

**Effects of a Movement-based Curriculum on the Motor and Cognitive Development of
Preschool-aged Children**

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Aaron P. Wood
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ABSTRACT

Physical activity has been shown to be positively associated with improved motor skill and cognitive development in young children. Intervention designs are often constructed without focus on interrelatedness of the development of motor and cognitive self-regulatory skills.

Purpose: To investigate the impact of a movement-based curriculum designed to integrate both motor skill and cognitive development in preschool children. **Methods:** Preschool-aged children [n=34; intervention group (n=28); control group (n=6)] participated in the study. Locomotor and object control motor skills were assessed via the Test of Gross Motor Development – 3rd Edition. Cognitive self-regulation (attention, working memory, and inhibition) was assessed via the Early Years Toolbox. These assessments were completed at pre- and post-intervention time points. Perceived competence and enjoyment were assessed during the curriculum via adaptations of Harter’s Perceived Competence Scale for Children and the Physical Activity Enjoyment Scale. Multiple 2x2 repeated measures ANOVAs were run to determine the impact of the curriculum on motor skills (scaled scores) and cognitive self-regulation (accuracy and reaction time). **Results:** There were no differences between intervention and control groups from pre- to post-intervention for motor skill scores. There were differences in locomotor ($F=4.5^b$, $p=0.045$) and object control scaled scores ($F=13.1^b$, $p=0.001$) in the total group (intervention plus control groups) from pre-intervention (11.5 ± 0.5 and 11 ± 0.4 , respectively) to post-intervention (12.3 ± 0.4 and 12.2 ± 0.5 , respectively). There was a significant improvement in the intervention (3.1 ± 2.4 to 4.1 ± 2.5) compared to the control group (6.4 ± 2.6 to 4.2 ± 2.7) for visual working memory accuracy ($F=5.15^b$, $p=0.035$). In the total group, there was a significant time effect only for the auditory working memory reaction time scores (9.5 ± 1.1 to 7.1 ± 0.7 ; $F=5.9^b$, $p=0.025$). Child self-reported perceived competence and enjoyment were perceived as

high throughout the program (2 ± 2.6 out of 25, and 30.2 ± 4.3 out of 35, respectively)]]]. **Conclusion:** This study appears to provide preliminary evidence that supports further exploration into the dynamic and use of a jointly tailored motor and cognitive movement program.

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CHAPTER I: INTRODUCTION

Physical activity is defined as any body of movement provided by skeletal muscles that results in a substantial increase over the resting energy expenditure. (Caspersen, Powell, & Christenson, 1985). Physical activity is a crucial part of children's physical and cognitive development (Zeng et al., 2017; Geertsen et al., 2016). It further plays a major role in their health during childhood, adolescence, and throughout life being associated with lower risk of several cancers (i.e., breast, kidney, lung, stomach), and has shown to aid those with chronic conditions and disabilities (i.e., hypertension, type 2 diabetes, dementia, multiple sclerosis, mental health) (2018 Physical Activity Guidelines). Research has shown that physical activity in early childhood, specifically during the preschool-aged period (3-5 years old), tracks through childhood and adolescence into adulthood (Fisher et al., 2005). These findings illustrate the fact that physical activity during that preschool-aged period is critical to the development of lifelong physical activity behaviors. Data show that a large proportion of the individuals in the U.S., regardless of age, do not meet physical activity recommendations and are considered physically inactive (Physical Activity Guidelines for Americans 2nd Edition, 2018). It is especially concerning that only 42-50% of those preschool-aged children are meeting their age-specific physical activity recommendations (Pate et al., 2015). These data were based on guidelines that predate the current U.S. guidelines for physical activity. Prior recommendations were three hours of physical activity or 15 minutes per hour of activity (extrapolated to 12 hours of waking time equates to 3 hours of daily activity). These previous guidelines ultimately influenced the 2018 Physical Activity Guidelines for Americans. To our knowledge this is the best understanding we have of how the U.S. population is doing at meeting the current guidelines within this population. The guidelines in the U.S. for preschool-aged children include engaging in active play of all intensities (light, moderate, and vigorous) for 3 hours per day and performing

activities that promote muscle- and bone-strengthening as well as future motor skillfulness (Physical Activity Guidelines for Americans 2nd Edition, 2018).

There is a growing understanding that the preschool-age is a critical time period for the fundamental motor skill development, motor skills that are considered the foundation for physical activity and may drive future physical activity later in development and throughout adulthood (Stodden et al., 2008, Robinson et al., 2015). Motor skills are collectively defined as “a coordinated pattern of movements acquired through practice involving the ability to execute movements effectively to achieve intended outcome” (Stodden, 2008). Motor skills are often distinguished as being comprised of gross motor skills, or “coordination of large muscle groups, such as kicking a ball” and fine motor skills or “coordination of small muscle groups, such as when picking up a bead”. Gross motor skills can be further broken down categorically into two separate subcategories. One are locomotor motor skills such as “running, galloping, hopping, leaping, horizontal jumping, and sliding” (Haywood & Getchell, 2005). The other are object control motor skills such as “striking a stationary ball, stationary dribbling, kicking, catching, overhand throwing, and underhand roll” (Haywood & Getchell, 2005). The understanding of the importance of developing these fundamental motor skills is highlighted as early as Seefeldt (1980) who touched on a hypothetical “proficiency barrier.” This “barrier” represents a certain stability in an array of fundamental motor skills that children would need to break through to have the necessary tools for certain sports, games, and in general more complex physical activity. Later Clark and Metcalfe (2002) suggested a similar concept but characterized it as a “mountain of motor development.” They suggested that fundamental motor skills are a precursor to both context-specific and skillful movement and to progress to the top of the “mountain” children must have competence and stability in fundamental motor skills.

Stodden et al. (2008) builds upon the groundwork laid by these concepts highlighting not only the how motor skills and physical activity interact, but the complexity of that dynamic and other variables involved. The Stodden et al. (2008) model proposes that the motor skill and physical activity relationship is reciprocal but directionality varies based on age. In the preschool-aged period physical activity drives motor skill development and then in later childhood through adolescence it is motor skill competence that drives physical activity. Physical activity drives motor skill development in the preschool-aged period through exposures and experiences in learning and practicing a wide array of fundamental motor skill. These opportunities facilitate neuromotor development, which is critical to establishing motor competency. As these motor skills are integrated into children's physical activity repertoire, activity will aid in influencing motor skill development. (Stodden et al., 2008). Previously it was thought that necessary fundamental motor skills naturally surface through maturation, though growing evidence shows that this does not happen and that they need to be introduced through experiences (Goodway & Branta, 2003; Goodway, Suminski, & Ruiz, 2003; Langendorfer & Robertson, 2002a, 2002b). Additionally, in a model proposed by Loprinzi et al. (2015), the authors emphasize the value of introduction and instruction of a range of fundamental motor skills as well as facilitating perceived and actual motor skills through physical education classes and sports and activity programs.

Robinson and colleagues highlight the influence that physical activity has on motor skill development in early childhood in a follow-up paper to the 2008 Stodden et al. paper. The authors remark that despite an abundance of research, interventions have had limited success (Robinson et al., 2015). A key aspect of development that may not be being accounted for in this limited success is cognitive development, which is essential for learning skills and being able to

sequence those skills. Specifically, the role of cognitive aspects of self-regulation, with self-regulation being characterized as higher order cognitive process referring to the capacity to direct and control one's actions. Cognitive aspects of self-regulation include attention, working memory, and inhibition. Attention being an "individual's ability to maintain focus on a particular task" (Rademacher, 2018). Working memory being "a system for temporarily storing and managing the information required to carry out complex cognitive task, such as learning, reasoning, and comprehension" (Rademacher, 2018). Finally, inhibition is "the ability to exercise restraint on the direct expression of an instinct or maintain focus on a relevant or intended cue while ignoring an irrelevant or unintended cue" (Rademacher, 2018).

In regard to physical activity and self-regulation, physical activity allows for loading cognitive demands inherent with structure of goal directed and engaging activities (Best et al., 2010). Further, physical activity can involve the execution of complex motor skills that require cognitive engagement (Best et al., 2010). In fact, the term "motor" implies cognition, in that carrying out physical movements require planning and deliberation (McClelland & Cameron, 2019). A concept paper by Diamond (2000) illustrated the interrelatedness of motor and cognitive development in young children. "In order for cognitive processes to have functional implications, these processes must influence and be influenced by our actions and thus engage the motor system and perceptual functions" (Geertsen et al., 2016). Additionally, "cognitive processes may assist decision-making, motor control and motor skill learning processes" (Geertsen et al., 2016). "Cognitive and motor functions even display these equally protracted developmental time courses and where in the event cognitive development is perturbed then so is motor skill development" (Geertsen et al., 2016).

Future endeavors to understand the interactions between motor and cognitive factors and improve interventions to better facilitate motor and cognitive development through physical activity that ultimately benefit lifelong physical activity may have their optimal potential at being successful by being guided by Dynamic Systems Theory. This theory presents a framework that may be useful in elucidating the relationships among physical activity, motor skills, and cognitive aspects of self-regulation. In general, Dynamic Systems Theory is centered in the sensitive, dynamic, and nonlinear nature of processes (or development in this case). The core elements of this theory involve emergence/soft-assembly/non-linearity, stability and timescales.

Emergence/soft-assembly/non-linearity refers to the theory that behaviors and cognitive skills are not “hard-wired” into the system and simply manifest over a certain period of maturation. This ties into the understanding referenced by Stodden and colleagues that fundamental motor skills are not something that simply appears over time naturally through development versus being hard-wired into the system. Fundamental motor skills must be introduced through physical activity experiences and then applied through other opportunities, such as structured activity sessions, sports, and physical education (Loprinzi, Davis, & Fu, 2015).

Stability in this theory refers to behavior being something that is expressed in the moment and can be more or less stable (the higher the frequency of a particular behavior, the more stable). This understanding aligns with how stability is characterized by Stodden and others where it is highlighted as playing an important role in the dynamic between physical activity and motor skill development. Specifically, after the fundamental motor skills are introduced, the amount of physical activity (frequency of the behavior) is often the determining factor for

establishing that necessary stability in those motor skills to break through the “proficiency barrier” that is referenced in early literature (Seefeldt, 1980).

Lastly, the aspect of timescales refers to what is happening in the moment is not qualitatively distinct from what is happening throughout learning or throughout development. For example, the experiences of introducing fundamental motor skills, engaging in physical activity over the preschool-aged period. Additionally, developing stability in those fundamental motor skills, and then the transition where stability in those fundamental motor skills then drive learning of more complex motor patterns and participation in physical activity.

Through these core elements, Dynamic Systems Theory proposes a system for development that not only considers step-by-step processes, but also multilevel interactions over time that are vital to understanding the true nature of development. Guiding research by Dynamic Systems Theory along with including the role of the development of cognitive aspects of self-regulation may significantly aid the understanding of this crucial time period for development and designing future interventions.

Definitions

Below are detailed definitions for terms that are commonly used throughout this document:

Physical Activity: defined as any body of movement provided by skeletal muscles that results in a substantial increase over the resting energy expenditure. (Caspersen et al., 1985).

Motor Skills: actions that involve the movement of muscles in the body to complete an action (Stodden, 2008).

Gross Motor Skills: larger movement requiring arms, legs, and possibly entire body (i.e.; running, jumping) (Gabbard, 2004).

Fine Motor Skills: smaller movement such grasping an object with ones fingers or the smaller movements coupled with larger movements (i.e.; targeting the placement of a throw in a pitch) (Gabbard, 2004).

Fundamental Motor Skills: the foundational motor skills (comprised of locomotor and object control motor skills) necessary for basic movement and physical activity (Stodden et al., 2008).

Object Control Motor Skills: motor skills such as throwing, catching, bouncing, kicking, striking, and rolling (Haywood & Getchell, 2005).

Locomotor Skills: motor skills such as running, galloping, skipping, hopping, sliding, and leaping (Haywood & Getchell, 2005).

Self-Regulation: higher order cognitive processes – referring to the capacity to direct and control one's actions (comprised of attention, working memory, and inhibition) (Rademacher & Koglin, 2018).

Attention: An individual's ability to maintain focus on a particular task (Rademacher & Koglin, 2018).

Working Memory: A system for temporarily storing and managing the information required to carry out complex cognitive tasks, such as learning, reasoning, and comprehension (Rademacher & Koglin, 2018).

Inhibition: The ability to exercise restraint on the direct expression of an instinct or maintain focus on a relevant or intended cue while ignoring an irrelevant or unintended cue (Rademacher & Koglin, 2018).

Dynamic Systems Theory: a theory centered around the sensitive, dynamic, and nonlinear nature of processes or development that emphasize the importance of understanding the role of stability, non-linearity, and timescales (Lerner, 2006).

Statement of Problem

Amongst preschool-aged children, there is some evidence of positive associations and relationships between physical activity and motor skills and between physical activity and cognitive aspects of self-regulation. Intervention designs often are constructed treating motor and cognitive developmental variables independently and do not focus on the interrelatedness of motor skill development and cognitive-self regulation. Interventions have had limited success and the lack of inclusion of both motor and cognitive factors may be part of the reason. Therefore, it is critical that both motor skills and cognitive aspects of self-regulation are incorporated into interventions and program designs in a way that optimizes the ability to demonstrate improvements in both areas.

Statement of Purpose

The purpose of this research is to investigate the impact of a movement-based curriculum designed to facilitate improvements in motor skills and cognitive development as well as explore how motor skills and cognitive aspects of self-regulation may be related. Specifically, this curriculum aims to do so through the tailoring of a movement-based curriculum to include physical activity that facilitates progression in motor and cognitive development in distinct yet also overlapping ways to potentially maximize the motor and cognitive benefits. It is hypothesized that there will not only be improvements in motor skill development but also in cognitive aspects of self-regulation (attention, working memory, and inhibition) that have not been seen in previous studies involving motor skill interventions that assessed cognitive variables. Additionally, we anticipate a positive and equally protracted relationship between the motor skills and cognitive self-regulation variables. These purposes will be accomplished through 1) introduction and practice of fundamental motor skills important to physical activity, 2) application of those fundamental motor skills through games, and 3) tailoring those games to improve both motor skills and cognitive aspects of self-regulation.

Aims

The current investigation aims to address the following:

1. To investigate the impact of the movement-based curriculum on motor skill development in preschool-aged children.
- Hypothesis: This curriculum will facilitate improved motor skill scores among all categories (gross motor quotient, locomotor motor skills, object control motor skills) in the experimental group.

- Motor skill development will be measured via the Test of Gross Motor Development – 3rd Edition (TGMD-3).
2. To investigate the impact of the movement-based curriculum on cognitive aspects of self-regulation.
- Hypothesis: This curriculum will facilitate improved self-regulation scores among all categories (attention, working memory, inhibition) in the experimental group.
 - Cognitive aspects of self-regulation will be measured via the Early Years Toolbox.
3. Investigating the correlations between motor skill development and cognitive aspects of self-regulation.
- Hypothesis: The variables will be related, and analysis will show relationships through similarly protracted improvement.

Limitations

Possible limitations to this study are:

- There will be a smaller fixed maximum capacity of group sizes based on classrooms participating in study.
- There will be fixed age distribution within sample based on the age distribution within the classrooms participating in study.
- The nature of instruction and practice of the motor skills will be in a group dynamic that limits that capacity for individualized instruction.
- The nature of the games will also be centered around group participation which will limit the ability to provide individualized feedback and assistance to an extent.

- The playgrounds that the experimental group and the control group though similar are not identical in design or space.
- Participants in study may already be at high level (motor/cognitive) as a result of higher level of education the preschool provides.
- Additionally, as a result of nature of the preschool it is likely that there will be a higher average SES/ Parent Education.
- These are convenience samples that will be included in this study.

CHAPTER II: REVIEW OF THE LITERATURE

Physical activity is an important part of a healthy lifestyle and is defined as any body of movement provided by skeletal muscles that results in a substantial increase over the resting energy expenditure. (Caspersen et al., 1985). Physical activity is a crucial part of children's physical and cognitive development playing a major role in their health throughout life, being associated with lower risk of several cancers (i.e., breast, kidney, lung, stomach), and has shown to aid those with chronic conditions and disabilities (i.e., hypertension, type 2 diabetes, dementia, multiple sclerosis, mental health) (2018 Physical Activity Guidelines) (Zeng et al., 2017; Geertsen et al., 2016).). Research has shown that physical activity in early childhood, specifically during the preschool-aged period (3-5 years old), tracks through childhood and adolescence into adulthood (Fisher et al., 2005). Physical activity during that preschool-aged period is critical to the development of lifelong physical activity behaviors and a significant proportion of the individuals in the U.S., regardless of age, do not meet physical activity recommendations and are considered physically inactive (Physical Activity Guidelines for Americans 2nd Edition, 2018)

The strong ties between the amount of physical activity in early years and the amount of physical activity in adolescents and ultimately adulthood lead to a need to focus on physical activity not only in all ages but in particular an emphasis in the early years of life (such as the preschool-aged range). Specifically, during early childhood, it is important to understand the factors that cater to and facilitate quality development of the necessary tools to be physically active. For example, the sufficient level of motor skill development to adequately execute movement and the cognitive development of aspects of self-regulation (attention, working memory, and inhibition) to comprehend learning and executing new and current motor skills and more complex motor development.

Physical Activity

Due to both the health advantages that physical activity provide and dangers associated with insufficient physical activity, understanding the physical activity recommendations are vital for individuals of any age. All children from 0-5 years should participate in daily physical activity that promotes “movement skillfulness and builds a foundation of health-related fitness”. Children who are ≤ 6 years of age are recommended to achieve 60 minutes of aerobic activity daily (2018 Physical Activity Guidelines). On at least 3 days per week children are encouraged to do vigorous–intensity aerobic activity. Activity that children participate in should also include “muscle and bone strengthening activities at least 3 days per week as part of a child's 60 or more minutes” (2018 Physical Activity Guidelines). In youth 6–19 years of age only 24% accumulate sufficient daily physical activity and time spent in daily physical activity drops significantly through the age range moving towards adulthood (CAHMI, 2016). Specifically, children aged 6–11 years participate in more daily physical activity (88 minutes) compared to adolescents aged 12–15 years (33 minutes) and 16–19 years (26 minutes). 42.5%, 7.5% and 5.1% of children 6–11, 12–15, and 16–19 years of age meet physical activity recommendations, respectively (Belcher, Berrigan, Dodd, Emken, Chou, Spruijt-Metz, 2010). Prior to the current physical activity recommendations set forth by the 2018 Physical Activity Guidelines, national recommendations had not been established for children under the age of 6 years old, and was more guided by the collection of recommendations from different organizations. This is reflected in recommendations from organizations such as SHAPE that recommend that preschoolers “should engage in at least 60 minutes and up to several hours of structured and unstructured physical each day”, respectively. It is additionally encouraged that children not be sedentary for > 60 minutes at a time.

