2018

Student and Teacher Perceptions of the Relationship Between Self-Regulation Executive Functions and Playing Team Sports

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STUDENT AND TEACHER PERCEPTIONS OF THE RELATIONSHIP BETWEEN SELF-REGULATION EXECUTIVE FUNCTIONS AND PLAYING TEAM SPORTS

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Submitted in Partial Fulfillment of the Requirements for the Degree of

Doctor of Psychology

May, 2018

COLLEGE OF
OSTEOPATHIC

DEPARTMENT OF PSYCHOLOGY

DISSERTATION APPROVAL

This is to certify that the thesis presented to us by Rebecca Edelsberg on the 30th day of April 2018, in partial fulfillment of the requirements for the degree of Doctor of Psychology, has been examined and is acceptable in both scholarship and literary quality.

COMMITTEE MEMBERS' SIGNATURES

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Acknowledgements

First and foremost I would like to extend my deepest gratitude to my dissertation chair, Dr. George McCloskey. He provided me with the utmost support, guidance, and wisdom throughout the entire dissertation process and my time at PCOM. I cannot thank him enough for his patience and the guidance that he provided for every question I had and the reassurance he provided that I needed to complete this journey. From my experiences learning from Dr. McCloskey in classes and during the dissertation process, and from the wisdom he has imparted upon me, I have learned so much about myself as a person, a writer, and as a school psychologist. I also want to thank my committee members, Dr. Kate Tresco and Dr. Timothy Brennan, for their time, support, and guidance. I am extremely grateful for Dr. Tresco's advice throughout my time at PCOM and her valuable input and feedback on my research to make it the best possible study it could be. I want to thank Dr. Tim Brennan for all of his support, guidance, and feedback on my writing, research, and being the best editor I could have asked for. He has been a mentor to me since our time in Long Beach Island, and I am so grateful he was part of this journey with me.

I would also like to thank my fiancé, Jason. He has been my rock and has provided me with unconditional love and support throughout my journey at PCOM. He has been an unbelievable support system and was the best study buddy by quizzing me on neuro-physiology and learning more about the brain than he ever wanted to; but he was so proud and told everyone I was going to be a "brain feelings doctor." He never complained that my books took up our entire bookshelf and that for months there were research articles in various places around our home in preparation for my "book." I also want to thank him for realizing when I was most overwhelmed and that all I needed was just a little bit of chocolate. I also want to thank Karen and Harris Sanders, my future in-laws for their support and love, for always keeping an interest in my studies, and for being a great cheering section.

To my parents, Joan and Irv, I would not have made it through this without them being my biggest cheerleaders, and without their unconditional love, and unwavering belief that I was going to cross the finish line. They have instilled in me the value of education, learning, and becoming an extraordinary person. Dad, I'm "Doctor E" now, too! I also want to thank my brother Zach for his friendship, devoted support, and listening to me talk psychology. I would not trade in our year together in Philadelphia for anything. Finally, this is for my "Bubbie", the most resilient person I ever knew, and who always told me "I had to be somebody."

Abstract

Executive functions (EF) are the directive capacities of the human brain that are responsible for a person's ability to engage in purposeful, organized, goal-directed behavior and to cue and direct perceptions, feelings, thoughts and actions in specific ways. There has been a growing body of research indicating that sports such as soccer, basketball, and baseball require the effective use of self-regulation executive functions that cue and direct attention, inhibition, shifting, flexibility and working memory. The objective of the study was to investigate student athletes' perceptions of the relationship between playing sports and their effective use of executive functions and teacher perceptions of student athletes' effective use of executive capacities. The data file used in this study consisted of the survey responses obtained from 70 student athletes divided into two groups: contact required sports (n=37), and contact nonrequired sports (n=33). The data file also consisted of teacher ratings of the athletes' current executive function abilities, which were divided into two groups: contact required sports (n=25), and contact nonrequired sports (n=25). The results of the student survey item analyses indicated that a majority of the athletes agreed or strongly agreed that playing organized sports helped them with the effective use of their executive capacities. The results from the student surveys did not indicate any perceived differences in the use of executive capacities between students in contact required sports and students in contact nonrequired sports. Teacher ratings indicated that a large portion of the athletes rated demonstrate executive strengths and did not indicate any perceived differences in the use of executive capacities between students in contact required sports and students in contact nonrequired sports.

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Chapter 1

INTRODUCTION

Executive functions (EF) are the directive capacities of the human brain that are responsible for a person's ability to engage in purposeful, organized, and goal-directed behavior. Self-regulation executive functions are used to cue and direct perceptions, feelings, thoughts and actions in specific ways. Although the type and nature of self-regulation executive functions vary, depending on the theoretical model used to define them, most models include the following capacities: focusing and sustaining attention, inhibiting impulsivity, shifting from one task to another, being flexible, and engaging working memory (Anderson, 2002; Barkley, 2001).

Focusing and sustaining attention involves the capacity to attend selectively attend to specific stimuli and to sustain attention for extended periods of time. Inhibition cues the suppression of urges to perceive, think, feel, or act on one's first impulse (Barkley, 2001). Working memory is the capacity to hold and manipulate information in mind. Flexibility is a willingness to alter the frame of reference for the direction and engagement of perceptions, thoughts, or actions in reaction to what is occurring in the environment (Denkla, 1996; Diamond, 2013). Shifting is the capacity to engage in a relatively quick change in direction and engagement of thoughts, actions, or perceptions in reaction to what is occurring in the environment (Denkla,1996; Diamond, 2013).

