10.0	459.1	9.4	0.12
Sedentary behavior (min/hr)	42.8	0.4	42.8	0.4	43.1	0.4	43.0	0.4	0.86
Total physical activity (min/hr)	17.2	0.4	17.2	0.4	16.9	0.4	17.0	0.4	0.86
Light physical activity (min/hr)	9.2	0.2	8.6	0.2	9.0	0.2	8.7	0.2	0.54
MVPA (min/hr)	8.0	0.2	8.6	0.2	7.9	0.2	8.3	0.2	0.33
Moderate physical activity (min/hr)	2.9	0.1	2.9	0.1	2.9	0.1	2.9	0.1	0.98
Vigorous physical activity (min/hr)	5.1	0.1	5.7	0.1	4.9	0.1	5.4	0.1	0.13
Wear time (min/day)	421.4	13.9	417.1	18.1	417.6	14.0	413.6	18.2	

[a] p-values from mixed effects models testing the effect of the intervention on accelerometer outcomes at follow-up controlling for baseline values and accounting for clustering of children within centers.

Changes in secondary outcomes

Of the four teacher practices included within the intervention, the largest change was observed for teachers encouraging children to be more active and less sedentary (Table 13). Intervention teachers reported a statistically significant increase in this practice compared to a decrease reported by control teachers (follow-up mean 4.7 vs 3.9, respectively, p=0.02). Also, joining in active play with children was reported more frequently by intervention teachers than control teachers at follow-up (4.0 vs. 3.6, p=0.22). Teachers in both arms reported that withholding of physical activity as punishment for bad behavior was infrequently used, and there were no differences by time or treatment group in this practice. No differences were found for teachers reporting that they made portable play equipment available during play sessions between groups. At follow-up, intervention teachers reported higher levels of self-efficacy, outcome expectations, and outcome expectancies than control teachers, but these differences were small and did not reach statistical significance.

Process evaluation and program satisfaction

All teachers randomized to the intervention group attended both in-person workshops. All teachers said they received each of the newsletters and all but 2 teachers said they read all the newsletters which were intended to be short and easily to read. Of the 104 goals set throughout the intervention (13 teachers for 8 weeks), most teachers chose to set goals to add one additional activity per day within each module (97/104 goals), with few choosing to extend activities they

Table 13: Changes in teacher-reported physical activity and sedentary behavior provisions and practices

	Intervention				Control				
	Baseline		Follow-up		Baseline		Follow-up		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	p-value [a]
Provisions for physical activity and sedentary behavior									
Outside time (min/day)	54.0	25.5	63.6	23.3	60.6	34.3	66.3	27.5	
Center time (min/day)	85.3	40.2	83.7	53.0	86.5	67.7	88.0	58.5	
Circle time (min/day)	26.2	14.5	24.4	12.5	21.3	17.2	23.2	15.3	
Activity rating during circle time [b]	2.7	1.4	4.4	1.4	2.4	1.1	3.2	1.3	0.05
Seated time (min/day)	27.6	14.7	22.7	8.0	32.6	16.8	33.7	16.1	0.05
Teacher-led PA outdoors (min/day)	10.5	11.1	16.3	16.9	14.3	14.6	12.5	16.7	0.58
Teacher-led PA indoors (min/day)	14.1	10.3	18.5	15.5	11.7	15.2	12.7	20.1	0.46
Teacher accelerometer outcomes									
Sedentary behavior (min/day)	259.7	85.3	269.3	85.1	207.0	87.0	285.1	49.8	0.46[c]
MVPA (min/day)	11.0	11.3	10.7	6.7	10.6	7.6	16.5	9.9	0.09[c]
Practices and perceptions around physical activity and sedentary behavior									
Teacher physical activity practices	4.1	0.8	4.6	0.7	3.9	0.8	4.0	0.6	0.05
Join in active play with children	3.8	0.8	4.0	1.2	4.1	1.1	3.6	0.8	0.22
Withhold physical activity as punishment	5.5	0.8	5.5	0.7	5.5	0.9	5.4	0.8	0.99
Encourage children to be more active or less sedentary	4.5	1.0	4.7	0.9	4.6	1.0	3.9	0.7	0.02
Make portable play equipment available	3.5	1.3	3.8	1.3	3.8	1.2	3.8	1.2	0.88
Center environmental support	3.8	1.0	3.5	1.4	3.5	1.1	3.9	0.9	0.46
Self-efficacy for promoting PA and reducing SB	3.9	0.5	4.2	0.7	3.9	0.9	3.7	0.8	0.14
Outcome expectancies	4.5	0.3	4.8	0.3	4.4	0.3	4.5	0.3	0.23
Outcome expectations	4.3	0.2	4.6	0.2	4.4	0.2	4.5	0.3	0.22

[a] p-values are from generalized linear models comparing mean follow-up values of intervention versus control groups, controlling for baseline values. Statistical comparisons were only made for constructs that were targeted for change within the intervention. For example, the intervention was not designed to change the amount of center time provided, and this data is intended to be descriptive in nature.

[b] Intensity of children's activity during circle time was rated by teachers from 1 (children were mostly sitting) to 7 (children were running).

[c] Differences in teacher accelerometer outcomes were based on total minutes per day estimates. Wear time differed by time and treatment arm, and controlling for wear time resulted in attenuated differences.

were already planning to do (7/104 goals). Technical assistance was mainly provided through phone calls, 80% of contacts), which lasted an average of 10 ± 4 minutes and was less frequently provided through text messages (20% of contacts). Participation in technical assistance was high; of the 104 possible technical assistance contacts, 72 were made (69%). All teachers said they received the text messages sent twice weekly, but no data were collected on when the messages were received.

Teachers rated the intervention favorably: all but one reported they were satisfied or very satisfied with the intervention and said they would recommend it to others. In exit interviews, teachers in the intervention arm frequently (69%) mentioned that the intervention gave them new ideas of activities to do with children in their classrooms and that they appreciated the support of the interventionist during the technical assistance contacts and other teachers during the workshops.

Discussion

This intervention was designed to increase children's overall physical activity levels by teachers modifying their existing classroom schedule and by incorporating practices supportive of children's activity behaviors. The intervention did not produce statistically significant changes in total physical activity for children in intervention classrooms compared to those in control classrooms. Intervention teachers reported increases in teacher-led physical activity during child care, their use of some physical activity and sedentary behavior practices, and psychosocial outcomes, but these increases were modest and inconsistent, i.e., not all outcomes increased as expected and control group participants sometimes increased more than controls. Process

evaluation data indicated that the intervention was well-received by teachers and that teachers received the intervention as planned.

Many reasons exist that could potentially explain our findings. One reason the intervention may not have been more successful in impacting child outcomes is that the goal setting process was specific to each module (i.e., teachers only set goals on the current module) and this approach may have been too compartmentalized. Having an isolated goal setting approach may have unintentionally resulted in teachers not making enough changes across different parts of their day to have meaningful changes on child outcomes. Future interventions may work better if goals accumulate throughout the intervention. For example, in the second module focused on circle time, a goal would have been set around circle time activities but also on maintaining the implementation of outdoor play time activities from module one. Teachers were willing to modify their classroom activities individually, but more integration across modules may have been needed to routinize these changes.

In addition, the intervention may have been less successful because teachers mostly used the activities exactly as they were provided (e.g., integration into math lessons) and did not modify the math example to fit other learning objectives that teachers were working towards (e.g., colors or letters). We intended for teachers to use the lesson plans as a scaffold to fit within their particular curriculum unit, for example modifying a circle time activity focused on acting out a story of a fall day adventure to be changed for a trip under the sea during a unit on oceans. Teachers reported these activities as beneficial, albeit still somewhat disconnected from some of their learning objectives. There may not have been a wide enough variety of activities to accommodate the needs of all teachers. Having a wider variety of activities could also facilitate teachers setting and reaching higher implementation goals, and future work should focus on

developing a larger set of classroom activities that can fit a range of commonly used curriculum units than what we were able to offer within this study.

