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The Effects of Cognitively Engaging Exercise on Children's Executive Functioning

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Abstract

This study examines the effect of combining vigorous exercise with cognitively engaging games on children's executive functioning skills such as self-direction, engagement, and focus. Over four weeks, the research took place in a Montessori early childhood classroom with 17 children ages 2.6 to 6. The four-week study included a one-week baseline week to collect initial data on the capabilities of self-direction and comprehensive data on energy levels and engagement. The children participated in a 14-minute movement activity with 7 minutes of vigorous exercise and 7 minutes of cognitive-engaging games. The researcher used both quantitative and qualitative data tools to examine the effects on children's ability to independently choose an activity, engage, and focus during the morning. The increased movement and cognitive exercise positively impacted children's executive functioning skills. Future recommendations would include extending the intervention to study further if productivity continued to increase as the children had more days to engage in the exercises. Based on the data gathered in this action research, I recommend that teachers provide an opportunity for children aged three to six to participate in a short morning gathering where they can engage in vigorous movement and a cognitively engaging game.

Keywords: executive functioning, self-regulation, engagement, focus, concentration, cognitive exercise, movement, vigorous exercise, Montessori, early childhood

Observation is critical in my field of work, and in the four years teaching young children in an early education environment, something has become glaringly evident: children have an innate need to move. This observation becomes even more apparent in February when temperatures hover around 20 degrees Fahrenheit on average, and we only receive about 5 hours of daylight every day. The children in my classroom want to run up and down the hallway or go outside to play, exhibiting a higher need to move their bodies and a lower ability to self-direct and engage.

By design, a Montessori classroom has both fine-motor and gross-motor movement opportunities built into the curriculum. In a typical Montessori classroom, children manipulate materials with their hands, whether washing a table, building a tower, or counting beads. Children also have opportunities to engage in small group movement games throughout the morning, which provides a meaningful way to move their bodies in significant ways. Yet, as previously mentioned, this does not seem to be sufficient in the winter months. Most mornings, children enter the classroom with a great deal of pent-up energy, and their need to move interferes with their executive functioning skills such as self-regulation, engagement, and focus, as they struggle to sit still.

Through research, I found various studies that correlated vigorous movement to classroom behavior, cognitive ability, and focus (Becker et al., 2013; Hill et al., 2010; Mahar et al., 2006; Savina, 2016; Tomporowski et al., 2015). In contrast, I only found a couple of studies that specifically used mindful movement (combining a cognitive element to movement and exercise) to increase children's cognitive functioning (Lakes & Hoyt, 2004; Shoval et al., 2017). As all studies had favorable outcomes, I wanted to take the research further by examining the

effect of combining vigorous exercise with cognitively engaging games on children's ability to self-direct, engage, and focus.

My study was conducted in a classroom of 17 children aged 2.5 to 6 during February when I decided that the children would most benefit from a movement-based intervention. The project examined the effects of aerobic exercise coupled with cognitively engaging games on children's ability to self-direct, engage, and focus. The four-week study included a one-week baseline week to collect initial data on the capabilities of self-direction as well as comprehensive data on energy levels and engagement. For the remaining three weeks, the children were invited to participate in a 14-minute movement activity, with 7 minutes of vigorous exercise and 7 minutes of cognitive-engaging games. The intervention was followed by the usual morning work period, when I examined the children's ability to independently choose an activity, engage, and focus.

Theoretical Framework

This study utilized the theory of psychomotor development, a concept that the human mind and body are united entities. Psychomotor development theory asserts that movement development provides children with the skills they need to interact with the world around them. Essentially, physical activity and movement drive a child's learning and development (Zoglowek & Aleksandrovich, 2016). A subtext to psychomotor theory is psychomotor therapy, which combines physical activities and cognitive awareness within an educational environment (Zoglowek & Aleksandrovich, 2016). The psychomotor approach aligns with Maria Montessori's theory that movement enhances cognitive learning (Lillard, 2007). Montessori (1967) states, "Watching a child makes it obvious that the development of his mind comes about through his movements…mind and movement are part of the same entity" (p. 142). Montessori, driven by

her observations, asserted that any given action which occurs relates to the mental activity going on.

Observations in the researcher's primary classroom revealed children wanting more opportunities for larger and more complex movement opportunities. This need for more movement seemed more prevalent in Alaska's cold, dark winter months, where the researcher's classroom is located. In mornings when gross motor movement did not occur, the researcher observed that the children were less likely to independently choose work, engage and focus. Through the psychomotor lens (Zoglowek & Aleksandrovich, 2016; Lillard, 2007; Montessori & Claremont, 1967) the researcher offered children movement activities and games that challenged them physically and cognitively. The researcher theorized that during the mornings of increased physical and mental activities, she would see a higher rate of self-directed choice, engagement and focus.

Through the psychomotor lens, the following literature review will highlight past research conducted on ways that body and mind are connected, specifically through movement and games that require cognitive thinking. The literature review also looked at studies that explored movement interventions in primary aged classrooms, and the effects these interventions had on children's executive functioning, cognition, and learning.

Literature Review

The purpose of this action research project is to explore the effects of aerobic exercise coupled with cognitively engaging games on children's inhibitory control functions such as self-regulation (the ability to choose independently) and engagement. The literature review investigated past research on the brain, including information on how executive function and engagement affect classroom behaviors. In addition, this section explores brain physiology and

how aerobic exercise affects executive functions and learning, and revisits Maria Montessori and her theories on movement and cognition. The literature review also explores past studies conducted on structured play and mindful movement interventions. This section is organized under the following categories: executive functioning and classroom behavior; movement and aerobic exercise: the effects on brain physiology, cognition, and learning; and structured play and mindful movement interventions.