It is highly encouraged that preschool-aged children are aided to develop stability and competence in a wide array of fundamental motor skills that are frequently considered the “building blocks for future motor skillfulness and physical activity”. To be more specific it is recommended that preschool-aged children get 15 min per hour of 12 waking hours (i.e., 3 hours per day) of physical activity, and should incorporate light–, moderate–, and vigorous–intensities of PA (Pate & O’Neil, 2012). These points of emphasis among others influenced and guided the current national recommendations for this age group. The 2018 Physical Activity Guidelines state in general that preschool–aged children should be physically active throughout the day to enhance growth and development, and further that the caregivers of these children should encourage active play that includes a variety of types. The 2018 Physical Activity Guidelines go in further detail with recommendations lining up with those currently put forth by Canada, the UK, and the Commonwealth of Australia in a target of 3 hours a day of all intensities (light, moderate, and vigorous) promoting bone and muscle strengthening. While many different groups and recommendations are highlighting the importance of physical activity in the preschool–aged population, the number of young children who meet recommended physical activity levels is low.

Olesen, Kristensen, Ried-Larsen, Grøntved, and Froberg (2014) studied the differences in motor skills and physical activity in 627 children (5–6 y) based on gender. Boys’ weekly physical activity levels showed to be higher than that of girls when the preschool they were attending was located in rural areas (862 ± 202 versus 773 ± 161 , $p = 0.02$). No difference was found in the weekly mean $\pm$ SD physical activity level between boys and girls (818 ± 190 versus 785 ± 187 , $p = 0.11$), or between urban vs rural areas (799 ± 173 versus 816 ± 247 , $p = 0.46$).

There were no gender differences observed in weekly physical activity across parental educational groups (Olesen et al., 2014).

Pate, O'Neill, Brown, Pfeiffer, Dowda, and Addy (2015) examined the proportion of preschool-aged children meeting newly established physical activity recommendations. Participants in sample 1 (286 children, 3–5 y) were enrolled in the Children's Activity and Movement in Preschool Study (CHAMPS). Participants in sample 2 (337 children, 3–5 y) were enrolled in the Study of Health and Activity in Preschool Environments (SHAPES). Physical activity was measured via ActiGraph (Model 7164; ActiGraph LLC, Pensacola, FL) and data of 5 days (consecutive) with greater than or equal to 8 hours wear time was used in the analysis. For both samples, "data were reduced using Pate et al. (2014) cut-points for total physical activity (≥ 200 counts/15 s), which was developed specifically for 3- to 5-year-old children. Periods of 60 minutes or more of continuous zeroes were considered non-wear times and were excluded from the analyses. Total day min/hr of total physical activity was calculated, using each child's daily wear time as the divisor". For the CHAMPS sample, mean age was 4.2 ± 0.7 years (42.7% male, 52.8% African American). Accelerometer wear time for the children averaged 13.4 hours per day. In the SHAPES sample, mean age was 4.5 ± 0.3 years (51.3% male, 48.1% African American). Accelerometer wear time for the children averaged 12.4 hours per day. Total physical activity was 14.5 min/hr (CHAMPS) and 15.2 min/hr (SHAPES). The prevalence of meeting the physical activity guidelines was 41.6% (CHAMPS) and 50.2% (SHAPES). Overall, regardless of which sample was examined it was found that males met the guidelines at a higher percentage than their female peers ($p < 0.05$) (Pate et al., 2015). About 50% of children over two different samples met the guidelines for physical activity in their age group.

Schlechter, Roenkranz, Fees, and Dzewaltowski (2017) set out to examine the pattern of physical activity across a typical preschool day. Sample included 73 children (3–6 y, 4.36 ± 0.85 y). This sample was comprised of 47% males and 53% females. Physical activity was measured using Actigraph GT1M devices (Schlechter et al., 2017). To capture the sporadic nature of children's activity, accelerometers were initialized to record in 15-second epochs. A validated, age specific cut-point (defined by van Cauwenberghe, et al., 2011) was applied to determine time spent sedentary/inactive (≤ 373 counts/15 seconds), and in total physical activity (> 373 counts/15 seconds). Classroom physical activity was recorded 3 days a week with those videos being later uploaded and analyzed via video analysis software. Each day of observation consisted of different categories including “morning indoor”, “morning outdoor”, “after lunch indoors”, and “after lunch outdoors”. There was 385.07 ± 89.42 minutes of observation daily. Of that time, $69.5 \pm 12.4\%$ was spent sedentary and/or inactive with only $30.5 \pm 13.5\%$ time spent being physical active. Whether morning/afternoon or indoor/outdoor, no significant differences were observed for sedentary/inactive time or in total physical activity ($t = 0.12, p = 0.904$; $t = 0.75, p = 0.456$; $t = 1.06, p = 0.289$, respectively). Children participated in a greater percentage of time in total physical activity while outdoors compared to indoors ($t = 10.00, p < 0.001$). In regard to subsamples within this study, children spent significantly more time being active while in a small group versus whole group ($t = 3.35, p = 0.009$ (Schlechter et al., 2017). Children participated in physical activity roughly 30% of the preschool day in total. These findings provided greater understanding of how much of their time in a preschool setting is spent engaged in physical activity.

Pate, O'Neill, Byun, McIver, Dowda, and Brown (2014) explored the role of the type of environment (type of preschool in this instance) compared the physical activity levels of children

(301 preschool-aged children) attending two different preschools (Montessori and traditional). Physical activity was measured using Actigraph models GT1M and GT3X and were “initialized to save data in 15-second intervals (epochs) to account for the spontaneous physical activity of 4-year-old children. Cut points developed specifically for preschool children were applied to the raw data to determine time spent in light, moderate, and vigorous physical activity. The cut points developed specifically for preschool-aged children for light, moderate, and vigorous physical activity were ≥ 200 counts/15 seconds, ≥ 420 counts/15 seconds, and ≥ 842 counts/15 seconds, respectively. Total physical activity was defined as the sum of light, moderate, and vigorous intensity activity. Sixty-minutes of consecutive zeros were considered as non-wear time and were excluded from the analyses”. Physical activity was measured across “In-School”, “Non-School”, and “All-Day”. The Montessori preschool children participated in more light (7.7 ± 0.4 min/hr), moderate-to-vigorous (7.7 ± 0.5 min/hr) and total physical activity (15.4 ± 0.9 min/hr) during the In-School period than those children at traditional preschool locations (light: 6.5 ± 0.4 min/hr; moderate-to-vigorous: 6.5 ± 0.5 min/hr; Total physical activity: 13 ± 0.9 min/hr). In Non-School and All-Day periods, Montessori preschool children accumulated more moderate-to-vigorous physical activity (8.5 ± 0.5 min/hr and 8.5 ± 0.3 min/hr, respectively) than children in traditional preschools (6.2 ± 0.4 min/hr and 7.6 ± 0.3 min/hr, respectively). Regardless of period of the day, males were more active than females ($p < 0.05$). These findings suggest that environment (in this case preschool location) may be tied to physical activity levels.

Schmutz et al., (2017) examined factors surrounding physical activity promotion and decreasing sedentary time (394 preschool-aged children, 3.9 ± 0.7 years, 54% boys). Physical activity and sedentary behavior were measured via Actigraph wGT3X-BT (Pensacola, FL, USA). “Cut-points for moderate-to-vigorous physical activity and sedentary behavior (min/day) were

chosen based on comparability with previous literature as well as recent work comparing cut-points for various intensities in preschool children, which found that best classification accuracy was achieved using the Pate cut-point for moderate-to-vigorous physical activity (≥ 420 counts per 15s) and the Evenson cut-point for sedentary behavior (≤ 25 counts per 15s). Total physical activity was calculated as mean counts per min (cpm)”. Children accumulated 93 ± 30 in moderate-to-vigorous physical activity and 374 ± 48 min/day in sedentary behavior. Mean total physical activity was 624 ± 150 cpm. Males were more physical active than females ($p = 0.005$). Single parent children had a higher level of activity than those children with two parents ($p = 0.021$). Age ($p < 0.001$), time outdoors ($p = 0.009$), number of fixed play items ($p = 0.013$), and child’s activity temperament ($p < 0.001$) were positively associated with total physical activity. Children spent more time active in the fall and spring months compared to summer ($p = 0.028$). Six of a total of 11 variables associated with the full model outcome were correlated to the final model (all $p \leq 0.032$). Males participated in more moderate-to-vigorous physical activity than females ($p < 0.001$). Furthermore, moderate-to-vigorous physical activity was positively associated with age, child’s temperament, and gross motor skills ($p < 0.001$, $p < 0.001$, $p < 0.001$, respectively) (Schmutz et al., 2017). Like for total physical activity, children spent more time in moderate-to-vigorous physical activity in fall and spring compared to summer ($p = 0.007$). These findings greatly expanded on the nature of different factors that impact preschool-aged children’s physical activity and how these factors can be modified to help those children.

Overall, the current body of literature provides insight into the physical activity levels of young children. There is very little literature regarding this population meeting current recommendations and what literature there is paints a picture of only about half of preschool-aged children engaging in sufficient physical activity (Pate et al., 2015). There is a need not only

for identifying the number of children meeting physical activity recommendations but also a better understanding of the nature of that physical activity (through possibly direct observation), and the factors that influence their physical activity (like development of motor skill and cognitive aspects of self-regulation).

Physical Activity and Motor Skill Development

Future motor competence in children is built upon the understanding that the preschool-age is a critical time period for the development of fundamental motor skills which are a foundation for physical activity and a driver of future physical activity (Stodden et al., 2008, Robinson et al., 2015). Motor skills are defined as coordinated patterns of movement acquired through practice involving the ability to execute movements effectively to achieve intended outcomes and are often distinguished as being comprised of gross motor skills which are defined as “coordination of large muscle groups, such as kicking a ball” and fine motor skills defined as “coordination of small muscle groups, such as when picking up a bead” (Stodden, 2008). Those gross motor skills can be further broken down categorically into locomotor motor skills (leaping, running, hopping, galloping, sliding, and horizontal jumping) and object control motor skills (kicking, catching, underhand rolling, striking a stationary ball, stationary dribbling, and overhand throwing) (Haywood & Getchell, 2005).

The value in developing fundamental motor skills is highlighted by Seefeldt (1980) who 40 plus years ago emphasized a hypothetical “proficiency barrier.” This “barrier” represents a certain stability in an array of fundamental motor skills that children would need to break through to have the necessary tools for certain sports, games, and in general more complex physical activity. This has been further refined and developed over the years in Gallahue and colleagues’ “Hourglass of Motor Development”, and Clark and Metcalfe’s metaphor of the

“Mountain of Motor Development”. These models suggested that fundamental motor skills are a precursor to context-specific, skillful movement, acts of daily life, lifelong recreational utilization, and children must have competence and stability in fundamental motor skills to succeed in these areas (Hulteen et al., 2018).

Stodden et al. (2008) builds upon the groundwork laid by these concepts highlighting not only the dynamic between motor skills and physical activity, but the complexity of that dynamic and other variables involved. The Stodden et al. (2008) model proposes that the motor skill and physical activity relationship is reciprocal but directionality varies based on age. In the preschool-aged period physical activity drives motor skill development and then in later childhood through adolescence it is motor skill competence that drives physical activity. Physical activity drives motor skill development in the preschool-aged period through exposures and experiences in learning and practicing a wide array of fundamental motor skill. These opportunities facilitate neuromotor development, which is critical to establishing motor competency. As these motor skills are integrated into children’s physical activity repertoire, activity will aid in influencing motor skill development. (Stodden et al., 2008). Previously it was thought that children “naturally” develop these necessary fundamental motor skills through maturation, though the literature shows that there is a need for these skills to be deliberately introduced into those children’s experiences (Goodway & Branta, 2003; Goodway, Suminski, & Ruiz, 2003; Langendorfer & Robertson, 2002a, 2002b). Additionally, in a model proposed by Loprinzi et al. (2015), the authors emphasize the value of introduction and instruction of a range of fundamental motor skills as well as facilitating perceived and actual motor skills through physical education classes and sports and activity programs.

Cliff, Okely, Smith, & McKeen, (2009) examined possible associations between motor skills and physical activity in preschool-aged children (25 boys and 21 girls; 4.3 ± 0.7 years). Motor skills were assessed using the Test of Gross Motor Development–2nd Edition (TGMD–2). This assessment included tasks specific to locomotor skills as well as object–control motor skills. Physical activity was objectively assessed using ActiGraph 7164 (MTI Health Services, Fort Walton Beach, FL, USA). Counts were converted to minutes of moderate-to-vigorous physical activity using a Q-BASIC data reduction program (Troost, personal communication, March 2003). Counts were converted to minutes of moderate-to-vigorous (≥ 3.0 METS) using the age-specific child equation developed by Freedson et al., which has been validated in children aged 6–17 years. Duration of physical activity was 4.1 ± 1.0 days and 641.0 ± 95.9 min/day, with 23.0 (15.0 – 44.2) minutes/day of participation in moderate-to-vigorous physical activity (Cliff et al., 2009). Females locomotor raw scores were higher than males (26.4 vs. 20.2, $p = 0.009$), though no difference for object control raw scores (22.0 vs. 20.6, $p = 0.467$) was observed. Once analysis was adjusted by gender, females scored higher than males on locomotor (9.9 vs. 7.9, $p = 0.003$), object–control standard scores (10.1 vs. 8.6, $p = 0.026$), and total gross motor skill (99.7 vs. 88.2, $p < 0.001$) (Cliff et al., 2009). Age was negatively associated with percent of time in moderate physical activity for males ($r = -0.48$, $p = 0.015$) and females ($r = -0.47$, $p = 0.032$). Locomotor standard score was not observed to be correlated with percent time participating in moderate-to-vigorous physical activity ($r = 0.34$, $p = 0.098$) for males; object control standard scores were observed to be positively correlated with percent of time participating in moderate physical activity ($r = 0.52$, $p = 0.008$), and moderate-to-vigorous physical activity ($r = 0.48$, $p = 0.015$). Locomotor standard scores were not correlated with total physical activity ($r = 0.37$, $p = 0.070$) among males. Total gross motor skill was not related to percent of time in moderate-to-vigorous

physical activity ($r = 0.38, p = 0.061$) and total physical activity in males ($r = 0.39, p = 0.056$), but was related to percent of time in vigorous physical activity ($r = 0.46, p = 0.020$). For females, object-control standard score was not related to physical activity outcomes; however, both locomotor standard score and total gross motor skill were negatively related to percent of time in moderate physical activity ($r = -0.52, p = 0.015$ and $r = -0.44, p = 0.047$, respectively) and moderate-to-vigorous physical activity ($r = -0.50, p = 0.022$ and $r = 0.46, p = 0.038$, respectively) (Cliff et al., 2009). These findings added to the understanding of how motor skills were observed to be positively correlated with habitual physical activity in males and negatively correlated with habitual physical activity in females (Cliff et al., 2009).

Iivonen et al., (2013) examined physical activity, motor skills, and the potential relationships between them in preschool-aged children (37 children; 17 boys, age = 4.2 ± 0.3 years) and 20 girls, age = 4.0 ± 0.3 years) (Iivonen et al., 2013). Seven test items from the APM Inventory manual and test booklet were used to assess motor skills. The APM consist of assessments of “balance (static and dynamic), locomotor, and manipulative skills”. Locomotor skills included “standing broad jump, sliding and galloping”. Manipulative skills were measured via “kicking a ball and throwing/catching activities”. Physical activity was assessed via ActiGraph GT3X over 5 successive days. Minutes per day spent in sedentary behavior, and in light, moderate, 4<http://support.theactigraph.com/dl/ActiLife-software> vigorous, moderate-to-vigorous, and light-to-vigorous physical activity were calculated using validated cut-points defined by van Cauwenberghe, et al. (2011). Cut-points were scaled to 5-sec. epochs: sedentary behavior < 125 counts / 5 sec., light physical activity 125–195 counts / 5 sec., moderate physical activity 196–293 counts / 5 sec., vigorous physical activity ≥ 294 counts / 5 sec., moderate-to-vigorous physical activity ≥ 196 counts / 5 sec., and light-to-vigorous physical activity ≥ 125

counts / 5 sec. Sedentary behavior was categorized as a percentage of sedentary time from the total time monitored. No gender differences were observed in total physical activity (boys: 671 cpm; girls: 688 cpm). Children participated in moderate physical activity the least and sedentary time the most. Children accumulated approximately one hour of moderate-to-vigorous physical activity throughout a day. Eighty five point eight percent of time was spent sedentary for boys and 85.1% of time was spent sedentary for girls. Total motor skills was positively associated with total ($\beta = 43.70 \pm 15.10$), light-to-vigorous ($\beta = 6.58 \pm 2.15$), and moderate-to-vigorous physical activity ($\beta = 5.00 \pm 1.63$). Moderate-to-vigorous physical activity was positively associated with galloping and sliding ($\beta = 7.00 \pm 3.23$), and the throwing and catching combination was significantly associated with total ($\beta = 62.11 \pm 19.27$), light-to-vigorous ($\beta = 7.49 \pm 2.77$), and moderate-to-vigorous physical activity ($\beta = 5.92 \pm 2.04$). Five of the seven skills “static balance, dynamic balance, standing broad jump, kicking a ball at a target, or throwing at a target” were not associated with physical activity (Iivonen et al., 2013). Gross motor skills were positively associated with children's habitual physical activity. Total motor skill scores had a positive and statistically significant relationship to all the physical activity outcomes when biological factors were accounted for. These findings provide a greater understanding of associations between physical activity and motor skills at a range of different intensities (Iivonen et al., 2013).

