A REVIEW OF LITERATURE ON THE EFFECTS OF EXERCISE ON EXECUTIVE FUNCTION IN INDIVDUALS WITH ADHD AND THE RECOMMENDATIONS FOR SCHOOLS

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Chapter I Introduction

Statement of the Problem

In the past few decades, the rates of diagnosis of individuals with ADHD have risen by roughly three percent (United States Food and Drug Administration, 2016). In addition to this increase in diagnoses, clinical studies have begun to look into the effects of exercise on executive function in individuals with ADHD (Ziereis & Jansen, 2015). Studies have indicated that children with ADHD often have deficits in cognitive performance, especially in executive function (Memarmoghaddam et al., 2016). It has been theorized that, "because executive function is related to motor skills and physical activity, one can hypothesize that improved motor functions or increased physical activity could lead to enhanced executive function (Ziereis & Jansen, 2015). This study will address the effect of exercise on executive function in individuals with ADHD. It will ask what effect exercise has on executive function in individuals with ADHD as well as the recommendations for the classroom.

Definition of Terms

1. Attention Deficit Hyperactivity Disorder (ADHD): According to the Centers for Disease Control and Prevention (2020), ADHD is one of the most common neurodevelopmental disorders of childhood. It is usually first diagnosed in childhood and often lasts into adulthood. There are three different types of ADHD depending on which symptoms are the strongest:

a) **Predominantly Inattentive Presentation:** It is hard for the individual to organize or finish a task, to pay attention to details, or to follow instructions or conversations. The person is easily distracted or forgets details of daily routines.

b) **Predominantly Hyperactive-Impulsive Presentation:** The person fidgets and talks a lot. It is hard to sit still for long (e.g., for a meal or while doing homework).

Smaller children may run, jump or climb constantly. The individual feels restless and has trouble with impulsivity. Someone who is impulsive may interrupt others a lot, grab things from people, or speak at inappropriate times. It is hard for the person to wait their turn or listen to directions. A person with impulsiveness may have more accidents and injuries than others.

c) **Combined Presentation:** Symptoms of the above two types are equally present in the person.

2. Exercise: Exercise in this study will be defined as physical activity of moderate to high intensity.

3. Executive Functions (EF): According to Benzing et al. (2018), executive functions are comprised of three core processes that include:

a) **Inhibition:** includes inhibiting predominant responses and controlling attention

b) **Switching:** includes switching between tasks or mental sets

c) **Working Memory:** includes retaining and processing information

4. Individualized Education Plan (IEP): According to the Wisconsin Department of Public Instruction (2018), "An individualized education program (or IEP) is a written statement for a student with a disability that is developed, reviewed, and revised by a team of people, including the student's family, that outlines an educational plan for the student."

5. 504 Plan: According to the United States Department of Education (2020):

> Section 504 requires recipients to provide to students with disabilities appropriate educational services designed to meet the individual needs of such students to the same extent as the needs of students without disabilities are met. An appropriate education for a student with a disability under the Section 504 regulations could consist of education in

regular classrooms, education in regular classes with supplementary services, and/or special education and related services.

Purpose of the Study

In 2016 it was estimated that 9.4% of all children ages 2-17 in the United States had received a clinical diagnosis of ADHD (Danielson et al., 2018). To reduce the symptoms of ADHD, roughly 6.1% of all children in the U.S. are taking medication (Birnbaum et al., 2005 in Piepmeier et al., 2015). While the primary symptoms of ADHD include impulsivity, hyperactivity, and inattention, children with ADHD often reveal deficits in executive functions (Ziereis & Jansen, 2015). This deficit can be a cause for concern. "Executive functions could be one of the cognitive regulatory processes that underlie and facilitate learning-related behavior in the classroom," as Colomer et al. (2017) hypothesized. In addition, since executive functions have great influence on performance, those functions highlight the importance of including their development as a top priority from early ages in the school setting in order to strengthen learning behaviors (Colomer et al., 2017). As a means to develop executive function, a growing amount of research has indicated a robust relation between exercise and executive function in children, as well as in adults (Zelazo et al., 2016). Because of the importance that executive functions play on learning behaviors, the purpose of this study is to examine what, if any, are the positive effects of exercise on the executive functions of students with ADHD. The information collected will help to determine whether or not students with ADHD should be given more opportunities throughout the school day to engage in physical exercise.

Significance of the Study

While working with students with ADHD, I have seen just how difficult it is for them to cope and control their symptoms to be successful in the classroom. In my conversations with

peers, many of them are looking for new techniques or methods that they can utilize in their classrooms to help these students. The findings of this study are significant as they may give teachers another strategy to help them guide and assist students with ADHD to be academically successful in the classroom.