Executive Functioning and Classroom Behavior

The term Executive Functions (EF) refers to a diverse group of cognitive processes located in the brain's pre-frontal cortex that act in a coordinated way to direct perception, emotion, thought, and action (McCloskey, 2011). There is a general agreement that there are three core EFs: inhibitory control, working memory, and cognitive flexibility (Diamond, 2012). Self-regulation involves a complex interaction between inhibitory control, working memory, cognitive flexibility, actions linked to movement, the body, and cognition (Becker et al., 2014). Children with developed self-regulation skills will display a solid ability to self-direct, engage, and concentrate (Diamond, 2010). Research has shown that even when only a couple of children have underdeveloped EF abilities, an entire classroom can become chaotic, diverting time away from essential learning activities (Building the Brain's Air Traffic Control Center, 2011). In addition, children that exhibit poor executive functions tend to hold negative self-perceptions as students because they have trouble paying attention, inhibiting impulsive behavior, and completing tasks, causing discord between themselves and their teachers (Blair & Diamond, 2008).

Most educational researchers agree that engagement is multidimensional in nature and is composed of three aspects: behavioral engagement, cognitive engagement, and emotional

engagement. Behavioral engagement includes the child's abilities to persist despite failure or distraction (i.e., repeating a task to completion or self-satisfaction). Children that possess strong cognitive engagement have the allocation of attentional resources and effort that is needed to master difficult skills, or in other words, the child can concentrate on a task for any given amount of time. Emotional engagement is defined as children's positive or negative reactions to teachers' presumptions of students' pleasure, happiness, withdrawal, sadness, and anxiety (Tomporowski et al., 2014). Diamond and Blair (2008) arrive at similar conclusions that classroom behavior partly relies on teacher perceptions of the child. Children who have better behavioral, cognitive, and emotional engagement are praised for good behavior, enjoy school more, and want to spend more time on schoolwork. They go on to say, "Teachers come to expect good self-control and good work from them, and the children come to hold more positive self-perceptions of themselves as students" (p. 906). Namely, children that possess higher-order executive functioning will perform better both cognitively and emotionally in a school setting. Self-directed learning and concentration are skills that will contribute to a child's school success, giving the child a sense of individual agency, or in other words, that they are an effective, capable learner (Blair & Diamond, 2008).

As this study aimed to utilize physical exercise and cognitive activities to promote improved self-regulation and engagement in children aged 3 to 6 years old in a Montessori classroom, the next section will discuss how movement and exercise specifically affect brain cognition and learning physiology.

Movement and Aerobic Exercise: Effects on Brain Physiology, Cognition, and Learning

One of the driving principles behind Montessori pedagogy is that movement and cognition are closely entwined, and movement can enhance thinking and learning (Lillard,

2007). If one were to step into a primary Montessori classroom, they would see this theory in action. One might see a child moving their body around an ellipse-shape taped to the floor of the classroom, or another child vigorously scrubbing a table, or two children working together to fold laundry. In a Montessori environment, children are encouraged to interact with materials and their environment by using purposeful movement, meaning the child will employ their body in the service of the mind to fulfill a meaningful goal (Lillard, 2007). Additionally, each time the child engages in a task and entirely focuses their attention on the motions required to complete it, their ability to concentrate increases (Woods, 2000). Montessori (2012) asserted that the development of movement is essential to the child's development, further stating, "Coordinated movement must be involved with something great and must be directly connected to the brain and intelligence" (p.159). Fuchs (2015) found that given the opportunity, children would frequently choose movement materials that provide purposeful movement practice. By incorporating gross-motor materials onto shelves, such as balancing and jumping over a rope or use of balance boards, children can practice fine-motor control and gross motor coordination. By incorporating pedagogically sound gross-motor materials into the curriculum, children will develop rudimentary stability and balance, control of the body, and in addition, absorb knowledge, personality, and character (Fuchs, 2015).

Evidence has shown that physical activity enhances brain functioning through increased oxygen and neural firing that facilitates better cognitive functioning, meaning our mind works better when we are physically fit (Savina et al., 2016; Diamond, 2010). Several studies have examined the effects of acute and chronic exercise, and overall fitness levels on executive functioning and the physiological changes in the brain. Best (2010) claimed various types of physical movement affect multiple capacities of the brain. For example, when children engage

in chronic exercise, performing exercises for several weeks, learning and memory are greatly improved. Acute exercise, a single bout of vigorous movement, in turn, has immediate neurochemical effects, causing arousal, essentially priming the child for learning. Tomporowski et al. (2014) found similar evidence, claiming chronic exercise training can correct executive functioning in children, whereas acute bouts of exercise can alter children's attention, processing speed, and executive control. Savina et al. (2016) found that even jogging at a moderate intensity for 30 minutes can improve inhibition, working memory, and attention in preadolescent children.

Three similar studies gauged exercise and executive function such as attention and concentration within children. A survey conducted by Mahar et al. (2006) researched the effects of physical exercise on children's on-task behavior. The study involved 200 students at a public school in eastern North Carolina, where teachers led a 10-minute activity per day, including jumping jacks and marching in place for 12 weeks, titled Energizers. The goal of this intervention was to increase daily physical activity levels during the academic school day and then immediately study the effects on engagement and concentration. On-task behavior was assessed for 30 minutes immediately before the intervention and 30 minutes immediately after the intervention. The study concluded after the Energizers activities were systematically implemented into the classrooms on-task behavior improved. Teachers also indicated improvements in classroom behavior, although a limitation to this finding may have been teacher bias in rating classroom behavior (p. 2092).