These self-regulation capacities are involved in the effective direction of daily life activities, appropriate behavior, and academic and social functioning (McCloskey, Perkins & VanDivner, 2008). Difficulties with the effective use of executive functions can result in difficulty processing information or identifying relevant information, difficulty with inhibiting of irrelevant thoughts, and problems with staying focused on tasks (Gapin, Labban, & Etnier, 2011). Students that exhibit difficulties with executive function use may have difficulty with understanding academic concepts, socializing with peers, and sustaining attention for instruction (Best, 2010).

There has been a growing body of research indicating that physical exercise helps with the effective engagement of executive functions. Physical activity and sports can play a very positive role in children's lives (Sattelmair & Ratey, 2009). They have a great potential to increase a child's self-esteem and motivation. Researchers have demonstrated that being on a sports team can play an important role in the development of identity, self-esteem and individual competence (Van Boekel et al., 2014). By participating in sports, adolescents have less free time on their hands and find motivation to do well in school. Students have to perform well academically to maintain eligibility to play sports which increases their motivation to excel on and off the field. Physical activity also plays an important role in developing and maintaining effective interpersonal relationships. Many of the sports activities that children engage in entail participation in group activities that require complex cognition in order to cooperate with teammates, anticipate the behavior of other players, employ strategies, and adapt to changing task demands. Sports such as soccer, basketball, and baseball require the effective use of self-regulating executive functions that cue and direct attention, inhibition, shifting, flexibility and working memory (Best, 2010; Ratey &Hagerman, 2010). In essence, participation in team sports requires the engagement of the same executive functions that are critical to effective classroom performance. It is possible, therefore, that the use of executive functions while participating in team sports may enable students to apply these same executive functions effectively in the classroom when engaged with academic tasks.

Statement of the Problem

Different sports may engage the executive functions involved in attention, shifting, working memory, and inhibition in different ways. A question that was addressed is whether or not contact required sports and non-contact required sports are perceived as affecting self-regulation executive functions use differently. Examples of contact required sports are football, soccer, basketball, lacrosse, and field hockey. In these sports contact between players and the likelihood of getting hit in the head with equipment is frequent. Examples of noncontact required sports are track, cross country, tennis, swimming, and baseball which has a much lower occurrence of bodily contact and head injury. There is a risk of concussion in all sports, but contact required sports have much higher risk of concussion which may have a negative impact on the use of executive functions. Contact required sports have a higher risk of repetitive impact head injury on the brain and the frontal lobe of the brain. The frontal lobe and the pathways connected to that area are the most vulnerable part of the brain to injury and are susceptible to microstructural changes. According to Virji-Babul et al., (2014), repeated injury decrease neurocognitive functions associated with executive functions, learning and memory, attention, and concentration. Important executive functions that may be impacted are working memory, flexibility, inhibition, planning, and regulation. In noncontact required sports the students are practicing the skills of working memory, flexibility, shifting, attention as in contact required sports and there is less incidence of repeated head injury. In repeated practice of executive functions in noncontact required sports students are further developing their skills and possibly integrating these learned skills into their daily lives. These skills may have a better chance of further developing than in contact required sports because there is a much lower risk of concussion.

Purpose of the Study

Although the scientific literature from Hillman et al., (2008) and Wigal et al., (2013), supports the connection between physical exercise and the development of effective self-regulation executive functions, the extent to which student athletes perceive this positive connection is not clear. The purpose of this study was to determine whether or not student athletes perceive a relationship between engaging in sports and engaging their executive functions.

Teacher and coaches' perceptions of student athlete engagement of executive functions were examined. Teachers and coaches completed rating scales that examined their perceptions and observations of students' use of executive functions. The teacher and student responses were compared in order to determine if student perceptions are consistent with teacher observations.

In recent years there have been increasing reports of sports related concussions and head injuries in the adolescent population. However, the actual incidences of concussions in the population may be under-estimated (Khurana & Kaye, 2012). This may be due to such factors as lack of initial recognition by athletes and/or coaches, lack of medical follow up, and the failure to report symptoms (Khurana & Kaye, 2012). Students and coaches may not be aware that head injuries are influencing their perceptions of student athletes' uses of effective capacities. The survey responses from student athletes may determine if repeated concussions and head injuries are influencing their perceptions of their use of executive capacities and may provide an understanding of dysexecutive (disorganized binders/materials, inability to follow multi-step directions, inability to sustain attention throughout a class period) behaviors. The study compared the results in reported levels of executive functions use between the noncontact required and the contact required athletes to determine if there is a significant difference in their perceived use of executive functions.

This study also examined if students and teachers perceived sports as having a positive influence on students' use of executive functions in the performance of academic tasks. Finally, this study also examined if students and teachers perceived sports as having a positive effect on students' emotions and their peer relationships.

Chapter 2

REVIEW OF THE LITERATURE

Conceptualization of Executive Functions

There has been a tradition of conceptualizing executive functions as a single construct: that it is the central executive responsible for multi-modal processing and high-level cognitive functioning (Brown, 2005; Goldberg, 2001). Alternately, some researchers have conceptualized executive functions as a set of capacities that are inter-related, inter-dependent and function together as an integrated control system (Barkley, 2002; Borkowski & Burke, 1996; McCloskey, Perkins & VanDivner, 2008). There are multiple models of how to conceptualize executive functions, but they have a unifying component. All address mental capacities that direct or cue the use of other mental processes, abilities and skills (Denckla, 1996, McCloskey, Perkins & VanDivner, 2009; McCloskey & Perkins, 2012). All address functions that have some link to the activation of portions of the frontal lobe region of the cerebral cortex. Although many of the multidimensional models of executive functions have been derived from factor analytic studies (Anderson, 2002), some of these models are based on research findings from cognitive neuroscience and clinical neuropsychology (McCloskey, Perkins & VanDivner, 2008; McCloskey & Perkins, 2012).

