2015

Playground Use and Executive Function Development During Preschool Years

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PLAYGROUND USE AND EXECUTIVE FUNCTION DEVELOPMENT DURING PRESCHOOL YEARS

BY

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

IN

HUMAN DEVELOPMENT AND FAMILY STUDIES

UNIVERSITY OF RHODE ISLAND

2015

MASTER OF SCIENCE THESIS

OF

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UNIVERSITY OF RHODE ISLAND

2015

ABSTRACT

The current research explores executive function (EF) development among the children at the University Of Rhode Island's child development centers (CDCs). Specifically, the research explores the role of outdoor play in executive function development. Two samples of children from the Providence Child Development Center and the Kingston Child Development Center are compared twice (time 1 and time 2) across 5 months to assess the role of outdoor play spaces in executive function development. The independent variable, playground type has two levels: a playground structure (Kinsgton CDC) and open outdoor space (Providence CDC). Executive function is assessed using three tasks, the Day/Night task, the Backwards Digit Span, and the Standard Dimensional Change Card Sort Task (DCCS). Findings reveal no significant difference between the two samples at time 1 and time 2. Results suggest an outdoor playground does not provide greater benefits for executive function development than the use of an open space. Results can be used to inform educators regarding the use of outdoor space for playtime.

ACKNOWLEDGMENTS

Apart from my efforts, the success of this research depended greatly on the encouragement and support of many others within the HDF department at URI. I take this opportunity to express my gratitude to the people who have been supportive from the thesis proposal to the manuscript writing.

I would like to express my deepest appreciation to my major professor, Dr. Karen McCurdy, for her support and guidance throughout the process. I am grateful for her endless advice and willingness to share her expertise. Without her encouragement and support, this study would not have been possible.

I would also like to express my sincere appreciation to my committee members, Dr. Sue Adams and Dr. Susan Brand, for their advice and feedback during my initial proposal. Their suggestions were monumental in the final design of the study.

Additionally, I am forever grateful to the former directors of URI's child development centers, Susan Warford and Deborah Morelle, for allowing me into the classrooms to work with their students. And to the teachers at each center, I am thankful for their support and accommodations that made this research possible. It was a pleasure working with everyone at the CDCs, I am grateful for their welcoming and positive attitudes throughout the data collection.

I thank my former professors in the HDF department at URI for providing the skills and training necessary to create and complete a research study of my own. Finally, to my parents, I am forever grateful for your love and support throughout my undergraduate and graduate career.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

Executive function (EF), an umbrella term that encompasses cognitive flexibility, inhibitory control, and working memory, has received increased attention over the past decade. Research suggests development of EF skills at a young age can lay the foundation for the healthy development of social and cognitive skills (Yeager & Yeager, 2013), making EF a topic of great interest for developmental research and lay domains. Although research has explored the various correlates of EF, questions remain regarding methods of promoting EF development, including what interventions can foster EF skills in young childhood. Past research suggests executive function is linked to physical activity in childhood, yet to date, little research explores the use of an outdoor play structure on EF development. Therefore, this research will explore the use of outdoor play space on the development of EF skills in early childhood.

Executive function, including inhibitory control, working memory, and cognitive flexibility, is used throughout life to organize and control goal-directed behavior (Banich, 2009). Specifically, inhibitory control enables self-control over one's behavior, emotions, and attention (Diamond, 2011). Working memory allows individuals to hold information in mind while actively manipulating the information, and cognitive flexibility refers to the ability to change perspectives and adjust to new or unexpected information (Diamond, 2011). These skills are important to ensure actions are not a result of impulse, challenges can be faced, and information can be built upon over time (Diamond, 2011). Moreover, these core components of EF lay the foundation for higher-order EF skills including reasoning, problem solving, and planning (Collins & Koechlin, 2012), making it important to foster such skills at a young age for success later in life.

Research supports the importance of EF for school readiness (Blair & Razza, 2007; Morrison, Ponitz, & McClelland 2010) and success in school across adolescence (Alloway & Alloway, 2010). Moreover, Blair and Razza (2007) found EF skills are more important for school readiness than IQ, as EF in preschool was related to measures of math and literacy ability in kindergarten. Additionally, previous research found EF is critical to career success (Bailey, 2007), making and keeping friends (Hughes & Dunn, 1998), and marital success (Eakin et al., 2004).

