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Investigation of the Effects of Physical Activity on Executive Function in the Early Childhood Setting

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Investigation of the Effects of Physical Activity on Executive Function in the Early Childhood Setting

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Investigation of the Effects of Physical Activity on Executive Function in the Early Childhood Setting

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Health is essential for children's cognitive and physical development, yet often is undermined in school environments. Research indicates the use of physical activity within the school environment as a protective factor, ultimately diminishing obesity and augmenting student health outcomes (Sallis et al., 1993; Sallis et al., 1999). Further, research evidence such as that physical activity (PA) is a facilitator of executive functioning among children (Davis et al., 2011; Diamond & Lee, 2011). The purpose of this dissertation was to elucidate the role of PA on executive function in early childhood. A sample of 210 children and 23 teachers participated in this series of three studies. **In study one,** children completed a psychosocial survey and engaged in a short duration, acute bout of PA. Teacher participants completed a survey investigating their perceptions of the classroom environment. Analyses revealed that student perceptions of enjoyment while participating in PA are significantly related to time spent in moderate to vigorous physical activity (MVPA), and that teacher perceptions of classroom environment are a significant predictor; inversely associated with student time spent in MVPA. **The second study**, utilized a repeated measures research design to investigate the effect of PA on executive

function and found that type of PA significantly contributed to cognitive performance. Participants who danced for approximately five minutes had increased accuracy and faster response time over participants engaged in aerobic or yoga activities. The attentional performance also significantly increased for dance participants as compared to those involved in aerobic and yoga. **In study three**, path analyses explored main and mediating effects of PA on psychosocial, environmental and cognitive variables. Although all PA did not significantly mediate EF, there were significant main effects for both dance and aerobic PA on cognition in early childhood. As a means of preventing disease and enhancing cognitive health, short bouts of PA hold value in the pre-school classroom as they enhance executive functioning, which subserves learning. Findings from these three studies are of public health interest as we find that classroom PA engagement is a critical factor to the health and academic success of the whole child.

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INTRODUCTION

Less than 50% of all children will participate in the recommended amount of daily physical activity (PA), including preschool-aged children (Tucker, 2008). There has been a societal shift to a more obesogenic environment where sedentary behaviors such as media consumption, increased time spent sitting at desks, and motorized transportation are considered the norm, have been associated with elevated blood pressure, dyslipidemia, insulin resistance and type 2 diabetes among children (Deckelbaum & Williams, 2001). Further such environmental changes have been linked to overweight and obesity status, which are negatively associated with cognitive performance among children (Li, Dai, Jackson, & Zhang, 2008). In response to these deleterious effects on the health and well-being of our youth, the Institute of Medicine (IOM) called on schools to intervene, requesting that administrators and teachers augment time spent in PA (IOM, 2013). Despite such calls to action, many educators fail to provide their students with optimal engagement in PA due to continued pressures to meet and exceed state mandates on standardized testing as well as decreased education funding (Pate et al., 2006; Story, Nanney, & Schwartz, 2009). Equally, but perhaps more even more important given the developmental stage; high-quality early child childhood programs offering ample time for play as well as cognitive and social stimulation have been found to positively impact lifelong physical health (Campbell et al., 2014).

Early childhood is critical to cognitive development as it plays a significant role in the formation of executive functions (Garon, Bryson, & Smith, 2008). Further, PA has been identified as an important facilitator of executive functioning in childhood (Diamond & Lee, 2011). Until recently little priority has been placed on research aimed at uncovering the dynamics between the young child's academic and physiological growth as well and the impact of personal and environmental factors on such development (Pate et al., 2013). It was not until 2013 when the educational and health entities combined forces to develop *The Whole School, Whole Community, Whole Child* (WSCC) model (see Figure I.1) that researchers and practitioners alike began to formally address the bidirectional interplay between a child's physical and mental development. Given that this model is still in its infancy both in research and practice, much remains unclear about how specific psychosocial and environmental factors contribute to the overall health and academic well-being of the child. The purpose of this dissertation is to advance this understanding through the examination of the type, intensity, and amount of time spent in PA as well as the mediating potential of psychosocial and environmental factors.

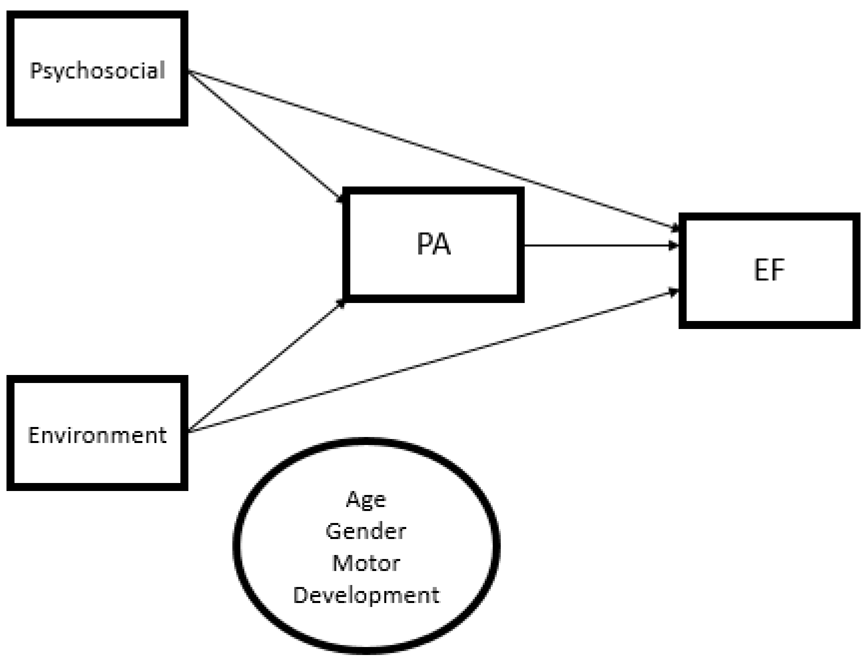
Figure I.1. *The Whole School, Whole Community, Whole Child* Framework

There are three studies within this dissertation investigating the relationships between PA and cognitive functioning within early childhood. Broadly, the first study of this dissertation sought to identify classroom contextual factors and their impact on classroom PA engagement. Specifically, this study examined how psychosocial and environmental factors influenced the child's engagement in an acute, short duration PA brain break. Both teacher and students completed surveys and students also engaged in an acute PA brain break session. Child participants wore accelerometers to determine the duration and intensity of their PA engagement. Present research conceptualizes PA as mediated through personal and environmental factors (Tomporowski, Lambourne, & Okumura, 2011) yet little is known about this relationship in the early childhood setting.

The second study examined the influence of different types of PA (coordinated, aerobic, and yoga/calming) on learning in the early childhood setting. Via classroom assignment, student participants were randomly assigned to a specific type of PA engagement offered through an online brain break resource. It is hypothesized that coordinative exercise may exhibit the most robust effects on executive functioning within the early childhood setting (Diamond, 2012) but it has yet to be demonstrated (Diamond, 2014). Further, only one study to date has examined the impact of PA type on cognitive outcomes in a sample of young children (Zach, Inglis, Fox, Berger, & Stahl, 2015).

The culminating study of this dissertation, study 3, examined the indirect and direct effects of engagement in classroom PA breaks on psychosocial and environmental factors as well as outcomes of cognitive functioning. Currently, no known research has conducted a path analysis to explain the interrelated factors influencing executive function (EF) and academic performance in the early childhood setting (Figure I.2; as guided by the WSCC model). Collectively, the findings from this dissertation seek to advance the current literature base by shedding light on the dynamic interplay between the development of the individual child and the surrounding environment.

Figure I.2. Mediation Model in Early Childhood



Study 1: Student Self-Determination and the Role of the Teacher in the Context of Classroom Physical Activity

Abstract

Purpose: The purpose of this study was to identify psychosocial and environmental elements which contribute to student's engagement in classroom physical activity (PA). **Method:** Teacher (n=23) and student-level data were collected across preschool (n=21), kindergarten (n=45) and first grade students (n=144) housed in two Texas school districts. Participants were randomized by classroom assignment to engage in an acute bout of high (treatment) or low (control) intensity PA. Two survey measures were administered; one on the teacher level (teacher perceived climate scale) and one on the student level (determination scale). Students wore an accelerometer to capture intensity (proportion of time spent in MVPA) of their acute bout of PA engagement. **Results:** Participating teachers were primarily Caucasian (91%) and child participants were primarily Latino/a (40.4%). The independent samples t-test indicated a significant difference in intensity of PA engagement between control and treatment groups $t(201)= -7.717$, $p \leq 0.001$. Bivariate Pearson product-moment correlations were used to explore the psychosocial and environmental variables. There was a significant correlation between MVPA and the determination scale construct of perceived interest and enjoyment factors, $r=0.169$, $n=148, p<0.05$. For teacher perceptions of classroom climate, there was a significant inverse association with MVPA, $r=-0.221$, $n=187$, $p<0.01$. Linear regression analyses indicated that teacher perception of classroom climate was a significant predictor of student MVPA $B=-0.187$, $t(125)=-2.09$, $p<0.05$. Student's perceived interest and enjoyment did not reach statistical significance as a predictor of MVPA B= 0.155, t(125)= 1.797, $p > 0.05$. **Conclusions:** A child's opportunity to engage in classroom PA may be reliant on the teacher's perceptions of the classroom climate. When the climate is viewed as chaotic, there is greater likelihood that opportunities for PA engagement will be offered. Utilizing classroom PA as a behavior regulation strategy may limit movement opportunities in the early childhood setting among compliant students.

Modern society has influenced the rate and total volume of individual and population physical activity (PA) participation. An increased prevalence of sedentary behaviors means that individuals spend less time moving about their environment, thus placing them at greater risk for disease because the protective factors associated with regular PA are not manifested. Broadly, some factors have been evidenced as contributory to the existing obesogenic environment including increased time watching television (Booth, Pinkston, & Poston, 2005) and video game playing on technological devices (Chaput, Klingenberg, Astrup, & Sjödin, 2011). These changes in the rate of PA participation are not only affecting adult populations, but they are also becoming a way of life for children.

Far-reaching environmental and lifestyle changes have shifted away from PA embedded in child's routine to a structure where there are few opportunities for a child to move, thereby increasing children's health risk. Data indicate that one in six children are overweight and obese (Ogden, Carroll, Kit, & Flegal, 2014). Further evidence shows that overweight status in early childhood significantly increases the likelihood of becoming obese in adolescence (Cunningham, Kramer, & Narayan, 2014) with predictions that 60 million preschoolers in the United States (U.S.) will be overweight or obese by the year 2020 (Blackstone, 2016). Obesity and overweight status place children at a greater risk of early onset comorbidities including type 2 Diabetes, asthma, and mental health issues (Pulgarón, 2013).

As these figures suggest, changes in PA engagement are not only increasing body weight and the current health status among children, but it is also placing children at lifelong risk of serious health-related issues. Because children spend most of their waking hours within school settings, there has been a call to action resulting in the creation of several national school-based interventions to counteract this growing problem. Programs such as *Let's Move! Active Schools*, *Fuel Up to Play 60!*, and *The Presidential Youth Fitness Program* (PYFP) have been identified as successful school-based PA promotion programs (Carson, Castelli, Beighle, & Erwin, 2014). When effectively implemented, school-based programs significantly increase time spent in vigorous and moderate to vigorous physical activity (MVPA) as exemplified through the *Child and Adolescent Trial for Cardiovascular Health* (CATCH) intervention (Luepker et al., 1996). Moreover, physical education interventions within the early childhood setting have also indicated positive results (Fisher et al., 2005); however, the objectives of these programs are primarily based on enhancing PA through physical education courses as the primary point of intervention. Despite the fact there could be opportunities to provide PA during the school day, research suggests that there is a lack of classroom PA engagement (Barcelona et al., submitted for review).

Whole School, Whole Community, Whole Child

In an attempt to redefine what constitutes a successful school environment the ASCD and CDC came together to create a *Whole School, Whole Community, Whole Child* (WSCC) model which urges educators to take a holistic approach to developing the academically successful child; prioritizing mental, social and physiological health components. The WSCC model emphasizes the importance of PA during the school day by naming it as one of the ten components driving a healthy school environment and by further asserting that active engagement in learning makes the child the focal point (Lewallen, Hunt, Potts-Datema, Zaza, & Giles, 2015). The WSCC model substantiates the need for a physically active classroom environment, yet it remains unclear what PA in the classroom, particularly for early childhood, might look like and how it might be most effective.

PA During the School Day

Physical education, recess, and active learning experiences in the classroom are plausible opportunities for children to be physically active during the school day. Interventions aimed at promoting classroom PA engagement through provisions of teacher training (Hannon & Brown, 2008; Pate et al., 2016), developing structured movement breaks (Hardy, King, Kelly, Farrell, & Howlett, 2010; Scruggs, Beveridge, & Watson, 2003) and enhancing play-based resources (Hannon & Brown, 2008) have significantly increased PA engagement within the early childhood setting. However, beyond the structural inputs provided to teachers as a mechanism for implementation of classroom PA breaks, little is known about the context surrounding its engagement in the early childhood setting.

Types of PA in the Classroom

Physical activity-friendly curricula are becoming a more readily accessible resource for teachers to implement in their classrooms and given their possible association with academic achievement and learning they have merit. The Physical Activity Across the Curriculum (PAAC) intervention exhibited that children who participated in physically active lessons significantly outperformed students within a traditional classroom environment on standardized academic performance assessments (Donnelly & Lambourne, 2011). Mavilidi and colleagues (2015) identified that lessons which incorporate MVPA significantly influence academic performance among preschoolers. Another early childhood study indicated that performance in content-based lessons such as language skill acquisition is significantly enhanced when combined with physical education (Connor-Kuntz & Dummer, 1996). Within the early childhood, literature play has also been represented as a component of PA that facilitates cognitive outcomes. Research evidence that children engaged in higher levels of physically active play enhance academic performance (Becker, McClelland, Loprinzi, & Trost, 2014). As these studies suggest PA within schools is a critical component of the school environment, which ultimately enhances the learning potential of young children (Lewallen et al., 2015).

Brain breaks, or brief classroom intercessions from sedentary learning that last no more than ten minutes in duration, have emerged as a mechanism through which teachers can facilitate classroom PA. Results of the TAKE 10! intervention found that through the provision of classroom PA breaks, children were able to significantly increase their daily PA levels (Stewart, Dennison, Kohl, & Doyle, 2004). Similarly, structured PA breaks within the early childhood setting have also been shown increase PA (Ward, Vaughn, McWilliams, & Hales, 2010). However, little evidence exists regarding the influence of brain breaks on academic performance and executive functioning. Four studies examined the effects of brain breaks on academic performance and completion of tasks that reuiqre excutive function. Broadly, results indicated that brain breaks improved attention to task among elementary school children, (Grieco, Jowers, & Bartholomew, 2009; Mahar, 2011) yet several studies suggest that a five-minute bout is not enough to elicit a response (Howie, Schatz, & Pate, 2015; Kubesch et al., 2009). Howie and colleagues (2015) employed a within-subjects study examined how brain breaks of 5 minutes, 10 minutes, and 20 minutes influenced academic performance and cognitive processing among 9 through 12-year-old children. The results indicated that 10 and 20-minute brain breaks significantly improved math scores as compared to when students were sedentary (Howie et al., 2015). As these results indicate a 10-minute bout of PA was enough to enhance cognitive performance; however, our understanding of the duration of precisely how long we should engage in PA to elicit cognitive benefits remains unclear. Further, an understanding of how short duration brain breaks may influence executive functioning within the early childhood population is unknown.

Online videos of individuals leading physical activity are gaining traction and have appeal among classroom teachers, given the ease of access and minimal preparation. In short, these resources aim to provide teachers with brief PA videos, organized by PA intensity or subject matter, which teachers can display on a wall or whiteboard in their classroom. Videos are 2-3 minutes in duration and accommodate varied intensities of PA. However, little is known about how such resource influences academic performance or the cognitive processes that subserve learning also known as executive function (EF), particularly about the intensity of a single bout when two videos are linked together. Current literature supports a relationship between physical fitness, PA, and EF within early childhood (Niederer et al., 2011), but we do not fully understand the dose-response relationship between PA and EF in the early childhood student (Hinkley et al., 2014).

Factors Influencing School Day PA

Broadly, personal motivation factors contribute to children's engagement in PA (Van der Horst, Paw, Twisk., & Van Mechele, 2007). Self-determination theory posits that all individuals possess psychosocial needs including, autonomy, competence, and relatedness. SDT indicates that through development and enhancement of these psychosocial tenets one can positively impact personal motivations and self-directed behavior (Ryan & Deci, 2000). Several studies have utilized the self-determination theory to investigate how personal factors such as perceptions of enjoyment and self-competency contribute to a child's willingness to engage in PA. Specifically, perceptions of enjoyment have been indicated as a significant factor related to physical education participation (Carroll & Loumidis, 2001; Cox, Smith, & Williams, 2008; Cox, Ullrich-French, & Sabiston, 2013) as well as sports participation (Weiss, 2000) among school-age children. Additionally, research posits that among adolescents, perceived competency significantly impacts PA engagement (Cairney et al., 2012; Shen, McCaughtry, & Martin, 2008) and is moderated by gender (Brustad, 1996). That is, girls with low perceptions of PA competency demonstrate significantly less engagement. As these findings suggest personal factors, the individual perceptions of enjoyment as well as how they interpret their skills are critical to engagement children in PA. However, such factors have been given little consideration within early childhood.

Classroom climate has also been evidenced as a critical factor related to children's engagement in PA. Although minimally studied in the early childhood setting, three qualitative studies find that teacher support is integral to student engagement in classroom PA (Dyment & Coleman, 2013; Gehris, Gooze, & Whitaker, 2015; Wilke, Opdenakker, Kremers, & Gubbels, 2013). Studies across educational levels corroborate these findings and identify a need for teacher support (Pate et al., 2016). Additional evidence exists across the school-age population finding the provision of classroom-friendly routines; providing ample opportunity for engagement, as well as administrative support are valuable facilitators of classroom PA (Derscheid, Umoren, Kim, Henry, & Zittel, 2010; Reunamo et al., 2014).

PA & Academic Success in Early Childhood

In this present study, early childhood education was operationalized as classrooms that housed young children ranging in age from four to seven years old who were working on the development and mastery of academic readiness skills (i.e., numeral recognition and counting, pattern recognition). Until recently, it was assumed that early childhood learners were receiving ample opportunity to engage in PA when it was discovered that a significant portion of a preschooler's day was spent sedentary (De Marco, Zeisel, & Odom, 2015). The move away from PA-rich routines is a result of increased academic expectations for the young learner (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). Recently, early childhood educators have started to adopt a similar PA brain break model as classroom teachers as a strategy to increase PA engagement for their students. However, little is known about the effect of short duration brain breaks on

PA participation. Further, it remains unclear how aspects of the individual child as well as the environment may impact this relationship.

Given the paucity of research on in-school PA among early childhood programs, the purpose of this study was to examine the influence of personal and environmental factors on the rate and intensity of engagement in a short duration, acute bout of physical activity. This study intends to answer the following questions: (1) How does perceived enjoyment and competency influence their engagement in classroom PA among young children? and (2) How does the teacher's perceptions of classroom environment influence intensity of PA engagement in early childhood?

Methodology

This experimental investigation used to collect PA, psychosocial and environmental data across six schools and twenty-three classrooms in Central Texas. All data were collected in a single classroom visit.

Participants

A purposeful sample of early childhood participants (M_{age} 5.6 years) including students from preschool through first grade (n=210), as well as preK, kindergarten and first-grade female teachers (n = 23), was selected because it was a representation of the population of interest. The intent of this sampling process was to ensure that participants could provide rich data representative of the physical and cognitive developmental period as well as the context in which it was fostered (Creswell, 2013; Patton, 1990). Participants were selected from early childhood classrooms housed within elementary schools across two school districts. As required by the Institutional Review Board, all participating children were required to have written parental consent as well as assent before these data could be used for research purposes. Because the research protocols in this study were determined to align with current educational practice and the learning outcomes of the curriculum, all children in a given classroom participated in the following procedures, regardless of his/her status with consent. Only those granting written permission were included in the database for this study.

Instruments and Measures

This section details the measures utilized to carry out this study that examined the effects of a single bout of PA in early childhood classrooms. Below you will first find an explanation of the PA measure followed by psychosocial instruments. Next, you will find an overview of the psychosocial surveys and environment assessment.

PA Measure. Direct observation of PA within early childhood has been identified as the gold standard of measurement (Pate, 2010). By these findings, PA intensity was directly measured.

***Actigraph accelerometry*.** This study utilized accelerometry to assess the intensity and duration of classroom PA. The Actigraph GT3X triaxial accelerometers are the gold standard PA measurement (LeMasurier & Tudor-Locke, 2003). All participants within a given classroom, were randomized into either the high-intensity PA group (i.e., running & jumping) or the low-intensity PA group (i.e., stretching). Each child was familiarized with how to wear the accelerometer on their right hip, which is the most sensitive placement for capturing PA in young children (Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). Epochs were calibrated to 5-second intervals as research has validated this user-specified time interval as developmentally appropriate for early childhood (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). Data were analyzed using Evenson cut points as research indicates that across youth populations and within children as young as 4, these cutpoints are significantly more accurate at capturing and classifying intensity such as MVPA above and beyond that of Freedson cutpoints which are better served in adolescent populations (Trost, Loprinzi, Moore, & Pfeiffer, 2011).