Anderson's (2002), model of executive functions is based on factor analytic studies that conceptualize EF as four distinct domains. The four domains are attentional control, information processing, cognitive flexibility, and goal setting. These domains are considered to be discrete functions that are likely to be related to specific frontal systems. These functions operate in an integrative manner in order to execute certain tasks, and together they can be conceptualized as an overall control system. Each of these domains involves highly integrated cognitive processes, and each receives and processes stimuli from various sources (Anderson, 2002, Lichter & Cummings, 2001).

The attentional domain by Anderson (2002) includes the capacity to attend selectively to specific stimuli and inhibit inappropriate behaviors, as well as the ability to sustain attention for an extended period of time. Attentional control is also important for the monitoring of actions so that goals are executed and achieved. Individuals with impairment in this area are likely to be impulsive, lack self-control, and fail to complete tasks. Information processing by Anderson (2002) refers to fluency, efficiency, and speed of output. If this domain is intact, it allows the integration of neural connections and frontal systems, and it is evaluated by the speed, quantity and quality of output. Information processing impairments include reduced output, delayed responses, hesitancy, and slowed reaction times. Cognitive flexibility referred to by Anderson (2002) is the ability to shift between response sets, to learn from mistakes, devise alternate strategies, divide attention, and process multiple sources of information concurrently. Impairment in this domain is associated with perseverative behavior and is manifested by the individual continuing to make the same mistake. The goal setting domain by Anderson (2002), incorporates the ability to develop new initiatives and concepts, as well as the capacity to plan new actions in advance and approach tasks in an efficient and strategic manner. Impairments in goal setting will result in poor problem solving ability. This is reflected by inadequate planning, disorganization, difficulties developing efficient strategies, and poor conceptual reasoning (Anderson, 2002).

Alexander and Stuss (2000) conceptualize executive functions as several specific mental capacities related to different regions within the frontal lobe. The capacities are distinct but work together as an integrated control system. They stress the fact that there are many types and levels of control that are more complicated than simple frontal/posterior dissociations might suggest. Stuss and Alexander (2000) have conceptualized executive functions, using a hierarchical approach of self-awareness. This model has several properties. The first property involves four operational levels of arousal: attention, perceptual-motor, executive mediation, and self- awareness. The next property is that there is movement forward and backward within the levels, and that the levels provide for a provisional organization system. In the perceptual motor domain there is direct contact with the environment. The two highest levels are located in the frontal lobes. The executive mediation is located in the ventrolateral and dorsolateral frontal regions. It is responsible for planning, inhibition, problem-solving and working memory. The highest level of self-awareness involves memory of experiences and knowledge. This level also engages in abstract thought about what can be anticipated for the future (Alexander and Stuss, 2000).

McCloskey (McCloskey et al., 2009; McCloskey & Perkins, 2012) has proposed a holarchical developmental model of executive function organization. This model was developed to help conceptualize the interaction of the multiple executive function capacities that involve frontal lobe neural functions. It differs from a hierarchial system; in that instead of executive levels being in successive ranks, there are multiple tiers in an inclusive system in which there is communication back and forth between the tiers in an integrated control system. The model is structured using five holarchically organized tiers of executive capacity. The first three tiers are directly involved with daily self-control functions. The first tier is a construct labeled self-activation. The second tier which is labeled self-regulation; is a collection of multiple directive capacities that are responsible for day to day activities. The third tier is composed of two general executive capacities which are carried out through two executive functions. The first is self-realization through self-awareness and self-analysis, and the second is self-determination through goal generation and long-term foresight/planning. The final two tiers are self-generation and trans-self integration (McCloskey et al., 2009; McCloskey & Perkins, 2012).

Self-Activation is defined by McCloskey (McCloskey et al., 2009; McCloskey & Perkins, 2012) as an individual's executive capacities as he or she awakes from sleep. Self-Regulation functions cue and direct how we perceive, feel, think, and act. This domain is comprises of as many of 33 executive functions that are separate from each other. These functions include, but are not limited to the abilities to sustain attention, initiate engagement in tasks, have cognitive flexibility, monitor behaviors, and organize. Self-realization involves the ability to be aware of one's sensations, emotions, thoughts, and actions. This involves sustained and enhanced reflection on perceptions, emotions, thoughts, and actions. Self-determination involves the skills of goal setting and long-term planning. When an individual engages in these skills, it allows them to develop foresight and to formulate plans that extend beyond the short-term. Self-generation is the capacity to inquire about the nature of existence, the purpose of life, and the ultimate source of what is experienced. In this stage an individual asks questions such as "Why I am here?", "Why do I exist?", and "What is my life's purpose?" The trans-self integration stage involves individuals seeking out activities that allow them to become one with the universe. McCloskey and colleagues suggest that experiencing trans-self integral experiences can have a significant influence on how a person engages all of the executive capacities of the lower tiers. They believe that it can have a positive influence on one's choices and the direction of one's life (McCloskey et al., 2009; McCloskey & Perkins, 2012).

The use of executive functions can vary widely across the four domains of perception, feeling, thought and action, and it is possible for an individual to have difficulty with executive control in only one of the domains yet have strong capacities in the others (McCloskey et al., 2009; McCloskey & Perkins, 2012). It is also entirely possible for an individual to have difficulties across multiple domains. There is a great deal of variation in the daily use of self-regulation executive functioning and the use of executive functions in the remaining tiers (McCloskey et al., 2009; McCloskey & Perkins, 2012).