Another possible reason for the lack of a significant intervention effect may be that the intervention had too diffuse of a focus for teachers to latch on to and succeed in any one particular part of the intervention. Within this 10-week intervention, we asked teachers to implement activities to increase children's physical activity and decrease their sedentary behavior across different parts of the day, and to modify their practices to that end. Perhaps more time was spent within the intervention on teacher practices than was warranted, given the inconsistent associations between teacher practices and child physical activity and sedentary behaviors. It is possible that teachers have less of an impact on children's physical activity and sedentary behaviors in ECE centers than other factors such as time and spaces provided to children, and more research is needed to understand the relative impacts of the physical and social environments on children's behaviors. Additionally, only one of the four modules focused on physical activity outdoors, where children accumulate much of their physical activity. The indoor space may be limited in its potential to increase children's physical activity, as indicated by findings from other studies.[201]

Also, our strategies trended more towards increasing physical activity but also on reducing sedentary behavior outright by focusing on times of day that are typically sedentary (i.e., transitions and circle time). It appears that teachers may have been more focused on shifting the intensity of physical activity, given the slight increase in vigorous physical activity but no change in overall physical activity in this study. The differences between the concepts of reducing sedentary behavior and increasing physical activity should be acknowledged, and more

specific work should be done to develop effective intervention strategies focused on reducing sedentary behavior at child care.

While the intervention was not able to produce changes in sedentary behavior or significant amounts of physical activity, teachers found the overall approach to be enjoyable and beneficial to their understanding of children's physical activity and to their classroom. Feedback from the post-intervention interviews and surveys indicate that all teachers found the program useful and that they gained knowledge from it. A majority mentioned that children in their classroom enjoyed the portable play equipment and the classroom activities. Future studies should consider leveraging the influence that children have over what activities are done within the classroom, as has been done in some studies with parent-child dyads.[202] Also, many teachers had "light bulb" moments related to children's physical activity and sedentary behavior, where teachers noted that they had not realized the far-reaching impacts of these behaviors on children's health. Teachers' receptivity to the professional development aspect of the intervention indicates that it remains a feasible strategy for delivering interventions.

The Move, Play, Learn! intervention was designed to be low-burden and not require that teachers to allocate time separate from their daily schedule for intervention activities. Prior interventions using this approach have had inconsistent impacts on children's physical activity, some successful[108,132] but others less effective in maintaining higher levels of physical activity.[121] We are only aware of one study that was successful by focusing teachers on integrating physical activity into their usual schedule with a "Move to Learn" unit.[126] However, this unit was one among three that required teachers allocate extra time for intervention activities, and the intervention seems to have primarily operated by increasing physical activity outdoors.[201]

This study had several strengths: we used a rigorous research design and objective measures to test an intervention to help teachers integrate physical activity and reduce sedentary behavior in the context of their usual daily routines. However, the study was limited by a short intervention period and a small, homogeneous sample where children's physical activity levels were already moderately high (baseline mean of total physical activity was 118 min/day, 50% meeting NASPE guidelines, and 88% meeting IOM guidelines). Also, no measures of the constructs from Self-Determination Theory were assessed to evaluate changes in motivation, and the intervention was implemented and assessed by the same unmasked researcher, which may have influenced teachers and increased their compliance to the program and responses during follow up assessments.

Conclusions

The Move, Play, Learn! intervention aimed to increase children's physical activity through professional development and technical assistance developed for teachers to integrate physical activity sessions and practices supportive of increasing physical activity and reducing sedentary behavior. The 10-week intervention was tested in a randomized sample of 13 classrooms (92 children) compared with a control group of 13 classrooms (90 children). The intervention was not successful in increasing children's physical activity or reducing sedentary behavior during the child care day. However, we observed modest increases in teacher-reported provision of teacher-led physical activity and some teacher practices, and the overall approach was well received by participants. Future studies are needed to determine the best strategies to decrease sedentary behavior of children in ECE centers and how to training and technical

assistance delivered through existing channels to support ECE teachers as they work to build physically active classrooms.

CHAPTER 7: SYNTHESIS

Overview of findings

Promoting physical activity and reducing the time children spend in sedentary behavior during the early childhood period are critical to ensuring that children reach their full developmental potential. In the United States, 7 million children under age 5 attend early care and education (ECE) centers for many hours each week, and the ECE setting is important to foster healthy behaviors. While there have been successes within this setting, this research attempted to address gaps around the questions of: what are the physical activity and sedentary behavior patterns across a typical child care day that could provide opportunities for increased activity; what are the teacher practices and perceptions that support or hinder child behavior that could be targeted for change; and how could teachers be engaged to modify aspects of the physical and social environment through theory-based professional development interventions. Thus, the overall purpose of this research was to identify opportunities and test teacher-implemented strategies to improve preschool children's physical activity and sedentary behaviors within ECE centers through modifications to the classroom's physical and social environments.

Together, this research provides new evidence about physical activity and sedentary behavior within ECE centers. Specifically, it provides quantitative descriptions of opportunities to increase physical activity and decrease sedentary behavior across the child care day during indoor classroom activities such as center time and circle time where children were less active

than outdoor time. Also, this research identified additional teacher practices that can support children's physical activity and reduce sedentary behavior, including the practices of making portable play equipment available and not withholding physical activity as punishment.

Aims 1 and 2 provide insights on indoor classroom activities and teacher practices that were targeted in the Move, Play, Learn! intervention tested in Aim 3. While the intervention did not produce significant increases in intervention children's total physical activity compared to children in classrooms randomized to the control group, the teachers' positive acceptance of the professional development and technical assistance model offers an alternative that could be leveraged in the future to implement strategies for change. Findings from these studies can inform future interventions, recommendations, and policies to increase physical activity and decrease sedentary behavior.

Limitations and strengths

Limitations

While contributing to evidence on physical activity and sedentary behavior in ECE centers, this research has several limitations that should be considered. First, study samples were small and homogenous, capturing a narrow range of classrooms compared with the general population of ECE classrooms. Because the study samples were likely different from those within other geographical and cultural settings or comprised of teachers of different educational attainment, our findings may not generalize to those other populations. For example, differences in climate or licensing standards could impact translation of these results to other geographic areas. Additionally, our sample for aims 1 and 2 was composed of predominantly 4- and 5-star centers (60%). Physical activity environments of centers with overall lower quality may be

different than the higher quality environments of centers in the present sample, and relationships of classroom provisions and teacher practices with child physical activity and sedentary behavior may operate differently. For example, centers with less educated staff (one of the criteria in the rating system) may provide less time for formal learning activities and more for unstructured play. This could result in a decrease as children are not prompted to be physically active within their classrooms, or an increase in children's physical activity as children naturally choose to engage in physical activity during unstructured play periods.[81]

Despite efforts to screening out centers whose directors reported providing the recommended amount of physical activity each day (≥120 min/day), the sample used in Study 3 was an active sample with children receiving an average of 118 min/day of total physical activity, 50% meeting NASPE guidelines, and 88% meeting IOM guidelines). This may have limited our ability to impact child activity, as there was less room for improvement within the child care day compared to programs where children have lower physical activity levels. The sample used for aims 1 and 2 also was more active, with an average of 118 min/day of total physical activity, 84% meeting NASPE guidelines, and 65% meeting IOM guidelines). These estimates are higher than in other studies measuring physical activity with accelerometers,[68] and may not be as well suited for investigating opportunities to increase children's physical activity as other samples with lower physical activity levels. It will be important to employ these strategies with more diverse samples to broaden our understanding of physical activity and sedentary behavior in ECE classrooms.

Second, our findings are limited by the cross-sectional nature of data used in Aims 1 and 2, which preclude our ability to draw casual inferences about how provisions and practices affect children's physical activity and sedentary behaviors. This is of particular concern when

considering that teacher behaviors may be impacted by their appraisal of children's physical activity and sedentary behavior. If teachers perceive children to be sufficiently active, they may not prioritize the adoption of new behaviors. Researchers have observed a bidirectional relationship between feeding practices and child diet,[203] and we would expect the same to be true for physical activity and sedentary behavior. As such, longitudinal study designs should be used to capture the complexities of these relationships and provide stronger evidence for causality.

The last major limitation across these studies is the measurement of teacher practices with self-reported surveys. Teachers rated themselves as highly confident and having a desirable profile of teacher practices. As a result, there was little variation of responses within the samples. A lack of variation and a ceiling effect within the measure likely impacted our ability to accurately assess relationships of teacher practices and perceptions with child outcomes and prevented us from identifying more practices to consider incorporating into Study 3. The measurement challenges likely stem from social desirability bias where teachers rate themselves as having a more favorable profile of a construct such as self-efficacy because they think that is what they are "supposed to" answer. Evidence for social desirability bias is difficult to ascertain for items that ask about usual practice or psychosocial constructs, but there is evidence that teachers rate themselves more frequently using behaviors compared to observed behavior, for example reading a book that contains a positive message about physical activity.[140]

Besides social desirability bias, a disconnect may exist between our conceptualizations of these practices as researchers versus those of teachers. Practices that are more simplistic, such as children losing outdoor time as punishment, are rated similarly between observers and teachers; however, teachers tend to rate practices that are more subjective, such as teachers reading a book with a positive message about physical activity or joining in active play with children, differently

than observers.[140] Future research should ensure that survey items are clear and interpretable to help teachers accurately assess their behaviors or establish alternate methods to evaluate teacher practices. For example, surveys could ask teachers to respond to a classroom-based video clip to understand how they would react in various scenarios, or camera-based observations could be used as a less intrusive way of assessing usual behavior.