A similar study conducted by Hill et al. (2010) investigated whether increased physical exercise during the school day influenced subsequent cognitive performance in children. This examination included a sample size of 1,224 students located in northeast Scotland. It used a

crossover, counterbalanced within-participant study design that controlled all factors other than age and classroom physical exercise. The children completed stretching and aerobic exercises, lasting 10 to 15 minutes while standing behind their desks. The regimen incorporated movements such as running in place and hopping sequences to music and were intended to be moderately intensive for the average student. In this study, the mean of overall performance showed gains in cognitive functioning across the 2-week intervention.

Finally, a study conducted by Becker et al. (2014) focused on gauging active play, which incorporated movement at a moderate to vigorous intensity. In this intervention, an accelerometer which is designed to detect vertical accelerations was attached to each child's right hip via an adjustable elastic belt to survey the amount and intensity of the child's activity during outside recess. After the children engaged in active play, the researchers administered a Head-Toes-Knees-Shoulders task (HTKS) to gauge levels of self-regulation. The results concluded a direct effect between active play and performance on HTKS, with higher levels of active play predicting better self-regulation.

Structured Play and Mindful Movement Interventions: Effects on Self-Regulation and Engagement

The research thus far is distinct- movement, exercise, and active play are proven to aid in self-regulation and engagement. Yet many of the studies previously highlighted only applied exercise and movement to study children's cognition. There is also growing research to investigate the effects of learning and cognition using structured play and mindful movement interventions (Shoval et al., 2017; Lakes & Hoyt, 2004).

One study conducted by Shoval et al. (2017) compared children who participated in mindful movement activities (MM) vs. movement for its own sake (MS) activities. The MM group participated in activities that incorporated movement coupled with cognitively engaging games such as: having children balance on wooden blocks in the shape of letters, encouraging the children to provide verbal movement directions to their peers, and adding objects to an obstacle course. In contrast, methods for creating a learning environment for the MS group included having outdoor playground facilities and providing small objects such as balls, loops, and rings indoors. They found that the children exposed to MM attained a significantly higher level of cognitive gains than the children who participated in the MS group (p. 362). Lakes and Hoyt (2004) received similar results when they employed a traditional martial arts program in an environment that emphasized respect and self-control, administered in place of conventional PE classes to elementary-aged children. The 3-month program involved martial arts instruction on blocks, kicks, etc., as well as mindful questions aimed at promoting self-awareness. At the end of the study, compared to the children in traditional PE classes, those in the martial arts program showed improved cognitive and affective self-regulation and classroom conduct (Tomporowski et al., 2014). These two studies demonstrated that exercise alone may be less effective than if schools aim to incorporate movement and cognitively engaging games.

In summary, research shows that movement, including acute and chronic exercise, fine motor, and gross motor, will enhance executive function and learning. In addition, research shows that movement and cognition are interrelated, and movement curriculum is valuable to managing classroom behavior, higher-order cognitive functioning, and academic gains. Yet finding the right recipe to support the child's cognitive development entirely is the task at hand.

This literature review concludes that future research is needed to combine vigorous exercise with cognitively engaging games to improve self-regulation and engagement in children aged 3 to 6.

Methodology

During a span of four weeks, I conducted an action research project intended to investigate the effects of coupling aerobic exercise with cognitively engaging games on primary-aged children's ability to self-direct and engage. The population for the study was a group of 17 children enrolled in a Montessori school in Alaska. The class was composed of thirteen girls and four boys whose ages ranged from 2.6 to 6 years. All students were enrolled full days, five days a week. Parents of students were given passive consent forms in advance of the research, and all parents chose to allow their children's data to be included. The four-week study included: one week of baseline data collection, when children only participated in a short non-movement gathering, and three weeks of the movement intervention when children participated in 15 minutes of movement each morning.

During the four-week intervention, children arrived at school between 8:00 am, and 8:45 am each morning. After each child was present, I asked them to either pause or put their activity away and join at the rug for a short gathering. During the baseline week, I invited children to choose an activity in the classroom after the gathering instead of providing the movement activities. During all three weeks of the movement intervention, after the gathering, we went to the Gross-Motor Room (GMR), a large room used in our school for children to play when the weather is too stormy to play outside. Once inside the GMR, children waited for the music to start, signaling the beginning of the intervention.

The first seven minutes of the movement intervention were used for aerobic exercise, during which I observed the children for signs of heavy breathing and fatigue. The children did the same movement-based exercise on all five days of the three-week period: Animal Themed HIIT (High-Intensity Interval Training) Workout, which promotes improvement of emotional regulation in just seven minutes. The children participated in seven rounds of 45 seconds of work, and 15 seconds of rest, moving like different animals. Movements included: frog jumps, bear walks, gorilla shuffles, starfish jumps, cheetah runs, crab walks, and elephant stops (descriptions included in Appendix E). I set an interval timer to ensure the proper protocol was followed. After the HIIT portion of the intervention, I invited the children to sit down in a circle on the floor and asked them to participate in one of these cognitive games.

- Catch the Ball
- Roll the Ball
- Bean-Bag Toss
- Tick-Tock
- Pass the Cup

After the game, the children played Red Light/Green Light or participated in an obstacle course (see Appendix E & F for movement schedule and descriptions). After roughly 15 minutes of aerobic and cognitive exercise, the children were then escorted back into the classroom and asked to choose their first activity for the day. I then began my data collecting process of the action research plan.

