The Impact of Physical Activity and Physical Education on Children with Attention-Deficit Hyperactive Disorder (ADHD)

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The Impact of Physical Activity and Physical Education on Children with Attention-Deficit Hyperactive Disorder (ADHD)

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Abstract

Physical activity is one of the most essential factors to physical and mental health and is vital to children. Understanding the importance of living a healthy lifestyle and being physically active is beneficial to children's futures. While important for all children, physical activity is especially important for children with Attention Deficit Hyperactivity Disorder (ADHD). Children with ADHD typically have difficulty with their executive functioning – that is, their abilities to plan, organize, concentrate on one task, and switch focus when needed. Regular physical activity improves executive functioning by reducing symptoms of ADHD such as inattention, impulsivity and hyperactivity (Verret et al., 2012). It is important, then, that physical educators improve their lessons in order to provide lessons with maximum activity, emotional, and behavioral support for students with ADHD. Therefore, the purpose of this synthesis is to review the literature on the impact of physical activity and Physical Education on elementary students with Attention Deficit Hyperactivity Disorder (ADHD).

Chapter 1

Introduction

Attention-deficit hyperactivity disorder (ADHD) is one of the most common psychiatric and health disorders among American children, affecting 3% to 7% of the school-aged population (Ziereis & Jansen, 2015). It is characterized by developmentally inappropriate levels of inattention, impulsivity and hyperactivity (American Psychiatric Association, 2000). ADHD is a chronic health condition that is considered the most common neurobehavioral disorder experienced by children in the U.S (American Psychiatric Association, 2000). ADHD is expressed in three different clinical forms: inattentive, hyperactive/impulsive, and combined (inattentive and hyperactive-impulsive) (American Psychiatric Association, 2000).

Theories of reason for diagnosis involving ADHD have focused on neurological differences in the structure and function of the prefrontal cortex (Piepmeier et al., 2015). This area of the brain is responsible for the performance of a set of higher order cognitive tasks. Causes of ADHD include genetics, the environment, and problems with the central nervous system at key moments in development. It is important to note that symptoms typically associated with ADHD can be caused by other issues, including emotional distress and environmental concerns, and therefore, the presence of these variables may lead to a misdiagnosis of ADHD (Cavanaugh et al., 2016).

In addition to the primary problems associated with ADHD (i.e. impulsivity, hyperactivity, and inattention), affected children often additionally reveal deficits in executive functioning. Executive functions (EF) are defined as “cognitive functions that serve to maintain an appropriate problem-solving set to attain a future goal and encompass cognitive domains that

are highly relevant for daily life activities, appropriate behavior, and academic and social function" (Gapin & Etnier, 2010). Children with ADHD consistently perform worse on executive function (EF) tasks relative to those without ADHD (Benzing et al., 2018).

In addition to deficits in executive functioning, students with ADHD typically also display associated attributes including a low frustration tolerance, temper outburst, mood liability, and poor self-esteem (American Psychiatric Association, 2000). Many times, these result in an array of impairments within social settings, school, and with family members (Smith et al., 2011). It is not uncommon for children diagnosed with ADHD to experience limitations in academic advancement, social, and emotional behavior (Piepmeier et al., 2015). For example, students with ADHD are diagnosed with impairments including lower cognitive functioning abilities, poor social skills, behavioral concerns and low rates of comprehension compared to their peers (Fedewa et al., 2020). Students with ADHD frequently score lower in academic achievement test scores (Smith et al., 2011). Students are also more likely to suffer disciplinary infractions and repeat a grade level (Bredemeier & Shields, 2006). These students have a high rate disciplinary problem during school, which compose 30% to 40% of the referrals to child guidance clinics (Bredemeier & Shields, 2006). Sometimes a child may have normal comprehension and cognitive abilities; however, symptoms of ADHD can be caused by other issues including emotional distress and environmental concerns, therefore presence of these variables may lead to a more common diagnosis of ADHD (Cavanaugh et al., 2016). Given all of the issues which students with ADHD have in school, it is not a surprise that teachers describe feeling overwhelmed by the stress of responsibility surrounding ADHD students (Fedewa et al., 2020).

Treatment for ADHD typically involves medications and behavioral interventions. Early diagnosis and treatment can make a big difference in outcome (Shuai et al., 2017). Physical exercise and activity are the most effective natural treatment for controlling ADHD symptoms such as inhibition, attention, and working memory (Piepmeier et al., 2015). Physical activity has a major impact on eliminating ADHD cognitive symptoms such as confusion, poor motor coordination, and loss of long- and short-term memory (Gapin & Etneir, 2010; Ziereis & Jansen, 2015). Physical activity may help improve symptoms of ADHD in students (e.g., their need for constant stimulation) and allow them to focus better in a school environment (Shaui et al., 2017). Any physical activity that helps a child exert lots of energy is going to be beneficial. This physical activity can occur as "physical activity breaks" in the classroom, as well as Physical Education programs in schools. Incorporating more physical activity programs within elementary schools then, can be positive for these students.

Statement of Problem

Children with ADHD are significantly less likely to engage in daily physical activity than their neurotypical peers (Shuai et al., 2017). Because of this, the inclusion of physical activity and Physical Education programs in elementary schools is doubly essential for students with ADHD. Students with ADHD require constant stimulation which physical education is more than capable of providing. As an educator, it's important to better understand the role of physical activity in assisting students with ADHD.

Purpose

The purpose of this synthesis is to review the literature on the impact which Physical activity and Physical Education have on elementary age students with Attention Deficit Hyperactivity Disorder (ADHD).

Operational Definitions:

1. Executive Function (EF): Executive function and self-regulation skills are the mental processes that enable us to plan, focus attention, remember instructions, and juggle multiple tasks successfully, the brain needs this skill set to filter distractions, prioritize tasks, set and achieve goals, and control impulses. (Cavanaugh et al., 2016)

2. Attention Deficit Hyperactivity Disorder (ADHD**):** a neurological condition that involves problems with inattention and hyperactivity-impulsivity that are developmentally inconsistent with the age of a child (American Psychiatric Association, 2000).

3. Physical Activity: any "body" movement that works your muscles and requires more energy than resting. Walking, running, dancing, swimming, yoga, and gardening are a few examples of physical activity (Bredemeier & Shields, 2006).

Research Questions

1. What is the effect of physical activity on the cognitive and executive functioning of elementary-aged children with ADHD?

2. What effect, if any, do sport and physical education programs have an impact on students with ADHD?

Assumptions

1. Research findings reported in reviewed literature were assumed to be accurate and reliable.

2. The literature reviewed defined ADHD similarly.

Limitations

1. The research selected may not cover the entire scope of the benefits of physical activity in children with ADHD.

2. The data collected for this study may not completely cover the scope of this topic.

Delimitations

1. Literature published only on ADHD and its relationship to physical activity on it was reviewed.

2. Literature selected and reviewed was published from 2011-2021.

3. Literature selected and reviewed included subject aged 7-12 years. The literature did not include secondary students in the research samples.

4. Literature reviewed was obtained only though Google Scholar and the EBSCO host Academic Search Premier.

Chapter 2: Methods

The purpose of this synthesis is to review the literature on the impact that physical activity and Physical Education have on elementary students with Attention Deficit Hyperactivity Disorder (ADHD). This chapter specifically details the methods used in obtaining the appropriate information for the synthesis.

Data Collection

Literature obtained for this project began with a search using SUNY Brockport's Drake Memorial Library website. Research guides within the library website are broken down by subject. For this particular synthesis the research guide subject selected first was "Kinesiology, Sport Studies & Phys. Ed." The databases within the research guide subject were Sports Discus and Google Scholar. A combined search of the two databases resulted in thousands of articles returned depending on the number of and the specific keywords used.

Keywords for the search were determined in order to focus the data collection. These keywords included *Physical Activity, elementary aged students, academic performance, executive function, cognition, Attention Deficit Hyperactivity Disorder (ADHD), Sport* and *Physical Education*. These keywords were selected based on their relevance to the research questions. *Physical Activity* and *Attention Deficit Hyperactivity Disorder* were identified as the two most important keywords in order to return results that would serve as a starting point for the search. These provided a broad set of articles to start with, before being refined by the keywords of *elementary aged students*, *executive function*, and/or *Sport and Physical Education*. *Attention Deficit Hyperactivity Disorder* was identified as a keyword because that is the particular type of mental health on which the research is mostly focused. The keyword elementary aged students

were important to help return results for the particular group of individuals in which the synthesis is targeting.

The first search of SPORT Discus and Google Scholar yielded 12,715 articles using the search terms *physical activity* AND *physical education* AND *elementary aged students* OR *elementary school* OR *exercise*. The search was then limited to peer reviewed articles and articles published between 2011-2021. These parameters limited the number of articles down to 2,100, so at this time the search terms, *ADHD* AND *executive function* OR *cognition* OR *relationships* OR *exercise* were added, resulting in 432 articles being identified. Of these 432 articles, 30 of them were relevant to the research questions. A few articles were relevant to the topic; however, the subjects were in preschool, high school, or college. These articles did not meet the criteria and were discarded. At this point the search came to an end. Out of the 30 articles, five articles were downloaded and saved; these articles were chosen because they were more transparent to the research questions and topic. From these five articles, two had relevance and were used towards the critical mass. Three articles were deemed relevant for this synthesis, but not suitable for the critical mass.

Using the same two databases, the search term *and cognitive functioning* was added first to *physical education* and then to *physical activity*. Using the delimitors of *elementary aged students* or *children* or *youth* or *elementary school,* 85 additional articles were found. Only one article was downloaded and saved to be used towards the critical mass. This was the only article deemed fit to be downloaded and saved due to its relevance to the topic and it was not found in the previous search.