Understanding the effect of an outside play space on young children's EF development is important for educators and policy makers alike, as outdoor play is a consistent predictor of physical activity, which is linked to children's social, mental, and physical health (Veitch, Bagley, Ball, & Salmon, 2006). If the use of playground structures correlates with EF skills differently than the use of open outdoor space, this information may be used by parents, teachers, and administrators to facilitate the positive development of young children. Similarly, if no difference is found, this information can inform parents, teachers, and administrators regarding the mechanisms of play that are important to foster positive development in childhood. Such information can guide the creation of lessons and plans for teachers, administrators, and parents, such as providing children access to open space or playground structures during free time.

REVIEW OF LITERATURE

Past research explores different developmental trends among the three domains of EF. To begin, cross sectional studies regarding working memory suggest the ability to hold a representation in mind over time develops before 6 months (Reznick et al, 2005), but the length of time representations are held and the number of representations that are retained develop after 6 months (Pelphrey & Reznick, 2002). Particularly, Diamond and Doar (1989) found a 10 second increase in the number of seconds an infant can hold information in memory from 6 months to 1 year. Additionally, several studies employing the Towers of London task, used to assess cognitive planning, have found the number of representations that can be retained over time differs from ages 3 to 5 (Bull, Espy, & Senn, 2004; Espy & Bull, 2005), and during this time period the ability to update this information also develops (Espy & Bull, 2005). Similar findings were reported by Davis & Pratt (1995) in their assessment of working memory using the backward digit span and forward digit span tasks. Carlson (2005) found between the ages of 3 and 5 the number of items a child can remember backwards improves, with 34% (n=29) of young three year olds completing 3 or more trials of the backwards digit span compared to 73% (n=65) of young four year olds completing 3 or more trials.

Similar age trends exist in terms of inhibitory control. In her sample of young children 24 months old to 4 years old, Carlson (2005) found age differences in the length of time children are able to delay a response. Specifically, 50% of 24-month-olds were able to suppress eating a treat for 20 seconds, whereas 85% of 4-year-olds suppressed the urge for 1 minute and 72% of 4-year-olds suppressed eating the treat for 5 minutes (Carlson, 2005). In addition, multiple research studies have found age differences in children 3- to 5-years-old in tasks that require following an arbitrary rule and suppressing a dominant response (Carlson, 2005; Diamond, 1991). Research suggests that children develop this ability rapidly from young 3s to older 3s, yet more difficult versions of the initiating-suppressing tasks, such as Simon Says, are challenging for even 4- and 5-year-olds (Carlson, 2005). Research regarding stroop-like tasks suggests children are able to solve tasks that involve greater conflict as they age. Specifically, Carlson (2005) found only 45% of 3-year-olds passed the grass-snow task, a task that requires children to inhibit a dominant response and follow an arbitrary rule, and not until 4.5 years of age did 80% of children pass the task. The increase in conflicting ideas is likely responsible for the difficulty children encounter during such tasks (Garon, Bryson, & Smith, 2008).

Research regarding cognitive flexibility suggests success in this domain is related to other EF components (Garon, et al., 2008). Researchers have found children 3-years-old and younger have difficulty completing the Dimensional Change Card Sort, a common measurement of attention shifting for young children (Carlson, 2005). In particular, Carlson (2005) found 3-year-olds are able to sort according to the first rule of the task but cannot shift to a new rule. After age 4, children are better able to shift to a new rule (Carlson, 2005). Many questions remain regarding shift-setting in the early preschool years (Garon et al., 2008).

Research suggests EF can be improved through various methods including social play, scaffolding, computerized training, and aerobic activity (Diamond & Lee, 2011). Best (2010) describes several studies that found both acute and chronic aerobic exercise aid in the development of EF among adolescents, with the latter being more beneficial (Budde et al., 2008; Davis et al., 2007). In addition, when 7 to 9 year olds were randomly assigned to 2 hours of fitness activities daily for a school year (70 minutes of aerobic activity, then motor skill development) compared to the control group, children who received fitness training showed more improvement in working memory (Diamond & Lee, 2011). Additionally, Davis and colleagues (2007) found a high-dose of aerobic exercise (40 minutes per day) compared to a low-dose of aerobic activity (20 minutes per day) or no activity, yielded greater EF benefits including planning behavior, among overweight but otherwise healthy children, ages 7 to 11 years old.