Data Collection

I used four data tools to collect information. On the first Monday of the baseline week, I utilized the Student Pre/Post Assessment Tool (Appendix A) that provided specific data on each child, including:

- The child's ability to choose (or not) choose an activity
- How the child organizes the activity
- Levels of concentration
- Their ability to sustain work
- Is the child self-directed, or is the child wandering frequently?

These assessments incorporated a Likert rating scale ranging from strongly disagree, disagree, neutral, agree, and strongly agree. On the last Friday of the 4-week intervention, I used the pre/post assessment again. Using this tool during the baseline week and then again at the end of the intervention, I was able to determine whether the child exhibited improvements in my research goals.

During all four weeks of the study (including the baseline week), within 15 minutes of the intervention, I utilized the Independent Choice Tally Sheet (Appendix B). This quantitative tool showed how many children independently chose work without the suggestion of an adult. I made sure to give the children a 15-minute window, so they had time to settle in.

The third tool I used was the Daily Observational Field Notes Sheet (Appendix D), a qualitative tool collecting data on the classroom's overall energy and engagement levels on the baseline week and the intervention days. By comparing my notes from the baseline week to intervention weeks, I determined if energy and engagement were calmer and more focused on

movement intervention days. I used this tool before I left school every day to ensure that my observations from the day remained fresh in my mind.

The last tool I used was the Behavioral/Participation Log (Appendix C). This qualitative tool helped provide information on specific students throughout the movement portion of the intervention, such as whether the child participated in the movement/cognitive games, whether the child independently chose a material, and whether the child exhibited signs of engagement. Other things noted: whether the child was unfocused and wandering; or if the child choose an activity but was not engaged in the material. I utilized a timer on my phone set to buzz in my apron not to disrupt the children every half-hour, observing the children four different times throughout the morning. I observed three or four children, depending on the day of the week, which included all children present by the end of each intervention week. A student ID number identified each child to keep student identity confidential. This tool helped determine the correlation between movement and independent choice/engagement. If the child did not choose to participate in the intervention, did it affect their ability to select and engage independently? This tool ensured that each child was considered in the study, which gave definitive results. All data tools are included in the appendix.

Analysis of Data

This study observed the effects of aerobic exercise coupled with cognitively engaging games on children's inhibitory control functions such as self-regulation (the ability to choose independently), engagement, and concentration. Data collection tools included a pre/post assessment, a classroom-wide independent choice tally, a daily behavior log used to observe for positive executive functioning characteristics in each child, and teacher field notes.

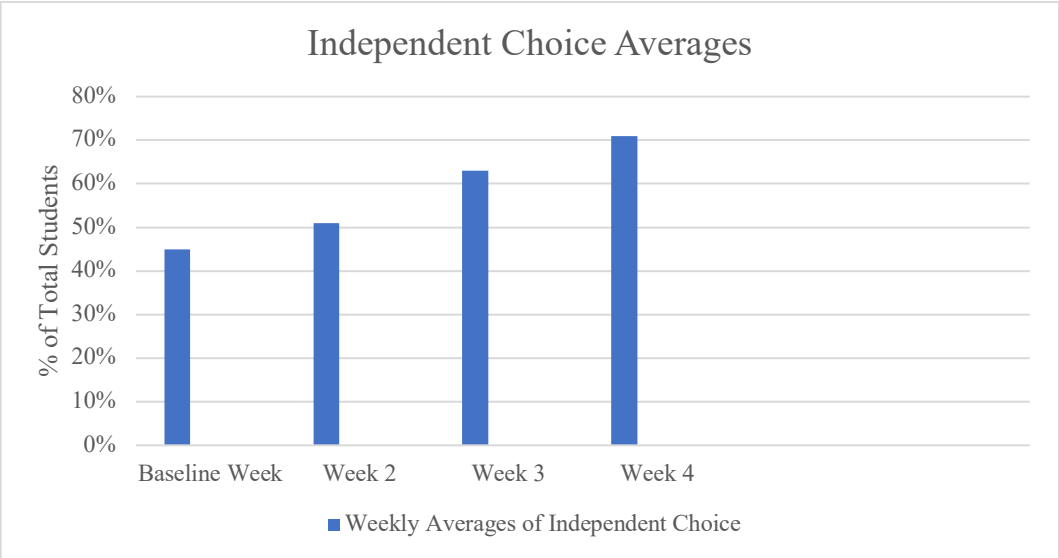
The population for the study was a group of 17 children enrolled in a Montessori school in Alaska. The class was composed of thirteen girls and four boys whose ages ranged from 2.6 to 6 years.

Self-Direction and Independent Choice

During the baseline week, the children were invited to join a morning gathering that did not utilize any movement. Children were then excused and observed within 15 minutes to see if they could choose a material or activity entirely on their own, without the suggestion of an adult. In weeks 2-4, the children were observed for independent choice within fifteen minutes after participating in the movement intervention, using the Independent Choice Tally Sheet (Appendix F). As depicted in Figure 1, the baseline week showed the lowest weekly average of 45%, compared to the last week of the study showing a high of 71% of students able to self-direct to a material or activity. This data only included children that chose a material or activity and did not include children that decided to have snack.