Psychosocial Measure. Surveys were adapted to the developmental abilities of the child (e.g. shortened length; developmentally appropriate vocabulary), and teacher level surveys were administered via an online platform to enhance ease of use.

Determination Scale. The Determination Scale measures an individual's perceptions as they related to seven constructs of self-determination including; interest/enjoyment, perceived abilities/competence, effort, value/usefulness, pressure/tension and choice, and relatedness (McAuley et al., 1989). To address the psychosocial variables of interest within the early childhood population this survey was modified to consider the specific constructs of; interest/enjoyment, and competence, as they relate to PA engagement. Therefore, the survey was limited to ten questions about enjoyment and competence. The first five questions measured perceptions of perceived enjoyment questions such as "*I like to move my body in class*." Questions six through ten measured perceptions of competence through questions such as "*I am good at moving my body in class*." All questions were measured on a five-point Likert scale where a score of five indicated that participants perceived the question "*to be a lot like me*" and one indicated that students perceived the question to "*not be like me at all*." If a child was a non-reader, a research assistant read the question and then the child pointed to the Likert scale number representing the degree of agreement. Further, smiley faces icons were added to scale to enhance the accuracy of interpretation. These data were collected at one-time point before engagement in an acute bout of PA.

Factor analyses were utilized to confirm that the modified variable structure appropriately loaded onto the constructs of interest/enjoyment and competence. Review of the scree plot and eigenvalues indicated that nine of the ten questions appropriately loaded onto each of the two factors explaining 67.66% of the variance. Because of a lack of agreement, question number seven was eliminated from the survey and all subsequent analyses. After this adjustment, the Kaiser-Meyer-Olkin value was 0.684, exceeding the recommended value of 0.6 (Cerny & Kaiser, 1977) and Bartlett's Test of Sphericity (Bartlett, 1954) was statistically significant. Results from these data were summed and scored with a higher score indicating strong perceptions.

Environment Measure. This study sought to understand the influence of classroom environment on PA engagement. Accordingly, one survey measure was utilized to capture teacher's perceptions of classroom climate.

Teacher Perceived Climate Scale. This 25-item survey was developed as a five subscale measure, which sought to assess teacher level perceptions of the classroom and school climate (Fraser, 1982; Loukas et al., 2006). The four subscales of interest for this study measure classroom climate constructs of; cohesion, friction, competition among students, and class satisfaction. Teachers answered questions such as "Students in this class are always fighting with each other" and "Some students in this class always try to do their work better than the others" utilizing a five-point Likert scale ranging from very true to not true at all. This survey was administered online and was completed once, before student participation in classroom procedures portion of the research study. Total scores were summed and interpreted such that higher scores were indicative of a teacher's perceptions of positive classroom climate and low scores were indicative of low perceptions of classroom climate.

Procedures

Before data collection, permissions were obtained from school administrators, and individual classroom teachers were contacted to inquire about their interest in the study participation. Upon obtaining student consents, the researchers scheduled a one-hour classroom visit which allowed enough time to take the classroom through the study protocol. The classroom visit began with confirmation of parental consent and signed assent from each participant who voluntarily agreed to study participation. All students were given an accelerometer to wear on their right hip. A brief explanation of what an accelerometer was and how it was worn was delivered to students by the researchers. Any student that had problems putting their accelerometer belt on were referred to the teacher for help.

All classrooms assembled on their morning circle carpets where each student had a designated area of personal space where they received a brief explanation of the day's research activities. Researchers provided all students with an overview of the self-determination survey as well as an introduction to the brain break activity. Students first completed the modified self-determination scale, which was read aloud by the researcher and projected on the whiteboard to ensure that students could follow along. Additional research assistants circulated through the classroom to help any student who got off track with the survey. Once the survey was completed students went back to their designated personal space area and waited for the PA break to begin.

All participating classrooms were randomly assigned to either a high-intensity dose of PA (e.g. jogging or dancing in place) or a low-intensity dose of PA (control; yoga or stretching), lasting an average of seven minutes. Students participated in the acute bout of PA via an online display of a peer model and mascot demonstrating PA that they were instructed to follow. Once the acute bout of PA was completed, students returned to their tables and removed their accelerometers. The participants were then allowed to drink water and have a snack.

Data Analysis

Descriptive statistics were used to explore the participant characteristics by school and treatment condition. Student level self-determination survey data were summed by each construct of perceived enjoyment and perceived competence. Accelerometry data was extracted using the ActiLife software utilizing Evenson cut points and reduced to a percentage of time spent in MVPA. Teacher level data were summed and scored to represent a teacher's overall perceptions of classroom climate.

Independent sample t-tests were performed to confirm the fidelity of the treatment (i.e. high and low intensity), by individual participant and class analysis. Two-tailed bivariate correlational analyses were conducted to compare group means across high intensity and low-intensity PA groups as they related to psychosocial, environmental and cognitive factors. Linear regression analysis was used to determine the predictive power of significant correlational associations. The standard goodness of fit statistics: χ^2 with a *p*-value were used for regression model analyses. Statistical significance was set at $p < 0.05$. Data analyses were performed using SPSS v24.

Results

The results of this investigation are described by data source and then by research question: (1) How does perceived enjoyment and competency contribute to engagement in classroom PA among young children? and, (2) How does a teacher's perceptions of classroom climate relate to student engagement in classroom PA?

Participants

A total of 31 teachers were asked to participate, and a total of 23 agreed through written consent to complete a survey and arrange a one-day site visit with students. Once teachers completed the climate survey, they were provided with student consent forms to send home with their students. Among participating classrooms, 242 students across two school districts, twenty-three classrooms of preschool, kindergarten and first-grade students returned consent forms agreeing to participate in this study. Across all participants, the mean free/reduced lunch percentage was 40.1%. All of the teachers were female and primarily Caucasian (91%). The child participants were primarily Latino/a (40.4%), and Caucasian (39.4%), Black, and Asian (both 7.4%), thus reflecting the larger population of this region of the US. Due to several unanticipated circumstances at the time of the scheduled classroom intervention activities (i.e., absence, resource pull out, specials, etc.), the data from 32 consenting child participants was able to be included in this study. The remaining sample (n=210) included 21 preschool children, 45 kindergarten, and 144 first grade students.

Intensity of Classroom PA Engagement

Table 1.1 illustrates the MVPA engagement by group and by gender. Independent samples t-test indicated a signficiant difference in PA engagement between control and treatment groups $t(201)= -7.717$, $p \leq 0.001$. There were no siginficant within group gender differences for control (M=0.049, SD=0.044) $t(77)=1.117$, $p=0.267$ and treatment (M=-0.011, SD=0.032) $t(124)=-0.359$, $p=0.720$.

Bivariate Pearson product-moment correlations revealed a significant association between MVPA and classroom assignment, r=0.229, n=205, $p \leq 0.001$. There was no significant correlation between MVPA and school, r=-0.04, n=205, $p=0.549$, and gender was not significantly associated with MVPA, r=-0.094, n=205, $p=0.180$ across the sample. Associations between MVPA and the psychosocial and environmental variables of interest are reported below by corresponding data point.

Student Perceptions of Self-Determination

Means and standard deviations (SD) for the overall self-determination score and by factor are reported across the entire sample and by group and gender in Table 1.1. Bivariate Pearson product-moment correlational analyses were conducted to explore associations with self-determination factors. Although there was no significant correlation between the overall self-determination score, r=0.119, n=147, $p=0.150$, there was a significant correlation between MVPA and the perceived interest and enjoyment factors, r=0.169, n=148,$p<0.05$. Further, there was a significant inverse association between the self-determination factor of perceived competence and perceptions of classroom climate r=-0.200, n=134, $p<0.05$. There was no significant association between MVPA and the self-determination factor of perceived competence, r=0.015, n=147, $p=0.858$.

Teacher perceptions of classroom climate

Across the six participating schools the classroom climate score range was 59.82-76.68. Further description of means and SD of classroom climate scores revealed that the mean score across the total sample was 70.19 (8.89) with the control group exhibiting 73.6 (4.91) and treatment 67.55 (10.31). Correlations were explored through Pearson product-moment analyses. There was a significant inverse association between MVPA and perceptions of teacher climate r=-0.221, n=187, $p<0.01$. There was also a significant inverse association between teacher perceptions of classroom climate and total self-determination, r=-0.177, n=134, $p<0.05$.

Predictors of MVPA engagement

To answer the research question, *How does perceived enjoyment and competency influence their engagement in classroom PA among young children?*, linear regression analyses were conducted. Perceived interest and enjoyment was not a significant predictor of the dependent variable, MVPA $B= 0.155$, t(125)= 1.797, $p=0.075$ nor was perceived competence, $B=-0.048$, t(125)-0.496, $p= 0.621$. The second research question, *How does a teacher's perception of classroom climate relate to student engagement in classroom PA?*, was also investigated using linear regression. When teacher's perceptions of classroom climate were regressed upon the dependent variable, MVPA, results indicated it was a significant predictor of classroom PA engagement, B=-0.187, t(125)=-2.09, p<0.05 (see Table 1.3).

Conclusion

Both student psychosocial and teacher level environmental data points were identified as significant contributors to a student's time spent in MVPA. This study considered the potential of the classroom climate as well as personal psychosocial factors as they relate to the intensity of PA engagement. The findings from this study indicate that the most significant factor associated with the intensity of PA engagement is a teacher's perceptions of classroom climate. Further, although student's perceptions of PA enjoyment was not a significant predictor of PA intensity, it was positively associated with a higher percentage of time in MVPA. Collectively these findings provide a deeper contextual knowledge as it relates to the WSCC model, as the study evidences the need to foster the individual child's psyche by tapping into their interest and enjoyment and enrich their environment through classroom climate.

Teachers are encouraged to utilize evidence-based teaching strategies; the pedagogical practices found to be most successful for promoting academic success among students. Often, evidenced-based practices favor traditional pedagogical approaches, such as rote memorization, board work, and worksheets to deliver the core subject matter because they have measurable academic outcomes. This utilization of common teaching strategies discourages innovative thinking which may limit an educator's motivation and ability to foster the child's interest and enjoyment in the learning process. Restricting a teacher's ability to connect the content with the student's interest and enjoyment, can become problematic when a child feels they cannot relate to the concepts being taught or believe that they are incapable of reaching their full potential. Teachers are the vehicles through which curriculum content is delivered and therefore must be in tune with the specific needs of the learner. As such, a full understanding of what children enjoy at a given developmental milestone as well as how they internalize competence becomes an essential component of the learning environment. We want children to fall in love with the content as well as the participation in PA opportunities.

Kinesthetic learning is an evidenced-based strategy for delivering curriculum content. This strategy is often underutilized in the classroom (Barcelona et al., submitted for review) despite the presence of a robust body of literature indicating that physical activity significantly enhances academic performance in children. That is, if teachers chose to utilize kinesthetic learning as a routine pedagogical strategy in their classrooms they might have the capacity to enhance academic outcomes. However, pedagogical practices cannot be a one-way street. Teachers must utilize a given strategy, and in turn, it must be readily received by their students. One key element that perhaps may go unconsidered as an antecedent to student engagement in classroom PA is the notion of enjoyment.

There are several pedagogical strategies that teachers may use to tap into a student's enjoyment of classroom based PA. Teachers may consider exploring different types of PA (i.e., running, hopping, skipping, or dancing) thereby offering multiple outlets for students to express their knowledge in a variety of ways. Students, in turn, may find alternative ways to demonstrate their knowledge. Having a focus on fundamental movement patterns is developmentally appropriate for early childhood students (Stodden et al., 2008).

Structured Versus Unstructured Movement in Early Childhood

One successful movement strategy is to vary access to both structured and unstructured play opportunities. Structured play provides opportunities for children to practice gross motor movements through repetitive games and activities (Hardy, King, Farrell, Macniven, & Howlett, 2010). By allowing children to "practice" and strengthen a skill set, it becomes a routine they can look forward to engaging in and enjoying. Unstructured play allows children to connect with their environment through movement while naturally helping them gain an understanding of how to act in their surroundings (Burdette & Whitaker, 2005). Through this self-discovery, during unstructured play, children gain autonomy through the exploration of unknown terrain as well as opportunities to self-select their movement.

Teacher as PA Models and Its Relation to Climate

Teachers may also find that through their modeling of their enjoyment of PA engagement that students, in turn, mirror the behavior (Klassen, Perry, & Frenzel, 2012). Therefore implementing strategies to increase student's enjoyment of PA may not only encourage more intense engagement but also may indirectly influence the classroom climate.

Findings from this study identify classroom climate as a significant predictor of student PA engagement. Further decomposition of this result identified an unanticipated finding; as there was a negative association between teacher perceptions of classroom climate and intensity of PA participation. That is, as the teacher's perceptions of the classroom climate increased (i.e., believe students are all getting along and can maintain attention while sitting for extended periods of time) the less MVPA a student had. Alternatively, as the teacher's perceptions of classroom climate declined (i.e., students disagreeing, unable to maintain focus) with increases in student MVPA. This inverse relationship suggests that either intentionally or unintentionally a teacher's perceptions of how the students in a classroom are behaving influences PA culture within the classroom. Teachers willingly provide PA opportunities but did not want PA breaks to lead to disruption in the students' behavior.

Summary of Study Findings

Collectively these results as they relate to student and teacher perceptions create a dynamic intersection between individual factors and the environment. The results from this study indicated that student enjoyment was significantly associated with MVPA in the classroom. A young child's potential for PA enjoyment is dependent on how the teacher perceives the classroom climate. If the climate is viewed as orderly and positive, the student may have less opportunity to develop an enjoyment of classroom PA. In turn, low classroom climates where students are seen as disruptive or disorderly may have the greatest capacity to foster an enjoyment of PA; not because it is considered to be a valuable component of the curriculum but rather because of the deep-rooted, institutionalized need to maintain order and compliance over students. These findings are particularly alarming as they shed light on a new factor contributing to the misuse of PA engagement within school settings.

Young children, regardless of teacher perceptions and biases toward their behavior need to move and this movement should not be labeled or conceptualized as a punishment used to “get the wiggles out.” Rather movement must be recognized as a core component of the young child’s learning. Just as we foster a love of learning, we must foster a love of movement. Moreover, until education unites the mind and body needs of the child, we may not see them reach their fullest potential.

Implications and Future Directions

Given the novelty of these findings in the early childhood setting, there are several implications for further research. Future investigations should utilize a mixed method approach to understanding better which specific factors of classroom PA the young child enjoys most. Further, these investigations should be used to identify specific student behaviors that shape a teacher’s overall perception of the classroom. Moreover, interventions may seek to offer early childhood teachers with classroom PA specific professional development providing the knowledge, resources, and strategies they require to provide equal opportunity to classroom PA across the school setting. When classroom PA is utilized to advance learning rather than as a behavior intervention, it holds the greatest capacity to promote the development of the whole child.

Delimitations and Limitations

There are noteworthy strengths of this study. Few studies to date have investigated what contributed to the intensity of PA participation in early childhood.

Specifically, there has been little consideration of the psychosocial elements such as personal perceptions that may motivate a young child to engage in PA. Additionally, this study presents a novel way of considering the role of the teacher, elucidating the potential impact of their personal perceptions as they relate to classroom PA engagement. Further, no known studies have investigated the use of short classroom brain break resources as a mechanism for PA engagement in the pre-school setting despite their popularity within this context. Therefore, this study is timely and warranted as educators are utilizing a resource based on underlying assumptions rather than scientific knowledge. PA can be integrated into early childhood lessons and have the children engage at both high and low intensities but is influenced by the teacher's perception of the class climate, developmental appropriateness, and student enjoyment.

This study is also not without limitations. An overarching goal of this study was to investigate intensity throughout a short duration, video-based PA break. However, accelerometers were only utilized to measure PA intensity within the context of the PA break offering little consideration for how an individual child may physically act upon their environment across the school day. As such, future studies may benefit from measuring PA intensity in longer durations of classroom time.

The field-based design of this study may also call caution to some of the findings. Although also a strength and need within early childhood research because the literature gained a deeper understanding of how personal psychosocial and environmental factors play out in "real-world" settings, this field-based study design sacrificed the overall ecological validity. For example, because each measure was administered as a classroom activity, several participants chose their survey responses based on their interactions with their peers and teacher, as social learning. Therefore, future investigations of online PA and brain break resources may benefit from a more tightly controlled clinical experiment to fully understand the personal factors at the early childhood level.

Table 1.1
Group Means (SD) of MVPA & Psychosocial Factors

Variables	Control			Treatment		
	Male	Female	Total	Male	Female	Total
n	40	44	84	77	49	126
MVPA (% time)	18.5(0.2)	13.6(0.2)	16(0.2)	35.1(0.2)	36.2(0.2)	35.6(0.2)
Perceived Interest/Enjoy	23(8.1)	21.67(7.2)	22.36(7.6)	21.82(7.41)	21.50(7.1)	21.70(7.3)
Perceived Competence	21.7(4.9)	21.6(4.8)	21.6(4.8)	21.5(5.2)	21.9(4.2)	22(4.8)
Total Self Determination	44.5(11.9)	43.3(9.5)	43.9(10.7)	43.4(11.1)	43.4(9)	43.4(10.2)

Note: MVPA (% time) = time spent in moderate to vigorous physical activity

Table 1.2
Correlations Across Variables of Interest

		Sex 1=M: 2=F	Interest/ Enjoy	Perceive Comp	SD Total	Class Climate	% MVPA
Sex 1=M: 2=F	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	210					
Interest/Enjoy	Pearson Correlation	-.041	1				
	Sig. (2-tailed)	.617					
	N	152	152				
Perceive Comp	Pearson Correlation	.023	.429**	1			
	Sig. (2-tailed)	.780	.000				
	N	151	151	151			
SD Total	Pearson Correlation	-.015	.908**	.767**	1		
	Sig. (2-tailed)	.853	.000	.000			
	N	151	151	151	151		
Class Climate	Pearson Correlation	.070	-.110	-.200*	-.177*	1	
	Sig. (2-tailed)	.332	.203	.020	.040		
	N	192	135	134	134	192	
MVPA (% time)	Pearson Correlation	-.094	.169*	.015	.119	-.221**	1
	Sig. (2-tailed)	.180	.040	.858	.150	.002	
	N	205	148	147	147	187	205

Note. Perceived interest/enjoy and perceived competence= self-determination constructs measured, SD total=self-determination total score, class climate-perceptions of classroom climate, MVPA (% time)=percentage of physical activity break spent in moderate to vigorous physical activity

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Note. n=sample size, MVPA (% time)=percentage of physical activity break spent in moderate to vigorous physical activity, perceived interest/enjoy and perceived competence= self-determination constructs measured.

Table 1.3

Predictors of Physical Activity Engagement in the Early Childhood Classroom

Variable	β	S.E.	Beta	Sig.
(Constant)	.565	.178		.002
Interest/ Enjoyment	.004	.003	.157	.100
Perceive_Comp	-.002	.004	-.048	.621
Teacher_Climate	**-.004**	**.002**	**-.187**	***.038**
Sex 1=M: 2=F	-.032	.036	-.075	.388

[a] Dependent variable=%MVPA

*p<0.05

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Study 2: Physical Activity Type and Executive Functioning in Early Childhood

Abstract

Purpose: The present study examined the relationship between physical activity (PA) by intensity and type and executive function (EF) in early childhood. The moderating effect of gender was also explored. **Method:** Students housed in twenty-three early childhood classrooms across two central Texas school districts participated in a one-day, pre-post study protocol including an acute bout of PA and EF measures of Trail Making Test (TMT), visual memory task, and emergent mathematics facts. Students were randomized into conditions of acute PA by: (a) low- or high-intensity PA and (b) type of PA (high intensity=dance and aerobic; low=yoga). **Results:** ANCOVA analyses indicated no significant effects of PA intensity on addition math facts, $F(1, 158) = 2.526$, $p > 0.05$, TMT, $F(1,158) = 0.147$, $p > 0.05$, and visual memory task, $F(1, 145) = 0.693$, $p > 0.05$. There was a significant main effect of PA type on EF outcomes of math facts $F(2,161) = 5.205$, $p \leq 0.01$ and TMT, $F(2,156) = 3.234$, $p < 0.05$. Tukey post hocs revealed that for the math fact task, the dance group posttest scores were significantly higher than aerobic and yoga. For the TMT task, the dance group posttest scores were also significantly higher than aerobic. There was no significant difference in cognitive performance by gender. **Conclusions:** Classroom PA may significantly enhance academic and attentional potential in early childhood. Engaging in dance before cognitively demanding tasks may enhance a young child's performance. Educators should incorporate various types of PA, such as dance, into their classroom routines.

Today there is increasing pressure to prepare young children cognitively, emotionally, and socially to succeed in school. Children entering Kindergarten who are unprepared, quickly fall behind in reading, vocabulary, and counting (Dorman, Anthony, Osborne-Fears, & Fischer, 2017). One focal point of early childhood education has been to engage the cognitive processes that subserve learning, such as the executive functions of attention and memory (Diamond, 2012). Executive functioning (EF), is how we schedule, plan and process information (Norman & Shallice, 1986). Regardless of age, humans rely on EF to think and act in the real world (Wellman & Gelman, 1992). Specifically, EF is referred to as a series of top-down mental processes involving inhibition (self-control), interference control (attention), working memory (thought holding/organizing), and cognitive flexibility (creative thinking and task switching), as a guide for individuals' thinking and problem-solving (Diamond, 2013). These processes are highly trainable showing significant gains that begin in preschool (ages 3-5) and continuing throughout childhood (ages 5-11). Research indicates that EF is a strong predictor of school readiness, thus the increased presence in early childhood education (Blair & Razza, 2007; McClelland, Morrison, & Holmes, 2000). Focusing on EF as a predictor of school readiness has not been without its limitations. An increased curricular emphasis placed on academic readiness has negatively impacted the physical activity (PA) and play time of young children by reducing the number of opportunities a child has to be physically active during early childhood programming (Bullough, Hall-Kenyon, MacKay, & Marshall, 2014).