Assumptions

It is assumed that all materials gathered were written by authors with the intention of providing valid, useful, and informative data. It is also assumed that any information used in this study was produced to be used to better understand the effects that exercise has on ADHD.

Delimitation of the Study

The research conducted in this literature review is limited to only existing studies that have been conducted by other individuals. I have not done any direct research with individuals on the effects of exercise on executive function in individuals with ADHD. The research was conducted from June 2020 September 2020. Research was primarily conducted using peer-reviewed journal articles that were accessed through Google Scholar and the EBSCOhost platform.

Methodology

The methodology used for research in this study came primarily from peer-reviewed journal articles. These articles were found using the databases available through the EBSCOhost platform as well as the search engine Google Scholar. When searching for articles the search terms most commonly used were “ADHD and Exercise”, “Executive Function and ADHD”, and “Effects of Exercise on ADHD.” In addition to using scholarly articles, government websites were also used to generate background knowledge on the topic of ADHD.

Hypothesis

Moderate physical exercise will lead to increased executive functions (working memory, inhibition control, and task switching) in individuals with attention deficit hyperactivity disorder.

Chapter II Review of Literature

The Cause of Executive Function Delay in Individuals with ADHD and the Result on Academic Performance

Studies have indicated that children with ADHD often have deficits in cognitive performance, especially in executive functions (Memarmoghaddam et al., 2016). However, why ADHD has an effect on executive functions needs to be examined further. A major theory regarding the effects of ADHD on executive functions places those effects in the prefrontal cortex, the portion of the brain that controls executive functions (Keilow, et al., 2018). According to Arnsten and Pliszka (2011) research has shown that, "the prefrontal cortex is essential for the 'top down' regulation of attention, behavior and emotion." However, when compared to their peers, children with ADHD have been found to have smaller prefrontal cortexes (Halperin & Healey, 2011 in Chang, Hung, et al., 2014). One study that looked at the pre-frontal cortexes of 223 children diagnosed with ADHD and 223 normally developing children found, "substantial delay in the maturation of the pre-frontal cortex among the children with ADHD" (Shaw et al., 2007 in Kielow et al., 2018). Research has also shown that the prefrontal cortex is also underactive in many patients with ADHD (Arnsten & Pliszka, 2011). This underactivity could be a direct result of alterations in the regulation of the catecholamine system that has been linked to ADHD (Villa-González et al., 2020). Due to the fact that the

prefrontal cortex is extremely sensitive to neurochemical changes, even small changes in the levels of the catecholamines, dopamine and norepinephrine, can cause altered functions (Arnsten & Pliszka, 2011). To counter these changes, the prime treatment for ADHD is stimulant medication, which is focused on restoring the levels of dopamine and norepinephrine (Arnsten & Pliszka, 2011; Villa-González et al., 2020). In conclusion, the alterations in the regulation of the catecholamine system and the neurotransmitter sensitivity in the prefrontal cortex could provide the reason as to why those with ADHD struggle with executive function. Ratey and Hagerman (2013) write:

> The problem for people with ADHD is that their attention system is patchy; they (scientists) describe it as discontinuous, fragmented, and uncoordinated problems that can stem from a dysfunction with either of these neurotransmitters (norepinephrine and dopamine) or in any one of the brain areas in the system, which helps explain how one disorder can have so many faces.

While ADHD greatly affects executive functions, when it is combined with academics, it can have a wide range of negative effects on academic achievement measures (Keilow et al., 2018). More specifically, students with ADHD are often at higher risk for poor grades, grade retention, and low academic achievement when they are compared to students without an ADHD diagnosis (Fried et al., 2016 in Colomer et al., 2017). Keilow et al. (2018) also reports that lower grade point averages, higher rates of absenteeism, and lower high school and college completion rates are also associated with ADHD. With so many adverse academic obstacles weighing on students with ADHD, there has been a renewed interest in the effects that executive functions play in learning and development during childhood (Zelazo et al., 2016). According

to Zelazo et al. (2016) in their report for the Institute of Education Science at the United States Department of Education, the reasons for the renewed interest include:

1) Childhood EF skills provide an important foundation for learning and adaption across a wide range of contexts, including school.
2) Difficulties with EF are associated with learning challenges and a greater likelihood of behavior problems, and they are a prominent feature of many emotional and behavioral disorders (EBDs); neurodevelopmental disorders (e.g., attention deficit hyperactivity disorder [ADHD]; autism spectrum disorders (ASD); and specific learning disabilities that interfere with children's education.
3) EF skills are malleable, meaning they can change and are influenced by both positive and negative experiences. For example, stress, poverty, and disadvantage are associated with worse EF skills. However, supportive caregiving, high-quality early education, and even practice can help improve EF skills. (p. 1)