O'Neill et al., (2017) examined the relationships between physical activity types and motor skills, and the relationship between motor skills and parent perception of athletic competence in preschool-aged children's (264, 4.1 ± 0.6 y). The standardized protocol that was used for assessment was based on the TGMD-2 and assessed the characteristics of six locomotor and six object control skills (O'Neill et al., 2017). The “Observational System for Recording

Physical Activity in Children–Preschool Version” was used for observing specific types of physical activity. Five of 18 possible physical activity types of interest were “walk, run, jump/skip, dance, and throw”. Observations were randomly assigned (including day, blocks, and observer) to participants throughout the 2 week period. Participants were observed for 10– to 12– minutes, and 30–minutes per session (600 to 720 intervals per participant in total). Parents also participated in a survey rating their perception of their child’s athletic competence. Children engaged in sedentary behavior 87.2%, light activity 8.3%, and moderate-to-vigorous physical activity 2.6% of the observed time. Throughout the day those in the highest locomotor tertile participated in a higher proportion of intervals of dancing (0.19 ± 0.04) than those in the lowest tertile (0.07 ± 0.05) ($p = 0.04$). There were no differences between walking or running in proportion of intervals. Those in the highest object control tertile threw at a higher proportion of intervals (0.14 ± 0.03) than those in the low and intermediate object control tertiles (0.06 ± 0.03) ($p < 0.05$) (O’Neill et al., 2017). These findings provided further understanding in relationships between motor skills and physical activity types in preschool-aged children.

Recently Loprinzi and Frith (2017) investigated whether greater motor skill development is associated with higher physical activity levels among preschool–aged children. Data from 329 preschool–aged children (4.0 ± 0.03 y) living in the United States pulled from the 2012 National Youth Fitness Survey were used for analysis. Motor skills were assessed via TGMD–2. Parents of provided a parent report of physical activity over a weekly (how many days were ≥ 60 minutes a day). An association was observed between motor skills and meeting physical activity guidelines with a mean score of 95.6 ± 0.8 ($p = 0.75$) in regard to motor skills, 10.0 ± 0.2 ($p = 0.59$) for locomotor, 8.5 ± 0.1 ($p = 0.95$) for object control, respectively (Loprinzi & Frith, 2017). Motor skills were observed to be associated with meeting physical activity guidelines in the ($p >$

0.05). Results were not significant after accounting ofr unadjusted/minimally adjusted models ($p > 0.05$). These findings provide a differing understanding (motor skills not associated with physical activity) than other findings found in the literature. This finding could be due in part to different physical activity recommendations, questionnaire versus wearable device assessment of physical activity, and parent report.

There appears to be a possible positive association and/or relationship between physical activity and motor skill development. The literature however is mixed in regard to gender differences (Cliff et al., 2009) or show no association (Loprinzi et al, 2017). Studies have shown that proficiency of motor skills is key to children having the ability to engage in physical activity. One major issue involving understanding the current body of literature regarding motor skill development is the inconsistency in assessment. Current literature shows six or more different motor skills assessments of different focus that could attribute to the varying findings between physical activity and motor skills. Motor skill assessments included in the literature are the “Bruininks-Oseretsky Test of Motor Proficiency Short Form” (Wrotniak et al., 2006, Cheng et al. 2016), the “Peabody Developmental Motor Scales 2nd edition” (Nervik et al., 2011), the “Körper koordination-Testfür-Kinder test” (Laukkanen et al., 2011, Olesen et al., 2014, Laukkanen et al., 2013), the “Movement Assessment Battery for Children–2nd edition” (Kokstein et al., 2017), the “TGMD–2” (Kit et al., 2017, Cliff et al., 2009, O’Neill et al., 2017, Loprinzi & Frith, 2017), the “Ohio State University Scale of Intra Gross Motor Assessment scale” (Vameghi et al., 2013), and the “Movement Assessment Battery” (Fisher et al., 2005, Reilly et al., 2006). This factor of a variety of different motor assessments as been show in the literature to potentially impact the differences in some findings (Roberts et al., 2012). This, in

addition to the sparse nature of literature, creates a need for not only more research into these variables and how they interact, but more studies using consistent methodologies.

The latest version of the TGMD, the Test of Gross Motor Development – Third Edition (TGMD-3) has been released and started to be used in research. The TGMD-3 has demonstrated to be a valid assessment of fundamental motor skills in the preschool-aged population like versions 1 and 2 of the TGMD. The TGMD-3 has demonstrated to be a valid assessment of fundamental motor skills in the preschool-aged population and has high test-retest reliability for both the locomotor ($r_c(r_u) = 0.93(0.74)$) and object control ($r_c(r_u) = 0.87(0.87)$) subtests for preschoolers (Valentini, Zanella, & Webster, 2017; Ulrich, 2019). Previous versions of the TGMD-3 have also been shown to be sensitive enough to observe changes in motor skill development over intervention periods that may be considered short (with studies ranging from 5-9 weeks) and minutes (with studies ranging from 540-900 minutes) in the preschool-aged period (Robinson & Goodway, 2009; Martin, Rudisill, & Hastie, 2009; Robinson et al., 2016). The TGMD is a commonly used tool in research even being used as the primary motor assessment by programs of studies such NHANES making it good for comparisons to other data collected in the field regarding motor skill development.

Physical Activity and Cognitive Aspects of Self-Regulation

Development of cognitive aspects of self-regulation (attention, working memory, and inhibition) may be as crucial to physical activity engagement as motor skill development and warrants significant attention in the literature. These cognitive factors aid in the focus and attention necessary to learn and develop motor skills that facilitate physical activity.

Physical activity allows for loading cognitive demands inherent with structure of goal directed and engaging activities and involves the execution of complex motor skills that require cognitive engagement (Best et al., 2010). As Diamond (2000) illustrated that for cognitive processes to have functional implications, these processes must influence and be influenced by actions. Further, “these cognitive processes may assist decision-making, motor control and motor skill learning processes” (Geertsen et al., 2016). “Cognitive and motor functions even display these equally protracted developmental time courses and where in the event cognitive development is perturbed then so is motor skill development’ (Geertsen et al., 2016).

The following studies explored the relationships between the inhibition and attention components of self-regulation, and physical activity. Zach (2015) examined whether physical activity improves attention in preschool-aged children. Their sample of subjects included 60 boys and 63 girls (4–5 years). These subjects were split between three groups, an experimental group with intervention-orienteeering (orienteeering; $n = 44$), an experimental group with intervention-dance (dance; $n = 40$), and a control group with no intervention (control; $n = 39$). Measurements included two different versions of the MOXO brand cognitive processing test (MOXO-CP), the Reproduction of Patterns subtest of the cognitive modifiability battery (CMB), along with pre-teaching test and post-teaching test phases. They implemented a pre-post intervention trial design that lasted over 9 weeks including a weekly program of physical activity that gradually increased in level of difficulty. They were tested one week prior to the intervention and again in the post-intervention phase. There were differences between the two groups (dance and control) via the MOXO-CP. Specifically, attention ($F(1, 67) = 8.71; p < 0.01 \eta^2 = 0.115$), and impulsivity ($F(1, 67) = 4.59; p < 0.05; \eta^2 = 0.064$) with no interaction. Additionally, a significant interaction was found in attention ($F(1, 68) = 4.53; p < 0.05; \eta^2 = 0.062$) and in

impulsivity ($F(1, 67) = 9.77; p < 0.01; \eta^2 = 0.126$) when the stimuli were accompanied by disturbances. The two experimental groups significantly improved from the pre- to post-intervention measurement; however there was no improvement in the control group (Zach et al., 2015). Overall, Zach et al. observed a positive impact of physical activity on both attention and inhibition in preschool-aged children.

Burkart, Roberts, Davidson, and Alhassan (2018) conducted a physical activity intervention called Project PLAY. The purpose was to examine the effects of a physical activity intervention on classroom behaviors in preschool-aged children. The participants were preschool-aged children ($n = 71$; age = 3.8 ± 0.7 years) were randomized to either locomotor-based physical activity group (LB-PA) or unstructured free playtime group (UF-PA). The teachers implemented these sessions for 30 minutes per day, 5 days per week for 6 months. Behavioral measurements were collected at baseline, 3 months, and 6 months, using the Behavior Assessment System for Children 2nd Edition (BASC-2). Scores from this assessment that were used in analysis that are important to this review are from the attention subscale. In addition, a computerized go/no-go task was used to assess inhibition in the participants. The children's physical activity was also measured via ActiGraph GT1M placed on the waist and positioned on the participant's lower back. Sirard et al. (2005) cut-points were used to process all data. Data from the 15-second epochs were converted to average counts per minute and percentage of time spent in sedentary, light, and moderate-to-vigorous physical activity for use in analysis. Average attention problems score at baseline for the UF-PA group was 51.79 ± 1.57 , ($p < 0.001$). The predicted average rate of change for the UF-PA group was 3.91 ± 0.81 , ($p < 0.001$), with the average rate of change for the LB-PA group being 5.50 points lower than the UF-PA group. In the UF-PA group attention scores increased over time (3.91 points, $p < 0.001$).

In the LB–PA group there were significant decreases in inattention (; 1.59 points, $p < 0.001$) (Burkart et al., 2018). These findings added to the literature an understanding of a positive impact on attention by physical activity.

Wen et al. (2018) examined the effect of a very specific physical activity type program (focused on mini-trampoline physical activity) on the development of executive function in preschool–aged children. Fifty–seven preschool–aged children were randomly assigned to either an intervention group ($n = 29$), or a control group ($n = 28$). The protocol included three phases of a pre-test, intervention (10-week intervention), and post-test. During the 10 weeks, the children in the intervention group participated in a 20 minute trampoline training program, implemented by a physical education teacher, after school for a total of 5 days each school week. Inhibitory control was measured using the Spatial Conflict Arrow (SCA) task, working memory using the Working Memory Span (WMS) task, cognitive flexibility through the Flexible Item Selection (FIS) task, and physical activity was measured using the Actigraph GT1M. The cut-points recommended by Cauwenberghe et al. (2011) were adopted to calculate children’s time spent in moderate-to-vigorous physical activity. Their results indicated that no significant differences in the SCA, WMS, and FIS tests between the two groups tested post-intervention. Results indicate that a 10-week trampoline physical activity training program may not be sufficient to elicit improvement of preschool children’s executive function (Wen et al., 2018). Overall, Wen et al. (2018) observed no impact in either working memory or inhibition.

The following study is the only study in our sample that explored the relationships between cognitive aspects of self-regulation (attention, working memory, and inhibition) and physical activity. Healey and Halperin (2015) examined 25 children (19 boys, 6 girls) aged 3–4 years and their parents in their Enhancing Neurobehavioral Gains with the Aid of Games and

Exercise (ENGAGE). This intervention was comprised of parents and children participating in a wide variety of games that targeted self-regulation every day over a 5-week period. Behavioral measurements were collected via the Behavior Assessment System for Children 2nd Edition (BASC-2) assessing hyperactivity, aggression, and attention. This assessment was conducted at six time points. A short form of the Stanford Binet (SB-5) was used as a test of intelligence including two subtests used to estimate IQ and working memory (administered both at baseline and post-intervention). Three tests from the Developmental Neuropsychological Assessment 2nd Edition (NEPSY-2) were used in the assessment of language, working memory, motor control and inhibition. Individual slopes were calculated for each child's raw multiple factors, one of which was attention problems ($M = -0.90$, $CI = -1.14, -0.41$). Paired-samples t -tests were used to compare baseline and post-intervention neurocognitive functioning scores. There were significant improvements in two of the four areas assessed, working memory and inhibition (referred to as visuomotor precision), were found post-intervention. All the behavioral correlations were significant ($p < 0.05$), including attention problems ($r = 0.562$). Four of the five neurocognitive correlations were significant, with two of those correlations pertaining to the children's working memory ($r = 0.386$, $p < 0.05$), and inhibition ($r = 0.616$, $p < 0.05$). A correlation with inhibition and children's time playing that was significant ($r = 0.326$, $p < 0.05$) was observed. All correlations were positive (range: $r = 0.157 - 0.303$). Significant main effects of time on all three measures displayed progress in behavior (over the 12-month period). The group $\times$ time interaction for attention problems ratings was not statistically significant. The ENGAGE group performed more poorly overall on both measures of working memory and inhibition (Main Effect Group: $F = 6.55$, $p = 0.014$ and $F = 14.10$, $p < 0.001$, respectively), and that performance on both measures improved significantly over time (Main Effect Time: $F =$

13.64, $p = 0.001$ and $F = 8.74$, $p = 0.005$, respectively). There was also a significant group $\times$ time interaction for working memory ($F = 6.74$, $p = 0.012$), such that those in the ENGAGE group had a significantly greater improvement over time (Healey & Halperin, 2015). These findings added understanding in the field regarding an observed positive impact for attention, working memory, and inhibition in a preschool-aged children.

Robinson, Palmer, and Bub (2016) aimed to investigate the impact of a motor skill intervention program on self-regulatory skills in preschool-aged children. This study included 113 preschool-aged children (51.9 ± 6.5 months, 56 males) enrolled in a federally funded preschool program. The children were randomized into either a group that received the motor skill intervention ($n = 68$) or a control group ($n = 45$). The intervention group participated in 15, 40-minute sessions that focused on the development of motor skills over a 5-week time period. The control group did not alter their typical daily program. Self-regulation was assessed using the delay of gratification snack task of the Preschool Self-Regulation Assessment. This task tested the children's impulse control, which fits into the inhibitory control component of self-regulation. Results demonstrated a significant interaction between time (pre versus post) and treatment (intervention group vs. control group) (0.49 , $t(65.76) = 2.31$, $p < 0.05$). The intervention group maintained the same level of control over their impulses throughout the duration of the study. The control group however saw a decline in their scores during the post-test assessment. These findings indicate that the intervention may play a role in maintaining inhibition scores. The authors did not expect scores to increase due to their high scores during the pre-test assessment, but they also stated that their intervention may not have been of a sufficient dose to elicit those changes (Robinson et al., 2016). To the authors knowledge this was one of the first movement interventions to focus on inhibition in young children and future

studies need to be completed to determine if there is a relationship between this type of activity and self-regulation.

Overall, the majority of studies reviewed showed a positive impact of physical activity on at least one cognitive aspects of self-regulation. There is very little literature however, especially in the preschool-aged population, and what is present is marred by inconsistency in methodology of assessment of both physical activity and cognitive aspects of self-regulation. The differences in algorithms used to assess physical activity data may also play a role in perceived results. Additionally, there has been only one study to our knowledge that has been inclusive of all cognitive aspects of self-regulation (Healy & Halperin, 2015). So, although there have been some promising findings there still needs to be much more research exploring the dynamic between these variables and doing so in a way that best elucidates the relationships among them.

The study of self-regulation and the individual components of self-regulation (working memory, inhibition, and attention) has growingly been assessed by tools like the Early Years Toolbox. This assessment has proven to be a valid assessment of cognitive self-regulation in preschool children and was designed specifically for the population (Howard & Melhuish, 2017).

Dynamic Systems Theory

Ties between physical activity, motor skills, and cognitive aspects of self-regulation, and how they develop might be best elucidated by a framework like that of Dynamic Systems Theory. In general, Dynamic Systems Theory is centered in the sensitive, dynamic, and nonlinear nature of processes (or development in this case). Dynamic Systems Theory is a framework that is sensitive to nonlinearity of processes building models on the foundation of variability (Aslin, 1993). With origins at the intersection of early behavioral development, biology, and evolution this theory holds a view on development involving cascading interactions

across multiple levels of causation (Spencer, Perone, & Buss, 2011). Core elements of this theory involve non-linearity, stability, and timescales. Emergence/soft-assembly/non-linearity again refers to the theory that behaviors and cognitive skills are not “hard-wired” into the system and simply manifest over a certain period of maturation. This ties into the understanding referenced by Stodden and colleagues that fundamental motor skills are not something that simply appears over time naturally through development versus being hard-wired into the system. Fundamental motor skills must be introduced through experiences and then applied through other opportunities, such as structured activity sessions, sports, and physical education (Loprinzi, Davis, & Fu, 2015).

Stability in this theory refers to behavior being something that is expressed in the moment and can be more or less stable (the higher the frequency of a particular behavior, the more stable). This understanding aligns with how stability is characterized by Stodden and others where it is highlighted as playing an important role in the dynamic between physical activity and motor skill development. Specifically, after the fundamental motor skills are introduced, the amount of physical activity (frequency of the behavior) is often the determining factor for establishing that necessary stability in those motor skills to break through the “proficiency barrier” that is referenced in early literature (Seefeldt, 1980).

Lastly, the aspect of timescales refers to what is happening in the moment is not qualitatively distinct from what is happening throughout learning or throughout development. For example, the experiences of introducing fundamental motor skills, engaging in physical activity over the preschool-aged period. Additionally, developing stability in those fundamental motor skills, and then the transition where stability in those fundamental motor skills then drive learning of more complex motor patterns and participation in physical activity.

Through these core elements, Dynamic Systems Theory proposes a system for development that not only considers step-by-step processes, but also multilevel interactions over time that are vital to understanding the true nature of development. Guiding research by Dynamic Systems Theory along with including the role of the development of cognitive aspects of self-regulation may significantly aid the understanding of this crucial time period for development and designing future interventions.

Throughout this literature review studies have been highlighted that explore the relationships among physical activity and motor skill development, physical activity and—regulation, and motor skill development and self-regulation in a preschool-aged population. Though these studies have added valuable understanding to the relationship among these variables they have as a whole provided an unclear picture of the directionality and causality of those relationships. Only one study to our knowledge includes all three of these variables (Robinson et al., 2016). This is a great launching point but there needs to be further exploration including all cognitive aspects of self-regulation and includes possibly a program that aim not only the improvement of motor skill development but also cognitive development. There is a need for research that not only is consistent in these early stages of exploration but that is also guided by a framework (like that of Dynamic Systems Theory) that facilitates the understanding of the complexities of the relationships between these variables.

Future endeavors to understand the interactions between motor and cognitive factors and improve interventions to better facilitate motor and cognitive development through physical activity that ultimately benefit lifelong physical activity may have their optimal potential at being successful by being guided by Dynamic Systems Theory. Dynamic Systems Theory presents a

framework that may be useful in elucidating the relationships among physical activity, motor skills, and cognitive aspects of self-regulation.

Perceived Competence & Enjoyment

Stodden et al. (2008), Robinson et al. (2016), and others, perceived motor competence has been shown to be strongly related to actual motor competence. Further, Meester et al. (2020) have shown perceived motor competence and enjoyment together can play a crucial role in developing actual motor competence, participation in activity, and motivation.