PA Engagement in Early Childhood

Since the turn of the century, research has indicated that today's preschool children are engaging in far more sedentary activities than physically active behaviors more frequently enjoyed by previous generations (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). Pate and colleagues utilized direct observation of PA within preschool settings and found that children are sedentary for more than 80% of the school day and engage in moderate to vigorous PA (MVPA) less than 3% of their day (Pate, McIver, Dowda, Brown, & Addy, 2008). Further, research has identified that even during allocated PA times such as recess, children may lack the ability to engage in MVPA due to environmental and structural constraints (Brown et al., 2009). These identified inadequacies within early childhood have prompted successful PA related interventions (Ward, Vaughn, McWilliams, & Hales, 2010).

Recently the *Whole School, Whole Community, Whole Child* (WSCC) model (Lewallen et al., 2015) was created to support interventionists in the delivery of comprehensive programs aimed at enhancing the health and development of the child. Rather than direct attention and resources to child growth and disease prevention, the WSCC unites the components of coordinated school health with the whole child approach focused on success in school, thereby aligning health and educational initiatives. By engaging the family and community and providing opportunities to learn about health behaviors, children have the greatest potential to succeed in school (Michael et al., 2015).

The WSCC model identifies ten different ways that policy, process, and practice can be aligned to create health oriented opportunities for children (WSCC). Of particular interest is the physical education and physical activity identified points of intervention, which will be investigated in this current study. The WCSS model identifies classroom PA as a critical factor in a healthy school environment as it facilitates socioemotional and cognitive development (Lewallen, Hunt, Potts-Datema, Zaza, & Giles, 2015). The WSCC model highlights the need for a classroom PA, yet what remains unclear is how PA may facilitate cognitive development especially in the early childhood setting.

The Impact of PA Intensity on Cognitive Outcomes

A robust body of literature suggests that the regular participation in PA leading to physical fitness (Castelli et al., 2014) and the intensity of single sessions of PA (Hillman et al., 2009; 2011) impact academic outcomes and cognitive performance (Sibley & Etnier, 2003) among children. Research has investigated the role of both acute and chronic engagement in MVPA as a mechanism for reducing health risk and as a means of promoting academic success and cognitive development. Several studies report positive effects of a single thirty minute session of aerobic PA on EF, which are evident across youth populations of early childhood, (Niederer et al., 2011; Palmer, Miller, Robinson, et al., 2013) school-age, (Tomporowski, Lambourne, & Okumura, 2011; Verburgh, Königs, Scherder, & Oosterlaan, 2013) and adolescents (Chen, Yan, Yin, Pan, & Chang, 2014; Hillman, Erickson, & Kramer, 2008). Longitudinal studies across populations of youth also indicate that chronic engagement in MVPA and increased fitness significantly increases attention, (Bartholomew & Jowers, 2011) working memory and attention, (Niederer et al., 2011) inhibitory control, (Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011; Drollette et al., 2014; van der Niet et al., 2016) as well as academic outcomes

(Davis et al., 2011). Despite this evidence, to date, few studies have examined such effects amount preschool aged, over elementary-school children. Only one known study has launched a continuing PA investigation within early childhood. Their intervention, nine weeks in duration looked across types of PA engagement and found significant effects of both coordinative and aerobic PA on attentional tasks (Zach, Inglis, Fox, Berger, & Stahl, 2015).

Mediators of PA Participation and Cognitive Outcomes

Despite the known relationship between EF and PA among children (Fedewa, Ahn, Erwin, & Davis, 2015; Howie, Schatz, & Pate, 2015; Sallis, Prochaska, Taylor, & others, 2000) several potential mediating factors such as the type of PA as well as the gender of the individual engaging in the PA remain unclear. Girls have been identified as experiencing more significant benefits of PA and physical education engagement than boys, yet reasons, why this occurs, remain unclear (Carlson et al., 2008; Howie et al., 2015). As Pate and colleagues (2013) assert, gender remains an understudied moderating factor that must be further investigated; particularly in formalized, educational programming that offers opportunities to participate in PA.

Similar to the unclear influence of gender, how the type of PA engagement may influence EF is largely unknown as most studies utilize one type of PA as a treatment rather than exploring the effects of aerobic versus muscular activities (e.g. specifically PA that is multimodal versus a single modality). One example of this research phenomenon is utilizing coordinative exercise to investigate its impact on inhibitory control (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Chang, Tsai, Chen, & Hung, 2012; Pesce et al., 2016). Chang and colleagues (2012), are the only known scholars to date who have examined this relationship in an early childhood population indicating that among kindergartners coordinative exercise facilitated inhibition regardless of intensity. Several studies utilized aerobic activity, but these failed to explore the effects of different types of PA, as a mechanism for eliciting EF responses (Castelli et al., 2011; Davis et al., 2011; Drollette et al., 2014; Hillman et al., 2009; Niederer et al., 2011; van der Niet et al., 2016). Unlike the coordinated PA studied by Chang (2012), Niederer and colleagues (2011) examined aerobic exercise only and its relationship with working memory. This paucity of research among children in early childhood programs and the limitations within those studies (e.g. failure to account for mediating and moderating factors) makes this present study timely and of great importance. Therefore, the purpose of this study is to examine the influence of varied modes of PA on executive functioning in the early childhood setting. Specifically, this study seeks to answer the questions of 1). What is the effect of PA intensity on cognitive performance in the early childhood setting? 2). What is the effect of gender and exercise mode on cognitive performance among young children? 3). How does gender moderate the relationship between PA type and cognitive function?

Methodology

This experimentally designed study was utilized to gather EF and PA relational data in authentic classroom settings. Data were collected in one southern state; across six schools and twenty-three classrooms in a one-day visit. Study procedures were carried out after Institutional Review Board and school district permission were granted and parental consent secured.

Participants

Public elementary schools located in central Texas that included early childhood classrooms including preschool, kindergarten, and first grade (n=210) (M=5 years) were solicited to participate. This purposive sampling strategy was employed to obtain rich physical and cognitive data within the population of interest (Creswell, 2013; Patton, 1990). Participants were randomized into the following conditions: (a) low- or high-intensity PA and (b) type of PA. The low-intensity condition served as the control for this study because this condition created a similar classroom environment, which sitting as desks would not represent. Further, this would permit the researcher to confirm the level of intensity, as manipulated by the PA type, over a comparison of total sedentary behavior and no movement whatsoever. In sum, the three PA conditions were: dance (high-intensity experimental group 1), aerobic (high-intensity experimental group 2) and yoga (control).

Instruments and Measures

This section overviews the measures utilized to carry out this study of an acute bout of classroom PA and its impact on EF. The PA instruments are described in detail first, followed by the measures of EF. All included measures were selected as appropriate assessments to conduct within the early childhood classroom setting.

PA measures. This study utilized two measures to investigate intensity and mode of PA in the classroom. A direct observation measure in addition to an evidence-based resource was selected based on their sensitivity in the early childhood setting.

Actigraph accelerometry. Actigraph GT3X triaxial accelerometers were utilized to measure both the intensity of PA engagement as well as the unique patterns of accelerations exhibited by coordinative dance and aerobic exercise (Ainsworth, Cahalin, Buman, & Ross, 2015). Accelerometers are considered the gold standard PA measurement (LeMasurier & Tudor-Locke, 2003) and therefore utilized to capture variability between models of PA. Regardless of random group assignment, high-intensity (dance or aerobic) or low- intensity (yoga), all participants wore their accelerometer at their right hip as the most sensitive placement has evidenced it for movement in young children (Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). All accelerometers were calibrated, and epochs were set to capture 5-second intervals (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). Evenson cut points were used as they have been validated in children as young as 4 for accurately capturing the intensity of PA engagement, over other youth based intensity cut-points such as Freedson, which have been validated in adolescent populations (Evenson, Catellier, Gill, Ondrak, McMurray, 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Patterns of intensity variation across different activity types were also captured through the Evenson cut points of intensity, given its accuracy.

Video-based online brain break. An evidence-based PA video delivery system using short video clips to engage students in classroom friendly PA engagement was utilized to deliver the PA opportunities consistently. Video-based online resources have become a popular mechanism (Gao, Hannan, Xiang, Stodden, & Valdez, 2013) among educators for implementing classroom physical activity as they are believed to improve students' classroom behavior and academic performance, yet this has not been scientifically confirmed. PA videos were approximately three minutes in duration and as a daily resource provide teachers with a multitude of PA engagement types ranging from mindfulness to aerobic. Specific videos were predetermined by the researcher to be high-intensity and low-intensity based upon both the resources' categorization of the PA based break as well as the child observed patterns of PA engagement.

Executive Function and Academic Achievement Measures. This study used three measures to investigate EF processes of attention, memory and academic readiness. Traditional measures commonly utilized in school-age populations were adapted to the developmental capacities of the child (e.g. tasks were shortened, pictures added, directions were read aloud).

Addition Math Facts**.** Researchers developed a total of 25 picture-based counting problems as a measure of ability to complete developmentally appropriate mathematic calculations. The math problems gradually increased in difficulty (i.e., outcomes began with single-digit results and moved to double-digit outcomes) in increments of five questions. Before starting the task, participants were familiarized with the task by completing one example problem with the researcher. Throughout the measure, participants could employ two different strategies: (a) the option of counting up the total number of symbols listed in a row or (b) sum the numeral values listed below each set of pictorial symbols. Participants had one minute to record their answers using paper and pencil. Emergent math, such as that in this measure, can be assimilated with academic readiness as it is the foundation for future academic success. A total number of correct responses was summed for both pre-and posttest measures. Pre-test sums were analyzed to determine potential baseline differences across groups, and posttest measures were analyzed as a representation of treatment effects (Diamond, Barnett, Thomas, & Munro, 2007).

Trail Making Test (TMT). The TMT measured the cognitive processes of visual attention and task switching (Tombaugh, 2004). This paper and pencil task was comprised of small circular bubbles that encapsulate the numerals one through twenty-five which scattered across the page. Participants were familiarized with the task through a short sample TMT measure comprised of larger circular bubbles numbered 1-8. For completion of this task, participants were instructed to trace a line connecting all numbers in ascending order beginning at one (i.e. completing a dot to dot moving from 1 – 20). Accuracy has been indicated as a developmentally appropriate measurement within childhood. As such, the traditional measurement technique of recording speed of completion was modified, and participants were given 20 seconds to accurately connect numerals (Diamond, Barnett, Thomas, & Munro, 2007). Data were recorded and analyzed as a total sum of accurate numerals connected both at baseline and post-treatment.

Visual Memory Task. Working memory was quantified by using an electronic light system that presented patterns of lights that needed to be recalled by the participant. Participants were shown a series of colors illuminated in a specific order which they were required to memorize and repeat verbatim. The task was progressive, beginning by recalling one color, then if correct they were shown the same color and then another color, for them to recall. The test continued until an error was made. The patterns of colored light were randomly presented. The visual memory task was completed in small groups where each student took two consecutive turns; the first turn was a familiarization trial which was not recorded as part of the final score. The second trial was continued until the participant made a recall error and then recorded. To score the test, each participant was given one point for each correct response. A score of the total number of color patterns was recorded. Pre-test scores were analyzed for baseline differences across groups, and posttest scores were analyzed for treatment effects.

Procedures

Across one academic year, a series of one-day visits were conducted all across twenty-three classrooms. Visits were arranged after gaining administrative and classroom teacher permissions to carry out research in the classroom. Among all students enrolled in the involved classrooms, 59% of the students consented to use the information for research purposes.

On the day of the classroom visit, parental consents were collected, and assent from individual students was obtained in writing, after a verbal prompt. Researchers then briefly introduced participants to accelerometers addressing what they look like, how they worked and modeled how to wear them properly. Participants were given an accelerometer to wear on their right hip.

Given the pre-post nature of this study, three cognitive assessments completed in the order of (a) addition math facts, (b) TMT, and (c) Visual Memory task. This series of cognitive tasks was administered in a small group setting with a 5:1 ratio of participants to researcher which ensured that participants stayed on-task with each measure. Before each measure, researchers provided their small groups with directions and an example problem to familiarize participants to the task. Rather than timing individual participants' speed of completion of the task at hand, both the addition math facts and the TMT tasks started and stopped at a specified time interval to measure accuracy. As a strategy to ensure that participants adhered to the protocol, researchers provided participants with a start and stop.

At the end of the pretest measures, students participated in an acute bout of PA via an online display of a peer model and mascot demonstrating a physical activity that they were instructed to follow. The PA video lasted approximately three minutes, so participants engaged in two consecutive PA videos that lasted six minutes in duration.

Post-intervention activities required that participants repeat all three cognitive measures of (a) addition math facts, (b) TMT, and (c) Visual Memory task. The same assessment protocols used for familiarization activities were implemented for the pretest measures. While participants took water and snack break, the researchers collected the accelerometers and cross-checked consent/assent forms and cognitive data to ensure that all study materials were properly secured.

Data Analysis

Descriptive statistics were calculated for instrument, class and between participants. The effects of PA intensity on cognitive outcomes was explored through ANCOVA analyses. Two-way between groups ANOVA's were conducted to examine the effect of sex and exercise mode on cognitive performance (math, TMT, Visual

Memory Task). Analyses were run using SPSS V24 software with significance levels set a priori at an alpha value of less than .05 (Peugh & Enders, 2005).

Results

Participants

Two school districts in Central Texas which included early childhood classroom settings were solicited to participate in this study. Across the two participating school districts, twenty- three preschool, kindergarten, and first-grade classrooms agreed to participate. Teachers sent home parental consent forms to all students enrolled in their classrooms, a total of 414 students. Of the solicited population, 242 students presented their written consent and assent forms equating to a 59% response rate.

Free and reduced lunch across the two school districts was 40.1%. Moreover, student participants were primarily Latino/a 40.4% closely followed by Caucasian 39.4%, then Black and Asian both 7.4%. On the scheduled day of the study, 32 students were eliminated from participating due to circumstances beyond the control of the researcher (i.e., absence, resource pull out, specials, etc). The remaining sample (n=205) included 18 preschool, 44 kindergarten, and 144 first grade students. Participants across this sample were 55% male with a M_{age} 5.6 years (ranging in age from 4 to 6 years).

PA Intensity Across Conditions

To confirm the intensity of PA participation the percentage of time spent in MVPA during the six minutes was quantified by group assignment, compared between treatment and control and gender (see Table 2.1). The mean percentage of time spent in

MVPA by control group was M= 0.160, SD = 0.19 and the percent of mean MVPA time for treatment were M= 0.356, SD= 0.17. Independent sample t-tests indicated a significant difference in MVPA engagement by control and treatment groups t(201)= -7.717, $p \leq 0.001$. There were no significant within-group gender differences for control (M=0.049, SD=0.044), t(77)=1.117, p=0.267 and treatment (M=-0.011, SD=0.032), t(124)= -0.359, p=0.720.

Type of PA. Variations in the patterns of PA engagement by activity type were explored using the dependent variables of MVPA, vigorous and Light PA (see Table 2.1). A two-way between-group ANOVA indicated significant differences in MVPA by mode F(2, 199) =26.981, $p \leq 0.001$. Post hoc analyses found that the yoga group M= 0.159 SD 0.19 was significantly different from the aerobic M=0.359, SD=0.167 and dance groups M= 0.352, SD= 0.186. There were no significant differences in MVPA between dance and aerobic. Further, the interaction effect for mode and gender on the dependent variable of MVPA was not significant F(2,199) = 1.552, $p > 0.05$.

There were also significant differences in vigorous PA by type F(2, 199) = 37.949, $p < 0.001$. Post hoc analyses found that the aerobic group M= 0.29, SD= 0.14 was significantly different from dance 0.21, SD = 0.16 and yoga M= 0.06, SD = 0.07. Further, light PA by type also exhibited significant difference by the group, F (2, 199) =9.184, $p < 0.001$. Post hoc analyses identified that the yoga group M= 0.291, SD = 0.15 was significantly different than dance M= 0.394, SD= 0.13. The dance group also exhibited significantly more time spent in light PA than aerobic M= 0.317, SD= 0.14. There were no significant differences in light PA engagement between the aerobic and yoga groups. Exploration of an interaction effect for mode and gender on Light PA was not significant $F(2, 199) = 0.314$, $p > 0.05$. As anticipated, the conditions reflected high- and low-intensity, with differences in activity type (Table 2.2).

Cognitive Outcomes

***Addition Math Facts*.** Baseline means of math scores were explored overall and by PA intensity and type. The sample used to conduct the math facts was n=170. A total of 35 cases were eliminated because of a lack of fidelity to treatment (i.e., did not start on time, did not stop on time, refusal to attempt the task, eligible marks). Across the remaining overall sample, baseline math facts scores at baseline were M= 5.06, SD= 2.03; posttest scores were M= 6.37, SD = 2.38, equating to an overall pre to posttest mean difference of M=1.10, SD= 1.69. Table 2.3 illustrates means by groups of intensity and mode.

A one-way between-group ANOVA was used to determine if there were baseline math fact differences by intensity groups. Results indicated a significant difference at baseline between control and treatment $F(1, 168) = 4.909$, $p < 0.05$. As such, baseline scores will be included as a covariate in analyses of treatment effects on the dependent variable. Baseline math differences were also explored by mode. One-way between-group ANOVA analyses indicated there were no significant differences at baseline $F(2, 167) = 2.749$, $p > 0.05$. Analysis of posttest treatment effects is reported below by research question.

***TMT*.** The participating sample size (n=205) was decreased in the analysis of TMT by 34 participants due to fidelity issues (i.e., did not start on time, did not end on time, did not follow directions for number task). The remaining sample (n=171) had an overall baseline score of M=13.38, SD=4.06 and posttest M=17.11, SD=4.65 with a mean difference of 3.59, SD=3.36. See Table 2.2 for mean breakdowns by intensity and mode groups.

A one-way between-group ANOVA was used to determine any baseline differences by the PA intensity and by type of activity. Comparison of high- and low-intensity performance at baseline indicated significant differences F = 5.927, (1, 170), $p < 0.05$. However, comparison across modes of yoga, dance and aerobic found no significant differences at baseline F = 2.949 (2, 169), $p > 0.05$. Results of treatment effects on TMT posttest performance are indicated below by research question. This analysis confirms that the participants randomized into the condition did not significantly differ from one another.

Visual Memory Task. For the visual memory task analysis, a baseline sample n=158 was utilized for analysis as 47 participants scores were eliminated due to a lack of fidelity to treatment (i.e., forgetting the total score, taking an additional turn) as well as instrument malfunctions. Across the total sample baseline scores were M=5.09, SD=1.98 and posttest scores were M=5.90, SD=2.47, equating to a overall mean difference M=0.8, SD=2.17. Table 2.2 details mean scores by groups of intensity and mode.

Analysis of baseline differences was conducted for both the PA intensity treatment as well as by type. A one-way between-group ANOVA indicated no significant differences between high- and low-intensity groups F = 2.42 (1, 156), $p > 0.05$. By type, one-way between-group ANOVA indicated significant baseline differences F = 4.677 (1, 156), $p < 0.05$. As such, baseline scores will be utilized as a covariate in subsequent analyses exploring treatment effects.

Effect of PA Intensity on Cognitive Performance

To answer the research question of *What is the effect of PA intensity on cognitive performance in early childhood,* a series of ANCOVA analyses were conducted to determine the effect of PA intensity on cognitive measures including addition math facts, TMT, and visual memory task. Because of baseline differences between the high and low-intensity groups on the addition math facts and TMT measures, the pretest assessment was used as a covariate. Results indicated that there was no significant effect of PA intensity on addition math facts, $F(1, 158) = 2.526$, $p > 0.05$ when controlling for age and pretest performance. Next, the effect of intensity on posttest TMT performance and results indicated no significant effect, $F(1,158) = 0.147$, $p > 0.05$ when controlling for pretest group differences. Finally, the effect of intensity on the posttest visual memory task was explored, and after controlling for age, no significant effects were identified $F(1, 145) = 0.693$, $p > 0.05$.

Effect of Gender and Exercise Mode on Cognitive Performance

To answer the research questions, *What is the effect of gender and exercise type on cognitive performance among young children?*; and *How does gender moderate the relationship between PA type and cognitive function?*, a series of two-way between group ANOVAs were conducted. Results are reported by cognitive outcome below.

Addition Math Facts. Group mean differences on posttest addition math fact outcomes, were compared across exercise type and gender controlling for age and baseline math fact performance. Results indicated that the interaction effect between gender and exercise type was not significant, F(2, 161) = 0.044, $p > 0.05$. There was a significant main effect for exercise type, F(2,161) = 5.205, $p \leq 0.01$ with partial eta squared=0.06 (Table 2.4). Post hoc comparison using the Tukey test indicated that the estimated marginal mean score for the dance group (M=6.941, SE=0.232) was significantly different from yoga (M= 6.081, SE=0.201) and aerobic (M=5.976, SE=0.253). The aerobic group did not differ significantly from the yoga group (Figure 2.1). The main effect for gender, F(1, 161) =0.011, $p > 0.05$ did not reach statistical significance.