Figure 1

Independent Choice Averages



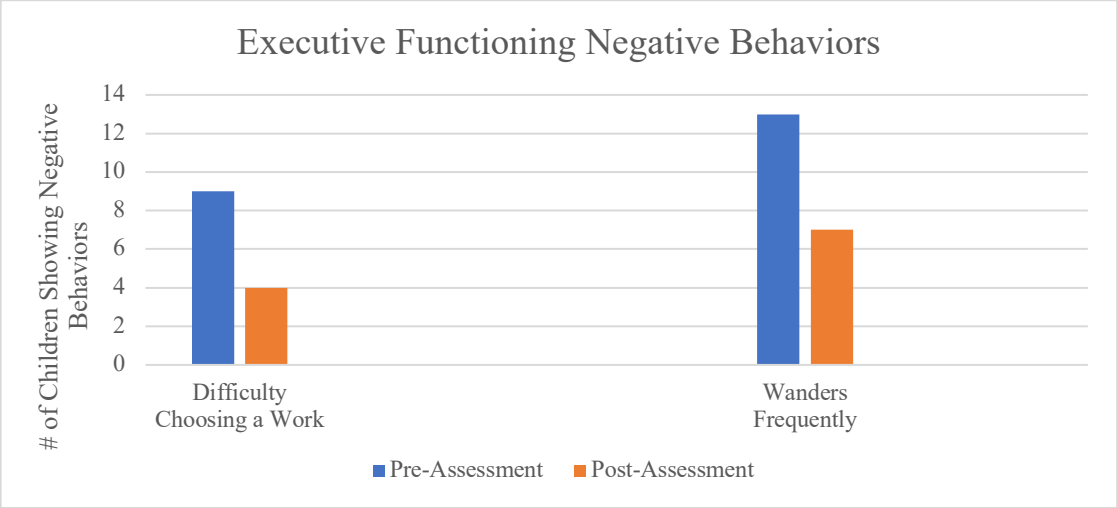
Note. This graph represents the weekly average of students that independently chose a material or activity within fifteen minutes after the intervention.

On the first and last day of the four-week study, I utilized a student pre/post assessment tool (Appendix A) which, using a Likert scale, assessed each child on specific behaviors applicable to executive functioning. Each child was evaluated before and after the study by the researcher on current executive functioning skills like concentration (focus) and their ability to self-regulate during the work cycle. The skills measured included: has difficulty choosing a work, organizes materials for effective work, concentrates well, sustains work, and wanders frequently. I tallied each question by adding the total number of children that scored responses such as "agree" and "strongly agree".

Figure 2 shows the children's lack of ability to self-regulate and make independent choices. Low self-regulation skills, in which children demonstrate inabilities to independently choose activities during the morning work cycle, are considered negative traits. The child should be able to independently choose a material, use it, put it away, and then select the next activity. The child with solid self-regulation skills will go through this cycle many times throughout the three-hour work cycle. A child that cannot choose and wanders frequently has low self-regulation skills. The results in Figure 2 show children had a lower incidence after the intervention by almost half of difficulty in choosing a material and wandering.

Figure 2

Executive Functioning Negative Behaviors



Note. The collection of data included in a pre/post-assessment, using a Likert scale, and reflects a decrease in negative executive functioning behaviors.

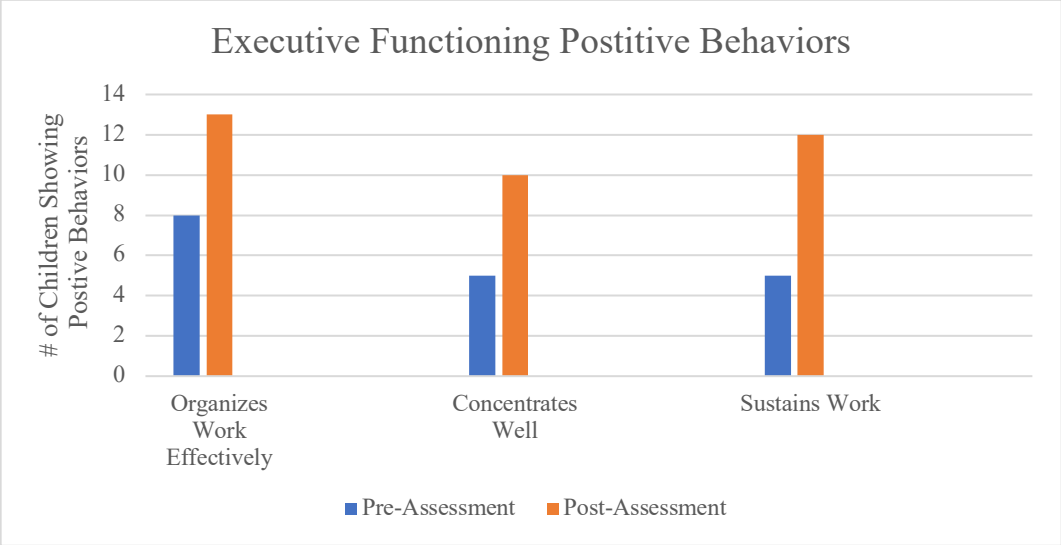
Engagement and Focus

Using the same student pre/post assessment tool which, using a Likert scale, assessed each child on specific behaviors applicable to executive functioning, I tallied each question by adding the total number of children that scored responses such as "agree" and "strongly agree" both before and after the four-week intervention. Figure 3 shows the number of children demonstrating behaviors indicating the child's ability to engage and concentrate. The data shows that children had a higher percentage of positive behaviors in each area after the intervention. The two areas associated with engagement which showed the most improvement, were the child's ability to effectively organize and sustain their work. I evaluated each child on their ability to "sustain work," meaning the child used an activity or material for an extended period, yet without necessarily achieving levels of concentration. For example, the child might have been "busy," but also talking or fidgeting. Additionally, I evaluated each child on their ability to

achieve a level of concentration, meaning the child had chosen a material, was physically engaged, had eyes towards material and limited movement, and wasn't talking. Focus, or the child's ability to concentrate, also had a higher percentage, yet not as high as the other two areas.