In the last decade, studies have begun to find that executive functions can be indicators of overall academic performance, with working memory having the most significant influence (Pascual et al., 2019; Visu-Petra et al., 2011). This has been found especially true in mathematics, where working memory and cognitive flexibility are needed when solving complex mathematical problems (Zelazo et al., 2016). In addition, when dealing with the language arts, phonemic awareness and spelling each require cognitive flexibility and working memory (Zelazo et al., 2016). In their study, Pascual et al. (2019) went even further and concluded that not only do executive functions predict academic performance, they also may, at an early age, predict future learning outcomes. This is not surprising since difficulties with executive functions are often linked to specific learning disabilities (Zelazo et al., 2016).

In summary, executive functions play a major role in the education process, with strong executive functions typically equating to stronger school performance and vice versa. With this correlation having a direct impact on students with ADHD, the question arises, "What can be done for those with ADHD to help improve their executive functions?" Pascual et al. (2019) write that all of the information that has been found should be used, "to develop specific intervention plans for the executive function components and deficient capabilities that can guide efforts to improve the learning process for students."

The Effects of Exercise on Executive Function in Individuals with ADHD

As a result of ADHD having a decreasing effect on executive functions, possibly as a result of the disruption in the catecholamine system, one main question arises: "What can be done to lessen this disruption?" While medication is the prime treatment for ADHD (Villa-González et al., 2020), research has begun to show that exercise can have beneficial impacts on executive functions (Dishman et al., 2006 in Memarmoghaddam et al., 2016). Some evidence has even suggested that "physical exercise may be associated with more sustained improvements in ADHD than medications" (Berwid and Halperin, 2012 in Cohen et al., 2018). Through research it is known that physical activity increases the release of the neurotransmitters dopamine and norepinephrine (Silva et al., 2015). However, to what degree does the increase in dopamine and norepinephrine during exercise elevate executive functioning?

"It has been argued that behavioral inhibition is the primary deficit underlying dysfunction in ADHD and causes deficits in sustained attention and executive functions" (Barkley, 1997 in Chang, Hung, et al., 2014). It was this argument that led Chang, Hung, et al. (2014) to research the effects of aquatic exercise on inhibitory control in children with ADHD. The study ran for 8 consecutive weeks where twice a week participants took part in 90 minutes

of aquatic exercise. At the beginning and at the end of the study, an inhibitory control assessment was given to record if any growth had taken place. When compared to the children in the control group who did not take part in the exercise program, the data recorded showed that the children in the exercise group "exhibited substantial inhibition enhancement over time." Using the same assessment tool as Chang, Hung, et al., (2014), Memarmoghaddam et al., (2016) also found that "exercise of a specific intensity could improve inhibition." It should be noted that in both of these studies, all of the participants either did not take, or were asked to abstain from taking ADHD medication 24 hours prior to the assessments so that the true effects of exercise could be calculated.

When it comes to the effects of acute exercise on inhibitory control, research has shown it to be beneficial. In their study of acute exercise's effects on executive functions, Chang, Liu et al. (2012) found that, "acute exercise particularly benefitted inhibition-related function in the ADHD population." Using the same assessment as Chang, Liu et al. (2012), Piepmeier et al. (2015) similarly found that inhibitory control performance improved in the exercise group when compared to the non-exercise group. While this research does show that acute exercise may improve inhibitory control, the effects may be limited to some degree. While Benzing et al. (2018) did find that inhibition reaction times did improve after acute exercise, they found that inhibition accuracy scores showed no signs of improvement after acute exercise. After looking at prior research, Benzing et al. (2018) speculated that, "children are able to invest the additional attentional resources resulting from acute exercise either in response speed or in accuracy." Even with a supposed "tradeoff", it can be concluded after looking at research that exercise, be it acute or long term, does have a beneficial effect on inhibitory control in individuals with ADHD.

While there has been little research done on the effects of exercise on task switching, the research that has been completed has produced conflicting results. In their study on acute exercise's effect on executive functions, Chang, Liu et al. (2012) used the Wisconsin Card Sorting Test (WCST) to assess task switching abilities immediately before and after a bout of acute exercise had taken place. The researchers found that acute exercise may improve correct set shifting as well as efficiency of incorrect set shifting. Even more importantly, the researchers hypothesized that "because there is evidence that links set shifting and dorsolateral prefrontal cortex, acute exercise could impact set shifting positively and may be accompanied by an influencing activation in the dorsolateral prefrontal cortex." Hung et al. (2016) came to the same conclusion when they found that bouts of acute exercise could help to compensate for the task switching deficiencies that affect children with ADHD. The researchers also hypothesized that the increased regulation of the neurotransmitter dopamine as a result of the exercise could be leading to the increased ability in task switching. These two theories by Chang, Liu, et al. (2012) and Hung et al. (2016) would seem to be in direct agreement with the idea that the alterations in the regulation of the catecholamine system and the neurotransmitter sensitivity in the prefrontal cortex could provide the reason as to why those with ADHD struggle with executive function and why exercise can improve prefrontal cortex functioning.