Harter's Perceived Competence Scale for Children is an example of a tool used to understand children's perception of physical or athletic competence. The Harter's Perceived Competence Scale for Children had been adapted using a 5-point Likert scale via a range of emoji-like faces displaying a range of expressions from sad to happy to reflect responses ranging from "not at all true" to "very true" referred to as a smileyometer to aid in its administration to some younger populations (Harter et al., 1982). This scale has been proven to be reliable (internal and test-retest) in populations including where the preschool-age range ends. It as well as been shown to be a valid (face, factorial, convergent, and construct) assessment in those same populations. Scales like this one have been and continue to aid in the understanding of perceived motor competence and the dynamic between it and actual motor competence and has been validated in numerous populations of young children (Harter et al., 2012). Enjoyment, like perceived competence has grown in its focus as it relates to many factors of children's development and is a part of the backbone of many motivational theories throughout the literature (Morano et al., 2019). Physical Activity Enjoyment Scale has been similarly adapted with the same 5-point Likert scale that was used to adapt the Harter's Perceived Competence

Scale for Children directed towards the child's perceived enjoyment. The children are asked to rate their enjoyment on different items such as "*Doing this activity/game was fun*" and "*I would describe this activity/game as very enjoyable.*" This scale has been validated for use in gauging physical activity enjoyment in multiple studies carried out by Kendzierski & DeCarlo (1991) in a variety of populations.

Recap and Synthesis

The literature that exists examining physical activity, motor skill development, and cognitive aspects of self-regulation (both independently and in combination) in preschool-aged children is sparse. Additionally, the research approach, assessments, and findings related to these variables varies within this population. There are findings throughout the literature that show elements of interrelatedness among these variables, but lack of strong relationships justifies further exploration in the field. Inconsistencies in methodology and gaps in the current body of literature exist and that it is paramount that they be addressed in order to further study these relationships.

Literature that prompts future exploration consists of findings like that of Cliff et al., (2009), Iivonen et al. (2013), O'Neill et al. (2017), and Loprinzi and Frith (2017) that all showed at least some element of positive association between physical activity and motor skill development (some sex differences were observed). This included positive associations with habitual physical activity, physical activity intensity (light-, moderate-, and vigorous), physical activity types, and meeting physical activity recommendations. Additionally, findings like that of Zach et al. (2015), Burkart et al. (2018), Healey and Halperin (2015), and Robinson et al. (2016) that showed at least some element of positive association between physical activity and at least one cognitive aspect of self-regulation (attention, working memory, and attention) also have

shown promise and prompt further exploration. Finally, Robinson et al. (2016) that showed an association with participation in a motor skill development program and maintaining scores in inhibition prompt further exploration into the interrelatedness of motor skill development and cognitive aspects of self-regulation.

Despite the highlighted findings there are gaps in the current body of literature that need to be addressed as well as more consistency established in the literature overall. Primary gaps in the literature exist in examination of possible interrelatedness between motor skill development and cognitive aspects of self-regulation. Only Robinson et al. (2016) to the authors knowledge as explored the dynamic between these variables but it did not examine all cognitive aspects of self-regulation (only inhibition) and it only examined these variables unidirectionally (motor skill development program on inhibition scores). The processes by which these variables interact needs to be explored in depth and with a bi-directional understanding like that of Diamond (2000) and Geertsen et al. (2016) highlight in their works. There needs to be a pointed effort to understand not just how motor skill development may impact cognition but also how cognition impacts motor skill development and how these interactions proceed over development. Once a better understanding of how motor skill development and cognitive development interact, how the interrelatedness of motor skill development and cognitive aspects of self-regulation impact physical activity can be explored appropriately. In regard to consistency, it is important for the methodology to be consistent (e.g. uniformity in approach to motor skill development assessment, inclusion of all cognitive aspects of self-regulation) to help establish a clear picture of how variables interact through comparison. These gaps in combination with the current inconsistencies that exist in the literature provide the foundation for what the current dissertation study is built upon and aims to address.

CHAPTER III: METHODOLOGY

This was an intervention study with a quasi-experimental design. The experimental group was composed of children enrolled in two preschool classrooms [potential n=36 (18 per classroom) ages 3-6y] at the White Avenue site for Early Learning Center for Research and Practice. The control group was made up of children enrolled in one preschool (potential n=18; ages 3-6y) classroom at the Lake Avenue site of the Early Learning Center for Research and Practice. This study was designed to determine the impact of a movement-based curriculum on motor skill development and cognitive aspects of self-regulation in a preschool-age population. A letter describing the curriculum and study was distributed to the parent(s) and/or guardian(s) of the children at a local university preschool prior to data collection (These documents can be found in appendix A). Along with this letter, documentation for parent permission, child assent and a demographic questionnaire were included to be returned to the preschool if the parent(s) and/or guardian(s) approve of their child's inclusion in the study. After collection of parent permission, child assent, and demographic information, initial anthropometric data and baseline measurements of study variables were collected. Following baseline measurements, the curriculum was implemented two-days per week (one hour per day) over an approximate 8-week span. During the curriculum, observational assessments were completed to ensure fidelity of the curriculum. Following the conclusion of the curriculum post measurements of the study variables were collected and analyzed.

Participants

Participants were preschool-aged (3-6 years) children attending a university-based child development laboratory school. Approximately 50 children were recruited into the study (~36 intervention participants; ~18 control participants). A power analysis was conducted using PASS

2021 (PASS 2021 Power Analysis and Sample Size Software (2021). NCSS, LLC. Kaysville, Utah, USA, [ncss.com/software/pass](https://www.ncss.com/software/pass)). This power analysis was based on data from a comparable study, utilizing a similarly aged population and assessment (TGMD-2, current study will use the updated version TGMD-3) as the current study. The following mean differences were used to generate sample sizes for each group: intervention sample (total motor score = 42.5 ± 15.5 , locomotor score = 20.4 ± 8.0 , and object control score = 22.1 ± 8.9 , respectively) and control sample (total = 8.7 ± 16.1 , locomotor = 2.7 ± 7.1 , and object control = 6.0 ± 9.8 , respectively) (Robinson et al., 2016). Based on this analysis, a minimum sample size of 16 participants (Locomotor 8 per group; Object Control: 8 per group) were needed for each group (experimental and control).

Children attending the Early Learning Center primarily Caucasian living in a SES that would be considered middle-to-upper class. At least one of the majority of parent/caregiver dyads had at least one parent working at the local university. Prior to enrolling participants in the study and beginning data collection, parental permission were obtained, and the children provided verbal assent. Approval for this study was granted by the university's Institutional Review Board.

Environment

The Early Learning Center has a Reggio Emilia-based philosophy on education that draws inspiration from creative play, developmentally appropriate approaches, and social constructivist beliefs. Both school locations (intervention and control) operates weekdays from 7:30am to 5:30pm and offers three opportunities every day for unstructured physical activity in an outdoor play space – early morning, late morning, and afternoon. The playground and

additional outdoor environment that the Early Learning Center uses is sufficient room to occupy all currently enrolled students (~50) at one time and features traditional and unique equipment on a nature-based playground designed to embody nature and natural components (e.g. a dirt track, sandbox, open green spaces, water table, outdoor classroom, and more). Typically, the playground is occupied by only one class at a time with overlapping of classes during the transitional periods. Additionally, children had the ability to freely move around during indoor time, though there is some required group learning time that tends to be sedentary in nature.

Intervention Curriculum

The intervention curriculum was a movement-based curriculum that takes place for 60 minutes per lesson, two days per week, for ~ 8 weeks (totaling 600 minutes of accumulated intervention time). This curriculum replaced regularly scheduled outdoor free play sessions on days that the curriculum is implemented. The control group continued with their regularly scheduled free play sessions on a daily basis. Each lesson was delivered by the lead investigator (Aaron P. Wood, M.S.). Each lesson consisted of a warm-up followed by a period of introduction to the skill, practice of the skill, and then application of the skill via a game that included aspects that foster cognitive development along with allowing practical use of the skill.

Example – Kicking a Stationary Ball Lesson

Warm-up: 2-5 minutes of a general full body warm-up (i.e. arm circles, leg swings, light walking).

Instruction and Practice: 3-5 minutes of introduction to the motor skill and steps involved in the successful execution of that motor skill. This was followed by ~20 min of practice where the children practice each step (i.e., rapid approach to ball, elongated step prior to kick, on-kicking

foot placed slightly behind the ball, and kick with instep) of the motor skill individually followed by practicing putting all the steps together for the complete movement.

Application: 10-15 minutes of the game for that lesson gave the children an opportunity to apply the skill in a particular context. This involved the execution of the motor skill to achieve a particular goal as a group. Additionally, this game included rules that aim to engage the cognitive aspects of self-regulation in the children while playing. They were required to pay attention to the goal of the game as well as the rules specific to that point in the game. They needed to engage their working memory to not only remember the goal and rules but the new rules that manifested as the game progresses. Then as rules change, they had to execute a certain level of inhibition to ignore the previous rules in the game and prioritize the new rules once they were implemented (i.e. kicking the ball to a certain color target, then having that rule switched for the cognitive loading to kicking to a target that is not a certain color).

There were 6 motor skills covered over the span of the intervention. There were 3 locomotor motor skills (hop, horizontal jump, slide) and 3 object control motor skills (two-hand catch, kick a stationary ball, overhand throw). These skills were chosen based on providing a diverse array of fundamental motor skills that children may not be exposed to regularly. An example of what each lesson will entail is provided below (a collection of the complete set of lesson plans can be found in appendix B).

Assessments

Pre- and Post- Curriculum Assessments

The following assessments were conducted pre- and post-curriculum to examine the effect of the movement-based curriculum on the main outcome variables, motor skill development and cognitive self-regulation (attention, working memory, and inhibition). These measures were conducted in addition to anthropometric assessments in the intervention and control groups. Due to feasibility both pre- and post-assessments were conducted by the same graduate researcher (Aaron P. Wood) as the individual who designed and ran the curriculum. The issues of feasibility were a product of limited undergraduate researchers (and limitations in the schedules of those available). There was also very limited availability of researchers with training in conducting and scoring of certain assessments as well as qualified individuals to conduct the curriculum. We acknowledge that this posed a conflict of interest with potential bias in “teaching the assessment” during the curriculum by the researcher. This referring to the researcher who is conducting the assessments being the same as the researcher conducting the curriculum possibly leading to inflated scores as a product of that researcher gearing things towards doing the assessments correctly rather than just delivering the curriculum as designed. Additionally, there was also potential bias in assessment with the same researcher who designed the curriculum being the one who evaluated its impact. This aspect creates a bias to perceive that the curriculum performed better than it actually did based on the researcher who designed it having the desire for the curriculum to have been successful in its application.

1. Test of Gross Motor Development, 3rd Edition (TGMD-3)

The Test of Gross Motor Development – Third Edition (TGMD-3) was used to test the motor skill development of all study participants in the intervention and control groups. The

TGMD-3 is a norm-referenced measure of common gross motor skills that develop early in life. The TGMD-3 has demonstrated to be a valid assessment of fundamental motor skills in the preschool-aged population and has high test-retest reliability for both the locomotor ($r_c(r_u) = 0.93(0.74)$) and object control ($r_c(r_u) = 0.87(0.87)$) subtests for preschoolers (Valentini, Zanella, & Webster, 2017; Ulrich, 2019). Previous versions of the TGMD-3 have also been shown to be sensitive enough to observe changes in motor skill development over intervention periods like that of the current study in both weeks (with studies ranging from 5-9 weeks) and minutes (with studies ranging from 540-900 minutes) in the preschool-aged period (Robinson & Goodway, 2009; Martin, Rudisill, & Hastie, 2009; Robinson et al., 2016). The TGMD-3 is an overall assessment of gross motor development that is comprised of two categories of assessment (locomotor and object control), both of which have six skills that assess development in different fundamental motor skills. For locomotor skills children's ability to "run, gallop, hop, leap, horizontal jump, and slide" were assessed. For object control skills children's ability to "strike a stationary ball, stationary dribble, kick, catch, overhand throw, and underhand roll" were assessed.

The following paragraph briefly describes each motor skill test. Full descriptions of the tests are published in the TGMD-3 Manual (Ulrich, D A. Test of Gross Motor Development (3rd Ed.). 2016 Austin TX: Pro-Ed.).

The following are descriptions of locomotor assessments conducted. For the "run" assessment 2 cones are set up 50 feet apart (60 feet of clear space is needed as a buffer to decelerate). Beginning at one of the cones the child is instructed "Run as fast as you can to the other cone when I say go". The data from the "run" is recorded on the data collection sheet and then a second trial is completed (i.e. the child runs back to the initial starting cone). The "gallop"

assessment 2 cones are set up 25 feet apart. The child is instructed to “gallop like a horsey to the other cone and stop”. The data from the “gallop” is recorded on the data collection sheet and then a second trial is completed. For the “hop” assessment 2 cones are set up 15 feet apart. The child is instructed to “hop fast to the other cone” (this is done on both the preferred and non-preferred leg). The data from the “hop” is recorded on the data collection sheet and then a second trial is completed. For the “skip” assessment 2 cones are set up with a minimum of 30 feet of clear space. The child is instructed to “skip to the cone”. The data from the “skip” is recorded on the data collection sheet and then a second trial is completed. For the “horizontal jump” assessment a singular cone is set up with a starting line marked off at the cone. The child is instructed to “jump as far as you can”. The data from the “horizontal jump” is recorded on the data collection sheet and then a second trial is completed. For the “slide” assessment 2 cones are set up 25 feet apart. The child is then instructed to “Slide sideways to the cone” (this is done on preferred and non-preferred side). The data from the “slide” is recorded on the data collection sheet and then a second trial is completed (for both preferred and non-preferred sides).

The following are descriptions of object control assessments conducted. For the “striking a stationary ball” assessment a tee is set up with a tennis ball placed on it and a light plastic bat given to the child. The child is instructed to “strike the ball towards the wall” (which wall is decided on the preferred direction the child wants to strike towards). The data from the “striking a stationary ball” is recorded on the data collection sheet and then a second trial is completed. For the “dribble” assessment the child is given a kickball sized ball. The child is instructed to “dribble the ball four times, using one hand” (concluded by stopping the ball by catching it). The data from the “dribble” is recorded on the data collection sheet and then a second trial is completed. For the “catch” assessment 2 cones are set up about 15 feet apart. The child is

instructed to “catch the ball with your hands” (only tosses that are between the child’s shoulders and belt are recorded). The data from “catch” is recorded on the data collection sheet and then a second trial is completed. For the “kicking a stationary ball” assessment, a line is marked off 30 feet away from the wall and another line 20 feet from the wall. The ball is placed on a beanbag on the line closest to the wall. The child is then instructed to “stand on the other line and run up and kick the ball hard at the wall”. The data for “kicking a stationary ball” is recorded on the data collection sheet and then a second trial is completed. For the “overhand toss” assessment the child stands 20 feet from the wall and throws a ball hard at the wall. For the “underhand roll” assessment two cones are placed against the wall four feet apart and a piece of tape on the floor 20 feet from the wall. The child is told then to “roll the ball hard, so that it goes between the cones”.

There are established criteria for each subtest performance (<https://www.cdc.gov/nchs/data/nnys/tgmd.pdf>). The TGMD-3 assessment form is included as Appendix A. Each skill tested consisted of between 3-4 performance criterion that are individually examined over 2 trials to establish a “performance criterion score.” For a correct execution of the skill, the examiner recorded a “1.” For an incorrect execution of the skill, the examiner recorded a “0.” The sum of both trials were then used to establish a “Performance Criterion Score” for each performance criterion. All “Performance Criterion Scores” are then summed to establish a “Skill Score” for each individual motor skill (an example can be seen in the figure below).

Partial scores are not allowed in the assessment of skills. If the child refused to perform the skill, he or she was coded as “Did Not Participate”. The subtest raw scores are reported as scaled scores. The Gross Motor Quotient is calculated by summing the raw locomotor and object

control scores. A standard score is reported for the overall Gross Motor Quotient. The final collection of scores for the locomotor, object control, and combined for total motor skill score are presented as “raw” scores. These raw scores can then be converted to both scaled and percentile scores using the TGMD-3 manual. These conversions take into account factors such as age that help understanding of where that child may be in relation to other children.

2. Early Years Toolbox

Self-regulation and the individual components of self-regulation (working memory, inhibition, and attention) were assessed using the Early Years Toolbox. This assessment has proven to be a valid assessment of cognitive self-regulation in preschool children (Working Memory, $r(79) = 0.46$, $p < .001$ (with visual-spatial) and $r(79) = 0.42$, $p < 0.001$ (with phonological); Inhibition, $r(80) = 0.40$, $p < 0.001$; and Shifting, $r(80) = 0.45$, $p < 0.001$) (Howard & Melhuish, 2017). The Early Years Toolbox is application specifically for a tablet that uses various assessments to determine self-regulatory skills in young children. The children completed four assessments that cover each of the three self-regulation categories: working memory, inhibition, and attention. These assessments resemble a game on the iPad, making these assessments appealing to young children. Outcome measures for each individual task included an accuracy measure (% of correct and incorrect responses) as well as reaction time (sec) for each response by each level of the task. All data collected using the Early Years Toolbox was stored on the tablet and then imported into Excel for analysis.

The "Mr. Ant" task examines visual-spatial working memory. In this game children are shown a picture of an ant with stickers on it (Figure 1.). After a set amount of time the stickers disappear, the child is then asked to recall and point out the location on the ant that the stickers

previously were. The difficulty progresses with the addition of more stickers that the child is asked to recall.

The "Not This" task examines working memory. In this game children are shown an array of different characters (Figure 2.) with different characteristics (different shapes, colors, and sizes). Before the child sees these images they receive auditory instructions to point to an image that does not have a particular characteristic (e.g., "Find a shape that is not blue", "Find a shape that is not small", "Find a shape that is not square"). The difficulty progresses by asking the child to select a shape based on a growing number of criteria (e.g., "Find a shape that is not small and not blue", and "Find a shape that is not large, not a triangle, and not green").

The "Go/No Go" task examines inhibition. In this game children are presented with fish and sharks that cross the screen (Figure 3.) and asked to tap the fish on the screen as they go by to "catch the fish" and to not tap the screen when they see a shark go by to "avoid the sharks". The test simply continues a set amount of rounds unless a threshold for incorrect responses has been reached and the game stops early.