McCloskey's model (McCloskey et al., 2009; McCloskey & Perkins, 2012) includes conceptualization for greater understanding of the full-range of variability in engagement of self-regulation capacities. This model indicates that executive control can vary, depending or not whether an individual is attempting to control one's own internal states (intrapersonal arena), interactions with others(interpersonal arena), interactions with the environment around him or her (environment arena), or engagement with the tools of the culturally derived symbol systems used to process and share information (symbol systems arena) (McCloskey et al., 2009; McCloskey & Perkins, 2012).

Research on executive functions has continued to expand and additional frameworks have been developed to conceptualize the various subsets of executive functions. Dawson and Guare (2010), regard executive functions as allowing individuals to manage their emotions and monitor their thoughts in order to work more efficiently and effectively. To summarize, they believe executive functions serve to regulate behavior. They divide the skills into two groups.

The first set described by Dawson and Guare (2010) involves the use of certain skills to select and achieve goals or to develop problem solutions. The specific skills in this area are planning, organization, time management, working memory, and metacognition. Planning involves the ability to create a plan to reach a goal or task. It also involves the skills needed to determine those decisions that are relevant to reaching the goal and those that are not important. Organization is the ability to design and maintain systems for keeping track of information. Time management is the capacity to estimate how much time one has, how to allocate it, and how to finish goals within those time limits. Working memory is the ability to hold information in mind while performing complex tasks. It encompasses the ability to draw on past learning and to apply it to the current situation. Metacognition is the ability to take a step back and to see the big picture in a situation. This is an ability to use self-evaluation and self-monitor one's abilities. This skill requires the individual to ask the questions, "How am I doing?"; "What am I good at?", and "What do I need to improve upon?" These skills help an individual to build a roadmap in order to accomplish the goals he or she would like to accomplish. There is also a set of executive skills individuals need to guide their behavior as they move along their roadmap. These skills include response inhibition, emotional control, sustained attention, task initiation, and flexibility (Dawson and Guare, 2010).

Response inhibition, the second set described by Dawson and Guare, (2010), is the capacity to think before one acts. This is the ability to resist the urge to do something that may not be appropriate and the ability to evaluate the situation before acting. Emotional control is the ability to manage emotions in order to achieve goals, maintain control, and direct behavior. Sustained attention is the capacity to attend to a task even when there are distractions in the environment or if a person is fatigued. Task initiation is the capacity to begin a task without succumbing to procrastination and to finish the task in a timely fashion. Goal directed persistence is the capacity to sustain efforts without getting distracted by competing interests until a goal is achieved (Dawson and Guare, 2010).

Neuropsychological Basis of Executive Functions

In recent decades, there have been multiple models of executive capacity development proposed by researchers. Most of these models draw on brain development research in neuropsychology. The development of the brain occurs through generation of nerve cells (neurons) and their supporting cells (neuroglia). These cells are the building blocks of the nervous system. Nerves develop branches called axons and dendrites that allow them to "talk" to each other in order to send and receive information from other cells (Best, 2009). It is important to consider the white matter of the brain that allows the neurons to communicate through a process called myelination (Dawson and Guare, 2010). White matter represents the bundles of axons that connect different regions of the brain and allows the neurons to communicate. Myelination is the process through which myelin sheath forms around the axon and provides insulation that helps to increase speed of transmission of nerve signals. Myelination begins in the earliest stages of development in the frontal lobes and continues well into adulthood (Dawson and Guare, 2010). Thanks to the extensive interconnectivity, each neuron is only a few synapses away from any other given neuron, and each neuron makes a small contribution to overall functioning (Gazzaniga, Ivry, & Mangun, 2014). Groups of interconnected neurons which process specific kinds of information are referred to as neural circuits. Neural circuits take in information; they evaluate the input either at a synapse, or a group of neurons, and they convey the results to other neurons, muscles or glands (Gazzaniga et al., 2014).

Executive functions are thought to involve activation of neurons within the pre-frontal cortex (Best et al., 2008). In order to execute a goal-directed behavior or action, however, the prefrontal cortex must integrate temporally separate units of perception, action, and cognition into a sequence that will lead to a goal (Fuster 2002; Jurado & Rosselli, 2007). To achieve this, the prefrontal cortex must function in cooperation with the subcortical structures and other areas of the neocortex (Jurado & Rosselli, 2007). The prefrontal cortex is contained in the frontal lobe and is anterior to the supplementary motor area (Fuster, 2002). Researchers have come to determine that the prefrontal cortex houses the executive functions that activate and inhibit posterior cortical and subcortical brain regions (Best et al., 2008). The prefrontal cortex is one-quarter to one-third of the cerebral cortex and contains many reciprocal connections within itself as well as with other cortical brain areas and subcortical and limbic brain regions (Luria, 1973).

Historically, Stuss and Benson (1984), have proposed that there are three subcortical circuits involved in cognition, emotion, and motivation. These include the dorsolateral, the ventromedial, and the orbitofrontal. Middleton and Strick (2001), have proposed modifications to their theories. Middleton and Strick (2001), determined that each of the circuits previously described are composed of multiple subcircuits. The dorsolateral frontal cortex is composed of multiple output channels. Channels project to the caudate nucleus and at least four separate basal ganglia circuits and have been linked to verbal fluency, ability to maintain and shift set, planning, response inhibition, working memory, organization skills, reasoning, problem solving, and abstract thinking (Alvarez and Emory, 2006; Middleon and Strick (2001). The ventromedial circuit begins in the anterior cingulate, projects to the nucleus accumbens, and circuits of the basal ganglia and is involved in motor output and modulating emotional function. The orbitofrontal cortex projects to thalamic and basal ganglia inputs and is linked to socially appropriate behavior (Alvarez & Emory, 2006; Middleton and Strick (2001). Lichter and Cummings(2001) describe the prefrontal cortex's connections as being a two-way in a position for both reception and for synthesis arriving from all parts of the brain and serving to regulate movement and actions. It has been determined that there are pathways that originate in the prefrontal cortex and connect with various parts of the brain to produce the wide array of executive functions and goal-oriented behaviors (Alvarez & Emory, 2006; Fuster, 2002; Lichter and Cummings 2001).