Next, 147 articles were found by replacing the search term "*cognitive functioning*" with the phrase "*cognitive and executive functioning*." Of these 147 articles, 10 were reviewed for

relevance to the research questions. One of the 10 was downloaded and saved to be used towards the critical mass. Only one article was used due to many of the articles involving participants that did not include elementary aged students and children. Lastly, a third search using "sport" and "physical education" and replacing "cognitive functioning" with "ADHD" was used. The databases and search parameters were kept the same as the previous search, 38 articles were found. These 38 articles resulted in four articles being downloaded and saved to be used toward the critical mass. These articles were saved due to having information relevant to specific sports and physical education programs. Other articles in this last search were not used due to having the wrong age groups, programs, and/or mental health issues.

In order to be included in the critical mass, an article had to be a data-based research study published in a peer-reviewed journal between 2011-2021. Another parameter to be included in the critical mass was that the article had to investigate one of the following criteria, based on the research questions: (a) What is the effect of physical activity on the cognitive and executive functioning of elementary-aged children with ADHD? and (b) do Sport AND Physical Education Programs have an impact on students with ADHD. A total of 10 articles met all requirements and formed the critical mass of the research synthesized in this paper. Some articles were excluded from this synthesis because they did not contain research relevant to the topic. Some of the articles selected also offered ideas for ADHD symptoms associated with ADHD students. Articles for this synthesis were obtained from the following peer reviewed academic journals: *Journal of Attention Disorders (1), Journal of Sport and Exercise Psychology (1), Journal of Sport & Health Science (1), Chinese Medical Journal (1), Child & Family Behavior Therapy (1), Journal of attention disorders (2), Healthcare (1),* and *Frontiers in Psychology (1).*

Data Coding

Information acquired for this study involved a two-step approach in an effort to extract the data and make it useful. First, all articles that were approved for the critical mass were put into a word document grid (see Appendix A). The purpose of the article grid was to have all article information in one area for reference. The article grid includes the following categories: (a) APA citation of the study, (b) purpose, (c) methods and procedures, (d) analysis, (e) findings, and (f) discussion and recommendations for future research.

Data Analysis

The critical mass for this synthesis consists of 758 children aged seven to 12 years old (655 males, 103 females). Subjects diagnosed with ADHD were a total of 457 and subjects without ADHD was a total of 301. All those diagnosed with AD/HD were recruited through advertisements placed at local AD/HD clinics, medical providers, specialty AD/HD schools, outpatient clinics, and various relevant support agencies. Some of the subjects were taking medication. Subjects were also recruited from child and youth psychiatric practices, private k-12 school, and the local community.

Data was collected from subjects located around the world. Demographic regions included descriptors such as the "Southeastern urban school district in the USA, "Quebec Canada", China, Switzerland, and "Northern Israel" as well as the European countries of Italy, Lithuania, Turkey, and Germany.

The articles selected for research included quantitative approaches. The literature review included nine articles that were quantitative in nature and two articles that utilized mixed methods. These studies collected information using a variety of methods including data collection from resources obtained from Child Behavior checklist, ADHD rating scale 5,

Behavior rating inventory (BRIEF-2), Daily PE logs, and one was a meta-analysis of information obtained from a 12-week PA intervention program. Data was analyzed using statistical and descriptive measures.

The essential challenge faced while managing this research was the fact that ADHD is an overly popular topic discussed among educators in higher education. However, the general concepts of ADHD in higher education and the acceptance of discussing the impact physical activity and Physical Education have on elementary students with Attention Deficit Hyperactivity Disorder (ADHD) returned enough results for the synthesis. To research this particular topic, it was important to acquire articles that included ADHD information regarding cognitive executive function of elementary aged students. Regardless of this particular challenge, the research still offers an abundance of awareness pertaining to the impact physical activity and Physical Education have on elementary students with Attention Deficit Hyperactivity Disorder (ADHD).

Chapter 3 – Review of Literature

The focus of this chapter is to present a review of literature on the impact that sports, physical activity and Physical Education programs have on the cognitive and executive functioning of elementary students with Attention Deficit Hyperactivity Disorder (ADHD). While each of the 11 articles utilized in this synthesis involved the use of a physical activity-related intervention(s), with testing occurring both before and after an intervention, they differed in other experimental conditions. These differences will form the basis for the following review of literature. Each of the studies is explained more fully, below.

Experimental Studies Involving One Group of Children

The first section focuses on studies that involved physical activity interventions given to a single group of children with ADHD. The purpose of the first study, by Gapin and Etneir (2010), was to collect data pertaining to the relationship between physical activity (PA) and executive functioning. The researchers hypothesized that higher PA would be associated with better performance on executive function tasks. Boys only were selected for this study because of the higher prevalence rate of ADHD in boys relative to girls and because behavioral and cognitive symptoms vary significantly as a function of gender. Eighteen boys ranging from the ages of eight to 12 years old (M = 10.61) were measured on four executive functioning tasks which took 45 minutes total. Parents completed a demographic questionnaire. All subjects were currently using stimulant medications, either methylphenidate or amphetamine, for treatment of ADHD and had been taking these medications for a period of six months or longer. On the testing day all the boys had taken their medication as prescribed.

The first task measured the EF function of inhibition by using *Conner's Continuous Performance Test-3*. In the task, the subjects were required to respond repeatedly to nontarget

figures (capital letters) and then be unresponsive when the infrequently presented target figure appears (the letter X). Planning was measured using the *Tower of London* (2nd edition) test, which required the boys to copy a modeled pattern of three colored beads (red, blue, green) in as few moves as possible. The boys' working memory was measured using *The Digit Span*, where during the DS Forward task participants listened to a sequence of numbers from two to eight digits long (e.g., 6-8-2) and repeating the sequence aloud in order. The *DS Backward* task follows the same procedure; however, the participants were required to repeat the number sequences in reverse order (e.g.,2-8-6). The last executive function measured was processing speed, by using *The Children's Color Trails Tests 1* and *2.* After the executive functioning tasks, accelerometers were distributed to each child in order to assess their physical activity for seven consecutive days. The subjects completed a daily activity log was also used to record activities such as skateboarding and swimming.

Data from all measures were analyzed statistically using SPSS 16.0. Descriptive analyses were performed on the MVPA and EF measures. Gapin and Etneir (2010) found that physical activity was found to be a significant predictor of planning as assessed with the *Tower of London*'s Total Move Score (TMS) and Total Execution Time (TET), despite the subjects being on medication. This article was similar to all other articles because physical activity and executive functions were measured by researchers. However, this study only included one intervention group. This displays higher physical activity is possible associated with better EF performance more generally.

Experimental Studies Comparing Two Groups With ADHD

The four studies in this category each focused on physical activity and its impact on executive functioning (EF). These experimental studies compared two groups of children, each

which were diagnosed with ADHD. First, Benzing et al. (2018) conducted a study investigating whether acute physical activity selectively affects the three core executive functions such as inhibition, switching, and working memory. The study included 46 participants between the ages of eight through 12, each who were diagnosed with ADHD. The study consisted of two groups - a control group (n = 22) and an experimental group (n = 24).

The study required participants to be wear a heart rate monitoring instrument. EF performance was assessed prior to and following the acute intervention which provided a pre- and post-test. Each acute intervention involved either Exergaming (the experimental condition) or the control condition, and lasted approximately fifteen minutes, including a short break of approximately one minute, during which the participants provided pleasure and arousal ratings. Immediately after the activity (i.e. during the post-test), perceived physical exertion, cognitive engagement and enjoyment of the activity were measured. In the Exergaming condition, participants were asked to play an exergame named "Shape Up." The Exergaming condition was conducted using the XBOX Kinect. Participants completed the "Beat Master Training Quest," which consists of six different exercises: waterfall jump, stunt run, derby skate, squat me to the moon, volcano skate, and slalom grove. In the control condition, the participants watched a documentary report about mountain running, with a similar duration to the Exergaming condition.

Several subjective and objective measures were applied during the study in order to gather data. First, parents of the eligible participants completed assessments providing demographic information which included pubertal status, socioeconomic status, physical activity behavior, and data on the ADHD diagnosis. Pubertal status was assessed using the German version of the *Pubertal Developmental Scale*. The families' socioeconomic status was assessed

using the *Family Affluence Scale*. Physical activity behavior was assessed using the *Physical Activity, Exercise, and Sport Questionnaire* and was filled out by parents. ADHD symptoms were assessed using *Conners' Continuous Performance Test-3*. This questionnaire showed well-established reliability, validity, and internal consistency and consisted of 108 items. The *OMNI Scale of Perceived Exertion* was used as a subjective measure of physical exertion. Heart rate (HR) (beats per minute) was recorded using the Polar Team 2 Pro system. Children's maximal heart rate was predicted using the formula 208 – 0.7 *(age). Valence and arousal were measured using the *Self-Assessment Manikin*. The *Self-Assessment Manikin* is a widely used non-verbal, pictorial, one item assessment to measure a person's affective reaction to stimuli. Inhibition and switching were included in one task – a single modified *Flanker Task*. Visual working memory was assessed using a modified version of the *Color Span Backwards Task*. Statistical tests were performed using SPSS. Analysis of covariance (ANCOVAs) using pre-test performance as covariates and post-test performance as the dependent variable were conducted.