Figure 3

Executive Functioning Positive Behaviors



Note. The collection of data included in a pre/post-assessment, using a Likert scale, where each child's evaluating executive functioning behaviors such as engagement and focus were evaluated.

I observed three or four children, depending on the day of the week, using the Behavioral/Participation Log (Appendix C). It is important to note that this tool was only used during the movement portion of the study. During the morning work cycle, I set a timer, and for every 30 minutes, three times each morning, I stopped and observed the selected children for spontaneous signs of concentration and off-task behaviors. The behaviors mentioned are considered "spontaneous" because I only observed three times every morning, and not all children were observed each day. The child in question might have had many other incidences

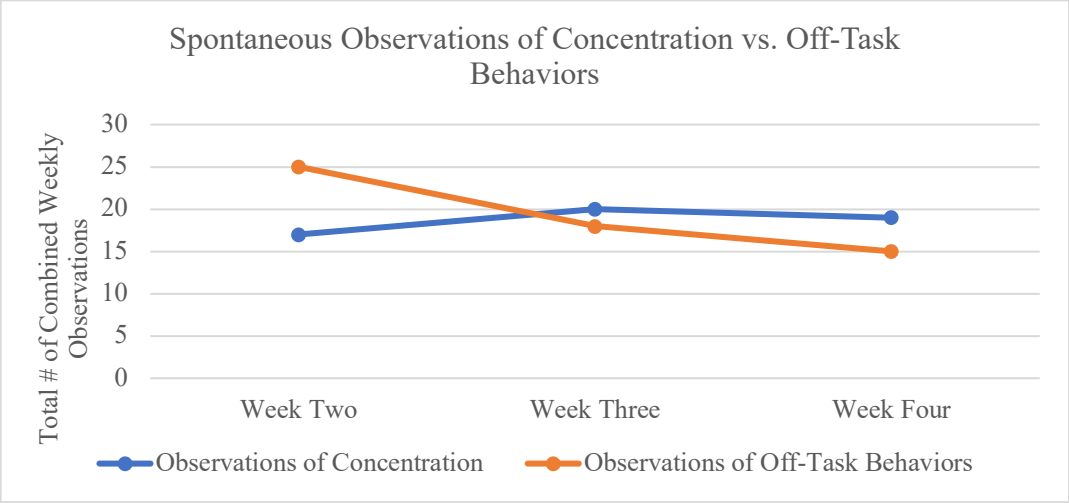
of positive or negative behaviors that I did not happen to observe, as I was otherwise engaged. Off-task behavior includes:

- Using a material but not engaged.
- Wandering away from their material.
- The inability to choose or engage at all.

All children were observed by the end of each week per the rotation. Figure 4 shows the tallied weekly incidences observed of children with a material in front of them and concentrating. It also reflects the tallied weekly incidences of children that were not on task, i.e., wandering. The data shows levels of concentration between weeks two and four and decreasing off-task behaviors. Signs of concentration sharply increased between week two and three and then evened out between week three and four. The graph shows off-task behaviors were highest on the first week of the movement intervention and then slowly decreased throughout weeks three and four.

Figure 4

Spontaneous Observations of Concentration vs. Off-Task Behaviors



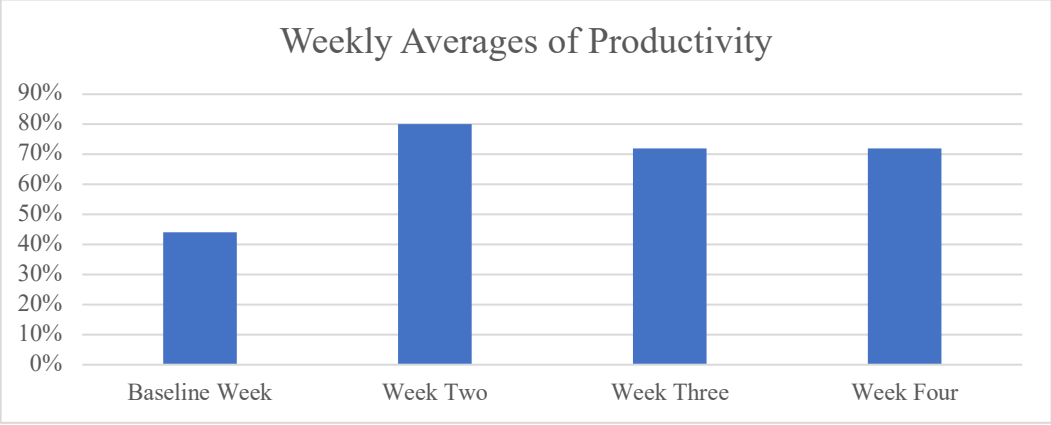
Note. The data from this line graph shows how many times the subjects exhibited signs of engagement and concentration vs. how many times the subjects participated in off task-behavior. This graph does not include the baseline week.

Productivity

Each day of the four-week intervention, I used my teacher field notes to rate the feel of the day on a 1-5 rating scale. Only mornings with a 4 or 5 rating were tallied. High productivity days included many children engaged in independent choice work and showing signs of concentration. Figure 5 shows that productivity only rated 44% during the baseline week and then increasing upward to 80% the first week of the movement intervention. In the last two weeks of the study, productivity evens out at 72%, still much higher than the baseline week. On the first Wednesday of the baseline week, I noted that the children were showing signs that more movement games were needed in my daily observational field notes, as the children had very high levels of energy, participating in a lot of rough and tumble play. This day was also rated a 3. On Wednesday of week two, the first week of the movement intervention and the highest-rated week for productivity, I noted that during the morning work cycle the children weren't asking to move on the line as much as they were during the baseline week. I observed two young children demonstrate intense concentration. This day was rated as a 4.