Many gaps exist within the executive function literature. To begin, the trajectory of EF disparities remains unknown. Although an association between socioeconomic status (SES) and EF development has been found throughout research, the causal nature of this association merits further research. Additionally, the critical period of EF development needs further research. Although prior research suggests EF development is particularly susceptible to environmental factors including stress, cognitive stimulation in the home, and nutrition throughout infancy and preschool, the exact timing and nature of this critical period needs future research (Hook, Lawson, & Farah, 2013). Lastly, further research exploring interventions aimed at fostering EF skills is needed. Research suggests aerobic activity improves EF, yet common aerobic activities, such as organized sports, have yet to be explored (Diamond & Lee, 2011).

With growing evidence suggesting that EF can be fostered through interventions (Diamond & Lee, 2011; Center on the Developing Child, 2011; Yeager

& Yeager, 2013), it is important that techniques aimed towards improving EF are implemented within the classroom in attempt to lay a solid foundation for children's success throughout their lifetime. Furthermore, as research suggests EF skills lay the foundation for future social and educational skills (Center on the Developing Child, 2011), it is important to identify the factors that impact and facilitate the use of executive functioning within a preschool setting.

The theory of embodied learning can be applied to physical activity and cognitive development. According to the theory of embodied learning, interaction between sensorimotor integration and the environment plays a pivotal role in the development of certain cognitive functions (Spencer et al., 2006). Although definitions of embodied learning vary across disciplines, there are several concepts that remain consistent throughout the literature. First, an individual's ability to interact with the environment influences cognition. As an individual explores his or her movement in a particular area, a framework for action control develops (Tomporowski, Lambourne & Okumura, 2011). Second, an organism is restricted in the type of cognitive processes possible based upon available physical structures (legs, arms, etc.). Lastly, physical structures influence the way the organism views the environment (Tomporowski et al., 2011).

According to the theory of embodied learning, the use of outdoor play structures may allow for cognitive processing that differs from processes used in the absence of structures. In addition, in line with the theory of embodied learning, the structures will influence the way children view the environment and explore their movement. The structures on the playground provide opportunities for children to jump, climb, explore space, and challenge their abilities. Furthermore, these structures may provide an opportunity for exploration and environmental feedback that differs from outdoor play in open space, such as the ability to power a swing through moving one's legs or exploring the distance and strength needed to reach across the monkey bars.

Additionally, motor development has been linked to EF (Koziol, Budding, & Chidekel, 2011). Koziol, Budding, and Chidekel (2011) explain the link between motor development and executive function, arguing that humans were designed to move and the fundamental purpose of an organism is to survive through environmental interactions. Koziol and colleagues (2011) posit that goal-directed action management requires the development of anticipatory control mechanisms to predict sensorimotor outcomes. This requires the development of "on-line" sensorimotor anticipation to adjust to the environment and "off-line" simulations to plan behavior. In this model, EF falls within "off-line" simulations. The authors argue that motor development and EF are inexorably linked and motor movements reflect action control, an early form of EF (Koziol et al., 2011). Supporting this argument is research linking motor development and executive function. For example, Piek, Dawson, Smith, and Gasson (2008) found a relationship between early gross motor problems and the later development of particular EF deficits in processing speed and working memory among school-aged children. In another study of adolescents, Westendorp and colleagues (2011) found children with learning disabilities performed more poorly on all motor tasks. Furthermore, rats engaged in exercise training that involved motoric climbing skills developed neural connections within the cerebellum, the area of the brain responsible for fine and gross motor skills, while rats engaged in aerobic activity improved cerebral blood flow (Black et al., 1990). Such research provides evidence for an association between exercise, motor development, and cognitive development. Lastly, research exploring the link between exercise and EF suggests the challenge of an activity may be what facilitates EF development, a finding that may support a difference in EF development through the use of playground structures that offer physical challenges compared to the use of open spaces (Tomporowski et al., 2011).

According to such theories, involvement in physical activities that allow for exploration, are unpredictable, and require problem solving may impact the development of EF skills (Tomporowski et al, 2011). Compared to open spaces, outdoor play structures may provide different opportunities for feedback. Structures may allow for more planning, exploration, and motor development. Playground structures may offer challenges that are different than open space, although it is possible these structures will be predictable if used daily. Such differences will require various motor movements (i.e., jumping, climbing, pulling, pushing) and offer a variety of opportunities for unique problem solving skills, as these structures are designed with these goals in mind. Furthermore, the use of an outdoor playground that allows for exploration of space and the environment may provide feedback that differs from the environmental feedback available in open spaces. Conversely, open spaces may allow for more aerobic activity and creativity, as children explore their environment and utilize what is naturally available for play (Fjørtoft, 2001). Furthermore, motor activity is challenged when interacting with the natural environment which provides dynamic and rough playscapes (Fjørtoft, 2001). Therefore, this exploratory study aims to discover if a difference exists among the different play areas in promoting EF development.