Development of Executive Functions

In order to understand better how children and adolescents use executive functions, it is helpful to understand perspectives on the development of these capacities during childhood and adolescence. Although there are multiple models of development proposed by researchers, they all agree that executive functions develop over time from infancy well into adulthood. Some researchers (Anderson, 2002; McCloskey, et al., 2008) postulate that executive functions develop rapidly throughout childhood. The progression of that development, however is not necessarily linear, but rather characterized by growth spurts and plateaus. Additionally, the various executive functions can demonstrate different developmental trajectories. It is also important to note that although executive functions emerge early in childhood, a significant period of development occurs before they are functional at a level that is desirable for independence, and that the developmental process extends into adulthood (Zelazo et al., 1997). Anderson (2002) has specifically outlined the development of the executive functions of control of attention and inhibition, regulation of information processing, cognitive flexibility and goal setting.

Anderson (2002) notes that infants younger than 9 months of age have difficulty inhibiting previously learned responses; by 12 months of age most infants can inhibit certain behaviors and shift to a new response set. By 3 years of age children inhibit "instinctive" behaviors reasonably well, although they can occasionally make a perseverative error. Around 6 years of age improvements in speed and accuracy on impulse control tasks can be observed. Children aged 9 years and older tend to monitor and regulate their actions well, although an increase in impulsivity occurs for a short period of time around 11 years of age (Anderson, 2002, Zelazo et al., 1997)

In the information processing domain according to Anderson (2002), increments in response speed and verbal fluency are observed, especially between 3 and 5 years of age. Processing speed continues to improve through childhood with significant gains in processing speed observed around 11 years of age. Improvements in efficiency and fluency occur during adolescence (Anderson, 2002).

In the cognitive flexibility domain according to Anderson (2002), perseverative behavior is common in infancy, declines during early and middle childhood, and is rare in adolescence. The ability to switch rapidly between two simple response sets emerges between 3 and 4 years of age. However children in this age range have difficulty switching when rules become more complex. At the age of seven, children struggle when switching behavior is contingent on multiple dimensions; however, the ability to cope with these multi-dimensional switching tasks improves. Switching fluency continues to improve through middle-childhood and into adolescence. The ability to learn from mistakes and devise alternative strategies emerges in early childhood and develops throughout middle childhood (Anderson, 2002; Zelazo et al., 1997).

In the domain of goal setting according to Anderson (2002), simple planning skills are exhibited by 4 year olds, but younger children struggle to plan and organize actions in advance. Planning and organization skills develop rapidly between 7 and 10 years of age and continue to develop gradually into adolescence. Young children utilize simple strategies which are usually inefficient, but between 7 and 11 years old strategic planning and reasoning abilities become more organized and efficient. Around the ages of 12 and 13, there may be a regression from conceptual strategies to piecemeal strategies, which suggests a developmental period in which cautious and conservative strategies are preferred. Refinement of strategies and improved decision making continue during adolescence (Anderson, 2002; Zelazo et al., 1997).

Diamond (2002) has described the development of the prefrontal cortex from the first year of life throughout adulthood and the progression of development of different executive capacities. In development from age one to three years, researchers have found that the ability to inhibit a prepotent response in order to perform a modulated or different response improved markedly from 22 to 33 months of age. The researchers also found that consistency in performance across the various measures also increased from 22 to 33 months of age. The period of 3-7 years, especially 3-5 years, is a period of marked improvements in the performance of many cognitive tasks that require both holding information in mind and inhibition (Diamond, 2002). Improvement in responding to inhibition tasks is relatively continuous from 3 ½ to 7 years of age; while the improvement in speed of responding occurs primarily from 3 ½ to 4 ½ years. Diamond (2002), believes that improvements in speed of processing, in ability to use strategies, working memory, and working memory with inhibition are seen after seven years and in most cases in early adulthood. Speed of processing increases greatly in early adolescence and continues improving gradually until early adulthood (Diamond, 2002). It has been noted that improvements in speed of processing with age account for a good deal of what has been taken to be age-related improvements in the ability to hold information in mind. It has been found that the faster people were able to repeat the word they had just heard, the more words they could hold in mind, and as the speed of word repetition improved with age, so too did word span. As children get older they are more likely to use strategies to improve their performance (Diamond, 2002; Zelazo et al., 1997). Around the age of seven, rehearsal strategies emerge as memory aides. From the ages of six through thirteen, there is marked improvement in a variety of tasks involving working memory. In tasks involving working memory and inhibition, children 4 years of age can begin to perform such tasks, but do so poorly. By age 11 children start to improve on the ability to exercise inhibitory control, and improvement on these tasks occurs throughout childhood and into adulthood (Diamond, 2002; Zelazo et al., 1997).

A fluid developmental model was proposed by McCloskey (McCloskey et al., 2009). McCloskey proposes that executive function development occurs over an extended period of time. The model posits multiple levels of executive control, including Self-Regulation, Self-Realization and Self-Determination, Self-Generation, and Trans-self Integration.