The "Card Sorting" task examines shifting attention. In this game (Figure 4.) children are presented with cards that are a particular shape (rabbit or boat) and color (red or blue) and are asked to sort the cards based on a predetermined rule before the round starts (e.g., "If the card is blue then sort it here and if it's red then sort it here"). The rule then is changed before the next round (e.g., "If the card is a rabbit sort it here and if it's a boat sort it here"). Finally, if the child has progressed far enough in the game the difficulty progresses to the child being asked to sort by either color or shape based on certain criteria (whether or not the card has a black square box around it). If the card has a box around it they may be asked to sort by color, but if the box is not present then they must sort the card by shape.

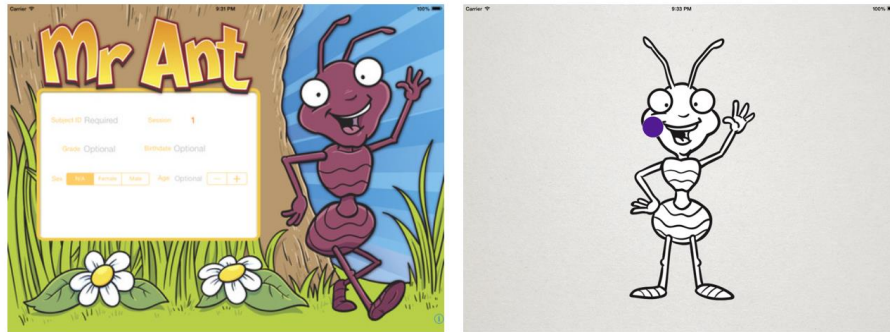


Figure 1. Mr. Ant Visual-Spatial Working Memory Assessment.

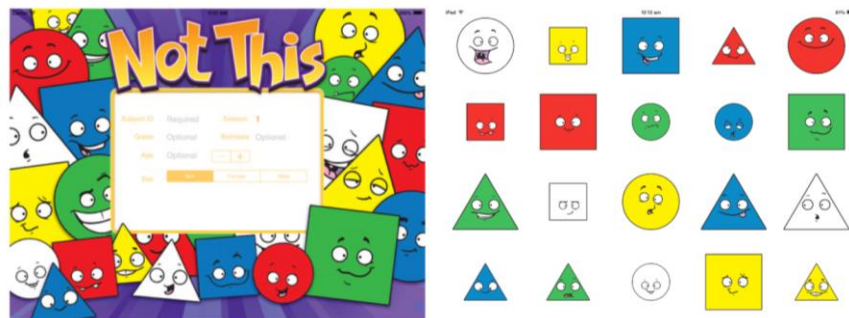


Figure 2. Not This Working Memory Assessment.

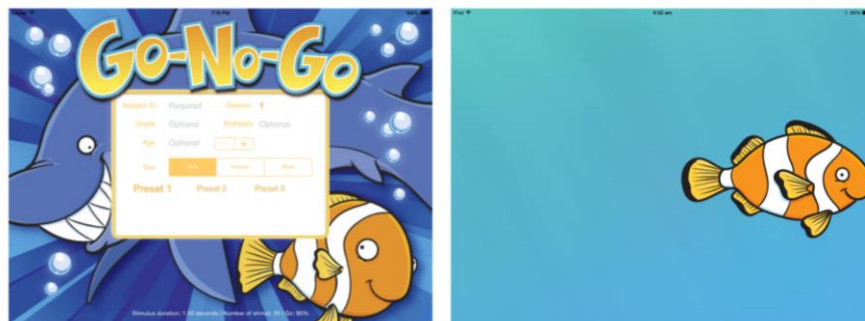


Figure 3. Go/No Go Inhibition Assessment.



Figure 4. Card Sorting Shifting Attention Assessment.

Additional Curriculum Assessments

The following assessments were conducted throughout the intervention for varying purposes. Perceived Competence and Enjoyment Scales were conducted with the children after each lesson of the curriculum to provide descriptive information regarding the children's perceived competence and enjoyment and during the curriculum. Perceived competence and enjoyment have been cited as key components to successful interventions in preschool-aged populations as well as both being cited as influencing factors in development (Weiss, 2000; Stodden et al., 2008; Loprinzi et al., 2015). Like with pre- and post-curriculum assessments, there was potential bias in assessment with the same researcher who designed the curriculum being the one who evaluated its impact. Video recording was conducted continuously throughout the curriculum implementation time periods to evaluate and determine curriculum fidelity.

1. Subjective Measures of Perceived Competence and Enjoyment

The perceived competence questionnaire that was administered was adapted from Harter's Perceived Competence Scale for Children. This questionnaire uses a 5-point Likert scale via a range of emoji-like faces displaying a range of expressions from sad to happy to reflect responses ranging from "not at all true" to "very true" referred to as a smileyometer. Statements that the children were asked to make reflections on included items such as *"I think I did pretty well at the activity/game, compared to others"* and *"I felt pretty skilled at the activity/game."* The perceived competence questionnaire includes five statements with total scores ranging from 5 to 25. The enjoyment questionnaire was adapted from the Physical Activity Enjoyment Scale and uses the same 5-point Likert scale as the perceived competence questionnaire. The children were asked to rate their enjoyment on different items such as *"Doing this activity/game was fun"*

and “*I would describe this activity/game as very enjoyable.*” The enjoyment questionnaire included seven statements related to enjoyment with total scores ranging 7 to 35. A copy of the perceived competence and enjoyment questionnaire is included as Appendix C.

2. Video Recording for Curriculum Fidelity and Evaluation

Video recording via tablet was conducted throughout the curriculum to ensure the fidelity of its implementation. These videos were unable to be reviewed and coded for the current study but will be at a later date. At that time videos will be examined by experts in this area who design and/or implement interventions to assess the components and delivery of the curriculum. Variables such as attendance, time spent during each session, proportion of time spent on each activity, and detailed notes of the activities that took place during each session day will be coded and assessed.

Statistical Analysis

Descriptive statistics will be calculated for demographic and anthropometric variables. T-tests will be used to determine any differences between the control and intervention groups at baseline. The following analyses will be utilized to test each aim of the study. The hypothesis and outcome variables are also presented for each aim.

Aim 1. Investigating the impact of the movement-based curriculum on motor skill development in a preschool-aged population

Hypothesis: This curriculum will facilitate improved motor skill scores among all categories (gross motor quotient, locomotor motor skills, object control motor skills) in the intervention group compared to the control group.

Outcome Variable: Motor skill development (Gross Motor Quotient, locomotor scores, and object control scores) will be measured via the Test of Gross Motor Development – 3rd Edition (TGMD-3).

Analysis: A 2-group (intervention and control) x 2-time (pre and post) repeated measures analysis of variance will be used to determine the effect of the curriculum on changes in motor outcomes (Gross Motor Quotient, locomotor scores, and object control scores). The dependent variable is the TGMD-3 scores. In the case of missing data a mixed model analysis of variance will be conducted.

Aim 2. Investigating the impact of the movement-based curriculum on cognitive aspects of self-regulation

Hypothesis: This curriculum will facilitate improved self-regulation scores among all categories (attention, working memory, inhibition) in the intervention group compared to the control group.

Outcome Variable: Cognitive aspects of self-regulation (attention, working memory, and inhibition) will be measured via the Early Years Toolbox.

Analysis: A 2-group (intervention and control) x 2-time (pre and post) repeated measures analysis of variance will be used to determine the effect of the curriculum on changes in cognitive self-regulatory skills (visuomotor memory, working memory, attention shifting, inhibition). The dependent variable is the Early Years Toolbox scores. In the case of missing data a mixed model analysis of variance will be conducted.

Aim 3. Investigating the correlations between motor skill development and cognitive aspects of self-regulation

Hypothesis: The variables will be related, and analysis will show relationships through similarly protracted improvement.

Analysis: Pearson's correlations will be conducted to determine whether there is an association between motor skill development and cognitive self-regulation.

Descriptive statistics will be computed for enjoyment and perceived competence variables for the control and intervention groups. Statistical significance will be set at $p < 0.05$.

CHAPTER IV: RESULTS

Demographics

The population involved in this study included 34 preschool-aged children (28 in the intervention group and 6 in the control group) with a mean age of 4.8 years (± 0.61). Overall curriculum attendance was at 74.68%. Anthropometric and demographic data are provided in Table 1. The control group was significantly older than the intervention group ($p < 0.05$). There were no other significant differences between the groups. Baseline motor skill development scores are presented in Table 2.

Motor Skills

At baseline, there were no differences in locomotor, object control or total motor scores between intervention and control groups (Table 2). The results presented in this section refer to the first aim of the study. There were no difference pre- to post- in motor skill scaled scores (total, locomotor, or object control) between intervention and control groups ($F = 0.386^b$, $p = 0.540$, $F = 1.415^b$, $p = 0.245$, and $F = 3.198^b$, $p = 0.086$, respectively). These data are presented in Figure 1. Although, there was no differences between intervention and control groups, there was a significant time effect with differences in locomotor and object control scaled scores found in both intervention and control groups from the baseline to the post-intervention assessments ($F = 4.47^b$, $p < 0.05$ and $F = 13.05^b$, $p = 0.001$, respectively).

Table 1. Demographics

	Intervention Group	Control Group
Age (yr)	4.7 (± 0.6)	5.2 (± 0.4)*
Height (cm)	108.8 (± 7.5)	113.7 (± 3.9)
Weight (kg)	18.7 (± 2.5)	19.8 (± 2.0)
BMI	15.8 (± 1.5)	15.2 (± 0.8)
Sex (%)		
Male	51.7	50
Female	48.3	50
Race (%)		
White	71.4	66.7
Black	7.1	16.7
White/ Native American/ Alaskan	0	16.7
Asian	14.3	0
Middle Eastern/ Jewish	3.6	0
Ethnicity (%)		
Hispanic	7.1	33.3
Non-Hispanic	92.9	66.7

Table 2. Baseline Motor Skill Scores (Mean $\pm$ SD)

	Raw			Scaled			Percentile		
	LM	OC	TM	LM	OC	TM	LM	OC	TM
Intervention	27.1 (± 7.6)	28.3 (± 6.0)	55.4 (± 11.0)	11.3 (± 2.0)	11.8 (± 1.8)	23.4 (± 3.1)	64.9 (± 22.5)	69.1 (± 19.0)	69.7 (± 18.4)
Control	32.2 (± 4.3)	26.7 (± 5.8)	58.8 (± 9.0)	11.7 (± 1.9)	10.2 (± 2.1)	21.8 (± 3.7)	69.7 (± 22.3)	52.0 (± 24.8)	63.0 (± 24.5)

LM=Locomotor Skill, OC=Object Control Motor Skill, TM=Total Motor Skill

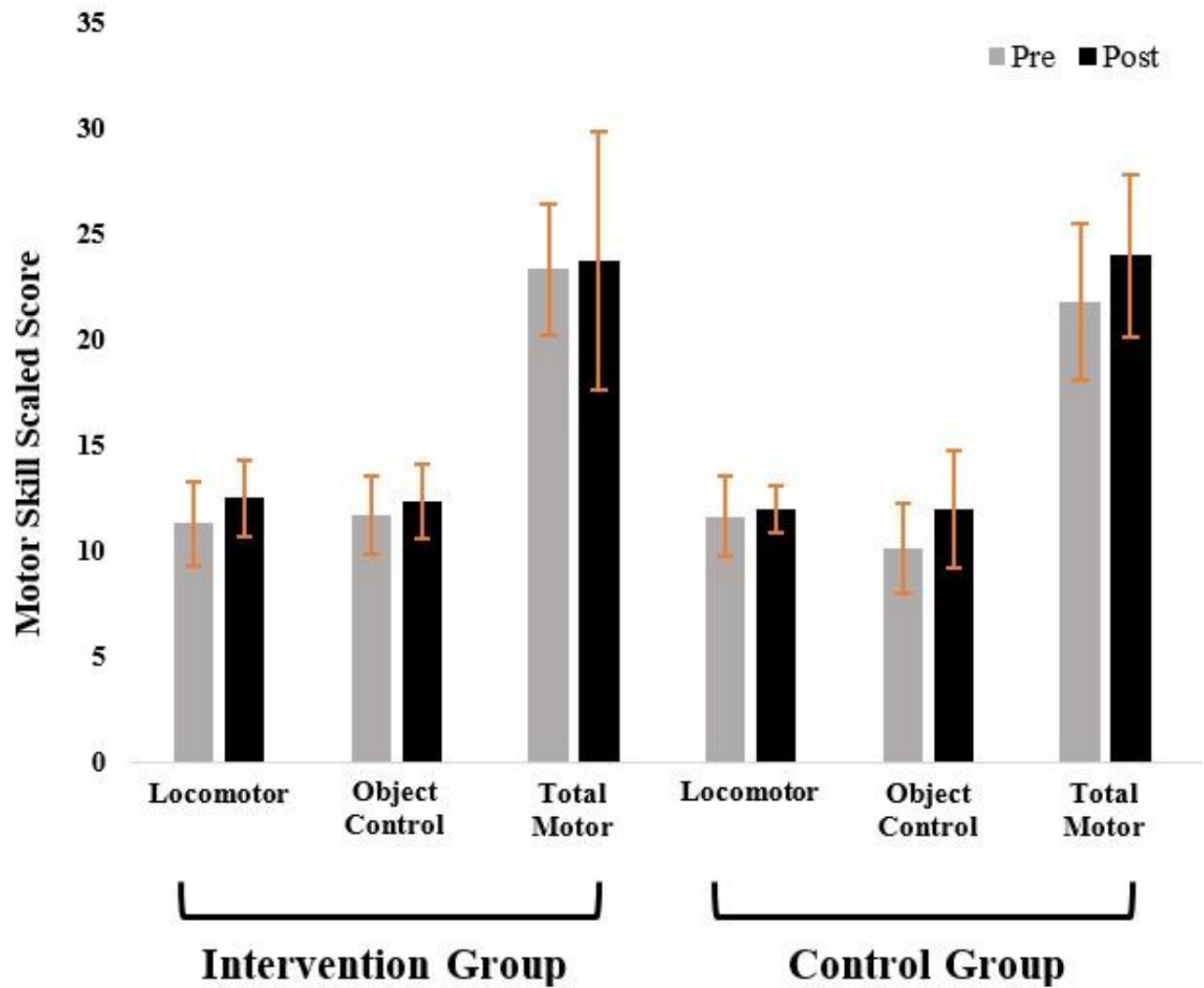


Figure 5. Locomotor, Object Control, and Total Motor Skill Scaled Scores for the Intervention versus Control Group Pre- to Post-Curriculum.

Self-Regulation

The following section includes data pertaining to the second aim of the study. This aim involved a comparison of accuracy and reaction time scores of all cognitive variables (Mr Ant, Not This, Card Sort, and Fish/Shark) between the intervention and control groups. The data from these assessments are presented in Table 3. There was a greater improvement in the intervention group over the control group for Mr Ant accuracy scores ($F=5.145^b$, $p=0.035$). There were no differences between intervention and control groups for any other cognitive assessment (Not This, Card Sort, and Fish/Shark, respectively) accuracy scores ($F=0.001^b$, $p=0.972$, $F=2.88^b$, $p=0.108$, and $F=0.418^b$, $p=0.526$, respectively).

Additionally, there were no differences between the intervention and control groups for any cognitive assessment (Mr Ant, Not This, Card Sort, or Fish/Shark, respectively) reaction time scores ($F=1.611^b$, $p=0.220$, $F=0.714^b$, $p=0.408$, $F=0.021^b$, $p=0.886$, and $F=0.000^b$, $p=0.985$, respectively; Table 2). When looking at the total group (control plus intervention groups), there was a significant time effect only for the Not This reaction time scores ($F=5.846^b$, $p<0.05$).

Motor Skills and Self-Regulation

In regard to the third aim of this study, investigating the correlations between motor skill development and cognitive aspects of self-regulation was conducted. First, pre- and post-curriculum total motor skill scaled scores were examined for possible correlation to all pre-curriculum cognitive tests (both accuracy and reaction time) in both the intervention and control groups.

Table 3. Full Descriptive Statistics for Self-Regulation (Accuracy Scores)

Intervention Group				
	Mr Ant	Not This	Card Sort	Fish/Shark
Pre	3.1 (± 2.4)	8.9 (± 4.0)	12.3 (± 4.8)	52.7 (± 14.8)
Post	4.1 (± 2.5)*	9.6 (± 3.3)	11.5 (± 5.0)	59 (± 9.2)
Control Group				
	Mr Ant	Not This	Card Sort	Fish/Shark
Pre	6.4 (± 2.6)	10.2 (± 4.0)	15.3 (± 1.0)	68.5 (± 1.7)
Post	4.2 (± 2.7)	11 (± 0.7)	16.3 (± 1.0)	70.5 (± 2.4)

* = statistical significance of $p < 0.05$

Table 4. Full Descriptive Statistics for Self-Regulation (Reaction Time Scores)

Intervention Group				
	Mr Ant	Not This	Card Sort	Fish/Shark
Pre	17.9 (± 5.3)	9.4 (± 3.7)	5.5 (± 6.5)	1.1 (± 0.2)
Post	16.4 (± 5.5)	7.8 (± 2.8)	5.6 (± 4.7)	1.0 (± 0.2)
Control Group				
	Mr Ant	Not This	Card Sort	Fish/Shark
Pre	12.8 (± 2.6)	9.7 (± 5.8)	4.1 (± 0.6)	1.2 (± 1.0)
Post	15.2 (± 5.3)	6.3 (± 1.5)	3.6 (± 1.2)	1.0 (± 0.1)

* = statistical significance of $p < 0.05$

In the intervention group there was significant negative correlation between pre-curriculum total motor skill scaled score and pre-curriculum Mr Ant reaction time ($r=-0.493$, $p=0.01$). In the control group there was a significant negative correlation between post-curriculum total motor skill scaled score and pre-curriculum Mr Ant accuracy score ($r=-0.901$, $p=0.014$).

No other statistically significant correlations were observed between pre- and post-curriculum total motor skill scaled scores and pre-curriculum cognitive tests. Second, pre- and post-curriculum total motor skill scaled scores were examined for possible correlation to all post-curriculum cognitive test (both accuracy and reaction time) in both the intervention and control groups. In the intervention group there was a significant positive correlation between pre-curriculum total motor skill scaled scores and post-curriculum Fish/Shark accuracy scores ($r=0.569$, $p=0.009$). Additionally, in the intervention group there was a statistically significant positive correlation between post-curriculum total motor skill scaled scores and post-curriculum Not This reaction time scores ($r=0.523$, $p=0.021$). No statistically significant correlations were observed in the control group between pre- or post-curriculum total motor skill scaled scores and any post-curriculum cognitive test). No other statistically significant correlations were observed between pre- and post-curriculum total motor skill scaled scores and post-curriculum cognitive tests.