Figure 5

Weekly Averages of Productivity

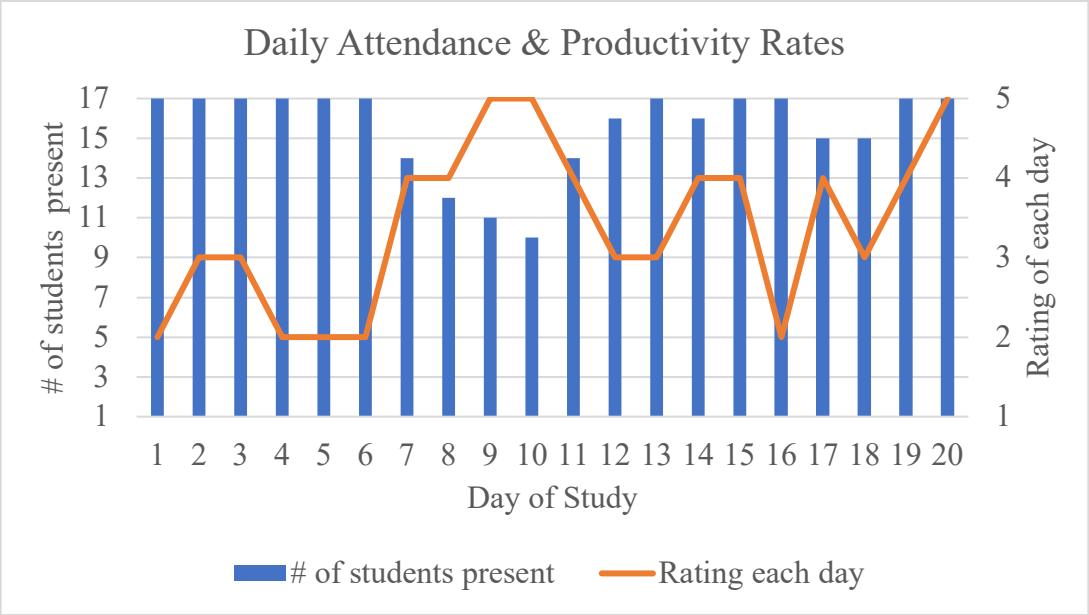


Note. This graph reflects the combined weekly averages of mornings that had an overall productivity rating of 4 or 5.

The data below considers if there is an association between attendance rates and the researcher's daily perception of productivity which included engagement, concentration, and independent choice. The second week of the intervention showed the lowest attendance rates due to COVID, and twice I mentioned in my field notes that the mornings were tranquil and productive. One morning, we had 14 of the 17 children present, and the other morning we had only had 12 of the 17 children. The graph shows that days 8 and 9 of the study showed the highest productivity at 100% for each day and with the lowest attendance. Days 18 and 19, the study had all students present, with productivity rates also increasing.

Figure 6

Daily Attendance and Daily Productivity Rates



Note. The data shows daily attendance rates and productivity.

I observed increases in independent choice, engagement, and focus within the four-week study. Overall productivity, meaning the collective feel of the entire group, did see an increase moving into week two, however, then leveling out in weeks three and four. Something to note is

that productivity rates started to steadily increase on days 19 and 20, even with everyone present in class. On the last day of the intervention, I noted in my field notes that I wished to continue the study for another week to examine further if productivity rates continued to climb. Next, I will discuss conclusions and implications on how aerobic exercise coupled with cognitively engaging games further supported children's inhibitory control functions such as self-regulation (the ability to choose independently), engagement, and concentration.

Discussion

This study aimed to investigate the effects on children's executive functioning skills, such as self-regulation. More specifically, I looked for positive changes in the child's ability to self-direct, engage, and focus by offering a combination of aerobic exercise paired with cognitively engaging games. Whether I would see positive effects during the morning work cycle by providing the children with these movement activities came to me as I observed children demonstrating decreased abilities to independently choose an activity and stay focused in the winter months of cold and dark Alaska.

The four-week study included a baseline week where I observed the children on self-regulation (independent choice) and overall energy levels each day without the morning movement intervention. For the following three weeks, during the first 15 minutes of the work cycle, the children engaged in a 7-minute HIIT workout, moving like different animals. After the HIIT portion, the children participated in one of five cognitive games and ended with either Red/Light Green Light or an obstacle course. The tools used to collect data included an Independent Choice Tally Sheet, Pre/Post Assessment, Behavioral/Participation Log, and Teacher Field Notes.

The first component of self-regulation I examined was the child's ability to choose independently or self-direct towards a material or activity. During the baseline week, I observed the children directly after the non-movement morning gathering and directly after the movement intervention for the following three weeks. Children showed an increasing ability to self-direct throughout the intervention based on the data gathered. The rate of independent choice increased steadily throughout the four-week intervention. The children's growing capabilities to self-direct during the four-week study were consistent with Tomporowski et al. (2014), who also found that chronic exercise training can correct executive functioning in children. A limitation to these findings is that I only observed for independent choice within 15 minutes after the gathering/intervention. Future recommendations should involve observing the children for self-direction or independent choice at multiple points during the morning.

Another component of self-direction is the frequency of wandering. Through the pre/post assessment used at the beginning and end of the study, I determined that children had a lower incidence of wandering by the end of the intervention by almost half. In combination with the Independent Choice Tally sheet, the data indicates that children's self-direction did improve.