In this model of executive control by McCloskey (McCloskey et al., 2009), Self-Regulation executive capacities begin to emerge near birth and can continue to develop throughout a person's lifespan. The model posits a minimum of 33 self-regulation executive capacities that can be arranged on 7 clusters. These 7 clusters are: Attention (Perceive, Focus, Select); Engagement (Energize, Initiate, Inhibit, Stop, Pause, Flexibile, Shift); Optimization (Monitor, Modulate, Balance, Correct); Efficiency (Sense Time, Pace, Sequence, Execute); Memory (Hold, Manipulate, Store, Retrieve); Inquiry (Gauge, Foresee/Plan, Estimate Time, Analyze, Compare Evaluate, Prioritize); Solution (Generate, Associate, Organize, Plan, Choose) (McCloskey et al., 2009).

McCloskey (McCloskey et al., 2009) states that although each self-regulation executive capacity follows a general developmental timeline that is similar across all individuals, the developmental trajectories of specific executive capacities can vary greatly among individuals. Most individuals show growth in executive capacities over time however the developmental trajectory of each self-regulation executive function capacity is variable from person to person. Individuals at the same age can vary considerably in their level of development of any specific self-regulation executive capacity. Development of each of the proposed 33 self-regulation executive capacities begins in infancy and continues well into adulthood (McCloskey et al., 2009).

According to McCloskey (McCloskey et al., 2009), Self-Realization and Self-Determination tend to emerge between the ages of 10 and 14 for most individuals. Self-Realization enables the consideration of personal strengths and weaknesses through self-analysis, and a heightened awareness of self and others. Self-Determination involves the emergence of personal goals that can be achieved only through delayed-gratification. Along with goals, the capacity for long-term planning also emerges as a way to achieve long-term goals. It is suggested that although self-determination and self-realization may emerge prior to adolescence; however, they are rudimentary at best and do not play an important role in executive function development until the adolescent period. The self-generation and trans-self-integration executive capacities typically do not begin to develop until early adulthood, if at all (McCloskey et al., 2009).

It is important to note that there is a common thread throughout the different theories of development. Executive capacities develop over time, and as an individual grows over time, changes are occurring and capacities are becoming more fully developed. The models also determined that executive functions begin developing in infancy and develop into adulthood. The researchers agree there is not a specific point in development at which an individual will become fully developed and have complete capacity for each executive capacity. The models are generalizable guides that estimate the trajectory of development for executive capacities. It is important to note that the various executive capacities emerge at different points in development, interact with each other to progressively reorganize the executive system at each new stage, and show overlapping growth trajectories with the continued development of earlier emerging executive functions, even after later developing executive capacities begin to emerge. The research is also in agreement that regions of the prefrontal cortex are responsible for the expression of executive capacities and that these pre-frontal regions communicate with other cortical and subcortical regions of the brain. There is a common understanding that strong neuroanatomical connections are necessary for effective use of executive capacities.

It is important to keep in mind that the models discussed here apply to typically developing children. These models may not hold for children with developmental disabilities or neurologically-based disorders. Attention Deficit Hyperactivity Disorder (ADHD) is characterized by difficulties with inhibition, attention, concentration, behavior regulation and other executive functions (Osterlaan, Scheres, & Sergeant, 2005). Other disorders characterized by deficits in executive functions are Autism Spectrum Disorders, Oppositional Defiant Disorder, Bipolar Disorder, Tourettes and Learning disabilities (Osterlaan, Scheres, & Sergeant, 2005). Developmental delays impact the rate at which executive functions progress and individuals with delays are developing levels of use later than typically developing children. It is important to understand that a delay does not indicate the executive capacities will never develop, but it suggests that they may take longer to reach that level of capacity. Having an understanding of executive functions and how they develop is critical to understanding how students learn. Having an understanding of how executive functions develop and how this development may be delayed is crucial to understanding different techniques to foster the development of executive functions.

Exercise and the Brain

There are many psychological benefits to regular exercise. Exercise normalizes the brain's stress response biologically, and exercise seems to give the body a chance to practice dealing with stress. Exercise can have a positive effect on mood and reduce tension. Physical activity can short-circuit the cycle of cognitive and physical tension that characterizes anxiety disorders. A person can lessen his or her anxiety through exercise (Akande, Van-Wyk, & Osagie, 2000; Van Boekel, Bulut, Stanke, Zamora et al., 2016). Physical activity makes human cognition stronger because it increases the blood supply to the brain, and according to Ratey and Hagerman (2010), that working out builds the mind's muscles. Some studies suggest that being fit helps a person to maintain cognitive abilities while aging (Lee, Wong, Wui-Man Lau, Lee, Yau, & So, 2014). Studies have also shown that exercise and nutrition regimens may enhance treatment for even for those with the most severe mental disorders (Akande, Van-Wyk, & Osagie, 2000; Van Boekel, Bulut, Stanke, Zamora et al., 2016). Physical activity and sports can play a very positive role in children's lives. Researchers have demonstrated that being on a sports team can play an important role in the development of identity, self-esteem and individual competence. Physical activity also plays an important role in developing and maintaining effective interpersonal relationships. An example would be that a workshop designed to improve interpersonal skills was more effective when combining physical training with interpersonal skills training than when using only interpersonal skills training (Akande, Van-Wyk, & Osagie, 2000; Van Boekel et al., 2016).