Perceived Competence and Enjoyment

Perceived competence and enjoyment were assessed after each intervention lesson throughout the program to document the children's perception of their competence and enjoyment during the program. On average, perceived competence was high (21.97 ± 2.59 out of

25) throughout the duration of the program. Additionally, on average, enjoyment was also high (30.16 ± 4.3 out of 35) throughout the duration of the program.

Video Recording for Curriculum Fidelity and Evaluation

At this moment videos have not been reviewed and coded for the current study. Videos will be reviewed/coded by external expert in the area and the analysis of that video data will follow.

CHAPTER V: DISCUSSION

The purpose of this dissertation was to investigate the impact of a movement-based curriculum on fundamental motor skills and cognitive self-regulation. Specifically, this curriculum aimed to do so through the tailoring of a movement-based curriculum to include physical activity that facilitates progression in motor and cognitive development in distinct yet also overlapping ways to potentially maximize the motor and cognitive benefits.

Motor Skills

It was hypothesized that the curriculum would facilitate improved motor skill scores among all categories (total, locomotor, and object control motor skills) in the intervention group. The results of this study did not support this hypothesis as improvement was shown in both the intervention and control groups with no statistical difference between the two groups.

One reason that could be a factor why no differences were observed between these groups stems from the rather high baseline motor skill levels of both groups at the onset of the study. Comparatively, Palmer, Chinn, & Robinson (2019) observed locomotor, object control, and total motor baseline raw scores of 19.25 (± 9.9), 9.41 (± 5.2), and 9.83 (± 6.1), that are much lower than the current study's raw scores 56.19 (± 10.48), 28.22 (± 7.28), and 27.93 (± 5.86). To put these values into perspective the statistically significant improvement in the Palmer et al. study only barely surpassed the baseline scores of the present study (66.19 ± 13.3 , 32.25 ± 7.2 , and 33.94 ± 8.9 , respectively). These lower baseline scores in Palmer et al. (2019) study provided a greater opportunity for improvement compared to our sample. Additionally, the other study population's total motor scores are at least below the 50th compared to the sample in the current which averaged scores well above the 50th percentile for total motor score. For both control and intervention groups at baseline (63 $\pm$ 24.5, and 69.7 $\pm$ 18.4, respectively).

Another factor that could be responsible for the differences in outcomes among the studies are the demographic characteristics of the study samples. The studies previously mentioned such as Robinson et al. (2016) included participants enrolled in Head Start programs. The Head Start program is a federally funded preschool program that enrolls children of low socioeconomic status families. Socioeconomic status has been shown to be a confounding factor related to motor development (Robinson et al., 2016). Children in lower socioeconomic status families may not have access to organized sport and activities due to financial burdens. Additionally, the preschool programs involved in this study has adequate resources that have been shown to improve activity levels and potentially allow for the development of motor skills. These resources include areas that children utilize to participate in activity (playground, multipurpose room) and equipment that could also benefit their development. These resources generally have higher associated costs that may not be an option for low socioeconomic status families. This lack of resources, such as reduced opportunities to participate in cost-associated activities and attending preschools with limited environments that promote or allow for activity, can play a role in minimized motor skill development in children. It's possible in future research with funding, equipment can be provided that the site/location gets to keep after the study to help with this in populations of need. Though regardless of funding future research should always consider how the population can feasibly maintain stability in these fundamental motor skills in the absence of the program. For example, making sure that in low-income populations where funding is minimal, that they can replicate continuation without a high financial burden. In contrast, the population enrolled in this study included children from higher socioeconomic status families, and they were attending a university-based preschool program. Anecdotally, when engaging with the students in the current study, they were familiar with many of the skills

involved in the TGMD-3 and the program and expressed that they participated in sports that utilized these skills (e.g., soccer, baseball, etc.)

The order and process of development of motor skills factored into the design of the curriculum and may have been an important influence on the observed findings (Langendorfer and Robertson, 2002). As children age, they are learning and developing skills starting with more simple motor skills (e.g., running) progressing to more difficult skills (e.g., single leg hop, kicking a ball) and complex combination of skills (e.g., running to sliding to catching back to running, etc.). This progression of development is complex and involves introduction, practice, and different applications based on unique experiences that all contribute to motor development, especially during this crucial period of development in the preschool-aged range. The skills selected for this program were chosen due to children's potentially limited exposure to them in their everyday life and due to their complexity (specifically more complex skills were chosen). Learning of these skills is facilitated by introduction and teaching of the skills as well as practice and application of the skills. Though this may be of great benefit it may also be the reason for limited findings in this study. Future research may should aim to make sure that a wider range of motor skills are included in program design. Specifically, run, gallop, hop, skip, horizontal jump, slide, two-hand strike, one-hand forearm strike stationary dribble, two-hand catch, kicking a stationary ball, overhand throw, and underhand toss may be beneficial to include in totality to appropriately help children have a more encompassing proficiency in fundamental motor skills. This study followed suit with other studies in regard to duration and frequency of the curriculum (600 minutes over 5–8-week range). Goodway et al. (2003) for example explored the differences between impact of direct instruction (similar to that of the current study) versus a control group that simply maintained regularly scheduled free play. Goodway et al. (2003) had a program

duration (9 weeks of 630 minutes) similar to the current study as well. However their intervention showed significant improvement and the control did not unlike our study. It may be that the nature of skills selected and where the children may have been developmentally, it may be that more exposure and time spent in these activities is needed to elicit desired improvements. Another similar program design to the current study was that of Robinson and Goodway (2009) which consisted of 9 weeks with a program total of 540 minutes. However, like some others (Cliff et al., 2007; Martin et al., 2009; Valentini and Rudisill, 2004a; and Valentini and Rudisill, 2004b) included a mastery approach consistently outperformed a direct instruction approach, as found in their studies. In the current study however a mastery approach was not feasible due to limitations of personnel.

Elements of Dynamic Systems Theory have shown to present in different ways across age groups ranging from infant, through elementary school-aged children, and on to adulthood (Bennet et al., 1999; Langendorfer and Robertson, 2002; Sweeting and Rink, 1999; Clemente et al., 2012). For example, Langendorfer and Robertson (2002) found that participants (children between the age of 5.7y and 13y) had similarities in in both order of development levels and pathways of development. However, there were differences due to the interaction developmental levels and pathways (Langendorfer and Robertson, 2002). Sweeting and Rink (1999) found that participants (kindergarten and 2nd grade children) demonstrated improve performance through environmental instruction guided by Dynamic Systems Theory.

Specifically in regard to the current study, the findings may speak to stability, a key element of Dynamic Systems Theory that frequency and duration play an important role in establishing stability in a behavior (how consistent the individual is reproducing that behavior). Since the frequency of a particular behavior over time indicates how stable the system is at

producing that behavior, there may have been aspects of the current curriculum design, such as amount of exposure to specific skills and frequency of skills being revisited in the application/game portions over the course of the curriculum, that were not sufficient to elicit significant differences in motor skill scores compared to the control group (it's also possible they already had sufficient stability in these skills). More frequency both within curriculum sessions and throughout the program overall may have given greater stability in producing those skills as well as tapped into Dynamic Systems Theory's understanding of timescales (what is happening in-the-moment, over learning, and over development not being qualitatively distinct. Again, the program followed suit with other programs regarding overall minutes and weeks in duration but may not have hit the mark in frequency and/or duration needed for the design of this program specifically. Each lesson had three main phases with the introduction, practice, and application with the introduction and practice phases taking significant time in the overall time allocation per lesson. This program due to this may not have had as much application time for the skills as other programs and will need to be taken into account in future designed curriculums. Though it is unsure the impact of time allocation per phase of the lesson due to the nature of even general frequency of skill exposure in many programs in other studies being often a mystery. In general, very few details are given regarding the exact design of curriculums and lessons aside from overarching summaries. At best there is a description of how many sessions, time they lasted, and duration of the program as a whole but that doesn't tell us much if anything about lesson/session design so it can be difficult to go off previous literature in that aspect of study design. This could be a crucial piece to why the inconsistencies that do exist in the literature are present because those details lesson to lesson may be pivotal in why an impact was observed.

Self-Regulation

It was hypothesized that the movement-based curriculum would facilitate improved self-regulatory scores among all categories (attention, working memory, inhibition) in the intervention group. The results of the current study show partial support of this hypothesis with significant improvement in Mr. Ant (working memory) accuracy scores in the intervention group. For all other assessments (This Not This, Card Sort, Fish and Sharks) there were non-significant improvements in both the intervention and control groups.

There are potentially a number of reasons why there were statistically significant findings with the Mr. Ant test (a measure of visual working memory) compared to the other assessments. In terms of the developmental trajectory of self-regulatory skills, after attention, working memory follows in the order of development of these self-regulatory skills in early childhood. Mr Ant task was one of the simplest tasks in the Early Years Toolbox battery and specifically measured visual working memory. All this assessment requires is simple visual working memory, the child has to remember the location of sticker(s) on the Mr Ant figure (there is even unique colors to each sticker that help the individual being tested better remember this location). Additionally, this task does not require the individual participating to act on a rule change or act in opposition to an initial cue presented at the beginning like the other task do. Additionally, with working memory being something that develops earlier than other cognitive aspects of self-regulation more children may have been better prepared to engage this cognitive skill at all ages in the preschool-aged range (3-5y) as opposed to some of the other cognitive aspects of self-regulation.

The design of the program may be an important factor as well in why there was a difference between Mr Ant (working memory) accuracy between intervention and control group.

The program itself stimulates working memory in the children as they learn new movements (so remembering the combination of movements to elicit the correct result like kicking a stationary ball), new games (remembering new rules and roles that come with exposure to a new game). There additionally is revisiting of components of games as the curriculum progresses (like going through a particular course of cones using a skill only when traveling through the cones) that requires children to remember the rules of previous games (and then challenges their inhibition at times requiring a new skill through the cones from lesson to lesson). Children received exposure to steps of a skill they had to remember, sequencing of that skill, and then in the application/game when and when not to do that skill (between the cones but not in transition for one set of cones to another, as an example). Additionally, these lessons were designed to load into cognitive development as some games required the children to learn a matching (often involving color of bags/balls and hoops) in combination with the skill and then in a later portion of the game act in opposition to that learned match (different color bags/balls with different color hoops).

These games require children's attention and working memory to remember which items to match and the addition of a requirement of inhibition to successfully transition to the new rule set after the rule change (different color bags/balls with different color hoops) and act in opposition to the initial matching. Sometimes when there was a rule change from matching the bean bag or ball to a hoop with the same color it was specific to another color (now red bean bags/balls go with yellow hoops, blue bean bags/balls go with blue hoops, etc.) All of these tasks challenged the children's attention and visual and auditory working memory frequently and repeatedly which again may be why there was significance seen with the Mr Ant task. When looking at why there may have been a significant difference in visual working memory and not

auditory working memory, aside from the nature of the test the design of the program itself may have unintentionally more geared towards this result. For example, in aspects of the program there was always a visual component to what might require the child's working memory. Whether it be in the demonstrations in the exposure to the skills, examples of the skills in application, demonstrations of the games, and almost every other like scenario there was always some presence of what would constitute as visual working memory. Those instances that involved auditory memory were never really absent from that of visual working memory and that may have played a role in the perceived findings of this study. It may be a crucial finding that there was some benefit to working memory specifically in this program as working memory has been shown to be crucial to learning and utilizing previously acquired information, to execute more complex motor and cognitive functions (Reynolds & Kamphaus, 2004; Swanson, Jerman, Zheng, 2008).

The reason for not observing significant differences in inhibition may revisit some of the same reasons as others, such as the complexity of the task and where this cognitive self-regulation skill falls in the order of development (after both attention and working memory) it may have been difficult to observe differences in this specific age range (Rademacher et al., 2018). Inhibition is one of the most complicated cognitive aspects of self-regulation developing following attention and working memory in childhood. It necessitates adequate working memory and attention and children at the lower end of the preschool age range (3-5y) typically have poor inhibitory control. For example, Healey and Halperin (2015) found significant differences in inhibition but their program composed of daily games targeting self-regulatory skills, such as inhibition, over a 5-week period versus games twice a week in the present study. Examples of these games include "copy me" where they would watch a sequence and then repeat the

sequence from memory, puzzles, two cup memory games, “musical statues” where they would move around while music is playing and the freeze when it stops, and more. That more condensed and greater frequency of these games may be closer to that necessary threshold needed to see benefits to inhibition and other cognitive aspects of self-regulation.

Also, the current study might have not reached a sufficient threshold to elicit change in the frequency of inhibition being challenged (instances throughout the program) as well as duration of the program (minutes, days, and overall weeks). Inhibition specifically may be one of the most challenging to gain an understanding of required nature and frequency of exposure in program design as current body of literature is varied in eliciting change in this variable through design activity programs (Wood et al., 2020). For instance, where Healey and Halperin (2015) found positive differences in inhibition in their daily sessions over a 5-week program, Burkart et al. (2018) found no differences with a program that consisted of daily sessions over a 6-month program. Adversely, where the current study saw no significant differences between intervention and control group with a twice a week over 6-week program, Robinson et al. (2016) found positive differences in inhibition in a 3 times per week over 5-week program similar to the current study.

Motor Skills & Self-Regulation

Regarding general correlations between motor skill scores and cognitive scores there were several informative findings of the present study. The intervention group pre-curriculum total motor skill scaled scores were negatively correlated with Mr Ant reaction time. This finding may speak to the dynamic that exists between motor and cognitive development and how they feed into one another from the onset of the study. It showed that those with higher pre-curriculum total motor skill scaled scores were more likely to have quicker reaction time scores

in the Mr Ant task. Further, there were also significant negative correlations in the control group between post-curriculum total motor skill scaled scores and pre-curriculum Mr Ant accuracy scores. This finding showed that in the absence of the intervention program those who had higher pre-curriculum Mr Ant accuracy score were oddly more likely to have lower post-curriculum total motor skill scaled scores. This could possibly mean or be a reflection of higher levels of cognitive development (at least in the case of visual working memory) not being enough to prevent a decline in motor skill development (if not simply a product of sample size in the analysis).

When exploring possible correlations with post-curriculum cognitive scores and pre- and post-motor skill scaled scores there were additional findings that may be of interest to the field. First, in the intervention group there was a significant positive correlation between pre-curriculum total motor skill scaled scores and post-curriculum Fish/Shark accuracy scores. This showed that those who had higher motor skill scores at the onset of the intervention had higher Fish/Shark (test of inhibition) accuracy scores after the intervention. Also, in relation to the intervention group, it was observed that there was a significant positive correlation between post-curriculum total motor skill scaled scores and post-curriculum Not This reaction time scores. This especially may be an interesting finding as it is surprisingly shown that those who had higher post-curriculum total motor skill scaled scores were correlated with slower reaction time scores in the Not This task post-curriculum. Looking in a positive light this could possibly be due to pre-curriculum they took less time due to lack of understanding and wanting to hurry to the next part of the task. Then after the curriculum they had a better understanding of what the task was asking of them and spent longer thinking of their actions throughout the task to make sure they got it right. This cannot be proven though with the current data and one would expect a

significant difference in accuracy scores in combination with those findings in that particular hypothesis. All of these findings in combination may be important to the shaping of future programs and particular areas of interest in the design of games and lessons.

Further understanding of the nature of how the frequency of practice and application of the skills as well as duration of the program in both minutes and weeks may require a closer look at stability and how it relates to Dynamic Systems Theory in these cognitive aspects of self-regulation. Understanding factors like stability as it relates specifically to cognition and how it may have played a role in some of the more complex cognitive tasks not being significantly different between the intervention and the control could be key. Where at least there is understanding in motor skill development of it being necessary for programs to be at least 600 minutes in duration and/or 6-9 weeks to see benefits and the progression of skills, in self-regulation there are no such markers for thresholds to see change. The minimum threshold of time necessary for changes in cognitive self-regulation through movement programs is currently not known. One of the few studies published that showed improvement in all three cognitive aspects of self-regulation was longer in overall minutes of the program duration (totaling at 750 minutes over 5 weeks) but studies like Burkhart et al. (2018) conflict with that threshold finding only positive changes in attention but no impact in inhibition with 30 min 5 day a week 6-month program (Healy & Halperin, 2015; Burkhart, 2018; Wood et al., 2020). It may be that in order to see a statistically significant difference in benefit of the program across all cognitive aspects of self-regulation a longer program and more frequency may be needed than the current study provided.

All of these factors revisit the role of Dynamic Systems Theory in regard to study design. The level of stability (how well individuals are able to reproduce the skill/behavior at

hand) that children are able to establish as a result of a particular program may need a stronger influence of all aspects of Dynamic Systems Theory to achieve the best result. The program needs to take into account the aspect of Dynamic Systems Theory of emergence/soft-assembly/non-linearity that highlights these behaviors/skills are not “hard-wired” in the system. These behaviors/skills may need to be introduced possibly in many different ways like through different types of games that involve introduction, practice, and application of behaviors in unique and different ways instead of one singular introduction and method of practice/application that seems to be the norm in curriculums/programs so far. Further, the curriculums/programs need to take into account the full understanding of the impact of timescales as it is understood through Dynamic Systems Theory. This meaning that they need to take into account not only how things are introduced and laid out over an entire program but understand that what is happening in-the-moment, over learning, and over development are not qualitatively distinct and that these timescales are all nested and feeding into one another. So these curricula/programs need to factor in within phases of lesson, over entire lesson, and over entire program design into greater consideration in curriculum/program design. Doing these things and having a stronger guiding presence of Dynamic Systems Theory in the curriculum/program design may be pivotal to establishing strong stability in producing and reproducing the desired behavior/skills in the involved participants.

Enjoyment & Perceived Competence

Both enjoyment and perceived competence were reported on the higher end of the scoring spectrum throughout the program. Reported high enjoyment scores are especially important as fun and enjoyment of activity has been shown to be a key element for success in motor interventions in young children (Meester, 2020). Participating in enjoyable activity can

help children be more engaged during the program, be more willing to incorporate aspects of the program into their life, and increase the overall value of the program. In regard to the perceived competence, the high scores show that the program may have done well at fostering high perceived competence through the use of developmentally appropriate activities to increase actual competence of motor skills. As highlighted by the work of Stodden et al., Robinson et al., and others, perceived motor competence has been shown to be strongly related to actual motor competence as well as physical activity, and therefore is a crucial aspect to be considered when developing any program.