TMT. To explore posttest differences on the attentional task the TMT group means were compared across exercise mode while controlling for age and baseline TMT performance. The results of the two-way between-groups ANOVA indicated that the interaction effect between gender and exercise type was not significant, F(2, 156) =0.522, $p > 0.05$. There was a significant main effect for exercise mode, F(2,156) =3.234, $p < 0.05$ with partial eta squared=0.04 (Table 2.4). Post hoc comparison using the Tukey test indicated that the estimated marginal mean score for the dance (17.994, SE 0.449) was significantly different from the aerobic (16,294, SE=0.506) group. There were no significant differences for the yoga group (17.08, SE=0.417; SD=4.77) (Figure 2.2). The main effect for gender, F(1,156) =1.745, $p > 0.05$ did not reach statistical significance.

Visual Memory Task. As indicated by the two-way between-groups ANOVA indicated, when controlling for baseline differences and age, there was no significant effect of exercise mode on the visual memory task, F(2, 143) = 0.919, $p > 0.05$ (table 2.4).

Additionally, there was no significant effect of gender F(1, 143) = 1.754, $p > 0.05$ (Figure 3.3).

Conclusion

The results of this study suggest that within early childhood the type of PA matters. Dance has the potential to significantly improve a child's attention and academic performance. Further, this type of PA is equally beneficial for both males and females. These findings advance our understanding of the relationship between PA and EF and more importantly, inform best practices within the early childhood setting.

This study also confirms Diamond and Ling's (2016) hypotheses that coordinative exercise may hold additional cognitive benefits above and beyond that of aerobic PA engagement. Children engaged in short-duration dance PA breaks outperformed their peers on both attentional and math performance tasks. These findings do not, however, diminish the effects of chronic participation in aerobic PA; in particular, engagement leading to increased levels of physical fitness. In the present study, children assigned to the short-duration aerobic PA did not significantly increase cognitive performance, yet they still performed above and beyond their yoga engaged peers. Further, compelling evidence of the effects of chronic aerobic and high-intensity PA on EF is published elsewhere (Campbell et al., 2001; Castelli, Hillman, Buck, Erwin, & others, 2007; Chang et al., 2012; Niederer et al., 2011; Pesce et al., 2016; Zach et al., 2015).

Several studies indicate that longer duration classroom PA breaks significantly impact attention, memory as well as academic readiness (REF). Pate and colleagues (2015) found that their 10-minute treatment significantly influenced academic performance yet their 5-minute treatment did not. As such, it is possible that a six-minute duration physical activity break did not offer enough time in intensive PA to elicit any significant cognitive outcomes. Collectively, these findings reiterate the necessity of providing children opportunities to engage in a variety of PA opportunities across the school day as it was found to enhance the young child's cognitive capacity.

PA in Classrooms

To date, no known study has found detrimental effects of school day PA on academic performance (Rasberry et al., 2011; Trudeau & Shephard, 2008). However, some field experts continue to question the value of classroom PA fearing that it takes away from instruction time and further doubting its ability to augment the academic and cognitive performance of the child (Johnson, 1998; Klein, 2004). The findings from this study contribute to the knowledge base finding PA engagement to be far from detrimental; rather it can augment learning.

Historically, educational settings have conceptualized learning as a sum of parts where learning was solitary; with mathematics, language arts, and physical education (PE) all taught independently from one another (Tanner & Tanner, 1990). Moreover, because PE is often segregated from the rest of the school, conducted only in the gym, its value and worth ha continued to go unnoticed further diminishing any forethought that PA may ultimately contribute to classroom learning (Bryant et al., under review). Progressive pedagogical practices have more recently started to challenge traditional approaches to teaching and learning. For example, problem-based learning (PBL) strategies seek to intertwine subject areas such as reading and math by developing lessons based on real-world settings (Torp & Sage, 1998). The flipped classroom approach was also developed to challenge traditional practices by limiting direct instruction to allow more time for child-centered learning (Staker, 2012). However, little has been done within these progressive PBL and flipped classroom strategies to incorporate PA (Leppo & Davis, 2005). The educational arena must continue to work to decompartmentalize all learning as the findings from this study further our understanding that, along with consideration for the real world and student-centered learning, also comes a need to act and experience one's environment physically. When educators start to visualize learning as an organic and fluid process where all concepts and subjects can be taught in harmony there might not just be a higher academic success; we may come to find that students enjoy their learning.

In addition to confirming the value of PA as it relates to learning, this study also provides teachers with practical strategies for how to strategically incorporate PA across their school day. This study examined three types of PA engagement (aerobic, dance and yoga) and found that dance positively related to academic performance and attention above and beyond other modes of PA. This novel finding not only fills a research gap but provides future direction for best practice. Classroom routines should be structured around cognitively appropriate and differentiated PA breaks. That is, educators should incorporate dance PA breaks before academically challenging lessons and tasks (i.e., math and literacy readiness assessments). Further, dance should be integrated into instructional components (i.e., direct instruction, circle time and read aloud) of the day where students benefit from maintaining higher attentional capacity. To date, classroom

PA engagement has been evidenced as one of the least utilized classroom practices (Barcelona et al., under review). Therefore, the findings from this study are timely and warranted as they address both the “hows” and the “whys” for incorporating PA into the learning environment.

This study has laid the groundwork for the future investigation into the impact of different types of classroom PA on specific learning and cognitive outcomes. Further research must be done on the differentiation of PA break type as it relates to different learning and cognitive demands throughout the day. It would also be helpful to better understand from a longitudinal perspective how differentiated PA breaks impact children’s academic success exploring the relationship across the developmental stages of childhood.

Delimitations and Limitations

No study to date has examined the variations in effect across different modes of PA in the early childhood setting. As such, there are significant strengths to the novelty of the present study. Further, no early childhood studies have investigated how variations across mode PA may mediate its effects on EF. Scientific understanding of how mode of PA impacts EF in early childhood is vital as it can inform classroom practice and curriculum development. This study lays the groundwork for the growing understanding of the value that PA has on the lives of our youngest generations.

The overarching goal of this study was to identify practical ways to ensure movement across the day in early childhood. Past research has given little consideration to the impact of acute PA breaks lasting less than ten minutes in duration. This study evidences that PA breaks as short as six minutes in duration may positively impact cognition in young children thereby enhancing their academic readiness.

Despite the novelty of findings resulting from this study, it is not without limitations. One primary limitation of this study is the small sample size. To examine various types of PA, participants were randomized into three treatments which diminished the total number of children engaging in each type. As such, these results may not be generalizable to the greater population. Future research will hopefully be informed by these results and replicate this study design within a larger sample.

The PA break resource utilized for this study offered varied types of PA including yoga, dance and aerobic. Although the three PA patterns mapped onto the hypothesized levels of intensity, there were some unanticipated findings. For example, the dance group exhibited significantly more light PA engagement than hypothesized. Further, the yoga condition was mostly sedentary to light movement. Therefore, the findings from this study may not be generalizable as traditional dance and yoga practices beyond this study's PA resource may exhibit different patterns of PA. Variations across these dance patterns may also elicit different cognitive outcomes. Further, given that there are variations across yoga and dance practices, the results of this study may not be indicative of every type of dance or yoga engagement. Future research should be conducted to explore these potential variations across different practices of PA and how their engagement may differentially impact cognitive outcomes in children.

Implications for Early Childhood Education

This study warrants valuable and translatable knowledge to those serving as educators within early childhood. For starters, early childhood centers must take note of the potential and value that dance may hold within the curriculum. Simple modifications to basic and rote components of the early childhood curriculum (i.e.: alphabet and numeracy), may be best delivered through dance and PA based mechanisms. Further, educators should feel empowered to provide more opportunities across their school day to free their children from sedentary instruction instead of meaningful movement opportunities.

The present study suggests that to reap the fullest cognitive potential from the young scholar, one must tap into their physical domains. Children learn from the experiences, and as this study suggests, they learn best from physically active experiences. If we deprive children of opportunities to learn, we just may be stifling their greatest future potential.

Table 2.1
Group Means (SD) of PA Engagement

	Intensity					
	Control (low)			Treatment (high)		
Variables	Male	Female	Total	Male	Female	Total
n	40	44	84	77	49	126
MVPA (% time)	19% (0.22)	13.6% (0.16)	16% (0.19)	35.1% (0.18)	36.2% (0.17)	35.6% (0.17)

	Mode								
	Yoga			Dance			Aerobic		
Variables	Male	Female	Total	Male	Female	Total	Male	Female	Total
n	37	42	79	41	25	66	36	24	60
MVPA (%)	0.18 (0.03)	0.13 (0.02)	0.15 (0.19)	0.33 (0.02)	0.38 (0.03)	0.35 (0.18)	0.37 (0.03)	0.33 (0.03	0.35 (0.16)
Vig (%)	0.06 (.0.6)	0.06 (0.08)	0.06 (0.07)	0.21 (0.15)	0.23 (0.17)	0.21 (0.16)	0.34 (0.13)	0.26 (0.15)	0.3 (0.14)
Mod (%)	0.08 (0.11)	0.07 (0.1)	0.08 (0.09)	0.15 (0.07)	0.11 (0.18)	0.13 (0.1)	0.13 (0.21)	0.09 (0.06)	0.12 (0.11)
Light (%)	0.29 (0.16)	0.28 (0.15)	0.29 (0.15)	0.39 (0.14)	0.39 (0.12)	0.39 (0.13)	0.33 (0.14)	0.29 (0.13)	0.31 (0.14)
Sed (%)	0.52 (0.20)	0.57 (0.21)	0.55 (0.21)	0.15 (0.07)	0.20 (0.14)	0.18 (0.16)	0.19 (0.05)	0.28 (0.03)	0.32 (0.13)

Note.MVPA (% time)= time spent in moderate to vigorous physical activity, Vig (%)= time spent in vigorous physical activity, Mod (%)= time spent in moderate physical activity, Light (%)= time spent in light physical activity, Sed(%)= time spent in sedentary activity.

Table 2.2.

Group Mean Comparisons Across PA Intensity

Type	Yoga	Dance	Aerobic	Main Effect of Mode	
		Posttest		F	*p*
MVPA	0.15 (0.19)	0.35 (0.18)	0.35 (0.16)	26.981	0.001*
Vigorous	0.06 (0.07)	0.21 (0.16)	0.29 (0.14)	37.941	0.001*
Light	0.29 (0.15)	0.39 (0.13)	0.31 (0.14)	9.184	0.001*

**p<0.01

Table 2.3

Group Means (SD) of Cognitive Outcomes by PA Treatment

	Intensity					
	Control			**Treatment**		
Variables	Math	TMT	Memory	Math	TMT	Memory
Pretest	4.66 (2.0)	12.47(4.2)	4.79(1.9)	5.35(1.9)	13.99(3.8)	5.29(2)
Posttest	5.82(2.2)	16.27(4.7)	5.47(2.3)	6.75(2.4)	17.65(4.5)	6.17(2.5)

	Mode								
	Yoga			**Dance**			**Aerobic**		
Variables	Math	TMT	Memory	Math	TMT	Memory	Math	TMT	Memory
Pretest	4.66 (2)	12.47 (4.2)	4.79 (1.9)	5.49 (1.8)	14.01 (3.9)	5.76 (1.75)	5.18 (2.14)	13.95 (3.7)	4.72 (2.1)
Posttest	5.82 (2.2)	16.27 (4.7)	5.47 (2.3)	7.33 (1.9)	18.43 (4.21)	6.23 (2.2)	5.97 (2.7)	16.63 (4.7)	6.09 (2.8)

Note. Math, TMT & Memory=exexutive function tasks

Table 2.4.
Group Mean Comparisons by PA Type

Test	Yoga	Dance	Aerobic	Main Effect of Mode	
		Posttest		F	*p*
Math	5.82 (2.2)	7.33(1.9)	5.97(2.7)	5.205	0.006**
TMTA	16.27(4.7)	18.43(4.2)	16.63(4.7)	3.234	0.042*
Memory	5.47 (2.3)	6.23(2.2)	6.09(2.8)	0.919	0.401

*p<0.05
**p<0.01

Figure 2.1. Math Outcomes by Mode

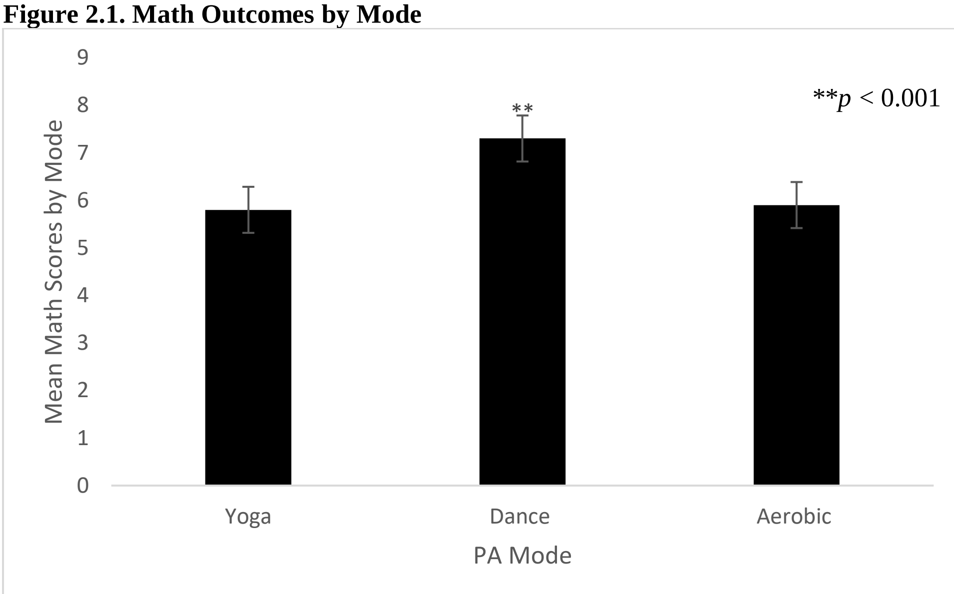


Figure 2.2 TMT Outcomes by Mode

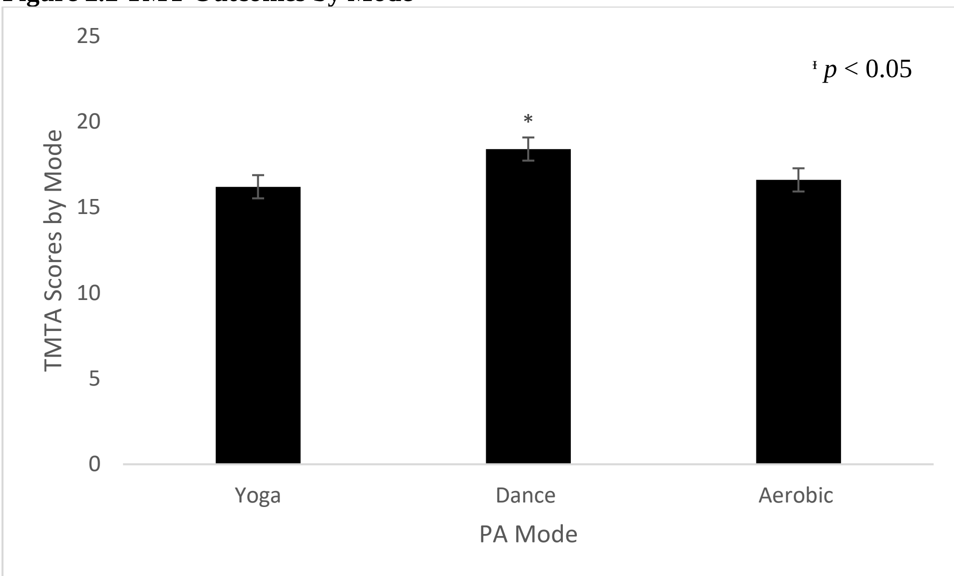
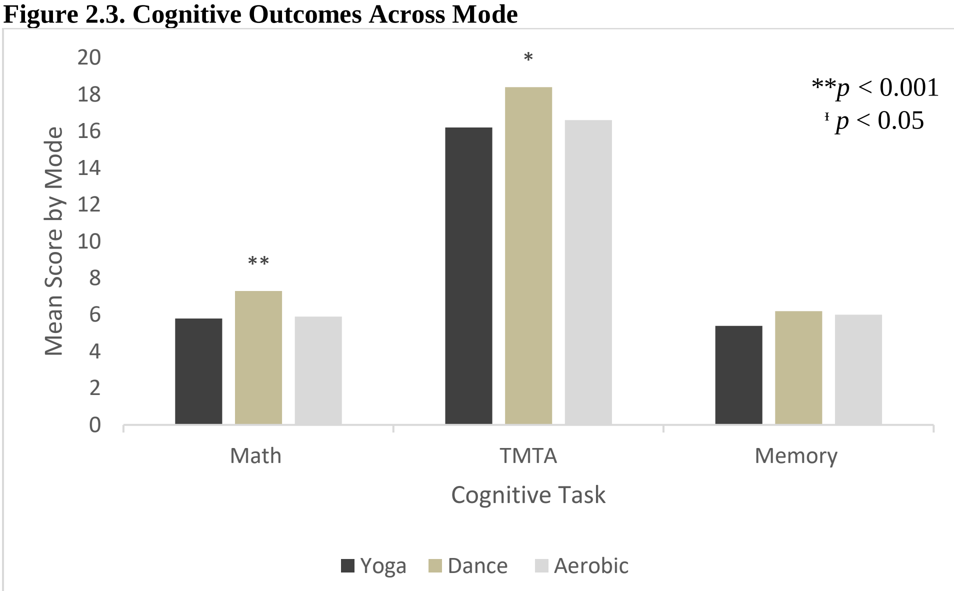


Figure 2.3. Cognitive Outcomes Across Mode



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Study 3: The Mediating Role of Physical Activity Patterns in Early Childhood

Abstract

Purpose: Utilizing the *Whole School, Whole Community, Whole Child* (WSCC) model, this study examined the main effects and the mediating potential of psychosocial, environmental, and physical activity (PA) variables on cognition in early childhood. **Method:** Purposeful sampling was employed to recruit students in preschool, kindergarten and first-grade classrooms (n=23) in two central Texas school districts. Teachers and their early childhood students engaged in a one-day study protocol. The teachers completed an environmental measure to examine their perceptions of the classroom climate. Students completed a psychosocial survey measure and participated in an acute bout of PA in between pre-post cognitive assessment. For the PA, students were randomized to: (a) dance (high-intensity experimental group 1), (b), aerobic (high-intensity experimental group 2) and (c) yoga (control group). **Results:** Teacher participants (n=23; 100% female; 91% Caucasian) were educators in six schools with an average free and reduced lunch of 38.86%. Student participants (n=124) were primarily Latino/a (40.4%) and male (55%) with a M_{age} of 5.6 years. Bivariate correlations between the variables of interest revealed several significant associations which were further investigated. Linear regression analyses indicated teacher climate B=-0.345 t(124)=-2.750, p<0.01 and the cognition B = 0.328 t (124) =2.213, p<0.05 as significant predictors of dance. For aerobic PA, teacher climate B=-0.348 t(124)=-2.897, p<0.05 and cognition B=-0.371 t(124)=-2.605, $p \leq$0.01 were both significant predictors. For cognition, dance B=0.192 t(124)=2.106, $p \leq$0.05 and aerobic B= 0.270 t(124)=2.918,

$p<0.01$ PA were significant predictors. Teacher’s climate did not reach statistical significance in either model. In two subsequent path analyses both PA models maintained a direct effect of dance ($B = 0.372$, $p \leq 0.001$) and aerobic ($B = 0.316$, $p \leq 0.001$) on cognition but no significant mediation pathways were detected. **Conclusions:** PA plays a critical role in early childhood as even short-duration, acute-engagement significantly enhances cognitive outcomes. Ample opportunities to move, play and be active may be more critical to the young child’s development than an academic focus.

The rise of obesity among children is well known for its deleterious physical health outcomes. However, there are many other facets of personal health and wellness impacted by childhood obesity. Burdette and Whitaker (2005) assert that when considering the impact of childhood obesity one must look beyond the physical aspects and consider the social, emotional, and cognitive outcomes that are also affected. Further, the intricacies between physical activity (PA) and multiple outcomes of emotional, physical and mental health must be considered because such charateristics are impossible to disentangle from the whole child (Tomporowski, Lambourne, & Okumura, 2011). The *Whole School, Whole Community, Whole Child* (WSCC) model illustrates this dynamic by suggesting a synergistic interplay between children's behaviors, cognitions, and the environment.

Physical Activity, Executive Function, and the Mediated Pathways

As the WSCC model asserts, there is the interplay between our behaviors, cognitions, and the environment that influences the development of the whole child (Lewallen, Hunt, Potts-Datema, Zaza, & Giles, 2015). The model further suggests the substantial impact that health behaviors such as physical activity (PA) have on cognitive development. As posited by Ryan and Deci, participation in PA is motivated by an individual's perceptions of autonomy, competence, and relatedness (Ryan & Deci, 2000). That is, one's personal relationship with PA is both intrinsically and extrinsically motivated. The personal beliefs, thoughts, and perceptions an individual possesses about their abilities shapes behaviors such as PA engagement. Extrinsic forces, how one identifies and perceives their place within the larger external group in behaviors such as PA, also facilitate engagement.