Strengths

In light of the limitations, this research has several strengths. First, we used comprehensive, objective measures of the ECE center physical activity and sedentary behavior environment and child behaviors with the Environment and Policy Assessment and Observation instrument (EPAO, Aim 1) and accelerometry across multiple days. This allowed for an understanding of usual practice within classroom settings, even within the limitations of a cross-sectional study design. Also, the use of a data-driven approach to identify factors to leverage within the intervention strengthened this research. Understanding the current activity levels of children during their indoor time allowed us to target defined organizational periods and teacher behaviors that could increase children's physical activity and reduce sedentary behavior.

To our knowledge, this is the one of only two studies that measured theoretical constructs within the context of classroom-based interventions, and this should be continued in other studies to understand how our interventions are operating on outcomes. Additionally, we identified and tested strategies that were minimally burdensome on teachers and could fit within the context of a classroom's usual schedule. A combined training and technical assistance approach like this has the potential to be scaled up and disseminated more easily than interventions that are highly burdensome and resource-intensive. The practical considerations of working within the ECE

center setting cannot be overlooked, and effective strategies that are designed with dissemination in mind are crucial to the success of our research efforts in this area.[204]

Future research directions

Based on the findings and limitations of this research, there are several future directions related to physical activity promotion and the reduction of excess sedentary behavior in preschool-aged children. These opportunities exist in research and practice settings, within the classroom and beyond the classroom walls.

Classroom level, research and practice considerations

At the classroom level, continued research is needed to **refine existing frameworks to understand physical and social environments** within ECE centers and its impact on child physical activity and sedentary behaviors. Based on the limitations we found with measuring the social environment via self-report and the paucity of research on teacher practices in general, there is room to clarify practices and perceptions for a more accurate measurement and a more comprehensive framework of these constructs. Additionally, the use of longitudinal studies with heterogeneous samples will improve our understanding of influences on children's behaviors.

An improved framework will also aid in understanding the mechanism of action of teacher physical activity practices on child behavior. For instance, it may be the case that teacher physical activity and sedentary behavior practices have a more distal effect on children's attitudes, values, and preferences for physical activity and sedentary behavior more so than immediate increases in activity. A parallel can be drawn to the idea of creating a "healthy eater," where we know that a child needs to be provided with more than healthy foods but also needs to

be in an environment where his or her caregivers do not force them to eat certain foods or use food as a reward or bribe.[205] Likewise, to develop a "healthy mover," a child needs to be provided with space and time in which they can choose to be active instead of sedentary, as well as praise and reinforcement from teachers for engaging in physical activity to develop their love of movement.

Also, more research is needed **to identify the most critical theoretical constructs and relevant behavior change techniques** that can support teachers to change their practices that influence children. The Move, Play, Learn! Intervention was developed and evaluated according to select constructs from Social Cognitive Theory and Self-Determination Theory. Intervention research in ECE settings should continue using theoretical constructs and may benefit from using these constructs along with other theoretical frameworks, such as those may facilitate change within organizations (e.g., Consolidated Framework for Implementation Research).[206] Additionally, behavior change techniques such as providing feedback on the targeted behavior could include both feedback on progress teachers make towards their implementation goals and how active or sedentary children are within their classrooms through the use of wearable devices that collect objectively measured physical activity and sedentary behavior and provide teachers with real time feedback.

This research also informs future directions for physical activity promotion and sedentary behavior reduction for young children led by public health practitioners. It is important to continue **engaging teachers in physical activity promotion and sedentary behavior reduction** because they are the most proximal influencer on children within the ECE setting. We need to better support teachers to be motivated to implement physical activity and decrease sedentary behavior by reducing barriers to implementation and by providing them adequate professional

development. For example, play-based learning, where physical activity is integrated with learning, is a promising alternative to traditional physical activity programming that can reduce the barrier of time and motivation, as play-based learning is fun for kids, developmentally appropriate, and does not require the teacher to be an expert in physical activity.[177,178,207] Aspects of play-based learning were incorporated into the Move, Play, Learn! Intervention, specifically within center and circle time activities; however, more work should be done to fully incorporate these philosophies into classroom-based interventions.

Additionally, we need to be thinking about **communicating clear, actionable best practice standards** with teachers around physical activity and sedentary behavior. It can be difficult to discuss vague standards such as "provide 120 minutes of active play each day" with teachers when there is disagreement among researchers on the interpretation of this standard, with some defining it as total physical activity (non-sedentary) and some as MVPA.[66] Operationalizing that standard into classrooms can be confusing to conceptualize and difficult for teachers to know where to begin. Instead, best practice standards should be supplemented with information on how to implement them. For example, an operational directive could be "have 5 types of portable play equipment available and offer it every 10 minutes during outdoor time," as clarity for the current best practice standard to "make portable play equipment available during active play." Having clear, action-oriented messages will make standards easier to implement and can increase their effectiveness on improving children's physical activity and sedentary behaviors. Directive approaches have shown promise in situations where individuals do not have necessary experience with a task, as is often the case for teachers implementing physically active lessons with preschoolers. However, nondirective intervention approaches, where individuals are responsible for determining how behaviors are implemented, have been shown to be effective in

promoting autonomy and routinization of behaviors.[208,209] Both approaches could be useful in helping teachers, and as such, future research should focus on how to balance directive versus nondirective approaches within an intervention. For example, teachers choose to focus on a subset of best practices and directive support is given to guide implementation of chosen best practice standards, which has been effective in the NAPSACC program.[210]

Beyond the classroom, research and considerations

In addition to future directions related to classrooms and teachers, there are several future directions that should be considered beyond the classroom itself. First, it is important to **differentiate strategies to decrease sedentary behavior and increase physical activity**, whether total physical activity, MVPA, or vigorous physical activity. There are opportunities to shift from sedentary behavior to light PA, or move sedentary behavior and light PA to MVPA. Strategies for each are likely different and include more than curriculum-based interventions like the one tested in this research.

Last and perhaps most importantly, we need to think broadly about **what is the incentive for ECE settings to implement physical activity and minimize sedentary behavior**. Essentially we need to make it easier for them to answer the question "what's in it for me and my center?" Knowing that these behaviors are important for children's development is insufficient when you consider the competing demands placed on ECE providers. There should be efforts to include physical activity provision and sedentary behavior reduction into licensing standards and quality rating and improvement systems (QRIS) that carry weight with providers and are more frequently monitored by licensing staff. For example, Wisconsin added an optional credit for providing of 90 minutes of daily physical activity to preschoolers within their Young Star

QRIS.[211] Physical activity standards are rarely specified within licensing standards, and their inclusion in Wisconsin's standards is a recognition of their importance. Whatever the strategy, efforts to make it easier for ECE providers to prioritize physical activity are warranted.

Public health impact and summary

Establishing healthy physical activity and sedentary behaviors during early childhood is critical to optimize children's physical, social, emotional, and cognitive development. As so many children attend center-based care, ECE centers have enormous potential to foster the development of healthy physical activity and sedentary behaviors in young children that they can carry with them throughout their lives. This research supports programs focused within ECE classrooms by identifying key opportunities and teacher practices that can inform future research. Leveraging natural opportunities across the child care day allows for child care providers to add physical activity and reduce excess sedentary behavior within the context of their schedule and directly addresses the burden of insufficient time.

Additionally, this research identified promising strategies to modify the classroom schedule and teacher practices through a low-burden, theory-based professional development and technical assistance intervention. Such approaches can be disseminated through existing channels that support child care providers (e.g., child care resource and referral agents). Additionally, this research shows the potential of the promoting physical activity and discouraging sedentary behavior within indoor spaces, which has been underutilized in previous work. Overall, continued research is needed to optimize physical activity and minimize sedentary behavior of preschool children attending ECE centers, so that child care staff can provide high-quality environments to set young children up for life-long success.