Benzing et al. (2018) discovered children's heart rates and perceived physical exertion were significantly increased for both groups, also both groups showed a comparably high level of enjoyment. Regarding accuracy scores of the *Flanker Task*, no significant differences were revealed for congruent, incongruent, or for switching trails. For visual working memory performance, no significant difference was revealed between the two groups in the *Color Span Backwards Task*.

In the second study, Ziereis and Jansen (2015) conducted research in order to determine whether physical activity improves cognitive performance in children with ADHD. The sample included 43 children made up of 32 boys and 11 girls between the ages of seven and 12 years old (mean age=9.0). The study occurred during a 12-week period in which a physical activity

intervention program with two experimental groups (EG) and a waiting control group (CG) participated in the program. Children were randomly assigned to one of the two EG (EG1=13, EG2=14) or to a waiting CG (n=16). None of the children were treated with stimulant medication (e.g. methylphenidate) at the time of testing. The intervention included a single exercise session of 60 minutes per week for each group, for a total of 12 weeks. The exercise program was instructed by coaches who received training.

Children were tested individually one week prior to the start and one week after the last session of the program. Children in the EGs were also assessed on cognitive performance immediately after the first session. Test sessions started with the tasks *Digit Span* (forwards/backwards) and letter–number-sequencing in order to measure verbal working memory performance. Subsequently, the participant was asked to complete the *Corsi block tapping test.* After the series of cognitive tests, which lasted about 45 minutes, the motor test was conducted. These focused on the training skills of catching and aiming, balance and manual dexterity for one of the two experimental groups (EG1). The PA program of the second exercise group (EG2) included sports with low demands on the motor abilities (e.g., give one or two examples). Immediately after the first session, each child was asked to complete the cognitive and motor tests to assess potential short-term effects of PA and coordinator exercises. Exactly one week after the last session, each subject in both EGs were individually assessed for long-term training effects. Children in the CG were post-tested 12 weeks after their individual pre-test without attending any sessions during the 12-week intervention period. Data were analyzed using a one-way analysis of variance (ANOVA) in order to determine whether the anthropometrical and fitness status of the three groups differed significantly. A second one-way ANOVA was used to compare pre-test measurements.

Ziereis and Jansen (2015) found there were improvements in tasks assessing verbal WM performance. No significant differences between a specific and non-specific training program were found. Ziereis and Jansen (2015) also found that the post-hockey *Turkey Test* did not reveal any significant differences between each combination of both factors group and time. Results also did not show a significant difference between the EG1 and the EG2, the EG1 and the CG, and the EG2 and the CG for all motor-related variables.

In the third study, Verret et al. (2012) explored the fitness levels of children by having them participate in a training program for the duration of 10 weeks. The purpose of the study was to investigate how a physical activity program affects the fitness, cognitive functions, motor skills and behaviors of students with combined or hyperactive-impulsive ADHD. It was hypothesized that the program would result in improved fitness, ADHD-related behaviors, and cognitive functions. Children were evaluated individually in order to validate the preliminary diagnosis and to specify diagnoses. The *Test of Gross Motor Development-2* (TGMD-2) as well as the *Bruce treadmill protocol* were presented 10 days before the training program in order to test fitness and motor measures. All participants were previously diagnosed with combined or hyperactive-impulsive ADHD. Following the pre-test, 10 children with ADHD were assigned to the physical activity training (experimental) program, and a second group of 11 children with ADHD diagnoses were assigned to the control group. All of the children in the control group were all taking stimulant medication, compared to only 30% in the training group. Parents and teachers were asked not to change medication. Twenty-one participants in the experimental group completed fitness sessions which included a warm up, a progressive aerobic activity, muscular and motor skills exercise, and a cool down.

The intervention consisted of a Physical Activity Training Program that occurred three times a week for 45 min. over a period of 10 weeks, with a goal to maintain moderate to vigorous physical activity (MVPA). Activities were aerobic in nature (soccer, basketball, exercise stations, etc.). Both groups were post-tested within one week of completion of the intervention. The subjects' height, weight, body mass index (BMI), flexibility, muscular endurance, and resting and maximal heart rate were also measured. Aerobic capacity was measured using the *Bruce Maximal Progressive Treadmill Test*. Gross motor skills were assessed using the TGMD, the two parts evaluated were locomotor and object control skills. Children's attention functions and response inhibition were assessed using the *Test of Everyday Attention for Children*. The Walk/don't walk part of the test was used to evaluate the child's response inhibition. Behavioral measures were assessed before and after the physical activity program using the *Child Behavior Checklist*. This was completed by parents and teachers and included eight subscales: anxiety-depression, withdrawn-depression, somatic complaints, social problems, thought problems, attention problems, rule-breaking behaviors, and aggressive behaviors.

Analysis of data included discovering group equivalence through independent samples (paired) *t* tests. Analysis of covariance (ANCOVA) was used to compare PA and control group data. ANCOVA assumptions were visually inspected and Pretest X group interaction test, the Shapiro-Wilk procedure for normality of sampling distribution on variable residuals, and Levene's test for homogeneity of variance (Verret et al., 2012). One-tailed *t* tests showed significance $p < .05$.

This study discovered that fitness for children in the physical activity group increased significantly because they completed more pushups than those in control group. Motor performance showed a significant group difference for locomotor skills and total motor skills,

with the PA group showing higher results. Behavior showed a significant difference for total problem scores and three subtests (social problems, thought problems, and attention problems). Teachers reported a small but not significant tendency for improvements in all scales. Cognitive behaviors showed significant differences had a higher level of information processing, faster scores in visual research, and better auditory, sustained attention.

This study's interventions were similar to the previous studies because it measured executive functions; however, it differed because it measured behavior as well. The parents and teachers observed better behavioral scores in the physical activity group. The impressive results of the PA program suggest that PA by itself can help children with ADHD improve their social behavior. This article focused on executive function, behavior, cognitive, motor test and physical activity engagement. Both the Benzing et al. (2018) and Ziereis and Jansen (2015) studies are similar because they both measured executive function such as attention functions, response inhibition, switching, visual working memory, and verbal working memory performance.

The final study in this section, by Gentile et al. (2020), analyzed the effects of an Enriched Sports Activity Program (ESA Program) on children's executive functioning. The purpose of the study was to evaluate the effects of a physical education program, while participating in an Enriched Sports Activity Program, on executive functions such as visuospatial working memory, inhibitory control, cognitive flexibility, and task switching. Participants consisted of 357 children made up of 48% males and 52% females whose ages ranged from seven to 14 years-old (M = 9.55, SD = 1.77). Participants from school classes were split in two groups - an experimental and a control group.

The difference between this article and all other articles in the synthesis is not one child in this study was diagnosed with ADHD. Children from both the experimental group (ESA

group) and control group completed a battery made up of three neuropsychological tasks derived by the *Color Word Stroop Task,* the *Trail Making Test* (TMT), and the *Digit Span Test*. Digit Span assesses working memory and The Stroop Task is designed for assessing inhibitory control. The TMT is a test developed for assessing cognitive flexibility and task switching. The ESA program lasted for 14 consecutive weeks. Following the ESA Program children completed 27 training units during physical education class, while children from the control group followed an ordinary physical education class.

The intervention was designed to enrich the warm-up of regular sports activities with cognitive stimuli (inhibition, working memory, task shifting) for improving children's EF. The program consisted of 27 units lasting for 25 minutes. The unit was made up of a baseline phase and stimulation phase, and it was obtained through a combination of two features: cognitive stimulus and movement domain. The neuropsychological tasks measured was working memory (*Digit Span forward/backward*) and inhibitory control (*Stroop Task*). Cognitive Flexibility & task-switching *Trail Making Test* (TMT). Data was analyzed using repeated measures ANOVA model (Time x Group) which compared cognitive scores at the pretest compared to those at the post-test. Descriptive stats for height, weight was also analyzed.

Gentile et al. (2020) discovered the ESA program produced positive effects for working memory, task switching, and cognitive flexibility, with no beneficial effects detected for inhibitory control and short-time memory. Authors also found that children from all the conditions improved their performance, but the ones from the gross motor conditions enhanced their performance significantly more than the other groups when tested immediately after the program. This article was similar to previous articles because authors measured children's

executive functions and physical activity. The difference between this article and all other articles in the thesis is not one child was diagnosed with ADHD.

In all of these the studies, researchers found that exercise benefits children with ADHD. Authors also found that physical activity would have positive effects on executive functioning in children with ADHD. Implementing long term physical activity improves motor abilities of children with ADHD. Executive functioning training programs are practical interventions to administer in a population of elementary school children with ADHD.

Experimental Studies Comparing One Group With and One Group w/out ADHD

These articles were categorized in this particular section because the participants were divided into two groups: one group with ADHD and one without. The last six studies in this category discussed how ADHD is associated with core deficits of executive functioning in students with and without ADHD. Students with ADHD typically score significantly lower in academic achievement test scores (Cavanaugh et al., 2016), are more likely to suffer disciplinary infractions and repeat a grade (Cavanaugh et al., 2016), and experience these educational impairments throughout the course of their schooling, thereby compounding the severity of their difficulties (Bredemeier & Shields, 2006).