The playground structures available at the Kingston CDC include a swing set, a seesaw, pull-up bars, monkey bars, a climbing structure, a sliding pole, a slide, and a rock children often use for climbing and jumping. These structures allow the children to climb, jump, push, and hang. The children at the Providence CDC have access to outdoor space throughout the city. These areas allow for running but do not provide opportunities for climbing or jumping aside from a stage children use while playing. Based on prior research, and utilizing the current play areas at each CDC, this exploratory study will aim to understand the differences and similarities in the use of outdoor space versus an outdoor play structure in fostering EF development in early childhood.

METHODOLOGY

The current exploratory study employs a longitudinal approach to understanding the influence of different outdoor play areas on EF development. Data were collected over a four month period, first in January, then again in May.

Participants

The study utilized the University of Rhode Island’s Child Development Centers (Providence and Kingston). Children ages 3 to 5 years old, enrolled in the full-day program, and their parents, were invited to participate in the study. The letter inviting parents to join the research was sent to 60 families, with 40 returning the consent form, i.e., 20 families refused to participate, resulting in a sample size of 40 children.

Three children refused to play at least one of the three games with the researcher, therefore, these children were removed from analyses. A fourth child was no longer with the CDC at the time of the second data collection, thus, this child was also removed from analyses. The final sample consisted of 36 children and their families: 7 three year olds, 18 four year olds, and 10 five year olds. Twenty of the children (55.6%) were female and 16 children were male. The majority of the sample was white (87.2%) and middle income ($25,000-$99,000) (57.9%). The majority of the sample (68.4%) had at least one parent who completed graduate school or higher.

Independent and Dependent Variables

The research explored play area as an independent variable. There were two levels of play area, 1= Kingston CDC (outdoor play structure) and 2= Providence CDC (open outside area). The outdoor play areas at the Kingston CDC includes various structures such as a swing set, a seesaw, monkey bars, pull-up bars, a slide, a sliding pole, a climbing unit, and a rock children typically use for climbing and jumping. The Providence CDC is able to use public parks which provide open space for the children to play, however, these play areas do not offer any play structures for children aside from a stage children utilize while playing. The stage is approximately 12 inches high. Additionally, teachers at the Providence CDC bring a wagon of toys to the play area. The wagon includes toys such as trucks of various sizes, pails, shovels, small rakes, "stepping stones", hula hoops, scarves, an expandable tunnel, a climber, bean bags, large plastic dowels, wooden planks, romper stompers, water, squirt bottles, paint brushes, chalk scooters, bikes, and books. Both centers spend an equal amount of time (more than 60 minutes per day) in their designated play areas.

Three dependent variables, aimed at measuring the three domains of EF, were used to assess overall EF: the Day/Night task was used to measure response inhibition, the Standard Dimensional Change Card Sort (DCCS) was used to measure cognitive flexibility, and the Backwards Digit Span was used to measure working memory. The three executive function tasks were taken from Carlson (2005) because past research suggests these tasks work well with preschoolers and demonstrated variation in difficulty across ages 3 to 5. Therefore, these three measures were used for the current study. Specifically, the Day/Night task measured response inhibition, the Standard Dimensional Change Card Sort (DCCS) measured cognitive flexibility, and the Backwards Digit Span assessed working memory.

Executive Function Tasks

Response Inhibition

Day/Night task (Gerstadt, Hong, & Diamond 1994): The researcher engaged the children in a brief conversation about when the sun comes up (in the day) and when the moon and stars come out (in the night). The researcher then presented a card with a yellow sun drawn (to represent the day) and a card with the moon and stars (to represent the night). Next, the experimenter explained this is a “silly” game and when the day card is shown, children should say night. Children were instructed to say day when the night card was shown. After practice trails children were tested on 16 consecutive trials. The number of correct trials (out of 16) was recorded for each child. If children completed 12/16 trials, or more, they were counted as passing the task.

Although the psychometric properties of the Day/Night task have not been extensively reviewed, research indicates the task possesses high internal reliability (α=.91) (Rhoades, Greenberg, & Domitrovich, 2009), high test-retest reliability (Thorell & Wåhlstedt, 2006), and high predictive reliability for academic achievements (Duncan, 2012). In her review of executive function measures for preschool children, Carlson (2005) found that 27% of their sample size of old 3-year-olds (n=45) passed the Day/Night task and 68% of older 4 year olds (n=19) passed.