APPENDIX 1: QUALITATIVE RESEARCH FOR PHYSICAL ACTIVITY IN ECE CLASSROOMS

Citation (Country)	Methods	Results

Bellows 2008[89] (US)	IDI (N=31 teachers)	• Teachers offered PA throughout the day, often in terms of theme-based PA or imaginary trips or journeys. Structured PA indoors often with a CD (music/movement)
		• Teachers reported not using a formal PA curriculum
		• Few teachers had formal PA training
		• Center-level barriers: time, equipment, and space
		• Ideal program components
		  ○ Turnkey: "If it is just there, I'd be more willing to do it.''
		  ○ 15-min sessions engaging children's imaginations
		  ○ Activities include a variety of music and theme-driven activities while enhancing school readiness skills

Copeland 2009, Copeland 2012, Copeland 2012[16,91,92]
 	
US
	FG (N=49 teachers), IDI (N=13 teachers)	• Time in child care may be the only opportunity for physical activity and/or outdoor play
		• Physical activity versus academics
		• Benefits of PA: physical and socio-emotional
		• Disadvantages of PA: children could get sick
		• Center-level barriers: safety, finances for equipment
		• Teacher-level barriers: teacher perception of weather, teachers' preferences for being outdoors, physical conditions (allergies/asthma)
		• Child-level barriers: inappropriate clothing
		  ○ Weather-related (coats/hats), inappropriate shoes (flip flops), dress clothes
		• Potential roles of teacher during outdoor play
		  ○ Teacher as facilitator, chaperone, or distracted/disengaged

De Craemer 2013, [93] De Decker 2013[94] Belgium, Bulgaria, Germany, Greece, Poland and Spain	FG (N=87 teachers)	• Teachers think children are very active • Children need to learn to sit down in preparation for elementary school ("be calm") • Facilitators of PA: sufficient facilities, nice weather, stimulating materials at their disposal • Teacher-level barriers: staff shortage, concern for child safety • Importance of role modeling for PA • Barriers specific to reducing sedentary behavior are similar: space and equipment constraints
Dwyer 2008[95] Canada	FG (N=22 parents, 17 teachers)	• Not all results separated by parent vs teacher • Benefits of PA: physical, psychological, social • Facilitators of PA: child personality, physical environment, teacher modeling, peer influence • Child-level barrier: safety concerns
Gehris 2014[96] US	FG (N=37 Head Start teachers)	• Teachers use movement experiences to teach academic concepts, prep for learning • Movement teachers social skills, self-confidence • Teachers connect with children by moving with them, co-activity is motivating to children • Moving outdoors promotes learning

Citation (Country)	Methods	Results
Lyn 2014[17] US	IDI (N=20 directors)	• Process evaluation for nutr/PA intervention • Hands-on activities important for child acceptance
Sansolios 2011[97] Denmark	FG with parents and teachers, N not reported	• Teachers feel increasing pressure to take responsibility for children's health • Emphasis on seeing health broadly, not just nutrition and physical activity • Any intervention needs to be supported by necessary resources and a management commitment

*IDI= In-depth interviews
*FG= Focus groups

APPENDIX 2: EVIDENCE TABLE OF CLASSROOM-BASED INTERVENTIONS IN ECE CENTERS

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Alhassan 2016 - STEP (Short bouTs of Exercise for Preschoolers)[106,136]	Group-RCT, stratified by size and existence of a PA policy Interv (SBS-PA) vs. comparison (UPA)	US (Massachusetts) 3-5y	N= 10 centers, 291 children	Based on Tutti Frutti Instant Recess (TFIR) Short bouts of structured PA (SBS-PA) = 10 min of TFIR via DVD + 20 min unstructured PA vs. 30 min unstructured PA (UPA) Training: 2-hr workshop at each center on importance of PA, how to implement intervention	PA	SEM, Meta-Volition Model (built on SCT and Diffusion of Innovations) Child: self-efficacy, outcome expectations, knowledge, skills	6 months	PA: accelerometers, OSRAP at BL, 3 mo, 6 mo Anth: BMI at BL, 6 mo Process eval: weekly observations of PA sessions to determine fidelity	No sig intervention effect. ↑ % time in sed and ↓ % time in light PA and MVPA for both arms. No between or with group differences by time, except within group ↓ in SBS-PA for %MVPA between BL-3 months
Alhassan 2012 - Project PLAY (Effects of Locomotor Skill Program)[105]	Group-RCT (classroom level) Locomotor skills intervention (LMS-PA) vs. unstructured free playtime (UF-PA) comparison	US (MA) 3-5y 39% Af-Amer, 61% Latino	N=2 centers, 71 children, 8 classrooms	30 lesson plans, each implemented 2-5 times. Lessons done 4 times/week Training: 8-hr workshop on execution of curriculum, received preparation sheets (lesson + prep needed) + equipment	FMS, PA	Curriculum only	6 months	PA: accelerometers (Sirard cutpoints) FMS: TGMD-2	Sig ↓ % sedentary time during preschool (Δ= -9.6, p=0.02) No interv effect on FMS

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Annesi 2013 (IJBM) - Start for Life[108] (Annesi 2013 Psych, Health, Med = pilot,[109] Annesi 2013 Southern Medical Assn = intro to full trial)[110]	Group-RCT Interv (n=18) vs. control (n=8)	US (Georgia) YMCA-affiliated preschools -mostly low-income, 86% Af-Amer Mean age = 4.4 y +/- 0.5 y	N= 26 centers, 1154 children, 98 classrooms	Daily 30-min sessions for structured PA, 3-5 min warmup, 12 activities (total of 2 min VPA, 30 sec LPA, 1 min MVPA), 3 min cooldown Achievement chart tracked progress, also had a daily activity log and certificate of accomplishment Training: 4-hr training, program binder (activities, age-appropriate cog-beh techniques for PA, rationale for activity)	PA	Reframing negative self-talk, goal setting, tracking and acknowledging short-term goal progress, specific performance feedback, setting graded tasks, encouragement specific to individual, providing info about behavior-health link (SE and SCT)	9 months	PA: accelerometers Anth: BMI	Sig ↑ in % time in MVPA ($p=0.016$) and VPA ($p<0.001$) for interv vs. control at 9 mo Sig ↓ in BMI for interv vs. control at 9 mo ($p<0.023$) (post-hoc analyses - boys had greater reduction b/w interv and control vs. girls) *Note: unable to determine if control for nesting
Bellows 2017 - Colorado LEAP (BMC Public Health)[113,137]	Community - randomized Food Friends/Mighty Moves	US (Colorado) Rural areas	N= 5 schools, 200 children	Implement Food Friends, Mighty Moves in preschool, w/ booster intervention in K and 1st grade Training: hands-on, participatory activities to demonstrate teaching gross motor skills and Mighty Moves activities	FMS, PA, diet	SEM	3 years (18 weeks in preschool, 1 booster for K and 1st grade each)	PA: pedometers and accelerometers (subsample) FMS: BOT-2 (primary) CC envir: NAP SACC self-assessment	Large ↑ in object control subtest on the BOT-2 for intervention vs control at 2 years, but no differences in other subtests No results from PA measures.

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Bellows 2013 - Mighty Moves, Food Friends (AJOT)[112] Bellows 2013 JNEB - process eval)[111]	Group-RCT interv vs. control	US (Colorado) 3-5 y old children in Head Start centers	N= 8 centers, 201 children	Lessons 15-20 min/day, 4 days/week each focused on a gross motor skill Training: covered gross motor development and age-appropriate PA, delivered resources (activity binder, CD, mats, flashcards, puppets, PPE) Both interv and control implemented Food Friends	FMS, PA	SCT, social marketing	18 weeks	PA: pedometers FMS: PDMS-2 Anth: BMI, %ile, z-scores	Sig ↑ FMS overall quotient ($p<0.0005$) for interv vs. control at F/U No interv effect on PA, BMI. Process eval: Feedback from teachers - activities aren't appropriate for all 3-5 year olds, clarify directions, simplify lesson structure, extend lessons
De Craemer 2014 - ToyBox (IJBNPA)[115] (De Craemer 2014[114], De Decker 2014[116], Duvinage 2014[117], Androutsos 2014)[107]	Group-RCT, stratified by SES Interv vs. control	Belgium 3-5 y	N= 27 centers, 472 children	Training: 3 trainings (1=2 hr, intro to ToyBox, water; 2=2 hr, PA, Sed, Snacking behaviors; 3 =~75 min, reiterate lessons, occurs during intervention; Received handbooks, PE lessons	PA, diet	Child level: SCT, theories of learning, information processing, self-regulation Teacher level: HBM, TTM, SCT, theories of learning, information processing, self-regulation	1 year	PA: accelerometers	No overall intervention effect found. Increases in PA found... Boys - VPA weekday afterschool, MVPA after school Girls - smaller decrease in LPA afterschool, total PA school hours High SES - MVPA in school hours or after school Low SES: Negative intervention effects for total PA, LPA during school hours