PA is one of the most influential health behaviors a child can foster as it is significantly related to decreased risk of early mortality (Blair et al., 1989; Erikssen, 2012), chronic disease (Warburton, Nicol, & Bredin, 2006), and is found to enhance mental health (Dunn, Trivedi, & O'Neal, 2001) across the lifespan. Further, PA contributes to cognitive well-being across the life span (Castelli, Hillman, Buck, Erwin, 2007; Kramer, Erickson, & Colcombe, 2006; Sibley & Etnier, 2003; Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011). Executive function (EF) is conceptualized as a tenet of cognition; that is working memory, inhibition, attention and flexibility are the cognitive processes that lead to higher order thinking (Diamond, 2006).

As a cognitive process of EF, working memory is the ability to hold onto and manipulate a developing thought such as observing a sequential pattern and then recalling it (Diamond, 2006). Inhibition refers to one's ability to filter out distracting stimulus in assessments such as the day-night task. Attention thought of as the degree to which one can control their thoughts and actions while quieting internal and external stimulus is commonly measured through the trails task (Rueda, Posner, & Rothbart, 2005). Finally, cognitive flexibility is best conceptualized as the degree of fluidity one maintains through task switching measures such as the Wisconsin card sort (Diamond, 2013). A robust body of literature points to the direct relationship between PA and executive functioning (Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011; Chaddock-Heyman et al., 2013; Davis et al., 2011; Drollette et al., 2014; Hillman, Buck, Themanson, Pontifex, &

Castelli, 2009; van der Niet et al., 2016) among school-age children. There is limited research suggesting such effects among children enrolled in early childhood programs.

The benefits of acute versus chronic PA. Both acute and chronic PA are indicated as having a strong and positive relationship with EF among youth populations (Best, 2010). Chronic engagement is defined as routine and habitual engagement over time while acute engagement is delivered in a single session. While the main outcome of regular PA participation is to enhance a child's overall fitness as a mechanism for improving cognition, acute PA seeks to measure the immediate EF behavioral responses.

Physical fitness has been evidenced as a strong predictor of cognitive outcomes among adolescent populations (Castelli et al., 2007). There are a multitude of ways to measure fitness among older children, adolescents and adults including assessments of flexibility, aerobic capacity, and muscular endurance. Among the early childhood population, researchers find that the most important measure of fitness is motor skill development. Researchers have assimilated motor skill development to the building block from which later physical fitness emerges (Clark & Metcalfe, 2002; Seefeldt & Nadeau, 1980). However, it often goes unmeasured in school-based settings for numerous reasons. Fisher (2009) suggests that the lack of evidence may be a result of current pedagogical beliefs surrounding developmentally appropriate practices, which discourage formal fitness assessments within schools until the third grade. One quasi-experimental study using kindergarten and first graders employed a pretest-posttest protocol of a modified version of the *FitnessGram®* assessment (i.e., modified pushup, pullups, long jump, and shuttle run) at the beginning and end of a 4-week intervention to assess the relationship between PA and fitness. Results found no significant immediate fitness effects, yet found significant cardiovascular fitness effects at a four-month follow-up assessment (Matvienko & Ahrabi-Fard, 2010).

Due to the lack of fitness clarity within early childhood, most research in the population seeks to investigate the acute effects of PA on EF. For example, five studies condcuted in early childhood settings identified a significant relationships between acute PA engagement and inhibition (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Chang, Tsai, Chen, & Hung, 2012; Pesce et al., 2016), memory (Mierau et al., 2014; Niederer et al., 2011) and academic performance (Howie, Schatz, & Pate, 2015). The evidence from the early childhood literature suggests a strong relationship between the provision of single session of PA on EF, yet the role of social and environmental factors on this relationship remain unclear (Diamond & Ling, 2016).

Psychosocial factors. Often conceptualized as the interpersonal elements an individual embodies, accounting for how psychosocial factors may influence a known direct association is necessary. In the Self-Determination Theory (SDT), self-motivation is ultimately enhanced through factors including competence, autonomy, and relatedness (Ryan & Deci, 2000). Competence, an individual’s self-assessment of their capacity to engage in a given behavior, is best related to a young child’s confidence in their abilities to participate in an organized sport (McKenzie, Butcher, Sallis, & Alcaraz, 2001). Autonomy refers to one’s level of independence which in early childhood may be fostered through opportunities to engage in free play (Roemmich et al., 2006).

Relatedness, how one identifies with the larger social group in a given behavior, is best defined as friendship building through play in early childhood (Jago et al., 2009).

SDT in the educational context suggests that enjoyment of and motivation to learn are ignited through the development of a child's competency, autonomy, and relatedness. Therefore, self-determination, and its constructs of competence, autonomy, and relatedness, are critical factors in the process of helping a child maximize his/her potential. SDT also has implications for health-related behaviors such as PA engagement, as they are related to an individual's personal level of self-determination.

Research suggests a strong relationship between PA and self-determination across youth suggesting that competence and enjoyment in childhood are necessary elements that should be embedded in early childhood education. For example, a child's perceived competence as had a positive effect on the intensity of PA engagement (DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998). Specifically, the intensity to which a child will engage in PA is related to how they perceive their abilities about other children (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Further, research indicates an interaction between a child's perceptions of enjoyment and their perceived competence, influences self-motivation toward PA engagement (Standage, Duda, & Ntoumanis, 2003; Standage, Gillison, Ntoumanis, & Treasure, 2012; Weiss, 2000). As these findings suggest, competence and enjoyment must be developed in children, and one suitable way to address these factors may be to have children be active during the school day, in their classrooms (e.g. moving and learning or taking a break from academic time to be physically active).

Environmental Factors. A child's interaction with their environment and the resources within that space impacts the rate of PA participation (Davison & Lawson, 2006). The Institute of Medicine (IOM) has identified schools as an appropriate environment for modifying health-related behaviors (IOM, 2013). Several environmental factors at the school level have been identified as contributory to student PA. When the school environment is supportive and educators are knowledgeable about and prioritize PA, the participation in PA has been has been linked considerably lager numbers of children meeting the national recommendtions for PA of 60 minutes per day (Derscheid, Umoren, Kim, Henry, & Zittel, 2010; Dyment & Coleman, 2013; Gehris, Gooze, & Whitaker, 2015; Pate et al., 2016; Reunamo et al., 2014; Wilke, Opdenakker, Kremers, & Gubbels, 2013). School environments identified as most conducive to student PA engagement have utilized non-traditional routines and classroom layouts to encourage free movement (Pate et al., 2014; Ross, 2012) and less sedentary time. To date, we have a sound understanding of how the environment must be structured, yet little is known about how the teacher's perceptions of classroom environment may impact student PA engagement.

Research has identified interdependent associations of PA participation with psychosocial and environmental factors, as well as with the cognitive processes of EF that subserve learning. To date, there is no clear understanding of how these relationships may intersect and how teachers can foster such outcomes (Pate et al., 2013). As such, the purpose of this study is to identify the main effects of psychosocial, environment, PA, and EF as well as the mediated pathways unique to this early childhood setting (Figure 3.1). The present investigation is based on the following questions: (1) What are the associations between PA, self-determination, classroom climate, and executive functioning within the early childhood population?, and (2) How does PA mediate the relationship between psychosocial and environmental variables as they relate to cognitive performance?

Methodology

This experimentally designed study was conducted to examine the indirect and direct effects of PA on EF in the early childhood setting. Psychosocial, environment, PA and EF data were collected throughout two urban school districts in the southern region of the US. Six schools and twenty-three classrooms participated in the one-day study, once approvals from the Institutional Review Board and the school district as well as parental consent were secured.

Participants

A purposeful sampling technique was utilized to target an understudied population and setting where little is known about the effects of classroom PA engagement on EF (Creswell, 2013; Patton, 1990). Children attending early childhood classrooms connected with two southern school districts in the educational levels of preschool, kindergarten, and first grade (n=410) were solicited to participate. Free and reduced lunch across the two school districts was 40.1%. and student participants were primarily Latino/a 40.4% and closely followed by Caucasian 39.4%, then Black and Asian both 7.4%. Teachers (n=23; 100% female) from the participating classrooms managed study recruitment communication with their student's guardians achieving a

59% response rate (n=210). Teachers, as adult participants, were asked to complete one survey measure focused on the climate of their classroom.

The child participant sample for the current study (n=124) was diminished due to missing data points for reasons beyond the control of the researcher (i.e., unanticipated absence, pull out for intervention and resource work, behavioral limitations, lack of participant fidelity to treatment). The remaining sample was 55% male with a M_{age} 5.6 years (range 4 to 6 years) where children were representative of the geographic culture: Latino/a (40.4%), Caucasian (39.4%), Black and Asian both (7.4%). Participants were randomized into either the treatment or control group which was further stratified by type of PA in the assigned condition. Children randomized to the control condition were administered low-intensity PA which was selected by the researcher because it was believed to better replicate active learning in the classroom environment over sitting and completing a worksheet. Children randomized into the treatment group were assigned either experienced aerobic or dance PA as a way to capture different patterns for PA intensity and engagement across different activity types. As such, there were three conditions which children were randomized into (a) dance (high-intensity experimental group 1), (b), aerobic (high-intensity experimental group 2) and (c) yoga (control group).

Instruments and Measures

This section outlines the measures utilized to investigate psychosocial and environmental factors mediated by an acute bout of classroom PA and their overall effect on EF. Each psychosocial tool is explained, followed by PA instruments culminating with the measures of EF. All measures were chosen because of the validity among the early childhood population as well as they feasibility in the classroom setting.

Survey measures. Two survey measures were used, one at the student level and one at the teacher level. Students completed a psychosocial survey investigating their perceptions of PA enjoyment and competence. Classroom teachers completed a classroom climate scale examining their perceptions of the classroom environment. Both surveys were utilized to test a potential indirect effect of PA on EF in the early childhood setting.

Teacher Perceived Climate Scale. The Teacher Perceived Climate Scale is a valid and reliable 25-item survey was developed to quantify teacher's thoughts and perceptions of their classroom and school climate (Fraser, 1982; Loukas et al., 2006). The original survey contained five subscales, but only four of the subscales were of interest for this study because they measured classroom climate through constructs of; cohesion, friction, competition among students, and class satisfaction. Further, eliminating the school-level climate scale reduced the survey to 20 questions thereby decreasing teacher participant burden. Teachers answered questions on a five-point Likert scale ranging from very true to not true at all. Examples of questions included "Students in this class are always fighting with each other" and "Some students in this class always try to do their work better than the others." This survey measure was completed by teacher participants at one single point before student treatment procedures. A total summed score was calculated where higher scores were indicative of more positive teacher perceptions.

Determination Scale. This validated tool was developed to assess self-determination constructs of interest/enjoyment, perceived abilities/competence, effort, value/usefulness, pressure/tension and choice, and relatedness *(McAuley et al., 1989)*. For the purpose of the current study conducted within the early childhood setting, this survey was shortened to a total of ten questions (five items on a total of two constructs), and the lexicon was adapted to better align with early childhood literacy capacities. The first five items measured perceived interest and enjoyment of PA and included questions such as "*I like to move my body in class*." The following five items measured perceived PA competence through questions such as "*I am good at moving my body in class*." Participants rated their responses on a five-point Likert scale with five indicating the participant felt that the question was "*a lot like me*" and one indicated that the child did not feel the statement resonated with them or was "*not like me at all*." A factor analysis conducted by the researcher in a previous study indicated that the modified items properly loaded onto the two factors of interest explaining 67.66% of the variance. A research assistant was available to read items to emergent readers who struggled to read the text. Further, shape-based icons replaced numbers on the Likert scale to increase the accuracy of student interpretation. Participants completed this measure at one time point before engagement in an acute bout of PA with a higher score indicating stronger perceptions.

Health Measure. A measure of motor competency was obtained from the participating schools to assess fitness as a mediator of the relationship between PA and EF. Physical education teachers provided their binary assessment of participants' gross motor competence

Gross motor assessment. A gross motor competency score of *under development* or *developed* was gathered from physical educators at participating schools because unlike in school-age children, no early childhood fitness data are maintained at the district level. These data were collected retrospectively and were recorded as 1 for under development and 2 for demonstrated motor competence. Results from these data were indicative of an individual's fitness level and used as a control variable.

PA measure. Student PA intensity and type were measured. The direct measurement was employed as a valid and reliable tool for capturing intensity and movement patterns. Within the population of interest (Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). Considered the gold standard of measurement, Actigraph GT3X triaxial accelerometers were utilized to capture the intensity and patterns of classroom PA engagement (Ainsworth, Cahalin, Buman, & Ross, 2015; LeMasurier & Tudor-Locke, 2003). All participants wore an accelerometer to allow for quantitative measurement of the movement patterns expressed through various PA modes (yoga, dance, aerobic). Accelerometers were worn on the right hip which has been shown to be the most sensitive placement for movement in young children (Sirard et al., 2005). Before use, each accelerometer was calibrated, and epochs were programmed to capture 5-second intervals (Ward, Evenson, Vaughn, Rodgers, & Troiano, 2005). Evenson cut points were used as they have been validated in children as young as 4 for accurately capturing the intensity of PA engagement over Freedson cut points which have been established as more sensitive in a child population with a mean age of 11.3 years (Evenson, Catellier, Gill, Ondrak, McMurray, 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Patterns of intensity variation, across modes, were also captured through the Evenson cut points of intensity, given its accuracy.

Executive Function and Academic Achievement Measures. Attention, working memory, and academic readiness were measured through a series of three cognitive tests. All measures were tailored to the developmental period of the participant sample. Thus, the measures were shortened, pictures were added as a visual orientation, and the researcher provided verbal directions.

***Addition Math Facts*.** Emergent math readiness predicts future academic success (Jordan, Kaplan, Ramineni, & Locuniak, 2009). As such, developmentally-appropriate, picture-based math worksheet was developed by the researcher to measure arithmetic calculations. This 25-problem measure sequentially increased in difficulty in blocks of five questions. For example, the magnitude of the outcomes increased from the first five questions to the next block of questions eventually reaching double-digit results in the last set of questions, 20-25. Participants completed one sample problem with the researcher who demonstrated a choice in numeracy strategies: (a) summing the numbers or (b) counting the pictures located above each number set. This paper-pencil measure was given at two-time points where participants had one minute to answer equations. The total number of correct responses was summed for both pre- and posttest. Variations in accuracy from pre- to posttest sums were analyzed to identify PA treatment effects (Diamond, Barnett, Thomas, & Munro, 2007).

Trail Making Test. This paper and pencil measure of visual attention and task switching was comprised of 25 number bubbles randomly scattered across the page *(TMT; Tombaugh, 2004)*. Participants were familiarized to this task through a short example where the researcher demonstrated the expectation of connecting the dots in an ascending order of numerals. During the data collection, the participants were given 20-seconds to connect as many numbers as possible is sequential order and did so by tracing a lot dot to dot. The accuracy strategy employed for this measure was a developmental modification of the traditional reaction time and speed typically calculated (Diamond, Barnett, Thomas, & Munro, 2007). Data were recorded as a sum of the total number of correct numerals connected both at baseline and post-treatment.

Visual Memory Task. This recall task utilized a patterned electronic lighting system to measure working memory. Colored lights illuminated in a definite order and the expectation was that participants would be able to memorize and succinctly replicate the color order. All participants were provided two turns, the first utilized as a familiarization to the task which was not included in the sum of their correct trials. The task was progressively ordered where the first trial required the participant to recall one color and with each correct response, an additional color was added onto the pattern. This portion of the protocol was completed in a small group setting where each participant took a turn and continued to play until a recall error was made. For each correct pattern recall, participants were given one point, and total points were recorded. Pretest and posttest scores were analyzed for treatment effects.

Procedures

This study was carried out over one academic school year where individual classrooms (n=23) participated in a one-day study protocol. These visits were scheduled once school administration and classroom teachers provided formal written consent to carry out research in their school environment. The study protocol was conducted as a learning activity in all participating classrooms with 59% of students consenting to have their materials recorded for research purposes.

Each classroom visit lasted approximately one hour in duration. Researchers explained the purpose of and activities involved in the study protocol to all students. Those with documented parental consent were then asked if they would like to participate in the study. All those with parental consents agreed to participate and provided written assent. Accelerometers were given to all assenting children, and the researcher demonstrated how to wear the device on the right hip. In the event of difficulty with putting on the device, the participant obtained help from their classroom teacher.

The researcher gathered students in their regular classroom meeting area to provide a brief explanation of the study procedures. For example, the researcher showed the students each instrument and explained the sequence of activities. Students were given time to ask questions about the instrument and activities before returning to their work stations to start the protocol.

Students first completed the self-determination survey which was verbally read aloud and visually displayed on the classroom wall or whiteboard to keep the classroom on task. I a student required extra help completing the survey, the researcher and research assistants were on hand to provide one-on-one assistance. Next, pretest cognitive measures were completed by the participants in the order of math facts, TMT, and visual memory task. The PA treatment promptly followed the class’s completion of the survey and cognitive measures.

The PA treatment, which was administered via an online video resource, was randomly assigned to the condition. Classrooms assigned to the high-intensity PA treatment engaged in approximately six minutes of running, jumping or dancing. The low-intensity classrooms completed approximately six minutes of yoga and stretching. Students returned to their work stations once the PA treatment was completed and were given the option to get a drink of water before the posttest measures commenced.

The posttest cognitive protocol was a repeated measure of the pretest following the sequence verbatim. As such, students completed math facts, TMT and the visual memory task under the same parameters as the pretest. Once all measured were finished, the researchers collected accelerometers and the electronic visual memory task devices. All consent and assent forms were verified against completed measures while students had a snack.

Data Analysis

Descriptive statistics were used to explore the participant characteristics by age, gender and treatment condition. For survey measures, each student participant's self-determination data were summed by construct (perceived enjoyment and perceived competence). The teacher classroom climate scale was calculated via a sum of each item and recorded as an overall score. For the accelerometry data, the ActiLife software extracted percentages of PA intensity including MVPA, Vigorous, Light and Sedentary engagement utilizing Evenson cut points. To investigate the treatment PA patterns, a dance variable was calculated using a proportion of time spent in MVPA and light PA engagement, an aerobic variable was created using a proportion of time spent in vigorous and light PA, and a yoga variable was created using a proportion of time spent in sedentary and light PA. The z-scores across the three cognitive measures (math, TMTA, and Visual Memory) were summed to create a composite cognition z-score to decrease statistical comparisons.

Two-tailed bivariate correlational analyses were conducted to explore significant associations between psychosocial, environmental, PA and the cognitive variable. A series of linear regression analysis were performed in SPSS v24 to determine the predictive power of the significant correlational associations. PA and EF were treated as dependent variables in separate analyses. Independent variables in the analysis were identified by the model but broadly included perceived enjoyment, competence, classroom climate and PA. The standard goodness of fit statistics: χ^2 with a *p*-value were used for regression model analyses. Informed by outcomes of the correlation and regression analyses a path analysis was conducted in MPlus to investigate mediating effects of PA. Statistical significance was set at $p < 0.05$. Data analyses were performed using SPSS v24.

Results

The results are presented in as relationships between and among variables, predictors of academic achievement, and the confirmed relational pathways between variables (Table 3.1).

Associations with PA and EF in Early Childhood. Two-tailed bivariate correlations indicated inverse associations between the dance PA pattern and teacher climate (r=-0.227, p<0.01) and positive associations between the EF variables of math (r=0.258, p< 0.001) and Visual Memory Task (r=0.167, p<0.05). The aerobic PA pattern also exhibited an inverse association with perceived teacher climate (r=-0.177, p<0.05) and positive associations with all cognitive variables of math (r=0.383, p< 0.001, TMT (r=0.194, p<0.05) and Visual Memory Task (r=0.208, p<0.05). The yoga PA pattern indicated a positive association with teacher perceived classroom climate (r=0.221, p<0.01) and an inverse relationship with student perception of enjoyment (r=-0.169, p< 0.05).

Predictors of PA patterns and EF in Early Childhood. Using dance PA as the dependent variable identified statistically significant associations with teacher perceptions of classroom climate B=-0.345 t(124)=-2.750, p<0.01 and the cognitive z-score B = 0.328 t (124) =2.213, p<0.05. Significant associations also emerged when the dependent variable of aerobic was regressed on teacher perceptions of classroom climate B=-0.348 t(124)=-2.897, p<0.05 and the cognitive z-score B=-0.371 t(124)=-2.605, $p \leq 0.01$. No significant associations were identified using yoga PA as the dependent variable regressed on teacher perceptions of classroom climate B=0.2 t(124)=1.537, p > 0.05, interest/enjoyment B=-0.024 t(124)=-0.179, p > 0.05, and the cognitive z-score B= -0.106 t (124) =-0.660, p>0.05.

When the cognitive z-score was regressed on aerobic PA and teacher perceptions of classroom climate, aerobic PA remained a significant predictor B=-0.270 t(124)=-2.918, p<0.01 while classroom climate did not reach significance B=-0.122 t(124)=-1.295, p> 0.05. Similar results were indicated for the dependent variable of dance PA which was identified as a significant predictor B=0.192 t(124)=2.106, $p \leq 0.05$ but teacher perceptions of classroom climate did not reach statistical signifcance *B*=-0.162 t(124)=-1.719, $p > 0.05$. No significant associations held when yoga PA *B*=-0.064 t(124)=-0.660, $p > 0.05$, teacher perceptions *B*=-0.166 t(124)=-1.718, $p > 0.05$ and enjoyment *B*=0.164 t(124)=1.640, $p > 0.05$ were regressed on the cognitive z-score.