First, Fedewa et al. (2020) pursued the effectiveness of daily physical activity in relation to a sedentary treatment condition for improving the attention, behavior and executive functioning of children with or at-risk for ADHD. The purpose was to evaluate the potential moderating effects of the intensity and duration of physical activity on children's attention, behavior and executive function. The article focused on MVPA on executive functioning, inattention, and hyperactive behavior in young children, including those children at risk for ADHD. The study compared the effects of MVPA to sedentary game play for children with and

without at-risk ADHD behaviors. During the fall of 2018, 95 students were randomly assigned to one of two conditions - a treatment/experimental group or a control group. Students demographic were 74% white, 12% African American, 3% Hispanic, 8% Asian, and 3% other. In the control group, 53 subjects were at risk for ADHD. In the intervention group, 42 students were identified as at risk for ADHD. The treatment group received a physical activity intervention for approximately 30 minutes before school three days each week for a total of 44 intervention days. Physical activity games included various forms of tag, 3v3 basketball, jump rope, obstacle courses, and relay races. The control group engaged in sedentary game-based play before school (e.g., board games, cards). This resulted in a total of 44 intervention days.

All parents and teachers of children who had consent for participation and were eligible for participation completed two scales - the *ADHD Rating Scale-5* and *The Behavior Rating Inventory of Executive Functioning-2* (BRIEF-2). In the *ADHD Rating Scale-5*, the child is rated on the frequency and severity of ADHD symptomology and impairment by both the teacher and the parents. The BRIEF-2 is a 63-item questionnaire for parents and teachers that evaluates impairment of executive function in children. Participants wore a heart rate accelerometer on their wrist throughout the intervention. To determine the participants' body composition, their BMI was calculated. During the post test of the intervention in the spring of 2019, he *ADHD Rating Scale-5* and the *BRIEF-2* were administered again as a post-test measure of inattention, hyperactivity, and executive functioning.

Data was analyzed using two statistical tests - chi-square analyses and independent samples *t* tests. These examined whether students in both groups were equal across various characteristics (i.e., grade level, gender, at-risk status for chi-square analyses; height, weight, heart rate, and BMI by independent samples *t* tests). Fedewa et al. (2020) found no statistical

differences at pretest between the intervention and control groups across all measures including ADHD inattention score/percentile. The authors also found no difference in children's average heart rate at the pretest between intervention and control groups. The students in the treatment group spent significantly more time in the moderate to vigorous heart rate zones in both percentage and minutes than those children in the control group.

Two studies tested a group of children with or without ADHD focusing on use of exercise sessions related to cognitive performance and student enjoyment. Taylor et al. (2019) examined the acceptability and the impact on symptoms of exercise for children with ADHD in a school setting. The purpose of the study was to examine the effects of exercise sessions developed to engage children with ADHD. A total of 12 participants between the ages of 10 and 11 years-old participated in the research. The study group of ADHD children consisted of five boys and one girl, with four of the children's ethnicity being white and two being Asian British. The control group consisted of three boys and three girls who were all white. All the children diagnosed with ADHD continued taking their normal medication. Baseline measures of ADHD symptoms for children in the study and control groups were recorded by both parents and teachers before the exercise intervention began.

Participants engaged in physical activity games as well as small sided games two times a week over a 12-week term. Each session started with a session-specific warm-up for five to 10 minutes with children taking turns leading exercises. This was followed by two different gym-based and outdoor activities, each lasting 10 minutes with a mini-break lasting 20 to 30 seconds. Participants finished the session with a five to 10-minute cool-down. The exercise sessions were mentally as well as physically demanding. They required the children to pay attention to the tasks and to the instructions from the leaders, to wait for their turn, and to work with other

children in shared activities. This required focused attention, because the children did not all complete the same activity at the same time.

The home and school versions of the *ADHD Rating Scale-IV* were used to measure the symptoms of ADHD. The overall ADHD symptoms were recorded by the class teachers and parents at three time points: before intervention begins, on week six and week eleven of the exercise intervention. The authors discovered teacher-rated ADHD symptom scores for the study group were significantly lower after 11 weeks of the physical exercise intervention than before the intervention. There were no differences in the teacher-rated or parent-rated symptom scores, which ranged from zero to two at the three timepoints for the children in the control group. Authors also found that specifically designed exercise sessions that stimulate engagement by the children with ADHD may be useful for symptom reduction while on their regular medication. This provides first evidence that these physical activity sessions are acceptable and enjoyable for other children. Therefore, they are potentially useful in the PE curriculum.

In the third study, Piepmeier et al. (2015) explored how 20 minutes of moderate intensity exercise impacted aspects of executive function performance by children with and without ADHD. The purpose of the study was to extend our understanding of the effects of an acute bout of moderate intensity exercise on performance of executive function tasks relative to ADHD status. The study's subjects included 32 K-12 grade private school students. The purpose of the intervention training program was to assist the child in skills and strategies to cope with difficulties and impairments related with ADHD. The intervention features included targeting multiple EF components, involve parents, intervene both with child and child's environment, lastly implement daily life functions to make sure EF skill is being exercised. The sample consisted of 14 children diagnosed with ADHD (five girls, nine boys) and 18 children who had

not been diagnosed with ADHD (seven girls, 11 boys). Parents completed a demographic and ADHD questionnaire. On day one participants performed a 30 aerobic exercise on a LODE Corival Recumbent Cycle-Ergometer made up of made up of a five-minute warm up, twenty-minute exercise, and a five min cool down. A polar HR monitor and T-31 coded chest strap measured participants' heart rate every five minutes while sitting on the recumbent cycle ergometer. OMNI ratings of perceived exertion were used to assess perceived intensity with a goal of having participants exercise at a moderate intensity for the twenty-min period.

On the other day participants were instructed to sit on the recumbent cycle ergometer while they watched a nature documentary for 30 minutes. Measures of HR were obtained every five minutes during the non-exercise condition. Once the exercise and non-exercise conditions are completed, four minutes later participants began a cognitive test such as the *Trail Making*, which measured the set-shifting component of executive function and general speed of cognitive processing. The planning and problem-solving components of executive functioning were assessed using the *Tower of London* task. The inhibition component of executive function and general speed of processing were assessed with an adjusted version of the *Stroop Task*. Peipmeier et al. (2015) discovered the *Stroop Task* data revealed that performance was faster in parts A (Word) and B (Color) compared to part C (Word/Color). The *Tower of London* task showed that an acute bout of exercise did not significantly influence performance on this task. The last cognitive test, TMT, indicated that performance (total time) on TMT A was faster than TMT B regardless of exercise or ADHD diagnosis.

It is estimated that about 3% to 5% of school-age children have ADHD (Kiluk et al., 2008). ADHD symptoms include a low frustration tolerance, temper outburst, mood liability and poor self-esteem (American Psychiatric Association, 2000). In the fourth study, Shaui et al.

(2017) sought out to look into the efficacy, feasibility, and acceptability of a cognitive training program as a nonmedication intervention for children with ADHD. The purpose of the study was to see whether combining traditional EF training for children with ADHD with behavioral intervention for parents could improve the EF and ADHD symptoms in children with ADHD. The study included 44 Chinese children diagnosed with ADHD and 88 children as a health control group. Participants attended one 90-minute sessions which consisted of 60-minute for children and 30 minutes for parents (except the first and the last session which was for parents only) per week for 12 weeks. After the final session, participants and their parents completed post intervention evaluations.

Measurements used during the study included the *ADHD Rating Scale-IV* in which parents rated their child's ADHD symptoms including intention, hyperactivity, and impulsivity. In the *Conners' Parent Rating Scale*, six factors were measured including conduct, learning, psychosomatic, impulsive-hyperactive, anxiety problems, and a hyperactivity index. The *Behavior Rating Inventory of Executive Function* (BRIEF) instrument included eight factors measuring parental reports of EF: initiate, working memory, plan/organize, organization of materials, monitor (formed metacognition index [MI]), inhibit, shift, and emotional control (formed behavioral regulation index [BRI]). The neuropsychological assessments were selected to cover the comprehensive domains of EF components. The *Stroop Color* and *Word Test* were used to capture the inhibition component of EF. The *Rey-Osterrieth Complex Figure Test* (RCFT) was used to evaluate visuospatial construction ability and visual WM. The *Trail Making Test* (TMT) has two parts, part 1 provided a baseline indication of visual search speed and visuomotor functioning, while part 2 estimated flexibility. The *Tower of Hanoi* (ToH) was used to assess planning. The VF test required the participants to name as many animals as possible in

two minutes. The last test was the false-belief task which is used to assess the children's hot EF by determining their understanding of a protagonist's false belief. Statistical analysis was performed using SPSS version 19.0. Parametric variables were analyzed using *t* tests. Nonparametric variables were analyzed using nonparametric Wilcoxon signed rank test.

Shaui et al. (2017) found that children's performance improved significantly on all of the EF tests. Results from pre-EF training compared to post EF training revealed that after the intervention the children with ADHD presented better performances of EF both in neuropsychological tests and reports of daily life.

In a fifth study, Kiluk et al. (2008) explored the relationship between participation in physical activity and emotional functioning in children with ADHD. The purpose of the study was to investigate the relationship between participation in physical activity and mood or anxiety symptoms in children diagnosed with ADHD. A total of 65 children pertaining forty males and 25 females diagnosed with primary ADHD were placed in one group, and 32 children diagnosed with a primary learning disorder were placed in the comparison group. The groups were divided between children who most likely participated in sports all year round (e.g., three or more) versus those who may not have been actively involved in sports the entire year (e.g., zero to two). The *Child Behavior Checklist* (CBCL) is a measure completed by a parent and scored by computer-based programs. It contains one hundred and twelve specific problem behaviors and one item that allows parents to write in other problems. Included in the measure are items directed at sport participation, activities, organizations, and jobs or chores. Additional items assess the child's social relationships and school performance.