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Finch 2010 - A cluster randomised trial to evaluate a PA intervention among 3-5 year old children attending long day care services[119]	Group-RCT Interv vs. waitlist control	Australia 3-5 y low income, long day care services (8+ hours of operation)	N=20 centers, 350 children	Daily PA opportunities offered (FMS sessions), staff role modeling of active play, improve quality of PA physical environment, decrease screen time, sedentary behaviors Program feedback/monitoring through program newsletter for centers Training: 1-day (6-hr) training, give out resources (manual, activity cards, DVD TA: 2X 15-min phone calls, 2-hr visit from intervention support staff	PA	Social ecological theory	15 weeks	PA: pedometers PA environment: EPAO	Mean step counts at baseline and follow-up were intervention: 17.20 (CI 15.94–18.46) and 16.12 (CI 14.86–17.30); control: 13.78 (CI 12.76–14.80) and 13.87 (CI 12.57–15.17) NS diff. Sig ↑ min structured PA in interv vs. control
Fitzgibbon - Hip Hop to Health Jr. [2002 (protocol),[120] 2005 (efficacy),[121] 2006 (Latino),[122] 2011 (effectiveness][123]	Group-RCT Interv (weight control intervention, WCI) vs. general health intervention (GHI)	US (Illinois) 3-5 y African-American and Latinos in Head Start centers	Efficacy: N= 12 centers, 420 children Latino N= 12 centers, 420 children Effectiveness: N= 618	40 min/session, 3 sessions/wk; 20 min introduce topic, 20 min to be active (5 min warmup, cooldown, 10 min PA); efficacy - delivered by study staff, effectiveness - delivered by teacher, 3rd session/week optional Parent newsletters Effectiveness training: 3 hr training, 3 in-center boosters, 2 weekly meeting w/ study staff	PA, diet	Children: SCT, self-determination theory Adults: transtheoretical model	14 weeks	PA: parent-report (efficacy), accelerometers (effectiveness) Anth: BMI, BMIz	Efficacy: at 1 and 2 years, sig difference in BMI, control group sig increased BMI vs. intervention. No diff in PA Effectiveness: No diff in BMI, but sig increases in MVPA for interv vs. control (p=0.02) Latino: No interv effect on outcomes

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Hardy 2010 - Much and Move[124]	Group-RCT Interv vs. control	Australia Mean age = 4.4 y	N= 29 centers, 430 children	Professional development program, part of a gov't obesity prevention initiative Training: 1 day workshop, deliver resources (manual + grant) TA: contact w/ health promotion professionals	FMS, foods brought from home	n/a	6 months	FMS: TGMD-2	NS increase in FMS for interv vs. control at 6 mo
Jones 2011 - Jump Start[6]	Group-RCT Interv vs. control	Australia 3-5y	N=2 centers, 97 children	Sessions 3X/week Each session day: 20-min structured lesson focused on 1 FMS in AM, unstructured activities in PM to reinforce that FMS Training: 4 × 30min workshops, theory and practical components	FMS, PA	Curriculum only	20 weeks	PA: accelerometers FMS: TGMD-2 Anth: BMI Process eval: fidelity, dose, reach, acceptability (eval of lessons, interviews)	Sig ↑ in total FMS score for interv vs control at 6 months (Δ= 2.08, p<0.001 - not accounting for clustering, Cohen's d=0.47) NS change in BMI
O'Dwyer 2013 - Effect of a school-based active play intervention[125]	Group-RCT Interv vs. control (controls still rec'd resource pack)	UK Mean age = 4.6y at BL Low income children	N= 12 centers, 240 children	Focus on staff training to improve PA in centers Lessons implemented 1 X/week, co-instruction w/ external staff + classroom staff (2-2-2 delivery) Resource kit - activity cards, lesson plans, user manual, posters	PA	SEM, implicit SCT (mastery experience)	6 weeks	PA: accelerometers at BL, 6 weeks, 6 months	No interv effect on PA. Subgroup analyses: Increase in sed time (11.3 min) and decrease in LPA (3.2 min) for girls vs boys. Children in school for 6 hours spent11.4 more min in sed time and 6.2 min less in MVPA vs children in school 3 hours.
Pate 2016 – SHAPES[126] (Pfeiffer 2014 protocol)[127]	Group-RCT Interv vs. control	US 3-5y	N= 36 centers, 379 children	4 components: move inside, move outside, move to learn, and enhanced social support for PA	PA	SEM	2 years	PA: accelerometers Anth: BMI	Mean MVPA min/hr sig higher in intervention (7.4) vs control (6.6)

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
				Trainings and workshops, site support visits, newsletters, and self-monitoring activities. Initial training: 2-3hr, background info on PA, intervention, discussion on barriers. 5 additional workshops 1-3 site visits/year					
Piek 2013 - Animal Fun[128,138]	Group-RCT, matched on SES ranking, location, size Interv vs. control	Australia 4-5 y Low income	N= 12 centers, 540 children	3 modules on gross and fine motor skills each, 1 module on emotional development 30 min/day, 4 days/week, 10+ weeks Training on study protocol and motor development	FMS		"1 semester" 10+ weeks	FMS: BOT-2 Anth: BMI, WC	Sig intervention effect for motor skills standardized score, with intervention having a steeper increase in motor skills vs. control Boys ↑ more than girls on BOT-2 test
Reilly 2006 - MAGIC[3]	Group-RCT, randomization stratified by center type, size, SES Interv vs. control	UK Mean age = 4.2 at BL	N= 36 centers, 545 children	3- 30 minute PA sessions each week over 24 weeks Training: 2 staff from each intervention center attended 3 training sessions TA: 1 monitoring visit from research staff Home component: resource pack sent to parents w/ materials to link intervention to home	FMS, PA	Curriculum only	24 weeks	PA: accelerometers FMS: Fisher 2005 scale Anth: BMI-SDS	No significant effect of the intervention on PA or BMI (primary) Sig ↑ in FMS for interv vs. control at 6 months ($\Delta = 0.8$, $p<0.05$)

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Trost 2008 - Move and Learn[132]	Group-RCT Interv vs. control	US (Kansas) 2 classrooms w/ 12 children each, with AM and PM class groups (4 class groups in total)	N= 2 classrooms, 42 children	Teachers req'd to include 2 activities (10 min/activity) each day, usually repeated for multiple days PA lessons integrated into curriculum - math, social studies and science, language arts, and nutrition education Training: 1 3-hour training initially planned, booster session required for 2nd half of program	PA	Curriculum only	8 weeks	PA: accelerometers (Sirard cutpoints), OSRAP - note PA grouped into 2 week increments	Classroom + outdoor time combined, intervention children ↑ MVPA for weeks 7-8. For only classroom time, intervention children exhibited significantly higher levels of MVPA than controls during weeks 5-6 and weeks 7-8 ($P < .05$).
Williams 2009 - Animal Trackers[133]	1 group pre-post (quasi-experimental)	US (New Mexico) 3-5y, Head Start (low-income), majority (74% Latino)	N= 9 centers, 270 children 32 teachers	10 units, each w/ 6 10-min activities around a different FMS, featuring an animal Training: 1.5-hr held, curriculum overview, role playing of activities, motor skill competence, importance of PA, study protocols	FMS, PA	Curriculum only	10 weeks	Process eval: teachers submitted weekly reports to tell the research staff how often they implemented the AT lessons	Teacher implemented AT lessons avg of 4.12 X/week (note: many programs only open 4 days/week). Avg duration of 495 activities implemented was 11.4 minutes (SD 1.7), (vs. goal of ≥10 min) Teachers would recommend program to others, felt that AT integrated PA and academics, instructions were easy to follow.