Cognitive Flexibility

Standard Dimensional Change Card Sort (DCCS) (Zelazo, 2006): Children were introduced to two boxes with target cards (a red bunny and a blue boat) glued to each box. The experimenter introduced the game as a sorting game and asked the children to place all of the red and blue bunny cards into the red bunny box and the red and blue boat cards into the blue boat box. This was considered the “shape game,” bunny vs. boat. After five consecutive trials the experimenter switched to the “color game,” red vs. blue, and explained to the children that all red cards were to be placed in the red bunny box and all of the blue cards were to be placed in the blue boat box, regardless of object shape. Based on previous research, there were five post switch trials—two were compatible with the old rule and three were incompatible with the old rule. The total number of correct incompatible trials was recorded. Children who were correct on all three incompatible trials of the DCCS (3/3) were considered to pass. Research has found high test-retest reliability for the DCCS (ICC=.94) (Beck, Schaefer, Pang, & Carlson, 2011), and high predictive reliability for academic achievements (Duncan, 2012). Twenty-five percent of Carlson's (2005) sample of 3-year-olds (n=79) passed the DCCS task and 76% of older 4-year-olds (n=38) passed.

Working Memory

Backward Digit Span (Davis & Pratt, 1996): The experimenter introduced the children to a puppet and explaining that the puppet is silly, and whatever she says the puppet says backwards. The experimenter demonstrated saying "1, 2" and the puppet followed "2, 1." Then, the children were invited to try using the example. The task began with two digits and the number of digits increased by 1 until the child made an error on three consecutive trials. The highest level of completion was recorded (two, three, four, or five). To pass the backwards digit tasks children must complete the task using 3+ digits. Gathercole (1995) reports a test-retest reliability correlation coefficient for digit span of .68 in a sample of 70 4- and 5-year-old children, and a Cronbach's alpha of .65 (Kroesbergen, Van Luit, Van Lieshout, Van Loosbroek, & Van de Rijt). In her sample, Carlson (2005) found 25% of old 3-year-olds (n=79) and 76% of older 4 year olds (n=38) passed the backwards digit span.

Demographic Covariates

To assess comparability of the two groups, parents completed a questionnaire on demographic information including education level, marital status, and household income as these have been shown to influence development throughout childhood (Ardila, Rosselli, Matute, & Guajardo, 2005; Hackman & Farah, 2009; Rhoades, Greenberg, Lanza, & Blair, 2011). Demographic variables were taken from the family questionnaire. Although many questions were addressed including household income, parental education, number of siblings, and time spent engaged in various activities, many variables were excluded from the final analyses because of homogeneity in responses. Variables used in the final analysis include: household income, parental education, gender, and child's age. Child's age was recorded in months, as a continuous variable. Gender was coded as a dichotomous variable (1=male, 2=female). Household income was originally collected as an ordinal variable (1=<25,000; 2=25,000-49,999; 3=50,000-99,999; 4=100,000-149,000; 5=150,000-199,999; 6=>200,000). However, due to little variability, responses were recoded to 1=<99,999; 2=>100,000. One response was missing, as one family did not return the questionnaire. Parental education was collected as an ordinal variable (1=graduated from vocational/technical school; 2= college graduate; 3=graduate or professional school). Due to little variability in responses, the variable was recoded so that 1= less than graduate school, 2=more than graduate school. One response was missing, as one family did not return the questionnaire.

Based on research suggesting associations between specific play activities and EF, parents were also asked to indicate the amount of time their children spend engaged in particular play activities outside of school. Specifically, parents were asked to estimate the typical amount of daily time (in 15 minutes increments) children typically engaged in running games (Tuckman & Hinkle, 1986), organized movement activities (Brown, 1967), informal sports with friends/family (Davis et al., 2007), imitation games (Carlson, 2005), aerobic activities, computer activities, martial arts, and mindfulness activities (Tomporowski et al., 2007) outside of school. Teachers were also asked to complete a questionnaire addressing the time spent within the classroom on each of the aforementioned activities.

Procedure

The researcher collected data in a private space within each of the CDCs. The research followed a pre-test and post-test design in attempt to gather data regarding development over 4 months. The test was first administered to each child in January 2015 and again in May 2015. Parents and teachers were asked to complete the questionnaire in January. A letter was sent home to parents explaining the project and procedures. The letter indicated a date and time the researcher was available at each center to answer any questions regarding the research and to distribute and collect signed informed consent forms. After parental consent and parental permission were given, children were asked to give assent prior to participation in the three tasks. The researcher explained to the children they had the option not to play, or to stop playing the games at any time. Parental informed consent, parental permission, child assent, and teacher consent were obtained and all research complied with URI's IRB.