There has been a growing body of literature on the role of physical activity in healthy child development. There is increasing evidence that physical activity enhances learning, memory, concentration, and mood. Evidence to support the benefits of exercise for the brain has been mounting in the academic fields of molecular science, cognitive science, behavioral science, neuroscience and psychology (Cotman & Engesser-Cesar, 2002). Physical activity presents a physiological stress to the brain that, when balanced with recovery, promotes adaptation and growth, preserves brain function, and enables the brain to respond to future challenges (Sattelmair & Ratey, 2009). Aerobic fitness in children is associated with faster cognitive processing speed and better performance in a test of executive control (Tomporowski, McCullick, Pendleton & Pesce, 2015). Multiple meta-analyses have confirmed the positive relationship between physical activity and cognitive and academic performance in school-aged children (Ploughman, 2008).

In order to understand how exercise enhances learning, it is important to understand the physiological process of learning. According to Ratey & Hagerman (2010), communication is a key concept in how learning works in the brain. The brain is made up of one hundred billion neurons of various types that chat with one another by way of hundreds of different chemicals to govern one's every thought and action. About eighty percent of the signaling in the brain is carried out by two neurotransmitters, glutamate and gamma-aminobutyric acid (GABA), that balance each other's effect. Glutamate stirs up activity to begin the signaling cascade and GABA clamps down on activity (Ploughman, 2008; Ratey & Hagerman, 2010). Glutamate is composed of the neurotransmitters serotonin, norepinephrine, and dopamine. Serotonin has been named the policeman of the brain because it helps keep brain activity under control. It influences mood, impulsivity, anger, and aggressiveness. Norepinephrine often amplifies signals that influence attention, perception, motivation, and arousal. Dopamine is thought of as the transmitter involved with learning, reward, attention, and movement (Ploughman 2008; Ratey & Hagerman, 2010).

It is also important to understand the different brain regions and circuits that play a role in exercise. The cerebellum, which has a trunk of nerve cells that connect to the prefrontal cortex, coordinates motor movements and allows people to do everything from returning a tennis serve to resisting the pull of gravity (Ratey & Hagerman, 2010). The motor center coordinates thoughts, attention, emotions, and social skills. When an individual exercise, particularly if it is a complex motor movement, that an individual is also exercising the areas of the brain involved in the full suite of cognitive functions. This is causing the brain to fire signals along the same network of cells which solidifies their connections. The prefrontal cortex is like the CEO of the brain (MClsokey 2008; Ratey & Hagerman, 2010). The prefrontal cortex organizes activity, both mental and physical, receives input, and issues instructions through the brain's most extensive network of connections. As previously mentioned, its key responsibilities are the executive capacities that engage working memory, inhibiting stimuli and initiating action, judging, and planning, (Cotman & Engesser-Cesar, 2002; McCloskey et al., 2008; Ratey & Hagerman, 2010). The hippocampus is also important because it receives inputs from working memory, cross-references that information with existing memories for the formation of new associations, and reports back to the prefrontal cortex (Cotman &

Engesser-Cesar, 2002; Hotting & Roder, 2013; Ratey & Hagerman, 2010). It can be thought of as a way station which receives the fragments from the cortex, and then bundles them together and sends them back as a map of a unique new pattern of connections (Cotman & Engesser-Cesar, 2002; Hotting & Roder, 2013; Ratey & Hagerman, 2010).

It is believed that exercise may influence enhanced cognitive functioning and higher brain volume due to the increase in blood flow after physical exercise (Barenberg, Berse, & Dutke, 2010; Sattlemair & Ratey, 2009; Verburgh, Konigs, Scherder & Oosterlaan, 2014). A neuropsychological hypothesis is that exercise induces increased levels of norepinephrine, dopamine, and serotonin in the pre-frontal cortex, hippocampus, and striatum. As a result of exercise, increased levels of dopamine enhance the focusing of attention to facilitate learning. Increases in norepinephrine improve executive operations, reduce distractibility, and enhance memory to assist in learning (Barenberg, Berse, & Dutke, 2010; Wigal, Emmerson, Gehricke, & Galassetti., 2012). Repeated activation or practice causes the synapses themselves to swell and make stronger connections (Ratey & Hagerman, 2010).

Wigal et al., (2012) discovered that there are also positive effects of exercise on specific cognitive processes. These may be attributed to an upregulation of neurotrophins such as the brain-derived neurotrophic factor (BDNF). BDNF plays a crucial role in hippocampal functioning and long-term potentiation for learning and memory (Hillman, Erickson, & Kramer, 2008). BDNF gathers in reserve pools near the synapses and is unleashed when blood flow increases. During this process a number of hormones from the body are called into action to help (Ratey & Hagerman, 2010). These include insulinlike growth factor (IGF-1), vascular endothelial growth factor (VEGF), and fibroblast growth factor (FGF-2). During exercise these factors push through the blood-brain barrier, a web of capillaries that block out intruders such as bacteria (Hillman et al., 2008; Wigal et al., 2012). It has been discovered by researchers that once these hormones are in the brain, they work with BDNF to crank up the molecular machinery of learning (Cotman & Engesser-Cesar, 2002). They are also produced within the brain, and during exercise they promote stem-cell division. Exercise has been found to increase the levels of hippocampal BDNF which may facilitate improvements in attention, behavioral inhibition, learning, memory, and affect (Ratey & Hagerman, 2010; Wigal et al., 2012). This evidence indicates that physical exercise may improve cognitive functioning in healthy children. Exercise appears to enhance brain development and function across a wide set of domains, including executive functions.

ADHD is linked to delayed brain development, immature brain function, and symptoms of executive dysfunction. It is thought that exercise may promote recovery in children with ADHD. Exercise interventions have been shown to improve the executive function deficits in children with ADHD as well as healthy populations (Halperin et al., 2014).