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Zask 2012 - Tooty Fruity Vegie[134] (Adams 2009,[104] Adams 2011,[103] Zask 2012)[135]	Group-RCT Intervention (n=18 centers) vs. waitlist control (n=13), in 2 waves	Australia Children aged 2-6y	N=21 centers, 537 children @ BL, 468 @ F/U Sample includes those there at BL, F/U, or both (repeated XS and cohort)	PA component of TFV is FunMoves, a games-based FMS program 2 terms/year, 10 sessions/term, and each session done ≥2X/week Each session: 5min warm up, 3 small group activities led by a staff or parent focused on 1 motor skill, then cool down Training: 1-day training workshop, program kit = 30 laminated cards with activities, small grant for equipment given Project management committees (PMCs = parents, staff, health professionals that oversaw implementation @ each center), parent workshop and newsletters	FMS + eating behaviors	Health Belief Model (for parents-perceived risk), Competence Motivational Theory (actual, perceived competence; social support; enjoyment of behaviors) Capacity building, community participation theories for sustainability	1 year	PA: parent recall of previous day FMS: TGMD Anth: BMI, WC	Sig increase in FMS movement skills quotient for interv vs cont at 1 year (Δ= 14.79, p<0.0001); girls showed higher increases in FMS in interv vs. boys - mostly through improvments in object control scores. At 3 years, increase in object control sustained, particularly in girls No sig interv effect on OW prevalence, but sig decrease in BMIz for interv vs cont (Δ= -0.15, p= 0.022) at 1 year
Protocol only									
Roth 2010 - Prevention through Activity in Kindergarten Trial (PAKT)[129]	Group-RCT, stratified by urban/rural Interv vs. control	Germany 4-5 y Rural and urban	N= 41 centers, 409 children	Daily 30-min PA sessions for 1 year Training: 2 afternoon workshops, 1 at BL (study protocol, receive instructional mat's), and 1 halfway through intervention (more info on importance of PA) Home component: activity cards sent home every week to reinforce activities, parent education seminars 3X	FMS, PA	Curriculum only	1 year	PA: accelerometers FMS: obstacle course, balance, jumping, long jump, balance, throw, stand/reach, static balance on force platform Anth: height, weight, skinfolds (triceps, biceps, subscap, hip)	

Citation	Design & Comp. Groups	Population & Setting	N	Intervention Overview	Interv. Targets	Theory / BCT	Duration	Relevant Measures	Outcomes
Skouteris 2014 - Ben10[130]	Group-RCT Interv vs. waitlist control	Australia 4-5 y	N= 30 centers, 300 children	360 degree marketing approach, training teachers to develop curriculum, focused on children's knowledge Training: workshop to cover implementation - extensive practice and review of teachers' lesson plans to implement intervention, given an implementation checklist, + booster session 6 weeks into intervention	PA, knowledge of active play, diet (primary)	Curriculum development only	6 months	PA: parent self-report EPAQ Anth: BMIz	
Tucker 2016 – SPACE[139]	Group-RCT Interv vs. control	Canada 2.5 – 4y	N= 22 centers, 348 children	1. Shorter, more frequent bouts of outside time (4 × 30 min periods, 2. new portable play equipment, 3. staff training Training: 4hr workshop covering guidelines for PA, why shorter bouts are good for PA, incorporating PA indoors, overcoming barriers to PA.	PA	PRECEDE-PROCEDE	8 weeks	PA: accelerometers Anth: BMI %ile	

APPENDIX 3: TEACHER PRACTICE AND PERCEPTION SURVEY QUESTIONS

Original items and response options of teacher survey items on physical activity practices perceptions. Pairs of items indicated by the same superscript were those that were highly correlated, and from which one was chosen to be entered into the exploratory factor analysis.

Survey Question	Response options
Teacher Daily Survey	
I read a book to the children today that included a positive message about physical activity.	0 = "Neither" 1 = "In the morning only" 1 = "In the afternoon only" 2 = "In the morning and the afternoon"
A child in my class lost outdoor time (more than 5 minutes) because of misbehavior.[a]	0 = "Neither" 1 = "In the morning only" 1 = "In the afternoon only" 2 = "In the morning and the afternoon"
My entire class lost some time outdoors because of misbehavior.[a]	0 = "Neither" 1 = "In the morning only" 1 = "In the afternoon only" 2 = "In the morning and the afternoon"
Teacher General Survey	
How much do you use your own behavior (modeling) to encourage your class to be physically active?	1 = "I don't use my own behavior to encourage my class to be active." 2 = "I rarely use my own behavior to encourage my class to be active." 3 = "I often use my own behavior to encourage my class to be active." 4 = "I constantly use my own behavior to encourage my class to be active."
How important is it for teachers to be actively involved in their classes' physical activities?	1 = "It is not particularly important." 2 = "It is important." 3 = "It is sort of important." 4 = "It is extremely important."
In comparison to other teachers at your child care center, how much do you feel you encourage your class to be physically active (e.g., run around with them, encourage them to move more, play indoor active games, etc.)?	1 = "much less than other teachers" 2 = "less than other teachers" 3 = "about the same as other teachers" 4 = "more than other teachers" 5 = "much more than other teachers"

Survey Question	Response options
Children can easily get toys during outside playtime without help from an adult.[b]	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
When outside children can get toys and equipment without help from an adult.[b]	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I prompt children to increase their physical activity.[c]	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I am a role model for being physically active for the children in my class.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I avoid sedentary activities so children don't do them.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I encourage children to be physically active.[c]	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"

Survey Question	Response options
I enjoy being physically active at work.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I enjoy being physically active in my spare time.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I feel confident that I can get children in my class to be physically active even when they aren't interested.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I feel confident that I can help the children in my class to be physically active for at least one hour each day.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I feel confident that I can teach children in my class why being physically active is good for them.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I increase outside time as a reward for good behavior.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"

Survey Question	Response options
I join children in physically active play.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I make comments to children that promote physical activity.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I make positive statements about being physically active.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
I seek professional development opportunities to enhance children's physical activity	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
It is my job to teach children in my class about being physically active.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
My behavior encourages children to be physically active.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"

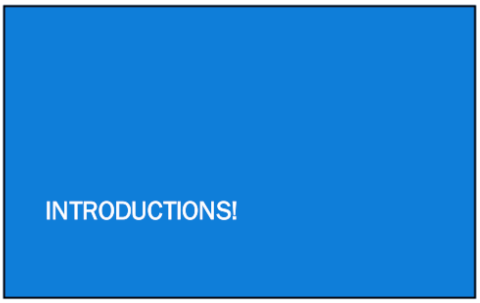
Survey Question	Response options
The center director communicates the importance of physical activity.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
The center provides outside resource people that enhance the children's physical activity.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
The posters and pictures in my classroom show children being physically active.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"
When outside, plenty of toys are available for children to use without waiting for a turn.	1 = "strongly disagree" 2 = "disagree" 3 = "slightly disagree" 4 = "slightly agree" 5 = "agree" 6 = "strongly agree"

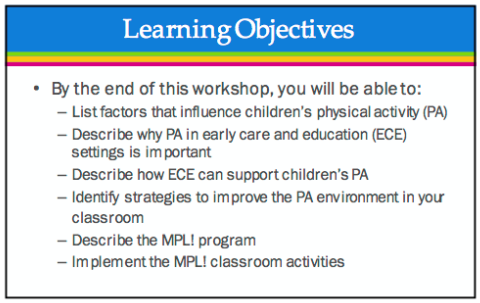
APPENDIX 4: MOVE, PLAY, LEARN! THEORY AND BEHAVIOR CHANGE TECHNIQUES (BCTS)

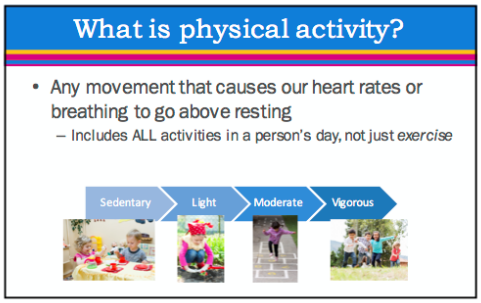
Intervention component	Theoretical construct	BCT (number)[a]
Training workshop	Competence[b] Observational modeling[c] Outcome expectations Outcome expectancies Behavioral capability Self-efficacy	Behavioral practice/ rehearsal (8.1) Commitment (1.9) Framing/reframing (13.2) Information about emotional consequences (5.6) Demonstration of the behavior (6.1) Information about health consequences (5.1) Information about social and environmental consequences (5.3) Instruction on how to perform a behavior (4.1) Reduce negative emotions (11.2)
Move, Play, Learn! activities	Autonomy Behavioral capability Self-efficacy Observational modeling	Adding objects to the environment (12.5) Habit formation (8.3) Instruction on how to perform a behavior (4.1) Prompts/cues (7.1) Restructuring the physical environment (12.1) Restructuring the social environment (12.2)
Newsletters	Competence Self-efficacy Outcome expectations Outcome expectancies	Action planning (1.4) Feedback on behavior (2.2) Goal setting (behavior) (1.1) Self-monitoring of behavior (2.3) Information about emotional consequences (5.6) Information about health consequences (5.1) Information about social and environmental consequences (5.3)
Behavioral coaching and tailored feedback	Competence Relatedness Self-efficacy	Focus on past success (15.3) Framing/reframing (13.2) Reduce negative emotions (11.2) Social support (unspecified) (3.1) Verbal persuasion about capability (15.1)