Studies have shown perceived motor competence and enjoyment can play a crucial role in developing actual motor competence, participation in activity, and motivation (Yun and Ulrich, 1997; Almeida et al., 2017; Meester et al., 2020). Though the literature has shown very promising evidence for the impact of perceived competence and enjoyment on actual motor competence, findings throughout the literature have not been consistent (Meester et al., 2020). One possible reason for this may be that though there is an importance of perceived motor competence and enjoyment, a barrier exists related to young children having a full understanding of the statements that they were providing scores for in assessment of these variables. For example, the one “negative” question regarding if they felt the lesson was boring on the enjoyment scale sometimes would receive a score reflective of not a full understanding of the statement, especially in relation to other given responses that contradict. Further, some children seemed to gravitate towards extremes of either good or bad as though they had trouble thinking of the statements with the complexity (range from bad to good on a 5-point Likert scale) that they were intended to. A possible lack of understanding the statements that children were

providing values for could potentially bias the data, so caution is needed when interpreting the data and what that data tells us about the program.

Strengths & Limitations

Strengths of this study start with its innovative design of the curriculum. The current curriculum was modeled after the highly successful CHAMP program designed by Dr. Leah Robinson and colleagues. That influence combined with the addition to not only facilitate the increase of motor skills but also cognitive aspects of self-regulation make it unlike any other program of its kind (even those collecting data on cognitive variables). The current study takes a step in this direction with the incorporation of specific elements intended to foster cognitive development with the introduction and fostering of motor development but further understanding of how best to do this is still needed. Other studies have been designed to increase motor skills specifically, few even with exploring the understanding of that increase on cognition but have not been designed to improve both. This could be very important due to the equally protracted development of motor skills and self-regulation and how they interact with one another in fostering or blunting that development.

This study is not without limitations. This study was conducted in a single preschool program with three classrooms (at two different sites) with children in the age range of the study. This convenience sample provided a limited participant pool. At the site of the intervention there were two classrooms and only one classroom at the control site. This ultimately led to the uneven nature of the groups and a smaller sample for the control group than desired for statistical power ($n=6$). Due to feasibility both pre- and post-assessments were conducted by the same graduate researcher (Aaron P. Wood) as the individual who designed and ran the curriculum. The issues of feasibility were a product of limited undergraduate researchers (and limitations in the

schedules of those available). There was also very limited availability of researchers with training in conducting and scoring of certain assessments as well as qualified individuals to conduct the curriculum. We acknowledge that this posed a conflict of interest with potential bias in “teaching the assessment” during the curriculum by the researcher. This referring to the researcher who is conducting the assessments being the same as the researcher conducting the curriculum possibly leading to inflated scores as a product of that researcher gearing things towards doing the assessments correctly rather than just delivering the curriculum as designed. Additionally, there was also potential bias in assessment with the same researcher who designed the curriculum being the one who evaluated its impact. This aspect creates a bias to perceive that the curriculum performed better than it actually did based on the researcher who designed it having the desire for the curriculum to have been successful in its application.

COVID-19 played one of the largest roles in limitations of the current study. The shutdown/move to virtual delivery of many schools for safety of the children made it impossible to do any initial pilot testing of methodology and curriculum design within populations and sites for the current study. Even when schools started to convene in person again almost all preschool locations were not allowing access to the children for research purposes (the one who did is included in the current study) given their increased risk and lack of vaccine at the time for children under the age of 5. These factors greatly impacted preparation/design and ultimately lead to a smaller sample size than was the initial aim of the current study.

Another limitation was the time of year and weather that the duration of the program took place in. The time of year (Summer 2022) provided difficult challenges with federal holidays and families of some participants taking vacations more often during this time of year than they typically would in the Fall or Spring. Additionally, the summer weather posed its own unique

challenges. These factors stretched what was an initially designed to be a 6-week program to an 8 week program which may have played a role in differences in finding observed in more condensed programs (e.g. 3-5 days a week over 5 weeks for example). Attendance for the total duration of the curriculum was 74.68%. At least one day was rescheduled due to a heat index into the triple digits by early in the day and many other days it was necessary to account for the high heat index as all lessons were conducted outside. This included scheduling lessons as early in the day as possible, incorporating water breaks when necessary, and taking into account shading of the environment to name a few.

Conclusion/future directions

The findings of this study in combination with both its strengths and weaknesses provide potential considerations for future research in the area. Future studies, however, should consider several factors as the field moves forward with exploration of the dynamics between these variables. In program design, researchers should consider longer durations like that of Apache (2005), Cliff et al. (2007), Goodway and Branta (2003), and Valentini and Rudisill (2004a and 2004b), especially when taking into account the added element of what may be a higher necessary threshold for impact in cognitive variables. Additionally, a mastery approach, if feasible, like that Cliff et al. (2007), Martin et al. (2009), and Valentini and Rudisill (2004a and 2004b), should be considered given their findings of a greater impact on motor skill development improvement of that of a direct instruction approach. The environment may also be an important consideration as it is frequently in the field. Shielding from the elements (heat, rain, etc.) as well as adequate space and appropriate terrain should all be at the forefront of study and program design. Other factors to consider include a more balanced and diverse sample size as well as where the sample are developmentally at onset of the study. Additionally, Though Dynamic

Systems Theory was present in consideration when designing the program in this study it could be used to further tailor not only the design of the program but the way in which data is collected and analyzed to truly understand how components such as emergence/soft-assembly/non-linearity, stability and timescales. Specifically, using Dynamic Systems Theory to try and better understand minimum program thresholds for frequency to elicit stability, nature of introduction of skills that are not “hard-wired” into the system, and dynamic of timescales in development of motor skills and cognitive aspects of self-regulation.

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APPENDIX

Appendix A

Forms & Letters

IRB Approval Letter

March 31, 2022

Dawn Podulka Coe, Ph.D.

UTK - Coll of Education, Hlth, & Human - Kinesiology Recreation & Sport Studies

Re: UTK IRB-22-06846-XP

Study Title: Effects of a Movement-based Curriculum on the Motor and Cognitive Development of Preschool-aged Children

Dear Dawn Podulka Coe:

The UTK Institutional Review Board (IRB) reviewed your application for the above referenced project. It determined that your application is eligible for expedited review under 45 CFR 46.110(b)(1), Categories 4, 6, and 7. The IRB has reviewed these materials and determined that they do comply with proper consideration for the rights and welfare of human subjects and the regulatory requirements for the protection of human subjects.

Therefore, this letter constitutes full approval by the IRB of your application (version 1.1) as submitted, including the following documents that have been dated and stamped IRB approved:

- Parental Permission Form v 2.0
- Parent Letter v 1.0
- Assent Script- Control Group v 1.0
- Assent Script-Experimental Group v 1.0
- Letter of Support A Wood v 1.0- acknowledged
- APPROVED-20211227-70001- Program for Minors v 1.0- acknowledged
- Intervention Plans v 1.0
- Early Years Toolbox Assessment v 1.0
- DataSheet v 1.0
- Perceived Competence and Enjoyment Scale v 1.0
- TGMD3 v1.0

You are approved to enroll a maximum of 54 participants. Approval of this study will be valid from March 31, 2022 to 03/30/2023.

Any revisions in the approved application, consent forms, instruments, recruitment materials, etc., must also be submitted to and approved by the IRB prior to implementation. In addition,

Institutional Review Board | Office of Research & Engagement
1534 White Avenue Knoxville, TN 37996-1529
865-974-7697 865-974-7400 fax irb@utk.edu

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you are responsible for reporting any unanticipated serious adverse events or other problems involving risks to subjects or others in the manner required by the local IRB policy.

Finally, re-approval of your project is required by the IRB in accord with the conditions specified above. You may not continue the research study beyond the time or other limits specified unless you obtain prior written approval of the IRB.

Sincerely,



Lora Beebe, Ph.D., PMHNP-BC, FAAN
Chair

Permission for Child to Take Part in a Research Study

Title: *Effects of a Movement-based Curriculum on the Motor and Cognitive Development of Preschool-aged Children*

Researchers: Dawn P. Coe, Ph.D., The University of Tennessee, Knoxville
Aaron P. Wood, M.S., The University of Tennessee, Knoxville

Your permission is requested for your child to take part in a research study. This consent form explains the purpose and requirements of the study. Please read this form carefully. You will be given a chance to ask questions. If you decide to permit your child to be in the study, you will be given a copy of this form.

If you do not permit your child to take part in the study, it will not affect your child's rights to care or services. If you do permit your child to take part, you are also free to remove your child from this study at any time without penalty.

Why is my child being asked to be in this research study?

We are asking your child to be in this research study because your child is enrolled in a preschool classroom at the Early Learning Center for Research and Practice. The participants will be split into one of two groups, experimental or control, meaning your child will be assigned to either the control group and complete assessments or the experimental group and complete the movement-based curriculum plus assessments.

What is this research study about?

The primary objective of this study is to investigate the impact of a movement-based curriculum designed to facilitate improvements in motor skills and cognitive development.

How long will the study last?

Your child's participation will last for 10 weeks [6-8 weeks for curriculum, 2-4 weeks for pre and post-assessments; experimental group] or 2-4 weeks for assessments (control group) during normal school hours when they would engage in regularly scheduled outdoor time. The total time of involvement in the study is approximately 750 minutes (12.5 hours) for the experimental group and 150 minutes (2.5 hours) for the control group.

How long will my child be in the research study?

The total time of involvement in the study is approximately 750 minutes (12.5 hours) over the course of 10 weeks for the experimental group and 150 minutes (2.5 hours) for the control group. Your child's height and weight will also be measured (~3 min) at the beginning of the study (experimental and control groups). Assessments of fundamental motor skill (~35 min to complete) and cognition (4 assessments taking ~9 min each to complete) will be conducted during Weeks 1-2 and 9-10 (experimental and control groups). Assessments that will take place during the application of the movement-based curriculum include assessments of enjoyment and perceived competence after participation in each lesson twice a week over the 6-8-week

curriculum period (~2 minutes per assessment; experimental group only). All data will be collected at the Early Learning Center (ELC) location where your child is enrolled.

- Week 1-2 (experimental and control groups): Height and weight assessment (~3 minutes), fundamental motor skill assessment (~35 minutes), and cognitive assessments (~35 minutes).
- Weeks 3 – 8* (experimental group only): Curriculum participation 2 days per week for 60 minutes each day (enjoyment and perceived competence assessments will be completed as part of this time period (~120 minutes per week for a total of 600 minutes)
- Week 9-10 (experimental and control groups): Fundamental motor skill assessment (~35 minutes) and cognitive assessments (~35 minutes).

* It is the goal of the program to run in two 60-minute curriculum sessions per week over 6 weeks to total approximately 600 minutes. However, there may be weeks when only one session may be completed due to weather or classroom changes, so the program will range from 6-8 weeks.

What will happen if I say “Yes, I want my child to be in this research study?”

During the study, your child will be assessed on multiple days during Weeks 1-2 and 9-10 at the ELC. Assessments will vary in duration. Fundamental motor skill assessment will take approximately 35 min to complete. Four cognition assessments (~9 min each) will take approximately 35 min to complete over multiple days. Your child’s fundamental motor skills will be assessed through participation in the Test of Gross Motor Development. This test consists of assessments of gross motor skills (running, hopping, leaping, galloping, sliding, horizontal jump, catching a ball, throwing a ball, underhand rolling a ball, striking a ball, stationary dribbling a ball, and kicking a ball). After a demonstration by the researcher, your child will complete each of these activities two times.

Your child will also complete four (4) tasks to assess cognition. All of these assessments will take place on separate days and will last no longer than 9 minutes each, with your child spending approximately 35 minutes in total on these assessments. These tasks will resemble interactive games that will be completed on the iPad.

During the movement-based curriculum (experimental group only) your child’s enjoyment and perceived competence will be assessed after each lesson. Both of these assessments will be conducted via questionnaire using a 5-point Likert scale via a range of emoji-like faces displaying a range of expressions from sad to happy to reflect responses ranging from “not at all true” to “very true” referred to as a smileyometer.

Your child will then participate in the movement-based curriculum (experimental group only) taking place in lesson form twice per week for 60 minutes each day over a 6-8-week period. Each lesson will consist of a warm-up (2-5 min), instruction and practice (3-5 min and 20-25 min, respectively), application (10-15 min), and cool-down (5-10 min). Specifically, the instruction and practice portion of the lesson will consist of 6 fundamental motor skills including 3 locomotor motor skills (hop, horizontal jump, and slide) and 3 object control motor skills (two-handed catch, kick a stationary ball, and overhand throw). The application portion of the lesson will consist of a game including the fundamental motor skill covered in the instruction and practice as well as

elements intended to benefit cognitive development. Following the game there will be a cool-down (10-15 min) to end the lesson.

During the curriculum sessions (experimental group only), the researchers will video-record your child. This recording will be completed to observe and review activity and context during the sessions.

What will happen if I say “No, I do not want my child to be in this research study?”

Your child's being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your relationship with the Early Learning Center for Research and Practice/The University of Tennessee, Knoxville or the services your family receives.

What happens if I say “Yes” but change my mind later?

Even if you decide to allow your child to be in the study now, you can change your mind and stop at any time. If you decide to stop before the study is completed, please email Dr. Dawn Coe (dcoe@utk.edu).

Are there any possible risks to my child?

There is relatively little risk to the children in this study. Risks associated with the study are minimal and considered to be equivalent to the risks that the children normally face when they are active while performing physical activity. Some of the tests may lead to leg cramps, falling, and muscle sprain/strain.

All of these investigators are CPR certified in case of an emergency. The children will be told to let the investigators know if they feel anything abnormal (i.e., injury, joint pain, soreness, etc.).

Are there benefits to my child for taking part in the study?

If your child is in the experimental group, your child will benefit from receiving a high quality movement and /or physical activity program designed to enhance motor skill development and self-regulation. Although, the highest quality instruction will be provided, there is no guarantee that your child will receive any or all benefits. There are no direct benefits to children in the control group.

Who can see the information collected for this research study?

We will protect the confidentiality of your child's information by keeping the data private and data will be kept in a confidential file in a locked cabinet in a locked University of Tennessee laboratory office. There will be ID numbers created and a key to the ID numbers for your child. The key will be kept separately from the ID numbers. The ID number and key with your child's information on it will be destroyed after the study is finished. Therefore, your child will not be identified in any reports.

If information from this study is published or presented at scientific meetings, your child's name and other personal information will not be used. We will make every effort to prevent anyone who is not on the research team from knowing that your child gave us information or what

information came from your child. Although it is unlikely, there are times when others may need to see the information we collect about your child. These include people at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly or if a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my child's information after this study is over?

We will keep your child's information and video-recordings to use for future research. Your child's name and other information that can directly identify them will be kept secure and stored separately from their research data collected as part of the study. We will not share your child's research data with other researchers. . Although, we will remove your child's name and other information about them collected as part of the study, it may be possible that your child will be recognized. We may share your child's video-recording with other researchers without asking for your permission again.

Will my child be paid for being in this research study?

Your child will not be paid for being in this study.

What will it cost me anything form my child to be in this research study?

It will not cost you anything for your child to be in this study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the researchers, Dr. Dawn Coe [dcoe@utk.edu; 865-972-0294].

For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board

The University of Tennessee, Knoxville

1534 White Avenue

Blount Hall, Room 408

Knoxville, TN 37996-1529

Phone: 865-974-7697

Email: utkirb@utk.edu

STATEMENT OF PERMISSION

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am giving permission for my child to be in this study. I will receive a copy of this document after I sign it.

Child's Name (printed) _____

Parent's Name (printed) _____

Parent's Signature _____ Date _____

Permission for use of images

I agree that [photographs/videorecordings](#) of my child may be created and analyzed for research purposes.

Parent's Signature _____ Date _____

Please provide the following information:

Child's Date of Birth: _____ Sex: ____ M

How do you identify your child (please check all that apply)?

- | | |
|---|---|
| ☐ Asian, Non-Hispanic | ☐ Native Hawaiian/Pacific Islander, Non-Hispanic |
| ☐ Asian, Hispanic | ☐ Native Hawaiian/Pacific Islander, Hispanic |
| ☐ Black/African American, Non-Hispanic | ☐ Native American/Alaskan, Non-Hispanic |
| ☐ Black/African American, Hispanic | ☐ Native American/Alaskan, Hispanic |
| ☐ White, Non-Hispanic | ☐ White, Hispanic |
| | ☐ Prefer not to answer |

February 23, 2022

Dear Parent/Guardian,

The purpose of this letter is to invite you to permit your child to participate in a research study entitled: *Effects of a Movement-based Curriculum on the Motor and Cognitive Development of Preschool-aged Children*. This study will be open to all children (ages 3 – 6 years) enrolled in the Early Learning Center for Research and Practice preschool and Kindergarten program. The specific details of the study are provided in the attached consent form. This study is being conducted by Dr. Dawn Coe, Ph.D., an associate professor in the Department of Kinesiology, Recreation, and Sport Studies and pediatric exercise physiologist and a research team. Please contact Dr. Coe with any questions concerning this study (phone: 865-974-0294, email: dcoe@utk.edu).

Thank you for your consideration.

Regards,

A handwritten signature in cursive script, appearing to read 'Dawn Coe'.

Dawn Coe, Ph.D., FACSM

Appendix B

Lesson Plans

Movement-based Curriculum Lesson Plan

Instructor _____

End Time _____

Motor Skill for Today: Hop		
Criteria	- Non-hopping leg swings forward in pendular fashion to produce force - Foot of non-hopping leg remains behind hopping leg (does not cross in front of) - Arms flex and swing forward to produce force - Hops four consecutive times on the preferred foot before stopping	
Equipment	Different Color Hula Hoops, Cones,	
Mastery Climate	Progressive amount of consecutive times hopping on each foot	
Teaching phrase	Swing raised leg forward, flex and swing arms forward, repeat	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor’s actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of swinging raised leg while staying stationary - Repetition of flexing and swinging arms while staying stationary- Repetition of completion of a singular hop		
Activities putting everything together 10-15 minutes.		
Game Play	Start Time	End Time
Finding color/figure circle game. Placing different circles on the ground that have a distinct color and figure on them and then instructing the children to find a circle by hopping based on the color and/or figure (bunny, boat, etc.)		
Find your group game. Kids have different color bean bags and hop to find other kids with the same color bean bags. (not sure about this one).		