Data Analysis

All collected data was entered into SPSS V.21. Data was checked for normality, skewness, missingness, and distribution, with recoding of variables occurring as needed. The researcher then used cross tabs and t-tests to test for demographic differences between the two groups. Using cross tabs, a chi-square analysis was used to explore if the variables were independent, i.e., if the child development center was associated with specific demographics that may influence results. Next, correlational analyses were used to test for confounding variables; specifically if mean EF scores varied by demographic differences, which may influence findings. Then, t-tests were used to determine if mean scores on the Time 1

(T1) EF tests and the Time 2 (T2) EF tests varied by group status. A change score variable was created by subtracting T1 EF mean scores from T2 EF mean scores. The research question was then addressed using independent groups t-test to compare change scores by group status. Finally, a hierarchical regression was used to assess the strength of the association between variables and the power of the independent variables in predicting T2 outcomes.

FINDINGS

Crosstab analyses revealed the two samples were statistically similar based on gender, age, household income, and parental education (Table 1). Furthermore, the two samples engaged in similar activities throughout the day, with few exceptions. The greatest difference between the two groups was in time spent on an outdoor playground structure (Kingston= 60 minutes or more; Providence= 0 minutes). The two groups also differed on time spent doing mindfulness activities (Kingston= 15-45 minutes; Providence = 1-15 minutes). Both centers reported 60 minutes or more of aerobic activity. Independent sample T-tests revealed no significant difference in executive function scores at T1 (DCCS p>.52; Day/Night p>.87; Backwards Digit Span p>.58). Tests for normality revealed the distribution across the sample was approximately symmetric.

Exploratory analyses revealed little variability among children in results of the DCCS task, at both pre and post test. Specifically, 84% of the sample completed the task successfully at T1 and T2. Therefore, the DCCS task was removed from analyses. Using the Backwards Digit Span task and the Day/Night Task, overall, results revealed no significant difference in executive function scores between the two centers. Independent samples T-tests revealed no significant difference between the two groups on each task, at T1 and T2. Table 2 shows the mean and standard deviations for each sample at pre and post tests.

Table 1. Descriptive Statistics of the Sample

Variable	**Kingston CDC (frequency)**	**Providence CDC (frequency)**
Gender		
Male	7 (43.8%)	9 (56.3%)
Female	12 (60%)	8 (40%)
Income		
<$99,999	12 (57.1%)	9 (43%)
>$99,999	7 (50%)	7 (50%)
Age		
Three	5 (71.4%)	2(28.6%)
Four	8 (44.4%)	10 (55.6%)
Five	6 (60%)	4 (40%)
Parental Education		
≤ College	5 (50%)	5 (50%)
≥ Graduate Degree	14 (56%)	11(44%)

Next, paired sample T-tests were used to compare mean scores for T1 and T2 tests among each sample. Although children at the Providence Child Development Center made gains in the backwards digit span between T1 (M= 1.41, SD=.870) and T2 (M=1.76, SD=1.53), the gains were not significant $t(1, 17)=-1.38$, p=.188. Results approaching significance were found for the Day/Night task. Mean scores increased from T1 (M=12.76, SD=3.73) to T2 (M=14.29, SD=.369), the change in mean scores was significant at the .10 level, p=.07. Children at the Kingston Child Development Center made similar gains, with no significant difference. Particularly for the backwards digit span, T1 scores (M=1.63, SD=1.30) were lower than T2 scores (M=2.10, SD= 2.02), however, the difference was not significant. For the Day/Night task T1 scores (*M*=12.94, SD=2.87) were also lower than T2 scores (*M*=14.63, SD=3.14) again, the mean scores were not significantly different. It is likely these findings are due to the small sample size.