Exploring the Mediating Paths of PA. Regression analysis indicated significant patterns of PA, within the dance and aerobic conditions, leading to further investigation of mediating effects through two path analysis models. Due to the lack of statistical significance identified in regression analyses, self-determination variables of perceived enjoyment and competence were eliminated from the path analysis. The remaining variables of age, gender, and gross motor capacity served as covariates. Independent variables included teacher perceptions of classroom climate and patterns of PA (dance and aerobic).

The first path analysis utilized the cognitive z-score as the dependent variable to explore the potential mediating influence of dance PA, the chi-square test of model fit was non-significant ($\chi^2(2) = 1.240$, $p = 0.5378$). RMSEA = 0.000, CFI = 1.000, TLI = 3.202. In this model, the only significant predictor of EF was dance ($B = 0.372$, $p \leq 0.001$), see Figure 3.2.

The second path analysis model utilized the cognitive z-score as the dependent variable to explore the potential mediating influence of aerobic PA, the chi-square test of model fit was non-significant ($\chi^2(2) = 1.845$, $p = 0.3974$. RMSEA = 0.000, CFI = 1.000, TLI = 1.043. In this model, the only significant predictor of executive function was aerobic ($B = 0.316$, $p \leq 0.001$). However, teacher perceptions of classroom climate were trending toward significance as a predictor of aerobic PA ($B = 0.156$, $p \leq 0.08$), see Figure 3.3.

Conclusion

Results of this study indicate a clear relationship between intensive exercise engagement and cognitive outcomes. Further, one acute session lasting six minutes in duration significantly impacted EF. However, the psychosocial and environmental elements through which PA is mediated remain unclear. Teacher perceptions of classroom climate were exhibited as a significant predictor of high-intensity PA engagement, yet did not reach statistical significance in a path analysis.

This study reiterates that there is still work to be done investigating the WSCC model specifically the psychosocial and environmental components that contribute to the whole child. Future research must continue to inquire into the social, emotional and environmental factors impacting the relationship between PA and EF in the early childhood setting (Diamond & Ling, 2016). The present study sought to diminish participant burden through limited survey scales, therefore only examining strong associations evidenced in the literature as self-determination and teacher perceptions. However, they did not statistically contribute in this case. As such, future studies my consider investigating other facets of self-determination such as autonomy and relatedness. Although little is evidenced within early childhood, perceived autonomy has been indicated as integral to PA engagement among adolescents (Biddle, Gorely, & Stensel, 2004; Faulkner, Buliung, Flora, & Fusco, 2009; Hagger, Chatzisarantis, &

Biddle, 2002; Ryan & Deci, 2000). For example, Faulkner and colleagues (2009) identified active transportation as a strategy for fostering PA autonomy among adolescents which may be beneficial to investigate within early childhood. Further, Roemmich and colleagues (2006) indicated that greater accessibility to outdoor play significantly enhanced the young child's autonomy by providing opportunities to choose to go outside and be physically active (Roemmich et al., 2006). A deeper understanding of the role autonomy plays in developing PA engagement may also provide a clear picture of how EF in the young child.

The present study also identified an educational gap in early childhood. There are a multitude of ways to measure fitness among older children, adolescents, and adults including assessments of flexibility, aerobic capacity, and muscular endurance. Among the early childhood population, researchers find that the most important measure of fitness is motor skill development (Clark & Metcalfe, 2002; Seefeldt & Nadeau, 1980). Many school districts, including those participating in the current study, lack a robust measure of motor competence and how it tracks into later elementary school and lifelong patterns of engagement. Tracking the young child's motor development beyond a binary outcome of developed or under development allows educators to utilize data to drive their instructional practices. As such, future interventions should develop teacher-friendly mechanisms for developing and tracking fitness and motor development in early childhood, especially since such personal traits are related to EF at this and later developmental stages.

In sum, this study confirmed that PA significantly contributes to the cognitive development of the young child. Future directions in early childhood research must continue to explore the psychosocial and environmental elements contributing to this relationship. As the WSCC model asserts, developing the whole child hinges on these multifaceted understandings.

Delimitations and Limitations

Given the strengths of the present study, it will indeed move the early childhood literature base forward by evidencing the intersectionality of the physical, emotional and cognitive development of the child. It is the first of its kind to utilize the WSCC model to tackle the complex relationships that contribute to the cognitive development of the young child. Further, it sheds light on the value of PA in the early childhood classroom. This study exemplifies the saliency of the WSCC model when considering how to maximize the development of the child, yet there is more work to be done.

Although the WSCC model is valuable, it remains understudied in the early childhood setting. The present study, gained access to early childhood classrooms to measure specific psychosocial and environmental constructs through classroom friendly measures. Consideration of the potential effect of additional social, emotional, and environmental factors was not possible, and thereby additional factors were not controlled in this experiment. Future studies may benefit from exploring additional school-level, classroom-level, and individual factors that may mediate physical and cognitive development among young children.

This present study was also limited by a substanative loss of data. Given that this study was conducted in the authentic early childhood setting, several students were unable to complete the entire study protocol for reasons beyond the control of the researcher. The missing data diminished the statistical power for this study, yet still, exhibits the strong and positive relationship between PA and cognition in early childhood. However, it may be beneficial for future studies to replicate this protocol in a more controlled environment to explore variations across field-based and laboratory outcomes.

A purposeful sample from a southern region of the US was utilized for this study. As such, these results should be interpreted with caution as they may not be generalizable to the greater population. There is considerable variation across the US in early childhood resources and practices evidencing that future studies may also seek to replicate this in a geographically diverse sample.

Implications

The findings from this study have merit, especially for those seeking to augment early childhood education. This study identified the strong and direct relationship between intensive PA engagement and cognitive performance in early childhood. Specifically, dance and aerobic activity were identified as significant predictors of cognitive performance. The findings from this study provide valuable insight for the future directions of early childhood educations. The first being that PA and movement across the day are necessary and may even be more beneficial for educators to focus on above and beyond academic content.

Educators, specifically those housed in under-resourced school districts, may fear that providing students with PA within the classroom is not feasible due to a possible monetary commitment. However, video-based resources such as the one utilized in the current study provide free access to PA and movement breaks. Such resources have the potential to break down resource-based barriers that under-privileged schools often face when trying to provide students with innovative curriculum and instructional techniques.

Novel and easily accessible, online PA resources enhances the need for movement specific teacher professional development. Teachers must be trained in how to properly utilize such tools and how to effectively integrate them across the school day. It is not enough to simply provide PA breaks in response to classroom misbehavior or to fill transitional time. As this study suggests, PA and movement must be carefully planned and aligned with the cognitive outcomes teachers demand of their early childhood learners on a daily basis. Perhaps through the provision of movement specific professional development, education will move one step further toward a more holistic approach to educating the whole child.

Figure 3.1. A Priori Mediation Path Model

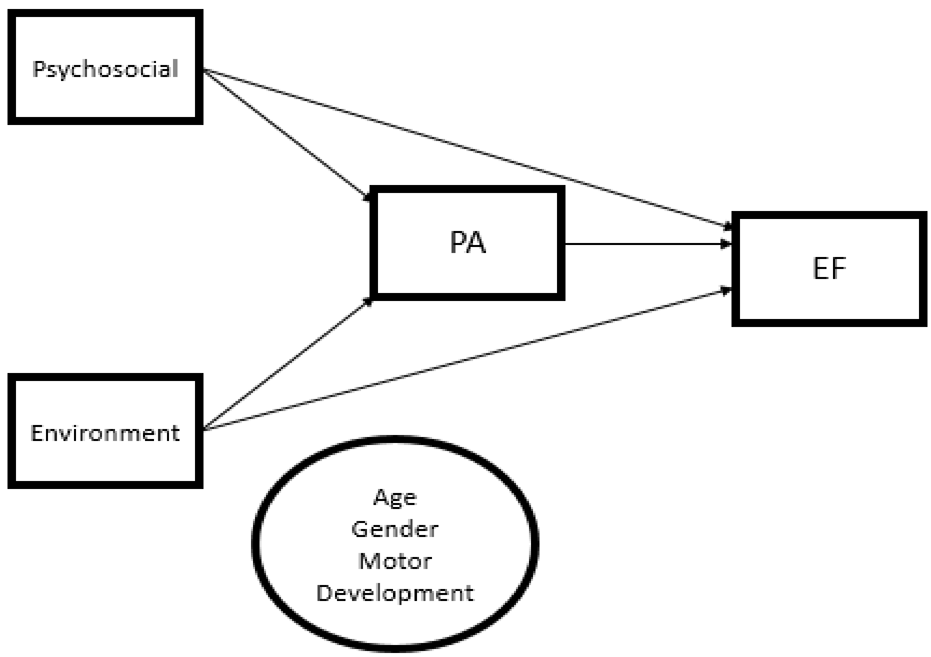
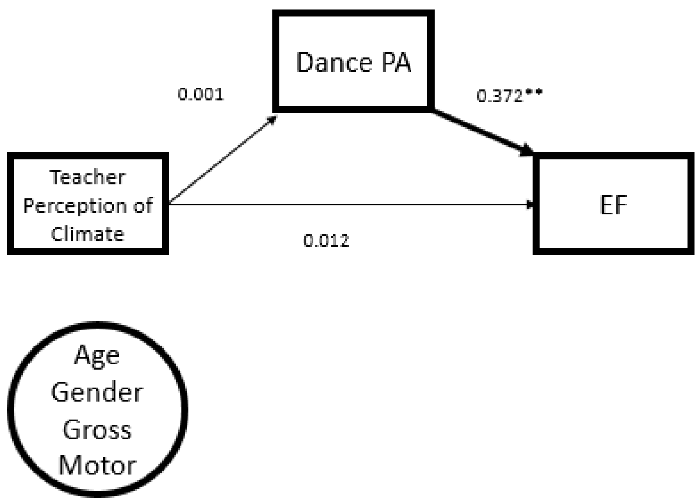


Table 3.1.
Group Means (SD) of Descriptive Data

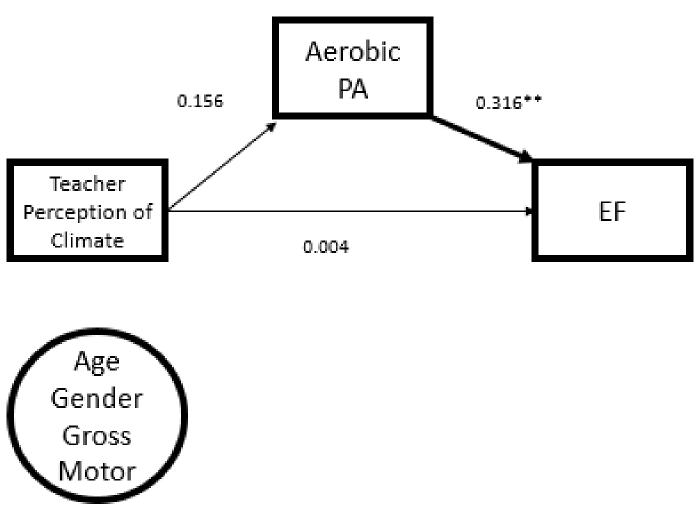
	Demographics			
Variables	Overall	Aerobic	Dance	Yoga
Age in years	5.6 (0.6)	5.5(0.7)	5.7(0.5)	5.6 (0.7)
Males (%)	55.7%	60%	59%	47.6%
Fully Developed Gross Motor	86%	88%	90%	88%
Hispanic (%)	37.14 (10.59)	35.13 (6.62)	38.05 (13.34)	37.86 (10.38)
Free/Reduced Lunch (%)	38.86 (15.71)	34.56 (10.87)	38.11 (19.86)	42.52 (14.18)
	Cognitive Baseline by Mode			
Baseline Variables	Overall	Aerobic	Dance	Yoga
Math	5.06 (2)	5.18 (2.1)	5.49 (1.8)	4.66 (2)
TMT	13.38 (4.1)	13.95 (3.7)	14.01 (3.9)	12.47 (4.2)
Visual Memory Task	5.09 (1.9)	4.72 (2.1)	5.76 (1.8)	4.79 (1.9)

Figure 3.2. Path Model for Dance PA



Note: Values are standardized regression coefficients and $p<0.001=$ **

Figure 3.3 Path Model for Aerobic PA



Note: Values are standardized regression coefficients and $p<0.001=$ **

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DISCUSSION

The current health status of our nation is declining with significant increases in the prevalence of obesity (Cunningham, Kramer, & Narayan, 2014). Blackstone (2016) predicts that by the year 2020, 60 million preschool children living in the United States will be identified as overweight or obese. Shockingly, this statistic remains despite us knowing the benefits a child gains from being educated on how to live a healthy and physically active life. Healthy habits such as physical activity stave off diseases including diabetes, respiratory issues such as asthma, and mental health problems (Pulgarón, 2013).

Current literature also has identified the potential hindrances that may result from a lack of PA and overweight and obesity status. As early as preschool, children are becoming more sedentary and far less active (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004) and the literature asserts that when PA lacks in early childhood, there is a significant association with overweight and obesity status (Moore et al., 2003). Further, we know that the onset of overweight and obesity in early childhood (Niederer et al., 2011; Palmer, Miller, Robinson, & others, 2013) is negatively related to cognitive performance including inhibition (Graziano et al., 2010; Levitan et al., 2015) working memory (Martin et al., 2016) and executive control (Nelson et al., 2016).

The *Whole School, Whole Community, Whole Child Model* (WSCC), has challenged researchers and practitioners alike to take a comprehensive approach to understanding what constitutes a successfully academic child. What research would suggest is that provisions beyond intellectual instruction may ultimately improve the academic potential of the child through the intersections of social, emotional and physical enhancement. Further, it is the micro-level environmental factors in a child's life that foster development.

To date, we know that even a single session of long duration aerobic PA can augment the cognitive readiness of our youngest learners by contributing to their ability to sustain attention (Niederer et al., 2011; Palmer, Miller, Robinson, & others, 2013) increase inhibitory control (Chang, Tsai, Chen, & Hung, 2012) and enhance working memory (Mierau et al., 2014). Further, additional studies mirror these findings that a single, thirty minute session of aerobic PA can positively impact EF in school-age children (Tomporowski, Lambourne, & Okumura, 2011; Verburgh, Königs, Scherder, & Oosterlaan, 2013) and adolescents (Chen, Yan, Yin, Pan, & Chang, 2014; Hillman, Erickson, & Kramer, 2008). Interestingly, most studies across various youth populations, hypothesized that aerobic PA would be the mechanism for eliciting an EF response (Castelli et al., 2011; Davis et al., 2011; Drollette et al., 2014; Hillman et al., 2009; Niederer et al., 2011; van der Niet et al., 2016). Only two known studies, before the current undertaking of this dissertation, have sought to investigate PA types beyond aerobic engagement within early childhood. One study utilized a coordinative exercise treatment and found that it significantly increased inhibition within a kindergarten sample (Chang et al., 2012). Another study examined differentiated types of coordinative PA within a kindergarten sample, including dance and orienteering, to find that both outperformed control on attentional tasks (Zach, Inglis, Fox, Berger, & Stahl, 2015). Although these findings suggest a strong and positive association for PA engagement within early childhood, especially for coordinative, no known study has considered the comparison of varied types of PA or investigating the potential of an acute, six-minute bout of PA.

In response to the gaps in the current literature base, the current studies of this dissertation sought to better understand PA in some different facets. First, this investigation wanted to better understand how the classroom environment contributed to PA engagement within early childhood. The findings were unanticipated and noteworthy. As the results of study 1 imply, there is an inverse relationship between a teacher's perceptions of classroom climate and the intensity of the PA that a child engages in and there are a few potential reasons for this relationship.

One possibility is that students in classrooms perceived to be chaotic and un-cohesive perhaps receive more opportunities to engage in PA because their teachers identify classroom PA as a behavioral strategy. In turn, students and classrooms perceived to have a harmonious and calm environment were less likely to engage in intensive PA. These findings shed light on an alarming nuance of classroom expectations; only those who are classified as misbehaving may gain the full benefits of daily PA engagement. The hidden messaging that classroom PA is only a reaction to disruptive behavior and a form of behavior management is shallow and unfounded. Further, such ideas suggest a lack of understanding and misinterpretation among educators and administrators that we as researchers must address and overcome. Districts, schools, and teachers must be informed of the academic and cognitive benefits of classroom PA, so it becomes a proactive part of the school day. Guided by this assertion, future studies may benefit from a better understanding of the differentiations between reactively and proactively utilized classroom PA and the long-term outcomes it may have on student health and academic success.

It is possible that the inverse relationship between teacher perceptions of classroom climate and intensity of PA engagement among children suggests factors unique to the individual child. In a classroom where the teacher's perceptions of climate corroborate the activity, children may differentially act on an opportunity to move and engage in classroom PA activities. For example, a classroom with a chaotic and un-cohesive environment may house children who when offered a chance to be physically active, may move at higher and more intense levels. Further, classrooms with cohesive dynamics may house children that choose to move less intensively as a result of personal and individually-based factors. Guided by the consideration for the potential impact of individual level factors, future studies may benefit from investigating children's self-identity to elucidate these indirect relationships further.

Findings from the first study, that routine PA cannot be considered a universal classroom resource prompted the second dissertation study. This study investigated the effects of an acute bout of classroom PA and how cognitive effects may differ by mode. The findings from this study uncovered the fact that even an acute, short-duration PA break has EF benefits. Further, the findings confirmed the apriori hypothesis of the researcher as well as those posed by lead investigators in the field that PA type is crucial. In the present study, it was found that participants randomized to the dance treatment significantly outperformed their peers in both academic and attentional tasks. This finding holds major potential for the educational arena; practitioners must consider slight modifications to their daily classroom routine which would provide students opportunities to dance and be physically active before academically and attentionally demanding tasks. As these findings suggest, such a modification would not take more than six minutes at a time which is a simple adaptation that could be carried out by teachers.

Given the outcomes of study two, that classroom PA facilitates EF consideration for pedagogical strategies which support movement is critical. Modern, constructivist approaches to teaching encourage organic learning that emerges from real-life problems and experiences. If educators were to take these problem-based learning strategies one step further children may be exposed to the active problem-based learning experiences where they not only consider a real-life problem, but they act upon it. For example, rather than observing the plant life cycle through a video or story, why not have children plan, develop and cultivate their garden. Through simple modifications such as the one posed, children have the opportunity to master the same curricular content, yet they do so while having opportunities to move, engage and physically act upon their environment.

To date, much of the classroom physical activity research has focused on academic outcomes, yet give little consideration for how positive findings translate into pedagogical strategies (Casey, Goodyear & Armour, 2017). International research has started to consider the practical implications applications of classroom physical activity in early childhood settings suggesting the use of active play as a strategy for facilitating school readiness (Stirrup, Evans & Davies, 2016). However, a lack of this translational research has been applied within US early childhood school environments. Therefore, the findings from the present study are indeed timely as dance has emerged as a potentially beneficial pedagogical strategy. This evidence provides tangible evidence that can inform differentiated learning strategies. For example, educators may want to strategically structure their classroom routine so that dance physical activity breaks are offered before cognitively and attentionally demanding tasks. Further, in the early childhood setting, it may be feasible to develop physically active learning stations where children may choose to engage in kinesthetic learning. Offering alternative physical activity opportunities such as dance at recess may be another key strategy for providing children with the coordinative exercise they require. Future studies must investigate the impact of dance as a pedagogical, specifically investigating how routine and structured engagement across the school day impacts executive function.

The first and second study combined led to the third and final study which sought to uncover if classroom PA engagement is mediated by the student's psychosocial factors and by the teacher's perceptions of classroom climate. Unfortunately, the study did not find any significant mediation paths. However, it did further confirm a meaningful and positive effect of classroom PA on cognitive performance in early childhood. For example, the current dissertation study was the first of its kind and was launched in an unexpectedly diminished sample pool. It is hypothesized that with a more robust sample, the mediated PA paths and their impact on cognitive development will become clearer. Further, as the WSCC model suggests, the environmental and psychosocial elements contributing to the physical and academic well-being of the child may not be limited to self-determination and teacher climate. As such, future research may consider investigating the role of self- efficacy, resilience and community support. There is much room for continued inquiry as it relates to early childhood and the WSCC model.

The findings from this dissertation present exciting evidence in the field of early childhood research. The evidence suggests that play and PA engagement over sedentary and rote instruction may contribute to improved EF, which subserves learning. Interestingly, this response may be elicited after just six minutes of PA participation. Further, the findings orient teachers to the importance of the classroom environment. Teacher's perceptions of the classroom environment may not only influence a child's PA engagement but ultimately shape their personal identities. This evidence poses a strong public health message; early childhood educators can contribute to a lifelong trajectory of physical and cognitive health. We as a society need to invest the time and resources in them as experts to execute such outcomes. Guided by these findings, educational policy must focus on the development of the whole child rather than settling for simply enhancing one part.