Before the intervention began all children included in this retrospective analysis had been referred to a behavioral health clinic and underwent a comprehensive neuropsychological

evaluation. Neuropsychological evaluations included various assessments such as the *Wechsler Intelligence Scale for Children*, the *Woodcock Johnson–III*, and the *California Verbal Learning Task*, the *Rapid Automatized Naming Task*, among others.

Subjects were divided into groups according to their diagnosis, gender, and the number of sports they participated in (zero to two, three or more) as reported by a parent on CBCL. All CBCLs were scored using the Assessment Data Manager Software and subsequent T-scores were compared using SPSS. Analysis of the data found that children with ADHD who played three or more sports displayed fewer symptoms of anxiety or depression than did those who played fewer than 3 sports, according to their parent's report. This study focuses on students with ADHD and learning disorder, neuropsychological evaluations, and sport participation.

In the sixth study, Lufi et al. (2011) examined treatment groups which combines physical activity and sport with behavioral techniques in the treatment of children with ADHD as compared to children with other behavioral problems. The purpose of the study was to assesses the therapeutic potential of physical activity employed in a group therapy setting. It was hypothesized that a group therapy based on physical activity and behavioral techniques would improve functioning of all participants, and the group with ADHD would improve more as compared to the boys with other behavioral and social problems. The target population consisted of two clinical groups consisting of 17 boys with various behavioral and social problems and 15 boys who were diagnosed as having Attention Deficit Hyperactivity Disorder (ADHD).

The boys were divided into two groups based on diagnoses by two clinical psychologists. None of the participants used medications during the time they participated in the group. Three questionnaires were used in the study. Each questionnaire was administered before the beginning of the group (pre-test), after the completion of the group (post-test), and a year after the

completion of the group (follow-up). Participants completed the *Youth Self-Report* (YSR) with eight behavioral categories: withdrawn, aggression, anxiety, attention, delinquency, social., somatic, and thoughts). The YSR is a widely used self-rating scale for children and adolescents ages five to eighteen years of age. The parents completed the *Child Behavior Checklist* and *Conner's Abbreviated Symptom Questionnaire*. Parents and subjects completed questionnaires (ASQ-P) (a) before the beginning of the study (pretest); (b) at the end of the study following the completion of the group therapy (posttest); and (c) 1 year after the end of the group (follow-up). All the boys from both groups participated in weekly group therapy sessions for one school year, two licensed child clinical psychologists led the groups.

The subjects in the groups met once a week for a period of 90 minutes, for 20 sessions during the school year. The daily schedule of the group was as follows: first, boys participated in 20 to 30 minutes of group discussion, led by the psychologists who conducted the group. Second, boys engaged in 20 to 30 minutes of individual sport activities. In this section of the group, participants engaged in pre-planned sport activities such as obstacle races, calisthenics, running, and relay races. Third, the boys played 30 to 40 minutes of team games. In this section, the boys participated in a full-scale match such as soccer, basketball, team handball, flag football, and field hockey. Lastly, boys engaged in a short discussion about the activity just performed with an attempt to assess how the various behaviors discussed and modified earlier were utilized in the game for five to zero minutes.

Several behavioral interventions were used during the sessions: immediate positive reinforcement, prompting, token economy, no exclusionary timeout, modeling, and social skills training. Lufi et al. (2011) discovered the ASQ-T for teachers showed that the group of ADHD boys had much higher scores, as compared to the group of Other Behavior Problems, indicating

more hyperactive behaviors in the ADHD group. Lufi et al. (2011) also found that in one questionnaire administered to the participants and two questionnaires administered to the parents, results displayed significant improvements in both groups. Lufi et al. (2011) also discovered during the group therapy session that physical activity and behavioral techniques would improve functioning of all participants, and that the group with ADHD would improve more as compared to the boys with other behavioral and social problems.

Summary

The articles in this synthesis suggest that a physical activity program may be beneficial for children with ADHD. Both parents and teachers observed better behavioral scores in physical activity groups or experimental groups in the studies. Due to the proper organization and participation of a physical activity program. Research suggests that physical activity by itself can help improve children with ADHD social behavior. Many of the experimental groups were more efficient in information processing by faster speeds of visual research and better sustained auditory attention than the control groups, this provides support to the effect of physical activity on this part of the cognitive domain.

Chapter 4

Results, Discussion and Recommendations for Future Research

The purpose of this chapter is to present the results of the review of literature on the impact that physical activity and Physical Education have on elementary students with Attention Deficit Hyperactivity Disorder (ADHD) and how these results align with the purported research questions which guided this synthesis project. In addition, this chapter will provide recommendations for future research as it relates to best practices in elementary school physical education programs.

The results of this review of literature found similar results regarding the impact that physical activity and Physical Education have on elementary students with ADHD. The overwhelming majority of research on this particular topic, in this synthesis, showed that exercise may benefit the cognitive performance of children with ADHD. Research has proven movement integration, classroom physical activity breaks, active learning, active classrooms, energizers, brain boosters, and classroom physical activity can increase the amount of time students are moving and reducing the amount of time they are sitting still. This leads to improved academic achievement as well as behavior. Research has also indicated that parents and teachers often report improved ADHD symptoms following engagement in physical activity. Results showed after participating in moderate vigorous physical activity children had higher levels of information processing, faster visual research, better auditory, and improved sustained attention also higher physical activity was associated with lower TMS and faster execution times. Additional results showed that an acute bout of exercise did not significantly influence performance on the Tower of London Task as well as improvements in tasks assessing verbal working memory performance. Many results showed physical activity have been demonstrated to

improve cognitive functioning such as response inhibition, planning, working memory, updating, and task switching in children with ADHD.

The results for physical activity and its effects on cognitive functioning in children with ADHD showed that children with ADHD who participated in physical activity throughout the year displayed fewer anxiety-related symptoms compared to those who participated in less activity. Interventions for children with ADHD can be effective in reducing behavioral problems and improving attention and academic performance in a school setting. The use of exercise sessions designed for children with ADHD in PE lessons was associated with a significant reduction in ADHD symptoms observed by the teachers in school.

Discussion

Interpretations

Several research questions were posed prior to the literature review. The first research question was, what is the effect of physical activity on the cognitive and executive functioning of elementary-aged children with ADHD? The results of the literature review show that increased exertion during physical activity is associated with better executive functioning performance in ADHD children. For example, in Ziereis and Jansen (2015), the research showed through data analysis that long-term physical activity has a positive effect on executive functions of children with ADHD. The research of Benzing et al. (2018) also displayed that acute physical activity improve aspects of executive functions in children with ADHD. The work of Piepmeier et al. (2015) was successful in proving that exercise benefited better performance in the *Stroop Task*. Verret et al. (2012) evidenced that participation in a physical activity program improves muscular capacities, motor skills, and behavior reports by parents and teachers.

The second research question that was examined was, What effect does sport and Physical Education Programs have on the impact of students with ADHD? The results shown throughout several studies displayed that active sport participation may be associated with a reduced expression of anxiety depression symptoms in children with ADHD. For example, Lufi et al. (2011) demonstrated the therapeutic potential of physical activity employed in a group setting. Kiluk et al. (2008) also explored the importance of the relationship between participation in physical activity and mood or anxiety symptoms in children diagnosed with ADHD. Kiluk et al. (2008) found children with ADHD displayed by a fewer symptoms of depression and anxiety if they participated in three or more sports as compared to participation in fewer than three sports. Fedewa et al. (2020) found that there was no significant relationship between the physical activity intervention and outcomes for student executive functioning. Findings by Fedewa et al. (2020) did not result in improved parent and teacher reports of children's ADHD symptoms. Fedewa et al. (2020) also found physical activity to be a useful intervention for improving motor, cognitive, social and behavioral functioning in children exhibiting symptoms of ADHD. Gentile et al. (2020) made a point to note that an enriched sport program produced positive effects for working memory, task switching, and cognitive flexibility.

Implications

Previous research on the impact which physical activity and physical education have on elementary students with Attention Deficit Hyperactivity Disorder shows that physical activity displayed improvement in behavior and cognitive function in children with ADHD. Many of the conclusions of the results are intertwined meaning the results are similar. The results of this synthesis offer practical implications which can benefit implementing a physical activity intervention program benefiting academic achievement and behavior.

For example, a specifically designed physical activity program can decrease the chances of children with ADHD scoring lower in academics, suffering disciplinary infractions, and repeating grade levels (Gentile et al., 2020). Also, school psychologist, teachers, and parents should receive ample training on identifying and treating students with ADHD. Many experienced educators should receive the skills and education to serve this population of students. Teachers, parents, and administration should actively work to increase students' access to specifically designed physical activity programs.

It should also be noted that children with ADHD require a unique approach to teaching and learning. Evidence has shown that exercise may have positive effects on both social and cognitive development in children with ADHD. Physical education lessons for the whole class could especially be beneficial for students with ADHD. Standard PE lessons can be difficult for students with ADHD due to long periods of the same activity. It is also worth noting that providing choice and multiple short duration exercises in Physical Education class may reduce students with ADHD symptoms (Gentile et al., 2020). Physical activity has a positive effect on students with ADHD EF inhibitory function, planning and problem solving, cognitive flexibility, and visuospatial attention. In fact, children with ADHD cognitive abilities have improved due to physical exercise, this has been found by Gapin and Etnier (2010). Physical activity on ADHD students' cognitive function has received minor attention, and therefore these physical activity interventions deserve careful consideration when teachers, administrators, and parents are collaborating about physical activity programs for ADHD children.