Table 2. Independent Samples T-test of mean EF scores by CDC

Task	N	Mean (SD)	T-value	Min	Max
DCCS Time 1					
Kingston	19	2.579(.901)	-.667	0	3
Providence	17	2.764(.753)		0	3
DCCS Time 2					
Kingston	19	2.579(.901)	-1.168	0	3
Providence	17	2.941(.243)		0	3
Day/Night Time 1					
Kingston	19	12.947(2.876)	.165	7	16
Providence	17	12.764(3.733)		5	16
Day/Night Time 2					
Kingston	19	14.631(3.148)	.344	4	16
Providence	17	14.294(2.687)		8	16
Backwards Time 1					
Kingston	19	1.631(1.300)	.589	0	5
Providence	17	1.412(.870)		0	3
Backwards Time 2					
Kingston	19	2.105(2.024)	.565	0	5
Providence	17	1.764(1.521)		0	5

Correlation analyses revealed a significant correlation between the Backwards Digit Span task T2 and age $r(36) = .429$, $p <.05$, and the Day/Night task and age $r(36) = .347$, $p <.05$ at T2. Specifically, older children performed better on each task, a finding supported by prior research.

Change score variables were created to compare the two samples over time (Table 3). Time score variables were created for the Day/Night Task and the Backwards Digit Span, by subtracting the results of T1 from the results of T2. Independent sample T-tests were then run to assess for differences between the groups. Overall, no significant differences were found related to the child development centers, for the Day/Night Task *t*(34)=1.27, *p*=.90, and the Backwards Digit Span

Table 3. Mean Change Scores on EF Tasks by CDC

Task	N	Mean(SD)	T-value
Day/Night			
Kingston Δ	19	1.68(3.987)	.127
Providence Δ	17	1.53(3.24)	
Backwards Digit Span			
Kingston Δ	19	.47(1.68)	.257
Providence Δ	17	.28 (1.18)	
DCCS			
Kingston Δ	19	.00(.75)	-.681
Providence Δ	17	.18(.80)	

t(34)=.247, *p*=.81; although the mean change scores for both tasks were slightly higher among children at the Kingston CDC, as reported in table 3.

Correlation analyses revealed two significant correlations between demographic variables and change scores. Specifically, age [*r*(36)=.407, *p*<.05] and was significantly correlated with the Backwards Digit Span change scores, i.e., older children performed better on the Backwards Digit Span task. Additionally, a significant difference was found between gender *t*(1, 35)=-2.08, *p*=.05, with females performing better than males on the Backwards Digit Span.

Finally, hierarchical linear regression analysis was used to develop a model for predicting children's scores at T2 from their T1 scores, age, gender, parental education, and child development center. For the Day/Night task the full model was significant *F*(6,28)=2.46, *p*=.05. The six predictor model accounted for 34% of the variance in T2 scores, although only T1 scores had significant (*p*<.05) partial effects in the full model. Specifically, an increase of 1 point at T1 leads to an increase of .31

in T2 scores. Moreover, children who scored higher at T1, scored higher at T2. Results are displayed in table 4. The Backwards Digit Span, T1 significantly predicted scores at T2 $F(1,33)=20.55$, $p<.01$. Additionally, the full model without child development center, was significant $F(6,28)=7.09$, $p<.01$. The six predictor model accounted for 60% of the variance in T2 scores, although only T1, gender (female), and age had significant ($p<.05$) partial effects in the full model. Specifically, an increase of 1 point at T1 results in an increase of 1.02 at T2, being female predicted higher results at T2, and an increase of 1 month in child's age leads to an increase of .06 on T2 scores. Results are shown in table 5.

Table 4. Summary of Hierarchical Regression Analysis for Variables Predicting Scores on Day/Night at Time 2 (*N=36*)

	Model 1			**Model 2**			**Model 3**		
Variable	*B*	*SE B*	*B*	*B*	*SE B*	*B*	*B*	*SE B*	*B*
Time 1	.299	.152	.33*	.42	.16	.46*	.437	.162	.48*
Female				-1.00	.93	-.17	-1.2	.97	-.20
High Income				1.71	1.06	.29	1.82	1.07	.31
Child Age(months)				.10	.06	.28	.10	.06	.28
>Graduate school				.74	1.08	.12	.65	1.10	.10
Providence CDC							-.71	.92	-.12
R^2		.11			.33			.34	
F for change in R^2		3.89			2.86*			2.45*	

**p<.05, **p<.01*

Table 5. Summary of Hierarchical Regression Analysis for Variables Predicting Scores on Backwards Digit Span at Time 2 (*N=36*)

		Model 1			**Model 2**			**Model 3**	
Variable	*B*	*SE B*	*B*	*B*	*SE B*	*B*	*B*	*SE B*	*β*
Time 1	.984	.22	.62**	1.03	.21	.65**	1.03	.21	.65**
Female				1.06	.42	.30*	1.08	.43	.31*
High Income				.82	.49	.23	.81	.50	.23
Child Age(months)				.07	.03	.30*	.06	.03	.30*
>Graduate School				-.27	.53	-.07	-.26	.54	-.07
Providence CDC							.10	.43	.03
R^2		.38			.60			.60	
F for change in R^2		20.55**			8.78**			7.09**	