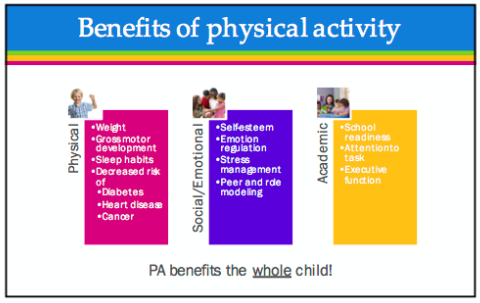
[a] Number corresponds to the BCT taxonomy developed by Michie and colleagues.[200]
[b] Green text indicates constructs from Self-Determination Theory
[c] Purple text indicates constructs from Social Cognitive Theory

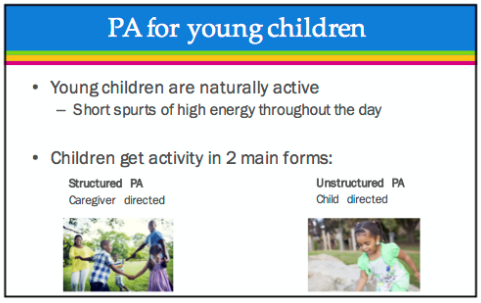
APPENDIX 5: SAMPLE MOVE, PLAY, LEARN INTERVENTION MATERIALS
Training Workshop Presentation



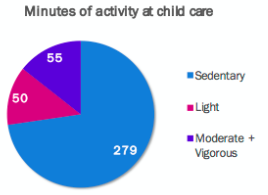








Time in PA in Child Care



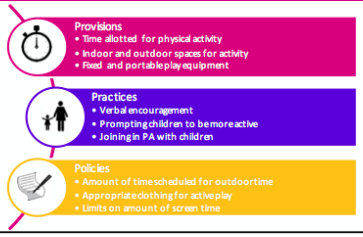
Tandon 2015 Pediatrics

Current Recommendations

- NC recommends 1 hour outside time/day
- National Association of Sport and Physical Education (NASPE) recommends daily at ECE:
  - 2 hours of total PA
  - 1 hour of structured PA
  - Daily outdoor time
  - <1 hour of screen time

National Association for Sport and Physical Education. Active start, 2002.

How does the ECE setting influence child PA?



How do teachers influence children's PA?

- Teachers are the gatekeepers to children's PA
  - Not just through time and lesson planning, but through your attitude and the way you interact with children
- Some behaviors encourage PA
  - Engaging in co-activity, verbal praise, prompting children to use active play equipment, suggesting that children to be more active
- Others may result in children being less active
  - Withholding activity for punishment, asking children to decrease their activity

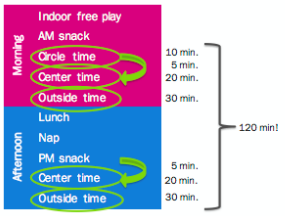
Key teacher practices

- Role modeling
- Informal PA education
- Prompting around PA
- Verbal praise

Structured PA in Child Care

- http://www.healthypreschoolers.com/?page_id=1648

PA happens across the day in child care!



Supporting PA isn't always easy

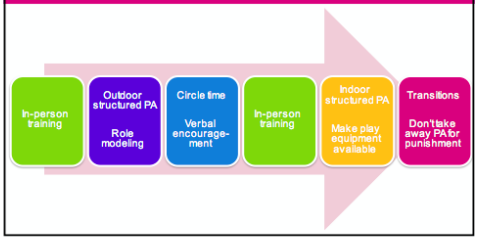
- Physical activity is one of many demands in ECE
- Space and equipment limitations
- Overall classroom management challenges
- It's sometimes hard to make this a priority with everything else going on in the child care day.
- Small steps can help to integrate PA across the day

THE MOVE, PLAY, LEARN! PROGRAM

But first…

- https://www.youtube.com/watch?v=vZzCTVnPDIs

Program Overview



Each week…

- You'll receive a newsletter to kickoff the week
- You'll do at least 1 activity each day in that week's focus area
- Coaching check-in middle of the week
- End of week reflection

Lesson Plans + Activity Cards

Active Play Equipment

Now, let's practice!

- Everyone will take turns leading an activity, with the rest of us participating in the activity
- Then, we'll talk about how each activity went and how it might work in your classroom
  - Make sure to think about things that go well or were hard with each activity!

Child preference

"I just can't find something that my kids like to do"

- Ask the children what kids of things they like to do at home
- Try different activities multiple times before you "rule it out"

Having the resources

"I don't have the right materials to do physical activity"

- PA doesn't necessarily require fancy equipment!
- Try to imagine the things you have in your classroom in a different light, use those things for PA

Classroom Management

"If I do an active game with children, they'll get all riled up, and I won't be able to get them to calm down and listen afterwards."

- Physical activity will help kids get out their energy to help them focus on tasks later!
- It will take time for them to get used to transitioning between activities – be patient!

Scheduling Time

"I don't have time in my schedule to lead physical activity"

- Integrate PA into activities you've already planned
- Try for shorter PA breaks, about 10 minutes each

Other Challenges

THANK YOU FOR COMING!

Module 1 Newsletter Text

Thanks again for participating in the training workshop with me last week, and I'm looking forward to working with you for the rest of your year!

This week we'll focus on *outdoor structured physical activity* as our time of day, and *role modeling* as our practice. For outdoor structured physical activity, we're talking about the instances where you as the teacher begin an active game with the kids in your class- anything from a 1-on-1 game of catch to a game of tag with the whole class. This type of play is great for kids to engage with the outdoors around them and to help them get in more of that vigorous activity that we talked about being important for many aspects of their development.

Role modeling, or you being active with children, can happen indoors or outdoors. When children see the people they admire being active with them, they learn that being physically active is enjoyable. They will learn to develop important gross motor skills by mimicking what they see you do. And, as they grow older, they remember the fun they had playing with the important adults in their life and are more likely to be physically active if they learn from an early age that it's fun! It can be as short as kicking a ball with a child for a few turns, or you joining in a game of hopscotch- the bottom line is that they see you being active.

So, take a few minutes to think about what you currently do for outside structured physical activity and role modelling. Can you add in 1 or 2 outdoor structured physical activities during your day? Remember that there are 8 lesson plans (1st tab) to get your creative juices flowing! And, how can you be more mindful of how you are a role model physical activity? Sometimes this can be hard, especially when you're outside, if you need a break from the craziness of your day! Try to think about how you can make small changes- a few minutes at a time being active with the kids in your class. It doesn't have to be a big change all at once!

Once you come up with a plan of how often and what sorts of activities work for your class, let me know so I can be sure to help with anything. Also, please share them with me what you think of the way you role model physical activity. Are there things you would like to change? If so, what road blocks have you hit in the past?

I'll check in with you during the week to see how things are going, too. We'll reset goals for next week with this same scenario and work out any kinks that come up. If you have any other thoughts or questions, please let me know!

Cheers!

Stephanie

Garden Harvest Game

Outdoor Structured PA Activity 2
Setting: Outside, large group
Purpose: To facilitate gross motor development and counting and sorting skills by running to gather and separate bean bags and polyspots of similar colors.

Objectives:
- Children develop the large muscle control and abilities needed to move through and explore their environment. (Health and Physical Development)
    - Children will refine movements and show generally good coordination as they play the Garden Harvest game.
- Children form relationships and interact positively with other children. (Emotional and Social Development)
    - Children will interact positively with others as they play the Garden Harvest game.

Materials:
- Bean bags and polyspots

Preparation:
- Gather the bean bags and polyspots and scatter around the outdoor space.

Procedure:
1. Explain the game to children.

a. Say to the children, Today we will be playing a game in which you will harvest fruits and vegetables and sort them by color. Harvesting fruits and vegetables happens on farms when we take the fruit or vegetable off of the plant or out of the ground so that we can eat it. The bean bags and poly spots are our pretend fruits and vegetables.

b. Go over and model harvesting movements with children: bending, digging, reaching, jumping, standing on the tips of toes, pulling, grabbing, and pulling.