Limitations & Recommendations for Future Research

Following a lengthy review of the data available regarding the impact physical activity have on students with ADHD, the following limitations were noted within the literature. A few studies were limited by the small sample size; utilizing larger sample groups will eventually lead to a greater population of students identified as at risk for ADHD. The reason being it provides a smaller chance of error. Capturing enough young children who are able to participate consistently in an intervention that occurs before or after school is challenging. In order to discover children at-risk for ADHD, researchers must search school districts where incentivizing parents and teachers is allowed. A second limitations was performances in EF's were detected; however, they weren't linked to children's academic achievement or their reading, writing, and calculating skills. Third, most of the participants were being treated with medication; therefore, the possible effects on medication symptoms and whether physical activity might be an alternative remain unclear. Meaning, future research should explore the role of physical activity in the absence of medication.

Based on these limitations, future research should consider the following recommendations:

1. Future research should examine the impact of combining interventions for physical activity and medication in children with ADHD.
2. Future research should continue interventions studying both male and females who are diagnosed with ADHD to further educate individuals according to what works best according to gender.

3. Research should be conducted in all countries so that we are capable of knowing and understanding all instructional and teaching strategies that work and do not work in order to provide best practices for children with ADHD.

Summary

The purpose of this synthesis was to review literature on the on the impact that physical activity and Physical Education have on elementary students with Attention Deficit Hyperactivity Disorder (ADHD). A through search of online databases using specific delimiting techniques and key words revealed 11 articles that were selected for this synthesis. These articles were synthesized to determine if physical activity and physical education have an impact on elementary aged students with ADHD cognitive and executive functions.

Research revealed significant results in behavioral outcomes in aggression, anxiety/depression, attention, externalized/internalized problems, and skill related fitness when participating in physical activity. Physical activity interventions appear to increase cognitive performance for children with ADHD related to hyperactivity/impulsivity.

Further research and enhanced analytic data from experimental investigation must grow within the physical education environment to investigate its impacts on children with ADHD. Research should evolve in all countries so that we are capable of knowing and understanding all instructional and teaching strategies that work and do not work in order to provide best practices for these children. It is significant that we continue interventions studying both male and females who are diagnosed with ADHD to further educate individuals according to what works best in regards to gender.

The articles' settings and the procedures in which participants were chosen was a huge surprise while investigating the articles. The location and environment in which the studies

settings took place were different parts of the world. The procedures to how children were selected for studies was also surprising. The reason being, in past studies researched all participants would be tested in a school setting. This wasn't the case for every article. For instance, in Ziereis and Jansen (2015), subjects were recruited from local psychiatric practices and were invited to participate by the children's psychiatrists. Verrett et al.'s (2012) study was conducted in Canada and participants were recruited from a specialized ADHD clinic of the Riviere Des Prairies Hospital and from a local school. Benzing et al.'s (2018) study was conducted in China and participants were recruited through an association for parents and caregivers of ADHD children. Gentile et al.'s (2020) study was conducted in the four countries of Italy, Lithuania, Turkey, and Germany.

One aspect of the research design that was beneficial was the fact that researchers tested children who were diagnosed with ADHD, children who were at risk for ADHD, and children with behavioral and learning disorders. One article consisted of researchers testing a health control group. Involving parents and teachers in the studies appeared to be beneficial, as appropriate and effective management of children with ADHD involves collaboration between parents, clinicians, and teachers. The effects of ADHD manifest themselves in multiple environments which can lead to issues at both home and school. Many articles used the *ADHD Rating Scale* which is the standard method for clinicians to collect data and monitor disease severity during evaluation and treatment of ADHD. The rating scale represents a one-way, parallel communication from parent and teacher to collaborate with key members of a child's ADHD management team.

A disadvantage of the studies was the fact that some studies required children to take their medication per usual during the interventions and some studies didn't require students to be

medicated. This has the potential to make results unreliable. Children should have been grouped based on the type and amount of ADHD medication they intake. Results maybe would have been different if all students were on the same medications.

Knowledge regarding ADHD can be beneficial to teachers because it plays a vital role in a child's education. If a child is diagnosed with ADHD and a treatment plan it's the responsibility of the teacher to implement an intervention to improve concentration and student's ability to stay on task throughout the school day. Educators can use these skills to reduce disruptive behavior, improve student's motivation and engagement, and improve students with ADHD academic performance. When teachers are aware of students needs they are better equipped to develop teaching and learning strategies along with behavior management strategies that are appropriate and effective (Gentile et al., 2020). Equipping teachers to teach children with ADHD may improve their confidence in teaching, as well as their overall well-being (Gentile et al., 2020). With an increase in knowledge teachers may be more confident and motivated to educate children with symptoms of ADHD and change their classroom management.

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Appendix A
Synthesis Article Grid

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Verret, C., Guay, M.-C., Berthiaume, C., Gardiner, P., & Béliveau, L. (2012). A Physical Activity Program Improves Behavior and Cognitive Functions in Children With ADHD: An Exploratory Study. Journal of Attention Disorders, 16(1), 71–80.	• assess the effects of a moderate- to high intensity physical activity program on fitness, cognitive functions, and behavior in children with ADHD • Hypothesized that the program would result in improved fitness, ADHD-related behaviors, and cognitive functions	• N=21 children 7-12 yo (mean = 9.1 yo) • 19 boys, 2 girls • All participants previously diagnosed with combined or hyperactive-impulsive ADHD • 2 groups: Experimental (PA program; n=10; 30% on medication) and Control (n=11; all on medication) -both groups pre-tested 10 days before intervention -Intervention: Physical Activity Training Program: 3x/week for 45 min.; over 10 weeks; goal to maintain MVPA; activities aerobic in nature (soccer, basketball, exercise stations, etc.) -both groups Post-tested within one week of completion of intervention **MEASURES:** • Fitness level: ht, wt, BMI, flexibility (sit&reach), muscular endurance (pushups, situps), resting and max HR measured during Bruce treadmill test (HR monitor) • Motor Skills (TGMD-2: locomotor movements, gross motor skills such as kicking and throwing) •)Behaviors: Parents and teachers completed Child Behavior Checklist (CBCL): 8 subscales: anxiety-depression, withdrawn-depression, somatic complaints, social problems, thought problems, attention problems, rule-breaking behaviors, aggressive behaviors) • Neuropsychological (cognitive functions): • Attention: Test of Everyday Attention for Children (Tea-Ch): Sky Search DT and score part • Response Inhibition: walk/don't walk part of Tea-Ch	• Group equivalence through independent samples (paired) t testss • ANCOVA (analysis of covariance) to compare PA and control group • ANCOVA assumptions tested visually and pretest X group interaction test, Shapiro-Wilk procedure for normality of sampling distribution on variable residuals, and Levene's test for homogeneity of variance • One-tailed tests; significance p<.05 •	• Fitness: children in PA group did more pushups than those in control group • Motor performance: significant group difference for locomotor skills and total motor skills (PA group higher) • Behavior: Significant differences for total problems score and 3 subtests: social problems, thought problems, attention problems. Teachers reported a tendency for improvements in all scales (but not significant). • Cognitive Behaviors: Significant differences had higher level of information processing, faster in visual research, and better auditory, sustained attention •	• Improvement in motor skills in PA group can be important as children with ADHD have motor skill difficulties that are related to limited PA participation • Surprising: aerobic fitness and body composition did NOT change as a result of the PA program—maybe b/c initial levels of aerobic and body comp were in optimal at start of study • No significant differences in inhibition deficit and impaired characteristics of hyperactivity-impulsivity: so, PA program did not affect all ADHD core symptoms. PA group did improve in behavior and attention functions—due to MVPA program?? • Both parents and teachers observed better behavioral scores in physical activity group: because of the PA program—suggests that PA by itself can help improve social behavior—very efficient way to do so (don't need special summer program such as STP, for ex.) • Experimental group were more efficient in information processing by faster speeds of visual research and better sustained auditory attention: provides support to effect of PA on this part of the cognitive domain. • Limitations (were minimal): difference in stimulant medication prescription between both groups. both parents and teachers were aware of the treatment and probably had expectations for changes (Halo effect) small sample size, some missing data. Conclusion: • Exploratory due to methodological issues results suggest that a physical activity program may be beneficial for children with ADHD.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Gapin, J., & Etnier, J. L. (2010). The Relationship Between Physical Activity and Executive Function Performance in Children with Attention-Deficit Hyperactivity Disorder. Journal of Sport & Exercise Psychology, 32(6), 753–763.	• collect data relative to the relationship between PA and EF in children with AD/HD • hypothesized that higher PA would be associated with better performance on EF tasks.	• (n=21 boys) 8-12yrs. • Diagnosed with ADHD • participants were using stimulant medications, either methylphenidate or amphetamine, for treatment of ADHD. • Data collected. September-December. • Participants instructed not to engage in structured PA within 3 hr of testing period to reduce the potential impact of acute PA on cognitive function. • Parents completed a demographic questionnaire while child completed 4 EF tasks. **Measures:** • First, the boys completed four EF tasks. (Inhibition- CPT-ll, Planning- tower of london, Working memory- Digit span DS, processing speed- CCTT1&2). **Physical Activity Measures:** • Accelermotor- children were instructed to put on the acc. for seven days. When they woke and took it off when they went to bed. It could only be removed for bathing, swimming, and sleep. • Daily PA log- used to record activities by participants •	• statistical analyses were conducted using SPSS 16.0 • Descriptive analyses were performed on the MVPA and EF measures.	• Regression analyses revealed that MVPA was a significant predictor of performance on the Tower of London TMS and Tower of London TET. • Higher PA was associated with lower TMS and faster execution times.	• Physical activity has a small effect on cognition in children and may be particularly beneficial for children with AD/HD by impacting fundamental EF deficiencies that characterize this disorder. • (AD/HD) is one of the most common psychiatric disorders among children • Executive functions (EF) are defined as the cognitive functions that serve to maintain an appropriate problem-solving set to attain a future goal and encompass cognitive domains that are highly relevant for daily life activities, appropriate behavior, and academic and social function. (Welsh & Pennington, 1988) • participants were using stimulant medications.