Engagement and focus, or the child's ability to concentrate, were the other two components related to executive functioning studied. I saw the most improvement in the children's overall abilities to engage, meaning I observed children throughout the morning work cycle independently choose and engage in a material. Observed engagement is when a child takes a material to a table or rug and uses it for any amount of time. The child may be using that material, yet could also be casually talking, wandering away, or displaying a general lack of focus. A few times in my field notes, I noted that the children were very busy yet not necessarily focused. Focus, or the child's ability to concentrate, did increase over the four-week intervention.

However, the data showed the sharpest increase occurred between weeks two and three, with numbers slightly dropping after week three. My assessment concludes that there were lower attendance rates between weeks two and three, which caused a positive increase in observed moments of concentration because there was less distraction in the classroom. Moreover, as noted by my teacher field notes, the out sick group was primarily children aged three and four, meaning the concentration observed mainly was older children. These findings coincide with a similar study conducted by Mahar et al. (2006) in their study of physical exercise and its effects on engagement and concentration. Future recommendations would include separating the data to see the differences in focus abilities of each age group present in the classroom.

Additionally, this study aimed to study how *combining* vigorous exercise and cognitively engaging games would affect children's executive functioning skills. The findings show increases in all positive behaviors and decreases in all negative behaviors associated with self-regulation. These findings are consistent with the results of Shoval et al. (2017) in their study, where they compared the cognitive gains of children who participated in Mindful Movement games instead of children who engaged in free play.

Throughout the four-week study, the children showed increased excitement for extra movement activities. During the last three days of the study, productivity sharply increased. In my field notes, I noted that some of the children expressed discontentment because they knew the intervention was ending. Future recommendations would include making this a longer study to examine further if productivity continued to increase as the children had more days to engage in the exercises. Another suggestion is to end the morning intervention with one of the cognitive games instead of Red/Light Green Light or the Obstacle course. I observed that ending the intervention with high-energy games left the children with higher energy levels instead of

finishing with one of the cognitive game's children performed sitting in a circle. Switching the order of exercises will aid in a smoother transition into the work cycle.

Based on the data gathered in this action research, it is my recommendation that teachers provide an opportunity for children aged three to six to participate in a short morning gathering where they can engage in vigorous movement and a cognitively engaging game. Furthermore, child participation should not be required to abide by the Montessori three-hour work cycle; the gathering should be an addition to the already established three-hour period. This daily gathering could be especially significant in the winter months to support children's innate need to move.

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Appendix A

Pre and Post Assessment

Pre- Assessment

Child (number) Date:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Has difficulty choosing a work					
Organizes materials effectively					
Concentrates well					
Sustains work					
Wanders frequently					

Post-Assessment

Child (number) Date:	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Has difficulty choosing work					
Organizes materials effectively					
Concentrates well					
Sustains work					
Wanders frequently					

Appendix B

Independent Choice Tally Sheet

Week:

Day of week	# Students present	# Students engaged in independent choice	Percentage
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			

Appendix C

Behavioral/Participation Log

Student ID #:

Date:

Day of the week:

Time (Every 30 minutes)	Behavior Code	Comments

Key:

1. The child participated in the intervention
2. The child did not participate in the intervention
3. Chose a material, physically engaged; eyes towards material, limited movement and not talking.
4. Chose a material, not engaged, talking to others.
5. Wandering away from material/activity
6. Has not chosen a material or activity for more than 5 minutes and is wandering

Appendix D

Daily Observational Field Notes

Date:

Number of students present in morning:

Questions to reflect upon:	**Reflections and Observations:**
Rate the mood and feel of the day from 1 to 5: 1: "this was a high energy, tough day" 5: "this was a productive, happy day!"	
What was the weather?	
Were there disruptions to the morning work cycle?	
What was attendance like? Low or high numbers?	
Describe how engaged the children were in the intervention: Did they seem happy to participate? Were they hesitant to participate and/or finish the intervention?	
How was the energy level/engagement immediately after the intervention?	
On a scale of 1 to 5, was the morning work cycle very unsettled or productive with children engaged in independent choice work.	
Other observations or thoughts:	

Appendix E

Movement Calendar

Monday	Tuesday	Wednesday	Thursday	Friday
7-minute HIIT Bean Bag Toss Red/Light Green Light	7-Minute HIIT Roll the Ball Obstacle Course	7-Minute HIIT Catch the Ball Red Light/Green Light	7-minute HIIT Pass the Cup Obstacle Course	7-minute HIIT Tick-Tock Red Light/Green Light

Appendix F

Descriptions

- First 7 minutes of intervention is vigorous exercise with the 7-minute HIIT activity
- The second portion of the intervention incorporates cognitively engaging games

Descriptions of cognitively engaging games played:

Bean Bag Toss: Children gather in a circle, standing. Child calls name of another child and tosses the bean bag to that child. Repeat until all children have had a turn catching/tossing.

Roll the Ball: Children gather in a circle, sitting. Child calls out name of another child and then rolls the ball to the child. Repeat until all children have had a turn.

Catch the Ball: Same procedure as Bean Bag Toss, but with a ball.

Pass the Cup: Children gather in a circle, sitting. Hand the child sitting next to you (the adult) a cup filled with water. The children then carefully pass the water to the friend seated next to them until the cup has been passed all the way around the circle. Repeat again, but this time invite the children to close their eyes.

Tick-Tock: Children gather in a circle, sitting. Invite the children to sit tall, backs straight, with hands at sides. Start rocking side to side, showing the children how to use their hands to "push off" the floor. Do this movement for a few times, then add the language. "Tick-Tock, like a clock, until I find my center, STOP!" Stop in the middle with back straight when you say STOP! Continue as interest allows.

Materials needed:

- Bluetooth speaker
- Interval Timer
- Bean bag
- Medium ball
- Cup with water
- Various items to set up an obstacle course