2. Split the children into pairs or small groups, depending on the size of your classroom.

3. Assign each pair or small group a color (red, orange, yellow, green, blue, purple) and ask each pair or small group to name a fruit or vegetable that is their color. Children will pretend to harvest that fruit or vegetable. Tell them that they have to run to get all the bean bags and polyspots of their assigned color.

a. Say, When I say “start,” everyone should run to one of their colors, pick it up, and bring it back to the harvest area in front of me. Keep your colors separate from the others so we will know what fruit or vegetable is what!
b. For root plants (like carrots, onions, beets, and potatoes), low runners (strawberries) and vines (like melons): use movements like bending down, digging, and pulling up

c. For taller bushes, plants, and vines (like grapes, blueberries, cucumbers, kiwi, tomato, beans, peas); use movements like reaching up and grabbing

d. For plants with leaves (spinach, lettuce) and florets (broccoli, cauliflower): use movements like reaching over and plucking
e. For stalks (like corn) and trees (like apple, pear, peach, plum, cherry): use movements like standing on tips of toes, jumping, reaching up, and pulling down

4. Encourage children to be active while they play!

5. Count the total number of bean bags and poly spots collected.

6. Repeat with several rounds**.**

Variation:

- Create a mixed bag of fruits and vegetables: Have children work together to separate the bean bags and poly spots so that they have 1 of each color in a pile (4 piles total).

Ready, Set, Action

Active Transition Activity 5
Setting: Large group
Purpose: To provide the children an active break

Objectives:

- Children develop the large muscle control and abilities needed to move through and explore their environment. (Health and Physical Development)
    - Children will move their bodies in space with good coordination.
- Children understand communications from others. (Language Development and Communication)
    - Children follow directions given by teacher and respond to a request for action.
- Children will show understanding of numbers and quantities during play and other activities. (Cognitive Development)
    - Children show their ability to count when given a number of times to do a movement.

Materials:

- Open space in classroom (generally circle time rug)

Preparation:

- Think about the actions you are going to ask the children to complete. Some examples include a big side step, hop, giant steps forward or backward, twist, or jumping jacks.

Procedure:

1. Before beginning the transition to another activity, have the children all stand up and say to them, “Friends, let’s stand up and move our bodies around!”

2. Then say, “Listen and watch me”, “Take one big step to the side (As you side step). Jump and twist two times (Count as you twist and jump; 1 twist 2 twists).

3. Have the children repeat this, saying “side step, twist, twist”.

4. Then say “Take one big step to the side, jump and twist two times, and do a jumping jack. Invite the children to join in by saying, “Join in with me this time.” “Side step, twist, twist, jumping jack.” Repeat this again.

5. Add more movements to the set or start a new set of movements.

APPENDIX 6: TEACHER-REPORTED THEORETICAL CONSTRUCT MEASURES

1. I feel confident I can…

		strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
a.	… help the children in my class to be physically active each day.	○	○	○	○	○	○
b.	… lead physical activities with children in my classroom.	○	○	○	○	○	○
c.	… teach children in my class why being physically active is good for them.	○	○	○	○	○	○
d.	… limit the amount of TV of media children in my class watch while at school.	○	○	○	○	○	○
e.	… get children in my class to be physically active even when they aren't interested.	○	○	○	○	○	○
f.	… get children in my class to be physically active even when the weather doesn't allow us to go outside.	○	○	○	○	○	○
g.	… get children in my class to be physically active even when you are busy with other classroom activitives.	○	○	○	○	○	○
h.	… teach children in my class why being physically active is good for them.	○	○	○	○	○	○
i.	… plan for activities that will get children active across my weekly lesson plan.	○	○	○	○	○	○
j.	… help the children in my class to be physically active for at least two hours each day.	○	○	○	○	○	○
k.	… limit the amount of TV children in my class watch to less than 30 minutes per week.	○	○	○	○	○	○
l.	… get children in my class to be physically active even when I am tired.	○	○	○	○	○	○
m.	… get children in my class to be physically active even when I am stressed.	○	○	○	○	○	○

		strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
n.	… get children in my class to be physically active even when I don't want to be active.	○	○	○	○	○	○
o.	… schedule time for children to be physically active outside every day.	○	○	○	○	○	○
p.	… schedule time for children to be physically active inside every day.	○	○	○	○	○	○
q.	… come up with ways to integrate physical activity into my classroom's daily routines.	○	○	○	○	○	○
r.	… incorporate physical activity into transitions between	○	○	○	○	○	○
s.	… be a role model of an active lifestyle for children in my classroom.	○	○	○	○	○	○
t.	… be physically active with children in my classroom every day.	○	○	○	○	○	○
u.	… control disruptive behavior in the classroom.	○	○	○	○	○	○
v.	… get children to follow classroom rules.	○	○	○	○	○	○
w.	… calm a student who is disruptive or noisy.	○	○	○	○	○	○
x.	… establish a classroom management system with each group of students.	○	○	○	○	○	○
y.	… keep a few problem students from ruining an entire lesson.	○	○	○	○	○	○
z.	… respond to defiant students.	○	○	○	○	○	○
aa.	… make your expectations clear about student behavior.	○	○	○	○	○	○
bb.	… establish routines to keep activities running smoothly.	○	○	○	○	○	○

2. Having children be physically active in my classroom…

		strongly disagree	disagree	slightly disagree	slightly agree	agree	strongly agree
a.	… helps them feel better physically	○	○	○	○	○	○
b.	… makes their mood better in general	○	○	○	○	○	○
c.	… helps them feel less tired	○	○	○	○	○	○
d.	… makes their muscles stronger	○	○	○	○	○	○
e.	… is an activity they enjoy doing	○	○	○	○	○	○
f.	… gives them a sense of personal accomplishment	○	○	○	○	○	○
g.	… makes them more alert mentally	○	○	○	○	○	○
h.	… improves their endurance in performing daily activities	○	○	○	○	○	○
i.	… helps to strengthen their bones	○	○	○	○	○	○
j.	… makes them feel more energetic	○	○	○	○	○	○
k.	… improves their concentration at school.	○	○	○	○	○	○
l.	… reduces their risk for some illnesses and diseases (e.g., heart disease, some cancers)	○	○	○	○	○	○
m.	… helps them learn better.	○	○	○	○	○	○
n.	… helps me manage my classroom better.	○	○	○	○	○	○
o.	… decreases problem behaviors in my classroom.	○	○	○	○	○	○
p.	… makes them participate more in other classroom activities.	○	○	○	○	○	○

3. How important is it for you to incorporate activities into your classroom schedule that…

		Not at all important	Only slightly important	Important	Extremely important
a.	… helps them feel better physically	○	○	○	○
b.	… makes their mood better in general	○	○	○	○
c.	… helps them feel less tired	○	○	○	○
d.	… makes their muscles stronger	○	○	○	○
e.	… is an activity they enjoy doing	○	○	○	○
f.	… gives them a sense of personal accomplishment	○	○	○	○
g.	… makes them more alert mentally	○	○	○	○
h.	… improves their endurance in performing daily activities	○	○	○	○
i.	… helps to strengthen their bones	○	○	○	○
j.	… makes them feel more energetic	○	○	○	○
k.	… improves their concentration at school.	○	○	○	○
l.	… reduces their risk for some illnesses and diseases (e.g., heart disease, some cancers)	○	○	○	○
m.	… helps them learn better.	○	○	○	○
n.	… helps me manage my classroom better.	○	○	○	○
o.	… decreases problem behaviors in my classroom.	○	○	○	○
p.	… makes them participate more in other classroom activities.	○	○	○	○

APPENDIX 7: MOVE, PLAY, LEARN! PROCESS EVALUATION INTERVIEW

Q1: To start, tell me about your experience with the project and any pieces you used, in general.

Q2: How did you integrate the program into your classroom's normal routine?

- What could have made this easier for you?

Q3: Describe any issues you encountered when delivering the indoor and outdoor physical activities? [Probe about possible barriers or challenges encountered. Ask for specific examples.]

Q4: What could have made this program easier for you?

Q5: How well did the training prepare you for using this program?

- What additional training or resources would have been helpful?

Q6: What suggestions do you have for improving the resources you received, the activities/activity cards and resource binder?

Q7: What would you say to other providers about this program?

Q8: How receptive were children to the program activities? What aspects of the program were particularly well-received or poorly received by children?

Q9: In what others ways could the program have been improved?

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