APPENDIX: LITERATURE REVIEW

The school environment is a setting in which all children have access to extensive learning opportunities. In January of 2002, President Bush signed into legislation the No Child Left Behind Act (NCLB), authorizing federal education programming with the intention of increasing the rigor of student learning. Although NCLB was ideologically appropriate, several unintended outcomes ensued including a significantly higher emphasis on high-stakes testing preparation (Bush, 2001; Dee & Jacob, 2011). The shift to a more objectively measured educational system resulted in learning that focused more on reading and math standardized test performance and less on provisions of a well-rounded education. A robust body of literature cites the deleterious effects of NCLB on student learning (Abedi, 2004; Dee & Jacob, 2011; Hursh, 2007; Kim & Sunderman, 2005). One unanticipated and indirect outcome of this legislation was the increase of childhood obesity, resulting from reduced opportunities for PA during the school day (Anderson, Butcher, & Schanzenbach, 2016). To provide necessary funding for augmentation of reading and arithmetic programs, physical education resources were diminished (Dee & Jacob, 2011). Further, to meet daily minute allotments in standardized testing preparation teachers cut students' opportunities to move and exercise (Berliner, 2009).

Another unanticipated outcome of the NCLB act was a shift away from play-based curriculum to the standards-based curriculum in the early childhood setting (Rushton & Juola-Rushton, 2008). This mandate caused decreases in opportunities to move, thus increasing a sedentary behavior (Ginsburg, 2007). The adverse effects of

NCLB on the health of the nation's youth prompted research into the effectiveness of a test-driven approach to education. Research indicates that swapping physical education time to increase sedentary testing preparation does not positively affect student test scores (Pate et al., 2006). Further, there is evidence that the provision of PA in the school setting positively influences academic performance among elementary students and school readiness in the early childhood population (Castelli, Hillman, Buck & Erwin, 2007; Sallis et al., 1999). In an educational climate where sedentary learning is still the norm despite access to current curriculum opportunities, research is needed to better understand the mediating factors that influence its adoption in schools. Further, given the pressure within the early childhood setting to enhance a child's school readiness, investigation of the role of PA in cognitive development is warranted.

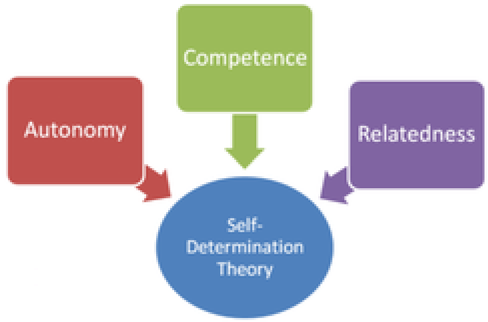
Theoretical Framework

Until recently there has been a divide between the health and education sectors' priorities for children's' developmental success. In an attempt to streamline the conceptualization of how to address the needs of the whole child, the Center for Disease Control and Prevention (CDC) and the Association for Supervision and Curriculum Development (ASCD) united to develop the Whole School, Whole Community, Whole Child (WSCC) model. Specifically, the model outlays the infrastructure as to how schools can meet the multiple needs, both physical and cognitive in nature, that the child requires for optimum development. Further, this model offered insights into the environmental factors that influence the whole child's development (Figure A.1). The WSCC model broadly draws the constructs of self-determination theory as well as the dynamic interactions of ecosystems presented in the social, ecological model. Combined, the SDT and Social Ecological Model (SEM) evidence the holistic consideration of the child, offering a micro-level consideration for the psychosocial elements rooted within the child as well as a macro perspective of the external forces influencing children's' health and development.

Figure A.1. The Whole School, Whole Community, Whole Child Framework

Broadly, the Self-Determination Theory (SDT) explores the internal and external motivations driving one's behavior (Deci & Ryan, 2012). SDT asserts that all individuals exhibit the same psychological needs of autonomy, competence and relatedness which when enhanced positively impact one's intrinsic motivations and governs self-directed behavior (Ryan & Deci, 2000). When applied to the classroom context, SDT indicates that through the development of a child's competence, autonomy and relatedness comes enjoyment of and intrinsic motivation to act upon the learning environment. (see Figure A.2).

Figure A.2. Self-Determination Theory

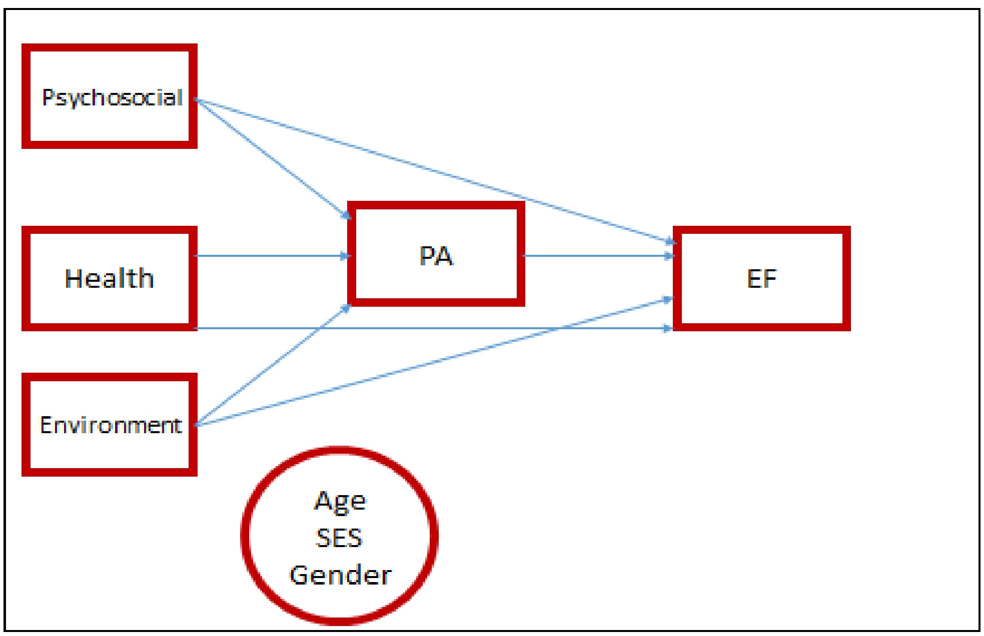


The SEM takes both a micro and macro level perspective to highlight the outcomes of environmental interactions (King, Stokols, Talen, Brassington, & Killingsworth, 2002). This model is valuable because it sheds light on the influence of societal-level factors, such as community, as a driving force of culture and climate. Consideration for environmental factors provides a deeper understanding of the interplay between individual behaviors and external environmental influences, which ultimately shape one's academic and health-related outcomes (Stokols, 1996) (Figure A.3).

Figure A.3. Social Ecological Model

Guided by the WSCC model which draws from tenets of SDT as well as the dynamic environmental context put forth through SEM, I propose an investigation into an adapted model to guide this literature review (Figure 4). The revised model places PA engagement as the central pathway mediating the impact of psychosocial and environmental factors on cognitive outcomes. Further, the adapted model emphasizes the critical role of psychosocial and ecological factors on the development of the whole child.

Figure A.4. Mediation Model in Early Childhood



To provide a thorough understanding of the pathways of interest, this literature review will address both the direct and indirect relationships between PA and cognitive function within the early childhood setting. First, this review will operationalize relevant constructs. Then, relevant evidence of the relationship between PA and cognitive development among children in the early childhood setting will be summarized via the pathways of; psychosocial, personal health, and environment.

Until recently, an investigation into the effects of PA on EF within the early childhood population was largely understudied (Pate et al., 2013), with only five published studies within the early childhood population. However, childhood development, especially that of EF, is being investigated to identify the key developmental and learning experiences occurring on a continuum which starts in early childhood and strengthens through adolescence into young adulthood (Best, 2010). Such a continuum of development makes it appropriate to investigate evidence and assertions made from childhood populations extending beyond the realm of early childhood. As such, this review of literature will include studies spanning populations of early childhood (age three years) through adolescence.

Conceptual Model Constructs Defined

This dissertation sought to investigate the multiple pathways through which the relationship between physical activity and executive function among young children are expressed. The following sections provide background and context evidencing how the author operationalized each construct under investigation. In alignment with the conceptual model, physical activity is defined first, as it is a central focus of model, followed by the psychosocial and environmental constructs and ending with executive functioning.

PA in young children. PA is a behavior which is expressed through engagement in an array of bodily movements such as running, jumping, and dancing (Graham, Hale &

Parker, 2010). In early childhood, PA behaviors are typically expressed through play (Becker, McClelland, Loprinzi, & Trost, 2014). Active play is defined as a locomotor movement at a moderate or vigorous intensity whereas free play is expressed through varied intensities of activity that also encompasses elements of social and emotional engagement (Burdette & Whitaker, 2005). In the early childhood setting, the objective of PA is to build a foundation for lifelong health through the development of motor competency and movement concepts. Benefits of building up the motor domain at an early age when advanced verbal communication skills are still developing do extend beyond the physical domain to enhanced psychosocial elements including self-efficacy and social engagement (Graham, Hale & Parker, 2010). There is a disparity in the measurement of PA engagement among young children, (Kohl, Fulton, & Caspersen, 2000) as researchers have employed various techniques in an attempt to gain accurate data on PA duration, intensity, and time. Recently, accelerometers, a direct and systematic measurement of PA, are frequently used among researchers (Cain, Sallis, Conway, Dyck, & Calhoon, 2013) and have been recognized as a valid, reliable tool and the gold standard in early childhood PA measurement (Adolph et al., 2012).

***PA engagement in young children*.** The American College of Sports Medicine (2014) uses frequency, intensity, time, and type to categorize the volume of PA participation. Frequency describes how often children engage in PA (e.g. the number of days per week, while intensity is defined as how hard the child engaged in PA (e.g. moderate, vigorous, moderate to vigorous, MVPA). Additionally, PA engagement may be described as chronic or acute bouts. Chronic PA in young children is defined as habitual participation in PA, that is PA that is recurring consecutively over a set amount of time (i.e., days, weeks), thereby contributing to fitness gains (Fisher et al., 2005). While acute PA engagement refers to participation in a single exercise-related event that elevates energy expenditure and heart rate for a short amount of time (Thompson et al., 2001). Both chronic and acute engagement in PA positively affects cognition in children (Hillman, Kamijo, & Scudder, 2011).

Contributory factors of PA and EF in young children. The relationship between PA and EF among children is complex and influenced by multiple factors (Tomporowski, Lambourne, & Okumura, 2011). Moderating factors, in essence, are the unmodifiable circumstances that identify the who and what of treatments, therefore better explaining the overall impact (Kraemer, Wilson, Fairburn, & Agras, 2002). Examples of moderators include factors such as age, sex, and socioeconomic status (SES) and culture.

Mediators help explain the why and the how, that is the pathways through which treatments reap significant effects (Kraemer et al., 2002). In the WSCC model, multiple pathways are impacting physical and cognitive childhood development which are broadly broken down into psychosocial, health-related and environmental factors. As such, this review of literature seeks to identify and explain the known mediating and moderating variables influencing the PA and EF development in young children. However, there is little evidence specific to children ages 4 through 7 years. Finally, this review included evidence cited in children through age 12 to provide a point of reference for factors which may or may not influence associations within the population of interest.

Psychosocial factors. Defined as changes in personal perceptions of self-concept, self-motivation, and self-efficacy (Tomporowski et al., 2011), self-concept refers to the thoughts and beliefs one forms about their strengths and weaknesses (Baumeister, 1999). Self-efficacy is defined as one's in their ability to successfully carry out tasks such as mastering academic challenges (Bandura, 1993). One's self-efficacy and self-concept are shaped by an internal drive; the motivation, autonomy, and competence an individual possesses. A robust body of evidence in support of self-determination as a critical component to developing both self-concept and self-efficacy exists within school-age children. However, this relationship remains understudied in the young child.

Health factors. Commonly expressed as height and weight status on growth charts, health, among children, is a well-documented mediator of PA and cognitive functioning across school-age and adolescent populations. There is emerging evidence in support of this association within the young child population.

Physical fitness is commonly utilized as a health marker among school-age and adolescent populations (Strong et al., 2005) and is a well-established, highly represented mediator of PA and cognitive functioning (Tomporowski et al., 2011). Physical fitness as a mediator provides potential to explore variations in frequency, duration, and intensity. An increasing literature base supports physical fitness as a mediator within school-age children. However, little remains known about the mediating effects of physical fitness variables of frequency, intensity, and duration in the young child. Given the understanding that both weight and fitness status are indicative of health, this literature review and dissertation will combine constructs of health and fitness making one construct referred to as health factors.

The environment and young children. Typically, young children only experience a few proximal environments such as home, preschool, and childcare; all of which have formally been identified as contributory toward PA engagement in children (Dowda et al., 2009; Strauss & Knight, 1999; Wechsler, Devereaux, Davis, & Collins, 2000). Further, as suggested by the WSCC model, proximal environments have the greatest potential to influence the behaviors, beliefs, and attitudes of children. Distal settings in the lives of young children, primarily representative of the outlying community, may also contribute PA engagement in the young child, but this is dependent on familial mobility (Roemmich et al., 2006).

Executive function in young children. Cognition broadly refers to one's mental capacities and abilities. Cognitive abilities are developed throughout the lifespan and are influenced by one's experiences (Poldrack, Wagner, Diamond, & Amso, 2008). One's cognition is not synonymous with knowledge; rather it is influenced by the experiences through which one expands their knowledge (Anderson, 1990). Higher order cognitive processes of decision -making, scheduling and planning can be termed executive functioning (EF) (Wellman & Gelman, 1992). It is through the EF cognitive control processes of inhibition (self-control), interference control (attention), working memory (thought holding/organizing), and cognitive flexibility (creative thinking) that one can interpret information (Diamond, 2013). These processes are believed to subserve learning as they are the mental tools one utilizes to gain knowledge (Diamond, Barnett, Thomas, &

Munro, 2007). EFs are trainable and develop over time, with inhibition and cognitive flexibility gains evident in preschool (ages 3-5), followed by further growth of cognitive flexibility, working memory, and speed in early childhood (ages 5-11). Since executive functioning is a strong predictor of school readiness at the beginning of childhood, the EF behaviors of; inhibition, working memory, attention, and cognitive flexibility will be the primary focus of this literature review (Blair & Razza, 2007; McClelland, Morrison, & Holmes, 2000). Each EF is defined and operationalized for the measure in this series of studies.

***Inhibition*.** Refers to the ability to overcome distraction to stay focused on the task at hand. Further, a behavioral response of this EF is the capacity to resist a natural response for one that appears unnatural (Diamond, 2006). Common measures of inhibition in the early childhood setting include the Stroop and day-night task.

***Working memory*.** A person's ability to maintain and manipulate an immediate thought (Diamond, 2006). A behavioral response that captures this EF is the capacity to listen to a story and sequence its events. Common measures of working memory among children in early childhood include arithmetic and problem-solving tasks such as memory and Simon games.

***Attention*.** The information selection and the exertion of control over thoughts and actions (Rueda, Posner, & Rothbart, 2005). Behaviorally, attention can be influenced by both the environment as well as internal cues (Rueda et al., 2005). A standard measure of attention is the Trail Making Test.

Cognitive flexibility. Ability to fluently switch from one task to another (Diamond, 2013). An example of this behavior would be responding quickly and appropriately to an unanticipated turn of events. Conventional measures of this EF employ task switching tactics to assess fluidity and adaptability.

Academic performance. The term academic performance has been operationally defined as the primary outcome of learning. Based on SDT as well as the WSCC model, academic performance is reliant on personal, behavioral, and environmental factors (Deci & Ryan, 2012; Lewallen et al., 2015). In the early childhood setting this capacity if often assimilated with a child's academic readiness such as their verbal skills, knowledge, and attitude toward the learning environment.

PA and Cognitive Function in Early Childhood

Within the literature, fourteen studies examined the direct effect of PA on EF in childhood through aerobic activity, play, coordinative exercise, and acute engagement. Twelve studies indicated positive and significant effects of PA on EF while two reported null findings. Among these studies, five explored outcomes in an early childhood population; however as evidenced by Carlson (2005) there is significant variation across early childhood measures of EF. Five studies examined the direct effect of PA on academic performance. There were no studies that reported a negative effect of PA on EF in early childhood. Diamond (2012) posited that aerobic exercise alone might not be enough to elicit a significant effect on EF at the beginning of childhood. Instead, she argued, that interventions must include psychosocial mediators such as self-efficacy and self-esteem or physical fitness variables such as flexibility (Diamond, 2012).

Inhibition. This capacity broadly refers to impulse control (Campbell, 2001). Seven studies examined the direct relationship between PA and inhibition; six indicated a positive and significant effect of PA on inhibition among children (Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001; Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011; Chang, Tsai, Chen, & Hung, 2012; Drollette et al., 2014; Mierau et al., 2014; Pesce et al., 2016; van der Niet et al., 2016; Verburgh, Königs, Scherder, & Oosterlaan, 2013). Measures that capture these inhibitory responses often employ task switching games which place demands on a child's ability to resist an instinctual response or action to follow an unnatural expectancy (e.g. go on a red light). As evidenced by the seven studies which examined the direct effect of PA on inhibition in childhood, there is significant variety in instruments utilized.

Early childhood researchers engaged children in cognitive contra-habitual tasks such as random number generation (RNG; Pesce, 2016) and the Flanker task (Chang, 2012). Behavioral tasks such as tapping and marble tasks (Campbell, 2001) were also utilized (Campbell, 2001). Studies including broader youth populations such as elementary school children and adolescents also presented significant variation in measures. Across these three studies, there was far less difference in their outcomes which evidenced significant effects of coordinative exercise on inhibitory control in children (Campbell et al., 2001; Chang et al., 2012; Pesce et al., 2016)

Consistent findings within the early childhood research indicated a significant effect of type of exercise on EF yet hypotheses explaining the dynamics of this relationship are still under examination. Chang and colleagues (2012), who examined this relationship among Kindergarteners, indicated that coordinative exercise facilitated inhibition regardless of intensity. Pesce and colleagues (2016) suggested that coordinative exercises may enhance executive functioning in children by placing demands on other systems such as motor coordination. Campbell and colleagues (2001) found a significant relationship between coordinative exercise and inhibition, further asserting that it is the type of movements young children engage in which ultimately influence their cognitive development. However, Mierau and colleagues (2014) identified through a 45-minute exercise session consisting of movement games that cortical arousal was heightened among preschool children, yet it failed to elicit any significant increases in their inhibitory response.

Studies among school-age and adolescent populations examined the role of aerobic activity on EF (Drollette et al., 2014; van der Niet et al., 2016). Van der Niet and colleagues (2016) launched a 22-week PA intervention that took place during lunch and recess time in an elementary school setting. Intervention classrooms exhibited significant gains from pre to posttest on an inhibition task as compared to their control group peers. Drollette and colleagues (2014) sought to both replicate the significant findings of aerobic activity on inhibition and extend them by indicating that children with reduced inhibitory control reap the most important gains from aerobic activity engagement. Castelli and colleagues (2011) extended the inquiry into the effect of aerobic activity by examining its intensity. Their results indicated that time above target heart rate zone was significantly related to inhibitory control among prepubescent children. As these studies and the results of a meta-analytic review suggest, there is compelling evidence that PA has a direct effect on inhibition of three age groups, preadolescent children, adolescents and young adults (Verburgh et al., 2013).

Working memory. Measurement of working memory can be completed as short recall and long recall of items such as pictures and digits (Cowan, 2008). Among preschool-aged children; short recall tasks utilize familiar concepts such as shape memorization and recognition (Niederer, 2011; Carlson, 2005). Cross-sectional studies utilizing short recall tasks (e.g. n-back & digit span) across childhood population confirmed that aerobic fitness was associated with memory assessments (Niederer et al., 2011; van der Niet et al., 2016). Application of such findings is limited because the fitness effects were not created as part of an experimental design and therefore we should use caution when attempting to apply such findings to an educational context.

Three studies investigated the direct relationship. Niederer and colleagues (2011) employed a cross-sectional analysis within a preschool sample to examine the relationship between aerobic exercise and working memory. Their results indicated that aerobic exercise was independently associated with working memory (Niederer et al., 2011). Van der Neit and colleagues (2016) implemented their aerobic activity intervention within an elementary school setting and found it to significantly influence working memory. Davis and colleagues (2011) also reported significant effects of high aerobic activity on working memory in a group of overweight children ages 7 to 11.

Attention. The saliency of results is linked to the rigor of the study design. The three studies which investigated the relationship of PA and attention employed strong scientific rigor evidenced by their randomized-control study design and functional magnetic resonance imaging (fMRI). One international, experimental study investigated the influence of varied modes of PA, dance and coordinated, on EF among kindergarten students. Results indicated that students assigned to both dance and coordinated exercise groups significantly outperformed controls on attention tasks as measured by target-based stimuli tasks on the computer (Zach, Inglis, Fox, Berger, & Stahl, 2015). Hillman and colleagues (2009) used fMRI protocols to assess the influence of an acute bout (20 min) of treadmill walking on cognitive control in school-age children. Children exhibited significant improvements in attentional resources following a single session of moderate intensity exercise (Hillman et al., 2009). Chaddock and colleagues (2013) also found that PA engagement significantly enhanced student performance (8-9 years) on attentional tasks as measured by fMRI (Chaddock-Heyman et al., 2013).

Cognitive flexibility. A review by Chaddock and colleagues calls for further research to better understand the cognitive flexibility and the factors which influence it, (Chaddock, Pontifex, Hillman, & Kramer, 2011) as the literature base is sparse. Several studies implicated PA as a significant facilitator of attention, working memory, and inhibition but failed to find a significant influence on cognitive flexibility (Castelli, Hillman, Hirsch, Hirsch, & Drollette, 2011; Hillman et al., 2009; Howie, Schatz, & Pate, 2015; van der Niet et al., 2016). Howie and colleagues (2015) assessed cognitive flexibility after a 10-minute acute bout of PA yet found no significant effects. All studies that included the examination of PA on cognitive flexibility employed a measure of moderate to high-intensity aerobic activity. Therefore, finding within the current literature remain unclear whether a different mode of PA may have differential effects.