However, unlike the findings by Chang, Liu, et al. (2012) and Hung et al. (2016) that suggested that exercise directly benefits set shifting, Piepmeier et al. (2015) found in their research that no observable effects on set shifting were seen after a bout of acute exercise. The researchers theorized that the lack of observable benefits may have been due to the intensity of the exercise as prior studies had shown benefits to set shifting using the same assessment when higher exercise intensity was used (Cordova et al., 2009 in Piepmeier et al., 2015). Based upon

these three studies and their own study that showed improvements in set shifting times, Benzing et al. (2018) concluded that "the effects of acute physical activity may not be as strong as that observed for inhibition." While it does appear, based on current research, that bouts of acute exercise may have beneficial effects on set shifting, more research will need to be conducted to confirm this.

Just as with set shifting, the current research on the effects of exercise on working memory has shown differing results. In their study of acute exercise's effect on executive functions in college students with ADHD, Gapin et al. (2015) used the Digit Span Test to assess working memory in 20 participants, 10 with ADHD and 10 without an ADHD diagnosis. While the data did show that the ADHD group's score was lower than the non-ADHD group's score in both the pre-test and post-test, no improvement was seen in the ADHD group between pre-test and post-test. In their research, Benzing et al. (2018) were in agreement with Gapin et al. (2015). While they did not use the same assessment to measure working memory, they did find that acute exercise did not produce a significant effect on visual working memory. While this research may suggest that acute exercise does not have an impact on working memory performance in individuals with ADHD, Gapin et al. (2015) cautioned that more studies need to be undertaken before any conclusions can be drawn. This caution proved to be warranted based on the study completed by Ziereis and Jansen (2015). Using the same assessment tool as Gapin et al. (2015), the researchers found significant improvements in the variables that assessed working memory performance after participants took part in a 12 week exercise intervention program. While this data would seem to conflict with the two previously discussed studies, it may suggest that a longer-term exercise intervention program will lead to stronger effects on working memory performance in individuals with ADHD as opposed to single bouts of acute

exercise. Going beyond a long-term exercise intervention program, research has shown that boys with ADHD who were more physically active during the day demonstrated higher performances in working memory than boys with ADHD who tended to be more inactive (Gapin & Etnier, 2010 in Ziereis & Jansen 2015).

Chapter III Conclusions and Recommendations

In the past decade there have been numerous studies to determine what, if any, are the effects of exercise on executive functions in individuals with ADHD. The results of these studies show that exercise has great potential in alleviating the deficits in executive functioning that are commonly found in children with ADHD (Memarmoghaddam et al., 2016). However, this benefit does not appear to be universal to all of the executive functions in those with ADHD. While a strong body of evidence suggests that exercise significantly improves inhibitory control, working memory and set shifting appear to be less impacted by exercise. As a result of these improvements, it has been proposed that exercise could serve as a complement or a replacement, under the correct circumstances, to prescription medication meant to treat ADHD (Lara, 2012).

Upon review of research, an important question arose around the differences that gender may play in the effects of exercise on executive functions. Due to the fact that school-aged boys are often seen as being more energetic and eager to engage in exercise, one could hypothesize that boys would have a more beneficial response to an exercise program. However, while many of the studies included both males and females with ADHD in their programs, the data produced gave no indication whether these males or females saw increases in executive functioning as a result of the exercise programs. This lack of information highlights the need for research into the correlation between executive functions and exercise in individuals

with ADHD as it relates to gender.

As a result of the correlation between elevated executive function and exercise in individuals with ADHD, it is recommended that schools implement interventions that allow for an increase in physical activity for students with ADHD throughout the school day. It is also recommended that any intervention plan be included in the student's IEP or 504 plan. With these recommendations it is understood that as a result of high-stakes, high-stress testing school days have been lengthened the time that students remain in their seats as well as reduced the minutes of recess (Flannery, 2016). This push to remain in the classroom to focus on academics may actually have an adverse effect on students with ADHD as the research has shown that physical activity leads to higher executive functioning. While it may seem counterintuitive to send a student out to recess or let them run laps in the gym in order to have higher academic achievement, this may be beneficial for students diagnosed with ADHD. Based on current research, it is essential that students with ADHD be allowed more opportunities to be physically active in order to alleviate the deficits that they face due to their disability.

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