IMPACT PHYSICAL ACTIVITY HAVE ON ADHD CHILDREN

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Piepmeier, A.T., Shih, C.-H., Whedon, M., Williams, L., Davis, M., Henning, D., Park, S., Calkins, S.D., & Etnier, J.L. (2015). The effect of acute exercise on cognitive performance in children with and without ADHD. Journal of Sport and Health Science, 4(1), 97-104.	-examine the effect of acute exercise on cognitive performance by children with and without ADHD	-N=14 w/ADHD (5 girls, 9 boys) -N=18 w/out ADHD (7 girls, 11 boys). t least 72 h apart. On day 1 30- watched a nature documentary -After completing the 30-min exercise protocol or the 30-min period of watching the nature documentary, participants sat quietly for approximately 4 min before beginning the cognitive testing. -Tests of cognitive performance were administered in the same order each day (i.e., Trail Making, Tower of London, Stroop). **Measurements** • Heart rate was measured using HR monitor and T-31 chest trap • Exercise related measures: Heart rate, the children's OMI scale measure ratings of exertion •	Three Separate mixed ANOVAs were used to determine the effect of exercise on cognitive performance using SPSS version 22.	• Stroop Task revealed that performance was faster in parts A (Word) and B (Color) compared to part C (Word/Color). • Tower of London Task showed that an acute bout of exercise did not significantly influence performance on this task. • TMT indicated that performance on TMT A was faster than TMT B regardless of exercise or ADHD diagnosis.	• 6.1% of children in the U.S. are taking medication to reduce ADHD symptoms. • symptoms of ADHD interfere with aspects of social, academic, and work life. • Prefrontal cortex area of the brain is responsible for the performance of a set of higher order cognitive tasks, designated as "executive function" tasks that require response inhibition, planning, working memory, updating, and task switching. • Participants performed a 30-min bout of exercise on a LODE Corival Recumbent Cycle-Ergometer (Lode BV, Groningen, The Netherlands), comprised of a 5-min warm-up, 20 min of exercise, and a 5-min cool-down. • All participants watched the same 30-min section of the Planet Earth nature documentary. • Cognitive performance measures: stroop test, tower of London, trail making test.

IMPACT PHYSICAL ACTIVITY HAVE ON ADHD CHILDREN

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Ziereis, Susanne and Jansen, Petra (2015) Effects of physical activity on executive function and motor performance in children with ADHD. RESEARCH IN DEVELOPMENTAL DISABILITIES, 38. pp. 181-191.	• whether PA improves cognitive performance. • whether there are beneficial effects of PA on EF in children with ADHD.	• (N=43 32 boys and 11 girls) 7-12 yrs • April - July 2013, 12 weeks • EG1=13 (3 girls and 9 boys) EG2=14 (2 girls and 9 boys). • CG(n=16) • Tested one week prior to start and one week after the last session. • Session occurred 60 min per week. • After 1st session each child completed the cognitive and motor test to assess potential short-term effects of PA and coordinative exercise • One week after last session children assessed for long term training effects. **Working memory MEASURES:** • The digit span was used to assess verbal WM performance. • To measure visuo-spatial WM performance, the Corsi block tapping test was used. **Motor performance MEASURES:** • The M-ABC 2 was chosen to measure motor performance •	• a one-way analysis of variance (ANOVA) was conducted to determine whether the anthropometrical and fitness status of the three groups differed significantly. • A second one-way ANOVA was used to compare pre-test measurements.	• There were improvements in tasks assessing verbal WM performance • No significant differences between a specific and non-specific training program were found. • Turkey Test didn't reveal any significant differences between each combination of both factors group and time. • Test didn't show significant difference between the EG1 and the EG2, the EG1 and the CG, and the EG2 and the CG for all motor related variables.	• Physical activity has been demonstrated to improve cognitive functioning in healthy populations. • ADHD affects 3–7% of the school-aged population. • EFs, are often described as the top-down control of cognitive processes and consist of the components working memory (WM), response inhibition, and set shifting. • Children with ADHD often experience deficits in motor abilities and EF.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Shuai, L., Daley, D., Wang, Y., Zhang, J., Kong, Y., Tan, X., et al. (2017). Executive function training for children with attention deficit hyperactivity disorder. Chinese Medical Journal, 130(5)	• to explore whether combining traditional EF training for children with ADHD with behavioral intervention for parents could improve the EF and ADHD symptoms in children with ADHD.	• N=44 w/ADHD • N=88 (HC). • Data was collected 2/06 – 12/12. 12 weeks **Measurements** • rating scales, • conners parent rating scale • Behavior rating inventory of executive function (BRIEF) **Neuropsychological measurements** • The stroop color and word test, • The Rey-Osterrieth complex figure test (RCFT) • Trail making test (TMT), • The tower of Hanoi (TOH), • The VF tests • The false-belief task • Participants attended one 90-minute sessions (60-minute for children, 30-minute for parents except the first and the last session which was for parents only). Parents and participants completed post interventions evaluation. **Intervention features** • Target EF components • Intervene with child and child's environment. • Involve parents • Implementing daily life.	• Statistical analysis was performed using SPSS version 19.0 • Parametric variables analyzed using t testss. • Nonparametric was analyzed using nonparametric Wilcoxon signed rank test.	• results (before vs. after EF training) showed that after intervention, the children with ADHD presented better performances of EF both in neuropsychological tests and reports of daily life. • Children's performance improved significantly on all of the EF tests • Parental reports of children's problem behavioral at home reduced. • ADHD symptoms and behaviors showed improvements. • Children's heart rate and perceived physical exertion increased. • Flanker Test- no difference for congruent, incongruent, or for switching trails. • Visual working memory- no difference between the 2 groups in Color Span Backwards Task.	• A cohort study following 1000 children from birth to the age of 32 years demonstrated that childhood EF predicted physical health. • Good academic performance is an important issue for Chinese parents not only because it is thought to be an important stepping stone to success, but also because is reflects well on parents and family in Chinese culture. • The EF training program was feasible to administer and could be successfully administered. • ADHD is associated with core deficits in EF.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Benzing, V., Chang, Y. K., & Schmidt, M. (2018). Acute Physical Activity Enhances Executive Functions in Children with ADHD. Scientific reports, 8(1), 12382	• investigated the effects of an acute bout of physical activity on multiple aspects of executive functions (inhibition, switching, and visual working memory) in children with ADHD.	• N=46 8-12 years. • children completed 15 minutes of acute exergaming (physical activity of moderate intensity) or a control condition (sedentary). **Assessments** • Pubertal status assessed using German version of Pubertal Developmental scale • Socioeconomic status was assessed using the Family Affluence Scale 2 • Physical Activity behavior was assessed using the Physical activity, Exercise, and sport questionnaire. • Children were provided hear rate monitors • EF performance was assessed pre and post intervention. • After posttest perceived physical exertion, cognitive engagement and enjoyment was measured. -OMNI scale of perceived exertion measured physical exertion. -Polar Team 2 Pro system recorded HR, maximal HR was predicted using the formula 208-0.7 age. -Self-assessment Manikin was used to discuss cognitive engagement of the activity. • Executive function performance in inhibition, switching and visual working memory were assessed before and after each condition, using a modified version of both the Flanker and the Color Span Backwards Task. **Acute Intervention** • The Exergaming condition was conducted using the XBOX Kinect, users completed the “Beatmaster Training Quest”, which consists of six different exercises. • In control condition, the participants watched a documentary report about mountain running, with a similar duration to the Exergaming condition. •	• Statistical tests were performed using SPSS. • (ANCOVAs) using pre-test performance as covariates and post tests performance as the dependent variable were conducted.	• results revealed that completing an acute exergaming intervention of a moderate to vigorous intensity for at least 14 min had significant beneficial effects on reaction times in inhibition and switching, but not on accuracy or visual working memory performance • both groups showed a high level of enjoyment.	• EFs are defined as the higher-order cognitive functions that modulate fundamental cognitive processes and are therefore required for goal-oriented, adaptive and flexible behavior. • Sample size and associated statistical power was not large enough to consider any sub group analyses. • Future research should explore the role of physical activity in the absence of medication