Distance game where children are asked to hop to a specific distance marked by a cone. Progression of distance with moving the cone further away. Possibly different colored targets of varying distances and based on the cue to go to a color or “not that color” children hop to different target.

Motor Skill for Today: Horizontal Jump		
Criteria	- Prior to takeoff, both knees are flexed and arms are extended behind the back - Arms extend forcefully forward and upward, reaching above the head - Both feet come off the floor together and land together - Both arms are forced downward during landing	
Equipment	Different Color Hula Hoops, Cones,	
Mastery Climate	Vary distances	
Teaching phrase	Knees flexed and arms back, arms forward and up as you jump forward and land feet together	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor’s actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of flexing knees and extending arms back behind that back while stationary - Repetition of going through the motion of extending arms forward and up while stationary and not leaving feet - Repetition of completion of the horizontal jump resulting in the proper landing		
Activities putting everything together kicking to a target 10-15 minutes.		
Game Play	Start Time	End Time
A red-light green-light like game where instead of running to the desired finish line the kids horizontally jump.		
Finding color/figure circle game. Placing different circles on the ground that have a distinct color and figure on them and then instructing the children to find a circle by jumping based on the color and/or figure (bunny, boat, etc.)		
Distance game where children are asked to jump to a specific distance marked by a cone. Progression of distance with moving the cone further away. Possibly different colored targets of varying distances and based on the cue to go to a color or “not that color” children hop to different target.		

Motor Skill for Today: Slide

Criteria	- Body is turned sideways so shoulders remain aligned with the line on the floor - A step sideways with the lead foot followed by a slide with the trailing foot where both feet come off the surface briefly - Four continuous slides to the preferred side - Four continuous slides to the non-preferred side	
Equipment	Different Color Hula Hoops, Cones	
Mastery Climate	Progressive amount of continuous slides in preferred and non-preferred direction	
Teaching phrase	Everything sideways, step first with the foot closest to the direction you're going, slide the other foot to follow	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor's actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of turning and aligning sideways properly - Repetition of moving out lead foot in the intended direction of the slide and back to starting position - Repetition of adding the following of the trailing foot to complete the slide instead of returning to starting position - Repetition of completing multiple slides		
Activities putting everything together kicking to a target 10-15 minutes.		
Game Play	Start Time	End Time
A game where kids line up at a center point and slide to one side of the play area or the other based on a color or shape cue. Could be based on questions where their answers is one direction or the other.		
Could do something like a course/maze type deal where they need to slide through the course/maze to finish.		
Finding color/figure circle game. Placing different circles on the ground that have a distinct color and figure on them and then instructing the children to find a circle by sliding based on the color and/or figure (bunny, boat, etc.)		

Motor Skill for Today: Two-Hand Catch	
Criteria	- Child's hands are positioned in front of the body with the elbows flexed - Arms extend reaching for the ball as it arrives - Ball is caught by hands only
Equipment	Different Color Hula Hoops, Cones, Different Color Balls
Mastery Climate	Vary distances to target

Teaching phrase	Hands in front, elbows flexed, reaching for the ball, catch with your hands not your body	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor’s actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of going from unprepared (arms down) to prepared (hands in front with elbows flexed) - Repetition of going from elbows flexed position to reaching arms extended- Repetition of catching the ball with hands only		
Activities putting everything together kicking to a target 10-15 minutes.		
Game Play	Start Time	End Time
Scarf or balloon game where children throw up scarf/balloon and try and catch it using proper mechanics repeatedly.		
Group catch game where group of children circles around instructor. Circle can get bigger increasing distance for catches.		
Color game where they go to a different person to catch from based on whether instructor says to “Go to ... color” or “Go to a color that is not ...”		

Motor Skill for Today: Kick A Stationary Ball		
Criteria	- Rapid approach to ball - Elongated step prior to kick - On-kicking foot placed slightly behind the ball- kick with instep	
Equipment	Different Color Hula Hoops, Cones, Different Color Balls	
Mastery Climate	Vary distances to target	
Teaching phrase	Run up, plant foot, kick with instep	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor’s actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of approach to the ball - Repetition of the elongated step - Repetition of follow-through		
Activities putting everything together kicking to a target 10-15 minutes.		
Game Play	Start Time	End Time

General directional kicking game based on color. Game includes rules of kicking certain color balls to certain color targets and then those rules are switched later in the game.
Clean up game. Want to kick balls that are not team color out of team area while keeping the balls associated with their team.
Target practice game. Targets are set up and children try kicking at the target. Progression of backing up further away from the target after successfully kicking to it. Also could have color target and options for ball to kick of different color and involve that for self-regulation component.

Motor Skill for Today: Overhand Throw		
Criteria	- Windup is initiated with a downward movement of hand and arm - Rotates hip and shoulder to a point where the non-throwing side faces the wall - Steps with the foot opposite the throwing hand toward the wall - Throwing hand follows through after the ball release, across the body toward the hip of the non-throwing side	
Equipment	Different Color Hula Hoops, Cones, Different Color Balls	
Mastery Climate	Vary distances to target	
Teaching phrase	Windup, turn, step, and throw	
Warm Up & Instruction	Start Time	End Time
Warm Up – Kids will walk around the play area and do some dynamic stretch 5 min		
Instruction – step by step – kids mimic instructor’s actions as explanation takes place		
Practice	Start Time	End Time
- Repetition of windup with the downward movement of the hand and arm - Repetition of rotating hip and shoulder to the desired point - Repetition of the step opposite the throwing hand - Repetition of the process of the throw all the way to follow through (without ball or without releasing it)		
Activities putting everything together kicking to a target 10-15 minutes.		
Game Play	Start Time	End Time
Target practice game. Targets are set up and children try throwing at the target. Progression of backing up further away from the target after successfully hitting it with ball/bean bag.		
A game where corners represent different colors and kids are at the center with balls and throw to a corner based on color. Rule change could be “throw to a corner that is NOT Color”, etc.		
Distance game where children line up and try and manage the distance they are throwing the ball/bean bag based on the how far the instructor has said to throw (throw to this line, etc.)		

Appendix C

Data Collection Materials

Test of Gross Motor Development – Third Edition

Test of Gross Motor Development-Third Edition

TGMD-3

Examiner Record Form

Ages 3-0 to 10-11 Dale A. Ulrich

Section 1. Identifying Information

Name _____ Female ☐ Male ☐

Year _____ Month _____ Day _____ School _____

Date Tested _____ Preferred Hand: Right ☐ Left ☐ Not Established ☐

Date of Birth _____ Preferred Foot: Right ☐ Left ☐ Not Established ☐

Age* _____ Examiner's Name _____

Examiner's Title _____

*When accessing the normative tables, use years and months. Do not round up.

Section 2. Subtest Performance

Subtest	Raw Score	Age Equivalent	%ile Rank	Scaled Score	% Confidence Interval	Descriptive Term	Difference Between Scaled Scores
Locomotor	_____	_____	_____	+ []	_____ to _____	_____	☐ Not important ☐ Statistical 3 or above ☐ Clinical 6 or above
Ball Skills	_____	_____	_____	=	_____ to _____	_____	
Sum of Scaled Scores				[]			

Section 3. Composite Performance

	Sum of Scaled Scores	%ile Rank	Gross Motor Index	% Confidence Interval	Descriptive Term
Gross Motor	[]	_____	[]	_____ to _____	_____

Section 4. Descriptive Terms

Scaled Score	1-3	4-5	6-7	8-12	13-14	15-16	17-20
Descriptive Term	Impaired or Delayed	Borderline Impaired or Delayed	Below Average	Average	Above Average	Superior	Gifted or Very Advanced
Index Score	< 70	70-79	80-89	90-109	110-119	120-129	> 129

Section 5. Administration and Scoring Guidelines

- Directions for all test items require you to first give the child a good demonstration of the skill, which includes all of the performance criteria. Next, give the child a practice trial, followed by two trials that you score. If you are unsure of whether the child performed a performance criterion correctly, administer another trial, look at only that performance criterion, and score it.
- Score each performance criterion as:
 - 1 = performs correctly
 - 0 = does not perform correctly
- Performance criteria scores are calculated by summing the scores on Trial 1 and Trial 2 for each performance criterion.
- Skill Scores are calculated by summing all of the performance criteria scores for each skill.
- The Locomotor Total Raw Score is calculated by summing the 6 Locomotor Skill Scores.
- The Ball Skills Total Raw Score is calculated by summing the 7 Ball Skills Scores.

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2 3 4 5 6 7 8 9 10 28 27 26 25 24 23 22 21 20 19



14807

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Section 6. Record of Item Performance

Locomotor Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet (18.3 meters) of clear space to run, and two cones or markers	Place two cones 50 feet (15.2 meters) apart. Make sure there is at least 8–10 feet (2.4–3.1 meters) of space beyond the cone for a safe stopping distance. Tell the child to run fast from one cone to the other cone when you say, "Go." Repeat a second trial.	1. Arms move in opposition to legs with elbows bent 2. Brief period where both feet are off the surface 3. Narrow foot placement landing on heel or toes (not flat-footed) 4. Non-support leg bent about 90 degrees so foot is close to buttocks			
						Skill Score
2. Gallop	25 feet (7.6 meters) of clear space, and two cones or markers	Place two cones 25 feet apart. Tell the child to gallop from one cone to the other cone and stop. Repeat a second trial.	1. Arms flexed and swinging forward 2. A step forward with lead foot, followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot) 3. Brief period where both feet come off the surface 4. Maintains a rhythmic pattern for four consecutive gallops			
						Skill Score
3. Hop	A minimum of 15 feet (4.6 meters) of clear space, and two cones or markers	Place two cones 15 feet apart. Tell the child to hop four times on his or her preferred foot (established before testing). Repeat a second trial.	1. Non-hopping leg swings forward in pendular fashion to produce force 2. Foot of non-hopping leg remains behind hopping leg (does not cross in front of) 3. Arms flex and swing forward to produce force 4. Hops four consecutive times on the preferred foot before stopping			
						Skill Score
4. Skip	A minimum of 30 feet (9.1 meters) of clear space, and two cones or markers	Place two cones 30 feet apart. Mark off two lines at least 30 feet apart with cones/markers. Tell the child to skip from one cone to the other cone. Repeat a second trial.	1. A step forward followed by a hop on the same foot 2. Arms are flexed and move in opposition to legs to produce force 3. Completes four continuous rhythmical alternating skips			
						Skill Score
5. Horizontal jump	A minimum of 10 feet (3.1 meters) of clear space, and tape or markers	Mark off a starting line on the floor, mat, or carpet. Position the child behind the line. Tell the child to jump far. Repeat a second trial.	1. Prior to takeoff, both knees are flexed and arms are extended behind the back 2. Arms extend forcefully forward and upward, reaching above the head 3. Both feet come off the floor together and land together 4. Both arms are forced downward during landing			
						Skill Score
6. Slide	A minimum of 25 feet (7.6 meters) of clear space, a straight line, and two cones or markers	Place two cones 25 feet apart on a straight line. Tell the child to slide from one cone to the other cone. Let the child decide which direction to slide in first. Ask the child to slide back to the starting point. Repeat a second trial.	1. Body is turned sideways so shoulders remain aligned with the line on the floor (score on preferred side only) 2. A step sideways with the lead foot followed by a slide with the trailing foot where both feet come off the surface briefly (score on preferred side only) 3. Four continuous slides to the preferred side 4. Four continuous slides to the non-preferred side			
						Skill Score
						Locomotor Total Raw Score

Section 6. Record of Item Performance

Locomotor Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet (18.3 meters) of clear space to run, and two cones or markers	Place two cones 50 feet (15.2 meters) apart. Make sure there is at least 8–10 feet (2.4–3.1 meters) of space beyond the cone for a safe stopping distance. Tell the child to run fast from one cone to the other cone when you say, "Go." Repeat a second trial.	1. Arms move in opposition to legs with elbows bent 2. Brief period where both feet are off the surface 3. Narrow foot placement landing on heel or toes (not flat-footed) 4. Non-support leg bent about 90 degrees so foot is close to buttocks			
				Skill Score		
2. Gallop	25 feet (7.6 meters) of clear space, and two cones or markers	Place two cones 25 feet apart. Tell the child to gallop from one cone to the other cone and stop. Repeat a second trial.	1. Arms flexed and swinging forward 2. A step forward with lead foot, followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot) 3. Brief period where both feet come off the surface 4. Maintains a rhythmic pattern for four consecutive gallops			
				Skill Score		
3. Hop	A minimum of 15 feet (4.6 meters) of clear space, and two cones or markers	Place two cones 15 feet apart. Tell the child to hop four times on his or her preferred foot (established before testing). Repeat a second trial.	1. Non-hopping leg swings forward in pendular fashion to produce force 2. Foot of non-hopping leg remains behind hopping leg (does not cross in front of) 3. Arms flex and swing forward to produce force 4. Hops four consecutive times on the preferred foot before stopping			
				Skill Score		
4. Skip	A minimum of 30 feet (9.1 meters) of clear space, and two cones or markers	Place two cones 30 feet apart. Mark off two lines at least 30 feet apart with cones/markers. Tell the child to skip from one cone to the other cone. Repeat a second trial.	1. A step forward followed by a hop on the same foot 2. Arms are flexed and move in opposition to legs to produce force 3. Completes four continuous rhythmical alternating skips			
				Skill Score		
5. Horizontal jump	A minimum of 10 feet (3.1 meters) of clear space, and tape or markers	Mark off a starting line on the floor, mat, or carpet. Position the child behind the line. Tell the child to jump far. Repeat a second trial.	1. Prior to takeoff, both knees are flexed and arms are extended behind the back 2. Arms extend forcefully forward and upward, reaching above the head 3. Both feet come off the floor together and land together 4. Both arms are forced downward during landing			
				Skill Score		
6. Slide	A minimum of 25 feet (7.6 meters) of clear space, a straight line, and two cones or markers	Place two cones 25 feet apart on a straight line. Tell the child to slide from one cone to the other cone. Let the child decide which direction to slide in first. Ask the child to slide back to the starting point. Repeat a second trial.	1. Body is turned sideways so shoulders remain aligned with the line on the floor (score on preferred side only) 2. A step sideways with the lead foot followed by a slide with the trailing foot where both feet come off the surface briefly (score on preferred side only) 3. Four continuous slides to the preferred side 4. Four continuous slides to the non-preferred side			
				Skill Score		
				Locomotor Total Raw Score		

Ball Skills Subtest

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Two-hand strike of a stationary ball	A 4-inch (10.2-centimeter) plastic ball, a plastic bat, and a batting tee or other device to hold ball stationary	Place ball on batting tee at child's waist level. Tell child to hit the ball hard, straight ahead. Point straight ahead. Repeat a second trial.	1. Child's preferred hand grips bat above non-preferred hand 2. Child's non-preferred hip/shoulder faces straight ahead 3. Hip and shoulder rotate and derotate during swing 4. Steps with non-preferred foot 5. Hits ball, sending it straight ahead			
				Skill Score		
2. One-hand forehand strike of self-bounced ball	A tennis ball, a light plastic paddle, and a wall	Hold the plastic paddle and ball to child. Tell child to hold ball up and drop it (so it bounces about waist height); off the bounce, hit the ball toward the wall. Point toward the wall. Repeat a second trial.	1. Child takes a backswing with the paddle when the ball is bounced 2. Steps with non-preferred foot 3. Strikes the ball toward the wall 4. Paddle follows through toward non-preferred shoulder			
				Skill Score		
3. One-hand stationary dribble	An 8–10-inch (20.3–25.4-centimeter) playground ball for ages 3–5 years, a basketball for ages 6–10 years, and a flat surface	Tell the child to bounce the ball using one hand, at least four times consecutively without moving his or her feet, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand at about waist level 2. Pushes the ball with fingertips (not slapping at ball) 3. Maintains control of the ball for at least four consecutive bounces without moving the feet to retrieve the ball			
				Skill Score		
4. Two-hand catch	A 4-inch (10.2-centimeter) plastic ball, 15 feet (4.6 meters) of clear space, and tape or a marker	Mark off two lines 15 feet apart. The child stands on one line, and the tosser stands on the other line. Toss the ball underhand to the child, aiming at the child's chest area. Tell the child to catch the ball with two hands. Count only trials in which toss is near child's chest. Repeat a second trial.	1. Child's hands are positioned in front of the body with the elbows flexed 2. Arms extend reaching for the ball as it arrives 3. Ball is caught by hands only			
				Skill Score		
5. Kick a stationary ball	An 8–10-inch (20.3–25.4-centimeters) plastic, playground, or soccer ball; tape or a marker; a wall; and clear space for kicking	Mark off one line about 20 feet (6.1 meters) from the wall and a second line 8 feet (2.4 meters) beyond the first line. Place the ball on the first line closest to the wall. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid, continuous approach to the ball 2. Child takes an elongated stride or leap just prior to ball contact 3. Non-kicking foot placed close to the ball 4. Kicks ball with instep or inside of preferred foot (not the toes)			
				Skill Score		

Appendix D

Perceived Competence and Enjoyment Scale

	 Not at all true	 Not very true	 Somewhat true	 True	 Very True
While I was working on this task I was thinking about how much I enjoyed it.					
I found doing this activity/game to be very interesting.					
Doing this activity/game was fun.					
I enjoyed doing this activity/game very much.					
I thought this activity/game was very boring.					
I thought doing activity/game was very interesting.					
I would describe this activity/game as very enjoyable.					
	 Not at all true	 Not very true	 Somewhat true	 True	 Very True
I think I am pretty good at this activity/game.					
I think I did pretty well at this activity/game, compared to others.					
I am satisfied with my performance on this activity/game.					

I felt pretty skilled at activity/game.					
After working at this activity/game for a while, I felt pretty competent.					

VITA

The author of this dissertation, Aaron P. Wood, is an Disabled U.S. Navy veteran originally from Cove City/New Bern North Carolina. After being injured in the navy Aaron started his academic journey at a local community college “Craven Community College.” From there he went to complete his Bachelor’s in Kinesiology with a concentration in Health Fitness Specialist at East Carolina University. After the completion of that degree, Aaron continued his academic path at East Carolina University completing his Master’s in Kinesiology with a concentration in Physical Activity Promotion under the guidance of Dr. Katrina DuBose. Aaron then started the last page of his educational journey going to the University of Tennessee, Knoxville to complete his PhD in Kinesiology, Recreation, and Sport Studies with a concentration in Kinesiology and specialization in Exercise Physiology. His research has followed the path of pediatric motor and cognitive development which he plans to continue his examination of throughout his career.