**p<.05, **p<.01*

DISCUSSION

The research analyzed the results of executive function tasks from two samples to explore the effects of outdoor play spaces on executive function development in young childhood. Overall, the results suggest the use of an outdoor play structure with several pieces of equipment targeted for preschool age children does not significantly differ from the use of an open outdoor play area in fostering executive development in early childhood. Although the children in the sample made developmental gains over the course of 4 months, the gains were not statistically significant and were not associated with type of play space. Although a brief, exploratory study, these results suggest the difference in outdoor play structures did not have an effect on children's overall gains in executive function development.

The significant effect of age on performance on executive function tasks aligns with previous literature that suggests EF skills increase with age (Carlson, 2005).

Mixed findings regarding executive function and gender are found throughout the literature. For instance, Raaijmakers et al, (2008) found boys exhibit greater deficits in overall EF than girls. Similarly, Diamond and Lee (2010) suggest young boys typically benefit more than young girls from interventions aimed at improving EF. These findings support the results of the Backwards Digit Task found in this study. However, some research suggests no significant gender differences in EF during young childhood (Thorell & Wåhlstedt, 2006). Thus, the association between gender and executive function development is an area that warrants further research.

Although previous research has not explored the association between playground structures and EF development, the results provide insight into the application of several theories previously discussed. To begin, using the theory of embodied learning, the results suggest an outdoor play structure designed for young children may not offer environmental feedback more beneficial for children than the natural environment. Additionally, the finding that gains were made across both centers, on each task, likely highlights the typical development of EF throughout young childhood. Specifically, an abundance of research suggests children's EF skills rapidly increase between the ages of 3 and 5 (Bull et al., 2004; Carlson, 2005). It is possible the increases in EF outcomes were not significant because 4 months does not allow enough time for significant gains in development. However, the increase in mean scores across the two EF tasks aligns with previous research (Carlson, 2005).

Several limitations must be noted. To begin, the homogeneity of the sample limits the generalizability of the results to white, middle class, educated families. Secondly, this was an exploratory study; therefore, the study did not use a randomized control group. A controlled study should be designed to further investigate the influence of play space on executive function development. For example, a study employing an elementary school with multiple classrooms that can be randomly assigned to a controlled play environment vs. free play on a play structure may provide further insight into the differences, if any, between play spaces in fostering EF development. Furthermore, an observational approach may be beneficial, to observe the activities children engage in when on the playground. Next, the research was conducted throughout the winter months, possibly influencing the amount of time children spent engaged in outdoor play. A recommendation for future research is to lengthen the time of the study to incorporate all four seasons and a longer developmental span. Additionally, previous research suggests high test-retest reliability for all of the measures used. Therefore, it is possible 4 months was not adequate time to show significant developmental changes with these measures. The small sample size also serves as a limitation as it reduces the power to reject the null hypothesis, i.e., when the sample size is small, small effects will not be statistically significant.

Lastly, the results of the DCCS task suggest this task may not be an accurate measurement of working memory in ages 3 to 5. This finding aligns with previous literature that suggests the standard DCCS task minimizes inhibitory demands (Best & Miller, 2010). Future research should explore possible measurements for this age group that allows researchers to explore the variability of working memory between ages 3 to 5. Specifically in this sample, 57.1% of three year olds successfully completed the task, 89.5% of four year olds successfully completed the task, and 88%

of five year olds successfully completed the task. It is likely little variability was found in this study because the majority of the sample was four and five year olds. Thus, these results suggest a more accurate measurement or modification of the current DCCS task is needed to explore differences in working memory between the ages of 3 and 5 years old.

CONCLUSION

Results can inform educators, parents, and policy makers regarding play options for fostering healthy development in young childhood. The finding of no significant difference between the groups suggests children can reap the benefits of outdoor play without expensive structures, although these structures do not have negative effects on development. These results may be of interest to preschool centers in the city and preschool centers with low funding. Often times, preschools in the city, like the Providence CDC, do not have space for an outdoor playground. Similarly, schools with low funding are less likely to have the funding for playground equipment. The results of this exploratory study suggest these circumstances do not necessarily result in a disadvantage if the children have access to outdoor space that enables aerobic activity and social play.

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