Academic performance. The evidence is building in support of the relationship between PA and academic performance (Rasberry et al., 2011). Three studies investigated the effect of acute bouts of PA on academic outcomes in the early childhood setting. All studies indicated significantly, benefits of integrating PA into classroom curriculum as it facilitated academic outcomes of language (Connor-Kuntz & Dummer, 1996), reading and math (Howie et al., 2015; Son & Meisels, 2006) and foreign language acquisition (Mavilidi, Okely, Chandler, Cliff, & Paas, 2015). Further, Son & Meisels (2006) assert that formal incorporation of PA into early childhood curriculum may have long withstanding, positive effects on academic achievement later in life. One study among school age children is also of interest to this literature review due to its novel investigation of dose. Researchers investigated how acute PA classroom breaks (5, 10, and 20 min) influenced academic performance as compared to sedentary classroom breaks. Their results indicated that 10 and 20-minute exercise breaks significantly affected math performance as compared to sedentary breaks (Howie et al., 2015).

The Mediated Pathways of PA and EF. Significant evidence within the literature points to a direct relationship between PA and EF within early childhood. Research also indicates that the path between PA and EF may be mediated by psychosocial, individual health factors and the environment. As such, this literature review seeks to further elucidate the mediated pathways between EF and PA in early childhood.

Psychosocial factors. The WSCC model broadly defines psychosocial factors as the social and emotional climate. Guided by SDT, this construct is more succinctly represented through autonomy, competency, and relatedness as the primary psychosocial factors among youth. Specifically, five studies found a positive effect of competency on PA engagement. One study found that self-perceived motor proficiency is significantly related to intensity (DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998) with an additional study specifying its association to time spent in moderate to vigorous PA (MVPA) among children (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). Research suggests that the relationship is moderated by gender as girls exhibit significantly lower perceived PA competence (Cairney et al., 2012) specifically with ball skills(Barnett et al., 2015). Further, a child's willingness to engage in sport play is significantly impacted by their perceived competencies (McKenzie, Butcher, Sallis, & Alcaraz, 2001). Decomposition of SDT correlates evidence that perceptions of enjoyment also contribute to one's perceived competency, ultimately influencing motivation toward PA engagement (Standage, Duda, & Ntoumanis, 2003; Standage, Gillison, Ntoumanis, & Treasure, 2012; Weiss, 2000).

Four studies cited perceived autonomy as integral to PA engagement among adolescents, although little evidence exists for this relationship among young children (Biddle, Gorely, & Stensel, 2004; Faulkner, Buliung, Flora, & Fusco, 2009; Hagger, Chatzisarantis, & Biddle, 2002; Ryan & Deci, 2000). Faulkner and colleagues (2009) specifically identified active transportation as a strategy for fostering PA autonomy among adolescents. Across young childhood populations, Roemmich and colleagues (2006) indicated that greater accessibility to outdoor play significantly enhanced the young child's autonomy by providing opportunities to choose to go outside and be physically active (Roemmich et al., 2006). Additional studies elaborated on these findings suggesting that through encouraging autonomy in the young child, offering them opportunities to choose PA engagement, personal enjoyment is fostered (Epstein & Roemmich, 2001).

While both competency and autonomy have been identified as antecedents to PA participation, a different interplay between the construct of relatedness and PA exists. As Jago and colleagues (2009) explained, it is PA engagement that significantly improved relatedness by building friendships among children (Jago et al., 2009). A robust body of literature exists affirming the positive impact of PA engagement on relatedness, yet all findings have been evidenced in school-age (Jago et al., 2009, 2011; Macdonald-Wallis, Jago, Page, Brockman, & Thompson, 2011) and adolescent populations (De La Haye, Robins, Mohr, & Wilson, 2011; Salvy et al., 2008, 2009; Schofield, Mummery, Schofield, & Hopkins, 2007). Schofield and colleagues (2007) extended the understanding of this relationship by identifying that among adolescent girls PA engagement creates a sense of interdependence. Given the breadth of findings on relatedness, it is surprising that early childhood is left undefined.

Educational research further supports the mediating role of psychosocial factors suggesting that competence, autonomy and relatedness influence academic performance (Niemiec & Ryan, 2009). Specifically, Ryan and Deci (2000) propose that psychological well-being and self-motivation are integral components of educational success. Strandage and colleagues corroborate these findings stating that enhancing a child’s self-motivation significantly impacts their physical education performance (Standage et al., 2003). Additional studies have also identified student perceptions of enjoyment and competence, as contributors to the effort a child experts in classes including PE (Fairclough, 2003). Further, personal perceptions of self-worth and competence have also been found to influence cognitive functioning among youth (Crocker & Wolfe, 2001; Lane, Lane, & Kyprianou, 2004). As Covington suggests through the theory of self-worth achievement motivation, students place value on themselves based on the degree of academic success they experience in the classroom (Covington, 1984).

Personal health factors. Childhood weight and fitness status are well evidenced as contributory to both physical and cognitive health. Stodden and colleagues (2008) assert that motor skill development in early childhood is a crucial component of physical fitness that influences a child's trajectory of engagement in physical activity as well as lifelong longevity (Stodden et al., 2008). Motor skills have been implicated by multiple researchers as the building block which PA hinges on (Clark & Metcalfe, 2002; Seefeldt & Nadeau, 1980). Seefelt and Nadeau (1980) explained motor skill acquisition as the hurdle one must surpass to reach any level of PA. Clark and Metcalfe (2002) extended this philosophy asserting that motor skills are a fundamental part of developing physical fitness which in turn later influences PA engagement. In contrast, one study which assessed the impact of early childhood motor skill development on adolescent PA found no relationship between low-level motor skills and later PA engagement (McKenzie et al., 2002).

Cardiovascular fitness as it relates to PA engagement among adults has been well-established. However, the representative literature on this relationship within early childhood remains unclear. The lack of evidence is due in large part to a current understanding of developmentally appropriate practice among young children which discourages formal assessment of the components of fitness and rather places emphasis on the introduction of fitness-related skills (Fisher, 2009). According to Fisher (2009) the younger the child is, the sooner they fatigue as a result of their energy expenditure during any given aerobic activity. Despite these concerns of developmentally appropriate practice, a recent study investigated the effectiveness of school-based PA interventions on increasing early childhood fitness. Matvienko and colleague's (2010) quasi-experimental study assessed the effects of engagement in a PA intervention on fitness among kindergarten and first-grade students. Results indicated that there were no immediate cardiovascular fitness effects among students in the intervention group, but there was a significant cardiovascular fitness effect at a four-month post-intervention follow-up assessment evidencing that habitual engagement in PA at an early age can significantly alter fitness (Matvienko & Ahrabi-Fard, 2010).

Robust findings support the relationship between physical fitness and cognitive functioning across the lifespan. In aging populations, chronic PA and physical fitness are linked to brain health (Kramer, Erickson, & Colcombe, 2006). Among school-age children and adolescents, physical fitness has been associated with multiple benefits including increased academic performance (Ortega, Ruiz, Castillo, & Sjöström, 2007). Several intervention studies evidence that level of physical fitness among school-age children is positively related to their academic performance (Chomitz et al., 2009; Grissom, 2005; Hillman, Erickson, & Kramer, 2008). Castelli and colleagues (2007) conducted fitness assessments among third and fifth-grade students and analyzed variability among children's' academic performance on state-level standardized tests.

Outcomes of their study indicated a positive relationship between cardiovascular fitness and academic performance; that is children of higher fitness academically outperformed their fewer fit peers. It remains unclear how fitness impacts academic performance in early childhood.

Additional support for the relationship between fitness and academic performance is exhibited among school-based PA interventions. Such interventions are developed to provide chronic engagement in PA that leads to increased fitness and positive academic outcomes. Sports, Play, and Active Recreation of Kids (SPARK) is an example of an evidence-based, school-wide intervention which targeted the fitness and academic enhancement of children in kindergarten through fifth grade by providing students in the experimental group with additional provisions of PA across the school week. Results indicated that those in the experimental group increased fitness and in turn outperformed control students on standardized test scores (Sallis et al., 1999). Another intervention, PA Across the Curriculum (PAAC), also employed physically active lessons among elementary school students. Results of this intervention indicated that students' exposure to physically active lessons increased their fitness and standardized test scores significantly (Donnelly et al., 2009; Donnelly & Lambourne, 2011). Kibbe and colleagues (2011) indicated similar outcomes of their intervention TAKE 10! stating that increases in child fitness positively impacted reading, math, and spelling (Kibbe et al., 2011). Conversely, one school-based PA intervention noted significant gains in student fitness yet reported no significant gains in academic outcomes (Dwyer, Coonan, Leitch, Hetzel, & Baghurst, 1983).

Other studies have investigated the role of physical fitness on executive functioning as PA is thought to enhance neurotrophic factors which increase EF, ultimately increasing learning and academic outcomes (Barenberg, Berse, & Dutke, 2011). Eight studies assessed executive functioning as it related to fitness in children (Chaddock et al., 2012; Hillman et al., 2014; Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Hillman, Castelli, & Buck, 2005; Kamijo et al., 2011; Niederer et al., 2011; Pontifex et al., 2010; van der Niet, Hartman, Smith, & Visscher, 2014). One longitudinal study conducted by Niederer and colleagues (2011) examined the relationship between fitness and executive function within early childhood. Fitness measures included motor agility, balance, and a shuttle run. Their results indicated that baseline fitness was positively associated with attention and memory nine months later. A recent study employed by Hillman and colleagues found both inhibition and cognitive flexibility to be influenced by fitness level among school-age children. The findings of their intervention study indicate, as a child's fitness level increases, so does their performance on tasks assessing inhibitory control and flexibility (Hillman et al., 2014). Chaddock and colleagues (2012) concur that fitness status is influential on cognitive flexibility among children. Two studies indicated a positive relationship between fitness and working memory (Hillman et al., 2005; Kamijo et al., 2011). In Kamijo and colleagues' randomized control intervention study, they investigated the role of fitness in executive functioning. Results indicated that as participants in the experimental group increased their fitness, their performance on a working memory task (Sternberg task) also significantly improved (Kamijo et al., 2011). Another study also investigated the relationship between EF and fitness among school age children utilizing EF measures including the Tower of London and Trail Making Tests. Results from this study also found a significant association between physical fitness and EF (van der Niet et al., 2014). Two studies employed a modified Flanker task of congruent and incongruent trials while measuring event-related potential (ERP's). Results indicated that higher-fit children exhibited significantly better allocation of P3 amplitude than their lower fit peers (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009; Pontifex et al., 2010). These results suggest that higher fit children can better adapt and attend to the changing demands of a task.

Within the literature on health factors among preschool-aged children, the most robust evidence points to the impact of obesity. Five studies specifically explored the role that PA plays in obesity prevention within early childhood. Of the five studies, four noted a significant and positive effect of increases in PA on Body Mass Index (BMI) among young children (Herman, Nelson, Teutsch, & Chung, 2012; Moore et al., 2003; Mo-suwan, Pongprapai, Junjana, & Puetpaiboon, 1998; Timmons et al., 2012). One longitudinal study was conducted over the course of seven years, following and tracking children's PA engagement and BMI. Results of this study found a significant and adverse relationship between the amount of PA and BMI (Moore et al., 2003). Two studies launched school-based interventions that increased PA with an intended outcome of reduction in BMI. Both studies cited significant reductions in BMI as a result of increased PA engagement (Herman et al., 2012; Mo-suwan et al., 1998), yet Mo-suwan and colleagues (1998) further noted a more significant effect on girls. Only one study indicated null effects of a PA intervention on BMI within early childhood (Reilly et al., 2006).

The relationship between obesity and cognitive functioning is also evident in the literature. As identified by one review, there is indeed a significant, negative correlation between childhood obesity and cognitive functioning (Liang, Matheson, Kaye, & Boutelle, 2014). When interpreted from a developmental standpoint, the relationship between obesity and cognition present early on in life as a lack of self-regulation (Graziano, Calkins, & Keane, 2010; Hughes, Power, O'Connor, & Fisher, 2015) and reduced inhibitory control (Levitan et al., 2015). As children progress into adolescence, the presence of obesity continues to tax their inhibitory control (Reyes, Peirano, Peigneux, Lozoff, & Algarin, 2015) and has been found to negatively impact cognitive flexibility (Pontifex et al., 2014). Accordingly, as Bustamante and colleagues suggest, school-based physical interventions exhibit the greatest impact on the executive functioning of overweight and obese children (Bustamante, Williams, & Davis, 2016).

Environmental factors. The WSCC model asserts that an individual's interactions with as well as their perceptions of their environment shape behavior (Lewallen et al., 2015). Further, because children in this study are nested in different classrooms, accounting for the environmental effects are necessary. Consideration of the school environment and how it relates to a child's PA and cognitive behaviors is essential. There is a robust body of literature that indicates environmental factors of; access, support, economics, and policy significantly influence a child's engagement in PA.

A supportive environment has been conceptualized within the literature as a school where PA is seen as an integral part of the learning experience and therefore prioritized by teachers and enhanced through professional development. Six studies indicated a significant relationship between the level of support within the school environment and the amount of student PA engagement (Pate et al., 2016; Derscheid, Umoren, Kim, Henry, & Zittel, 2010; Reunamo et al., 2014; Dyment & Coleman, 2013; Gehris, Gooze, & Whitaker, 2015; Wilke, Opdenakker, Kremers, & Gubbels, 2013). Results of a randomized control trial within the preschool setting identified teacher support as integral to increasing student PA (Pate et al., 2016). Two studies employed mixed methods including teacher level surveys and teacher interviews to investigate the role of teacher support on student PA. Results indicated that teachers who received support from their colleagues and administration felt more capable of providing their students with adequate opportunities for PA engagement (Derscheid, Umoren, Kim, Henry, & Zittel, 2010; Reunamo et al., 2014). Derscheid and colleagues went on to assert that without an administration that prioritizes the provision of PA within the school environment, teachers are unlikely to ensure students engage in PA. Three additional qualitative studies corroborated these findings further indicating the significant relationship between teacher support and student PA (Dyment & Coleman, 2013; Gehris, Gooze, & Whitaker, 2015; Wilke, Opdenakker, Kremers, & Gubbels, 2013). Dyment and Coleman (2013) specifically cited professional development as a source of support needed to enhance educator's abilities to provide PA opportunities.

Environmental policy has been identified as a potential strategy for increasing PA time (Brownson, Baker, Housemann, Brennan, & Bacak, 2001) As such, governing agents at the local level have been called upon to institute environmental PA policies in locations where children live and learn (Parker, Burns, Sanchez, & others, 2009). The investigation into the role of policy within the early childhood environment identifies that specific factors of a policy may either facilitate or inhibit a child's PA. Two studies indicated that establishing environmental policies increased the allocation of PA-based resources (Dowda et al., 2009) and increased time spent in PA (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). However, researchers warn that policies must be developed for different PA opportunities as child care educators have cited safety policies as detrimental to their ability to provide structured PA opportunities for children (Dyment & Coleman, 2013; Wilke et al., 2013).

The economic environment is a key determinant of health. As indicated by Gorden-Larsen and colleagues (2006), there is a stark difference in the infrastructure of high socioeconomic status communities and low socioeconomic status communities, which translates into a gap of access to facilities and resources for PA engagement. Their findings elucidated the fact that there was a significant inequality of PA facilities across schools of high and low socioeconomic status (Gordon-Larsen, Nelson, Page, & Popkin, 2006). Two other studies indicated that level of PA engagement among children in early childhood varied by measures of social class (Starfield, Robertson, Anne, & Riley, 2002) and socioeconomic status (O'Loughlin, Paradis, Kishchuk, Barnett, & Renaud, 1999).

However, when afforded support of and resources for PA in schools, children in low SES programs such as Head Start are found to increase PA levels (Dowda et al., 2009).

Evidence of a strong relationship between aspects of environment and PA engagement offer a compelling argument for PA interventions within the school environment. The Institute of Medicine (IOM) has pointed to the school environment as an optimal place for modification of daily PA (IOM, 2013). Several interventions have successfully altered the school environment indicating that creating a PA friendly school environment is feasible. The Child and Adolescent Trial for Cardiovascular Health (CATCH) employed a randomized control trial to investigate how modifying the school environment to increase PA and PE would alter health outcomes in students. Results indicated that intervention schools exhibited significant increases in their vigorous PA as well as time spent in MVPA (Luepker et al., 1996). Another intervention, TAKE 10!, sought to modify the classroom environment by incorporating PA into class routines. The results suggested that with the provision of classroom PA breaks, children significantly increased daily PA levels (Stewart, Dennison, Kohl, & Doyle, 2004). Similarly, preschool interventions have successfully modified the classroom environment through the provision of PA breaks and activities (De Marco, Zeisel, & Odom, 2015; O'Dwyer et al., 2013; Trost, Fees, & Dzewaltowski, 2008).

In addition to the environmental interventions aimed at increasing students' MVPA, other interventions have sought to decrease sitting time. Through the development of the "moving school," Cardon and colleagues (2004) were able to create an environment where students were encouraged to walk and move around their classroom as they learned rather than sit sedentary at their desk. Results of their pilot study indicated that students within the classrooms randomly assigned to the intervention had significantly higher step counts than controls (Cardon, De Clercq, De Bourdeaudhuij, & Breithecker, 2004). Other non-traditional school environments such as the Montessori model are built on a similar premise of developing open classroom spaces that encourage children to move and act upon their environment (Ross, 2012). In a study that compared the Montessori and traditional classroom settings, Pate and colleagues (2014) found that children exposed to a Montessori environment exhibited higher light, MVPA, and total PA than students enrolled in a traditional setting. Further, they found that students who had access to the Montessori environment also increased their PA outside of school time (Pate et al., 2014). As these findings suggest, school structure matters, as it is the school environment that plants the seed for habitual PA engagement.

The curriculum influences the classroom environment, therefore, having the capacity to impact executive functioning among children (Diamond & Lee, 2011). Tools of the Mind, a Vygotsky-based curriculum which encourages an environment of teacher modeling, self-talk, and dramatic play, has been identified as contributory to executive functioning in the early childhood classroom. In a cross-sectional study, researchers indicated that students randomly assigned to the tools of the mind curriculum outperformed their peers in inhibitory control tasks (Diamond et al., 2007). A Montessori environment is also found to challenge and support executive functioning among students throughout the day. In another cross-sectional study, Lilliard and Else-Quest (2006) found that children immersed in the Montessori environment performed significantly better on an inhibition task than their peers in a traditional classroom environment. Researchers attribute such difference to the fundamentally different structure of the Montessori environment (Lillard & Else-Quest, 2006).

Curricular environments which integrate PA into lessons have also been found to enhance executive functioning among children. Diamond and Lee (2011) contend that although the current educational arena is shrouded in budget cuts that minimize physical education, it is a movement-rich environment that children need most. Several interventions confirm the value of a physically active environment. Donnelly & Lambourne (2011) investigated the efficacy of the PA Across the Curriculum (PAAC), a school-based intervention which modified the classroom environment through adding moderate intensity PA into academic lessons. Their results found that intervention classrooms outperformed controls on standardized academic performance assessments (Donnelly & Lambourne, 2011b). In another preschool-based intervention, researchers altered the classroom environment by including whole body MVPA and hand gestures into vocabulary lessons. For this study, researchers randomized classrooms across four conditions of integrated exercise (MVPA embedded in the lesson), non-integrated exercise (engage in PA outside of learning), gestures (e.g., sit through the lesson and use hand motions), and traditional (sit and verbalize). Results of this study indicated that children in the integrated exercise classroom exhibited the highest academic performance suggesting that integration of PA into the classroom environment is beneficial (Mavilidi et al., 2015). As these studies suggest, PA can be considered a vital component of the environment in schools. Diamond and Lee hypothesize that a physically active classroom environment does not necessarily need to ensure moderate or high intensities. The Montessori environment is centered around a basic concept of open space encouraging children to move around and physically act upon their environment (Ross, 2012). As evidenced by Lillard and Else-Quest (2006), environments built to foster free movement also facilitate executive functioning.

Evidence suggests that an emotionally supportive classroom environment also facilitates EF (Blair, 2002). In a randomized control trial within Head Start preschool programs, researchers assessed the efficacy of a classroom climate intervention on the academic readiness of children. Results indicated that classrooms assigned to the intervention performed significantly better in areas of inhibition and attention than controls (Raver et al., 2011). In a longitudinal, intervention study which aimed to enhance the social-emotional classroom environment of second and third graders, researchers indicated a significant difference in the inhibitory control as well as verbal fluency among students assigned to the intervention (Riggs, Greenberg, Kusché, & Pentz, 2006). Riggs and colleagues (2006) further asserted that it is through the environments which foster behavioral changes that executive performance is enhanced.

The combination of SDT and the WSCC model illustrates the ecologic and organic factors mediating the complex relationship between PA and the outcomes of EF and AP. Since EF development is initiated within early childhood and continues well into adulthood (e.g. the late 20's), it is timely and warranted to gain a better understanding of the multiple factors influencing its development and progression. Further, identification of the effects of different types of PA on EF during early life helps to determine how much time should be dedicated to PA participation and at what intensity. Therefore, the focus of this dissertation will be to investigate the direct and indirect relationships that affect children's’ cognitive functioning.

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