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Lufi, D., & Parish-Plass, J. (2011). Sport-based group therapy program for boys with ADHD or with other behavioral disorders. Child & Family Behavior Therapy, 33(3), 217–230.	-assess the therapeutic potential of physical activity employed in a group therapy setting. -hypothesized that a group therapy based on physical activity and behavioral techniques would improve functioning of all participants, and the group w/ ADHD would improve more as compared to the boys with other behavioral and social problems.	• N=32 boys 8-13 yrs. • two clinical groups: (a) 17 boys with various behavioral and social problems • (b) 15 boys who were diagnosed as having (ADHD). • Psychologist interviewed and diagnosed (DSM-IV-TR) each child to place him in the appropriate treatment group. **Instruments** • 3 questionnaires • (Boys)Youth Self-Report- 8 behavioral categories: withdrawn, aggression, anxiety, attention, delinquency, social, somatic, and thoughts) • (Parents) Child Behavior Checklist, Conner's Abbreviated symptom Questionnaire Parents • Parents and participants answer questionnaires (ASQ-P) (a) before the beginning of the study (pretest); (b) at the end of the study following the completion of the group therapy (posttest); and (c) 1 year after the end of the group (follow-up). • All boys participated in weekly group therapy sessions for 1 school year. • participants in the groups met once a week for a period of 90 minutes, for 20 sessions during the school year.	• an alpha of 0.01 was used in order to reduce Type 1 error due to the many variables used in the analyses. • ANOVA showed significant main effects for two out of the eight scale domains (anxiety and somatic).	• Group of ADHD had much higher scores compared to the Group of Other Behavior Problems indicating more hyperactive behaviors in the ADHD group. • No significant differences in age or IQ. • This form of therapy is beneficial to participants displaying various psychological problems.	• children with ADHD might have difficulties in sportsmanship, which could be the result of deficiencies in communication, social knowledge, and emotional regulation. • Both the YSR and the CBCL display appropriate levels of reliability and validity. • More participants should be used to allow better generalization of the results.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Kiluk, B. D., Weden, S., & Culotta, V. P. (2008). Sport participation and anxiety in children with ADHD. *Journal of attention disorders*, *12*(6), 499–506.	explores the relationship between participationin physical activity and mood or anxiety symptoms in children diagnosed with ADHD.	N=65 (40 males, 25 females) diagnosed with primary ADHD were N=32 diagnosed with a primary LD were placed in the comparison group. 2 groups according to diagnosis, gender, and the number of sports participated in (0 to 2, 3 or more) as reported by a parent on CBCL. Parent completed Child Behavior Checklist scored by computer-based program. CBCL contains 112 specific problem behaviors and 1 item for parents to write in other problems. Measures are directed at sport participation, activities, organizations, and jobs chores. Parents list the number of activities in each category and rate how much time the child spends in each activity as well as ability level in these activities. Children in the underwent a neuropsychological evaluation with assessments such as the Wechsler Intelligence Scale for Children, Woodcock Johnson–III, California Verbal Learning Task, Rapid Automatized Naming Task, Controlled Oral Word Association and Category Test, Trail Making Test A and B, ADHD Checklist, Behavior Rating Scale of Executive Functioning, and a computerized vigilance task.	All CBCLs were scored using the Assessment Data Manager Software T-scores were compared using SPSS. Analysis of covariance (ANCOVA) was conducted between boys with ADHD using number of sports as the independent variable (0 to 2, 3 or more) and anxious–depressed T-scores as the	Children with ADHD displayed by a fewer symptoms of depression and anxiety if they participated in 3 or more sports as compared to participation in fewer than 3 sports (as reported	It is estimated that about 3% to 5% of school-age children have ADHD. Methylphenidate, the most commonly prescribed drug for the treatment of ADHD, is moderately effective, but not all children with ADHD respond favorably, and in fact about 20% experience side effects, including high blood pressure, sleep problems, or mood disturbances children with ADHD who participated in sports throughout the year displayed fewer anxiety-related symptoms compared to those who participated in less activity.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Fedewa, A., Mayo, M.R., Ahn, S. & Erwin, H. (2020). A School-Based Physical Activity Intervention for Young Children: Are There Effects on Attention and Behavior? Journal of Applied School Psychology, 37(4)	• to understand the impact of MVPA on executive functioning, inattention, and hyperactive behavior • The study compared the effects of MVPA to sedentary game play for children with and without at risk ADHD behaviors. • Examine effectiveness of daily physical activity in relation to a sedentary treatment condition for improving attention, behavior, and executive function of children at risk for ADHD. • Evaluate the potential moderating effects of intensity and duration of physical activity on children's attention, behavior and executive function. • Hypothesized children with higher percentage of time spent in moderate to vigorous physical activity would lower hyperactivity/impulsivity and inattention and higher executive functioning scores than children with a lower percentage of MVPA.	• 44 intervention days. • N=59 • study occurred in the school setting with a longer duration intervention. • two conditions: a treatment/experimental group and a control group • The treatment group received a physical activity (forms of tag, 3V3 basketball, jump rope, obstacle courses, and relay races) intervention for approximately 30 minutes before school three days each week • control group engaged in sedentary game-based play before school (e.g., board games, cards). **Instruments** -ADHD rating scale 5 -Behavior rating inventory of executive functioning-2 (BRIEF-2) -Heart rate -Body mass index	• A series of chi-square analysis or independent samples t tests were first used to examine whether students in both groups were equal across various characteristics (i.e., grade level, gender, at-risk status for chi-square analyses; height, weight, heart rate, and BMI by independent samples t tests).	• results from an independent samples t tests show that no statistical differences at pretest exists between the intervention and control groups across all measures including ADHD inattention intervention effects on ADHD- • These results were found regardless of the intervention, indicating that the physical activity intervention did not improve children's parent and teacher reports of children's ADHD scores. • Intervention effects on executive functioning- the more time spent in the blue and red zone (exerting light or vigorous physical activity), the higher the executive functioning scores as reported by the teacher. • time spent within the moderate activity zone resulted in teacher reports of executive functioning that were lower.	• findings did not result in improved parent and teacher reports of children's ADHD symptomatology. • no significant intervention effect was found across parental and teacher measures related to executive function. • results of this study indicate that more work and research is needed to examine the relationship between children at-risk for ADHD and physical activity. • Students with ADHD are more likely to be placed in special education, retained, and drop-out of school (DuPaul et al., 2011). These alarming and poor statistics indicate that schools must intervene early to prevent deleterious school outcomes. • Implementing a physical activity intervention reflects promising benefits for academic achievement and behavior (Pontifex et al., 2013; Smith et al., 2013; Verret et al., 2012). • Students with ADHD typically score significantly lower in academic achievement test scores (DuPaul et al., 2006; Loe & Feldman, 2007), are more likely to suffer disciplinary infractions and repeat a grade (Barkley, 2006; LeFever et al., 2002), and experience these educational impairments throughout the course of their schooling, compounding the severity of their difficulties (Massetti et al., 2008; Schultz et al., 2011). • Evidence-based interventions for children with ADHD can be effective in reducing behavioral problems and improving attention and academic performance in the short-term.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Taylor, A., Novo, D., & Foreman, D. (2019). An Exercise Program Designed for Children with Attention Deficit/Hyperactivity Disorder for Use in School Physical Education: Feasibility and Utility. Healthcare, 7(3), 102. MDPI AG.	• examine the acceptability and the impact on symptoms of exercise at school	• N=12 10–11 years • Study group 5 boys 1 girl, 4 white, 2 Asian British. w/ADHD • Control group 3 boys 3 girls all white. w/out ADHD • 40 min sessions • Each session started with a session-specific warm-up for 5–10 min with children taking turns to lead. • two different gym-based and outdoor blocks of mixed activity, each lasting 10 min with a mini-break (20–30 s) between. • The session then finished with a 5–10-min cool-down. • ADHD symptoms were recorded 3x's before intervention, on week 6 and week 11. **MEASURES:** • Home and school versions of ADHD Rating Scale 4 measure symptoms	• Univariate ANOVA, with Bonferroni correction was used to examine ADHD scores for the study group. • Test retest reliability was examined using Kendall's tau	• no differences in the teacher-rated or parent-rated symptom scores • ADHD symptoms level was affected by the number of weeks of exercise undertaken. • first evidence that physical activity sessions specifically designed with the help of children with indicate that specifically designed exercise sessions that stimulate engagement by the children with ADHD may be useful for symptom reduction.	• It is also interesting that progressive teaching methods have addressed the need for children with ADHD to have some physical movement during seated classroom activities. • the use of exercise sessions designed for children with ADHD in PE lessons was associated with a significant reduction in ADHD symptoms observed by the teachers in school. • Limited number of children of the correct age available.

Author Title Source	Purpose	Methods & Procedures	Analysis	Findings	Discussion/ Recommendations Research Notes – Commonalities/Differences
Gentile, A., Boca, S., Şahin, F. N., Güler, Ö., Pajaujiene, S., Indriuniene, V., Demetriou, Y., Sturm, D., Gómez-López, M., Bianco, A., & Alesi, M. (2020). The Effect of an Enriched Sport Program on Children's Executive Functions: The ESA Program. Frontiers in psychology, 11, 657.	• analyzes the effect of Enriched Sports Activity Program (ESA Program) on children's EFs. • test the effectiveness of the ESA Program on children's cognitive performances, EFs.	• Data collection: November and May • 4 countries: Lithuania, Italy, Turkey, Germany • N=357 children; ages7-14 yo (mean=9.55yo) • 48% male, 52% female • 2 Groups: Experimental (ESA) and Control -both groups took pre-test -Intervention: 27 units during PE class over 14 weeks (ESA group only; control group had regular PE) -post tested using same measures as pre-test **MEASURES:** • Neuropsychological tasks: • 1. Working Memory (Digit Span forward/backward) • 2. Inhibitory Control (Stroop Task • 3. Cognitive Flexibility & task-switching (Trail Making Test (TMT)	• Descriptive stats for height, weight • Repeated measures ANOVA model (Time x Group comparisons: cognitive scores at beginning compared to those at end	• the sport program produced positive effects for working memory, task switching, and cognitive flexibility, • no beneficial effects were detected on inhibitory control and short-time memory. • children from all the conditions improved their performance, but the ones from gross motor condition enhanced their performance significantly more than the other groups when tested immediately after the program.	• cognition and exercise were treated independently • EFs relate to a set of cognitive abilities that supervise the information processing for the implementation of goal directed actions and that require a certain amount of memory, attention, inhibition, and self-control.