Exercise works in a manner similar to stimulant medication because it increases levels of dopamine and norepinephrine, which are the catecholamines believed to improve information processing in the brain (Halperin et al., 2014). Researchers have performed studies to look at the effects of chronic aerobic exercise and acute aerobic exercise. According to Jurado & Machado(2013), researchers have shown that aerobic fitness is linked to global increases in executive capacities. Other studies have also reported links between aerobic fitness or exercise and performance on standardized clinical tests of executive functions (Jurado & Machado, 2013).

Chronic Exercise Studies

In chronic exercise design studies, children are randomly assigned to habitual aerobic exercise over several weeks or to a control condition of equal duration. The purpose of the exercise program is to improve children's cardio-respiratory functioning. These studies hypothesize that improvement in cardio-respiratory functioning will be associated with improvements in cognitive functioning (Best, 2010).

Zieres and Jansen (2014) wanted to see if chronic physical exercise would have an effect on the use of executive capacities by children diagnosed with ADHD. The researchers selected a group of 43 children with ADHD and divided them into an exercise group and a control group. They conducted the study for fourteen weeks. Before the exercise intervention began, they gave all children tests of working memory, visual-motor performance, and motor performance. Children also were assessed one week after the first session and one week after the last session. The exercise intervention groups, which were led by coaches, included one sixty- minute exercise session per week. The intervention included one sixty- minute exercise session per week. The exercise sessions included running, balance training, tennis, coordination exercises, relay races, climbing, wrestling, swimming, and gymnastics. These exercises were rotated weekly. Analysis of the results showed several significant changes in the effective use of executive capacities and increased motor development over time. The test, after the first week of the intervention, did not show any changes. There were significant improvements in the working memory tasks and motor performance tasks after the entire intervention (Zieres and Jensen, 2014).

Verret et al., (2012) investigated the effect of chronic exercise on children diagnosed with ADHD. They wanted to assess the effects of a multi-week moderate to a high intensity physical activity program on fitness, cognitive functions, and behavior. These researchers had a total of twenty-one participants diagnosed with ADHD. Ten children diagnosed with ADHD were assigned to a physical activity group and eleven were assigned to the control group. Prior to the intervention, parents and teachers completed the Child Behavior Checklist (CBCL) and the children completed the Test of Everyday Attention for Children (Tea-Ch). The CBCL evaluates behavioral problems and social competence. The CBCL scales include anxiety-depression, withdrawn-depression, somatic complaints, social problems, thought problems, attention problems, rule-breaking behaviors, and aggressive behaviors. Tea-Ch assesses the differential attention capacities of a child.

The physical activity program took place during ten consecutive weeks in a school gymnasium. Physical activity sessions were conducted three times a week for forty-five minutes and supervised by a physical education specialist. Sessions included a warm-up, progressive aerobic, muscular, motor exercises; and a cool down. The objective was to maintain moderate to vigorous intensity in each session. Basketball, soccer, exercise stations, and tag were the types of aerobic exercises used. After the activity program, post-tests were given. To assess the effectiveness of the program analysis of covariance was used to make comparisons between the exercise groups and control groups, and differences between pre-test and post-test scores. Results showed that for behavior there was significant improvement in the areas of social problems, thought problems, and attention problems. In the neuropsychological measures, children in the experimental group showed a higher level of information processing. They also had a higher outcome for auditory and sustained attention (Verret et al., 2012).

Kiluk et al., (2009) wanted to explore the relationship between participation in physical activity and mood or anxiety symptoms in children diagnosed with ADHD. The study used a sample of ninety-seven children aged 6 to 14, both boys and girls. In this study there was no direct exercise intervention. The researchers used questionnaires and rating scales that were completed by the parents. The researchers had parents complete the CBCL and also had the parents list the number of activities in which their child participated and how much time was spent in each activity. The children were divided into groups by gender and by the number of sports in which they participated. The cutoff for dividing groups by number of sports was chosen to distinguish between children who most likely participated in sports all year round (3 or more) versus those who may not have been actively involved during the entire year (0-2). Analysis of covariance was conducted between children with ADHD, using number of sports as the independent variable and parent ratings for the CBCL Anxious-depressed Scale as the dependent variable (Kiluk et al., 2009).

Results from the statistical analysis indicated a significant difference between Anxious-depressed T scores assigned to children diagnosed with ADHD who played 0 to 2 sports and those who played 3 or more sports. Scores were significantly lower for those diagnosed with ADHD who participated in 3 or more sports. The results supported the hypothesis that physical exercise can have a positive effect on mood and anxiety symptoms (Kiluk et al., 2009).

Hall, Poston, &Harris (2015) conducted a year-long study of the effects of a before-school physical activity program called Build Our Kids Success (BOKS). Hall et al. wanted to determine whether or not participation was associated with improvements in executive capacities such as working memory and the ability to shift between tasks. Children participated in the BOKS program daily for approximately forty minutes before school began. BOKS included moderate-to-vigorous activity through interactive games, exercises, running and physical skill building (Hall et al., 2015).

At the beginning and end of the school year the researchers collected surveys from teachers and parents of children who did and did not participate in BOKS. The researchers found significant differences on working memory and on shifting from the students who participated in the exercise program and those who did not. Students who participated in the BOKS program averaged higher scores on parent and teacher ratings of working memory and on shifting than students who did not participate in the BOKS program.

Lee at al., (2014) wanted to determine the relationship between chronic exercise and neurotrophic factors. A total of ninety-one subjects participated in the study. Among the ninety-one participants, forty-five of the subjects were adolescent exercisers who engaged in exercise regularly, and forty-six were matched-controls who did not exercise regularly. The study adopted a between-groups design to compare the cognitive functions and serum levels of neurotrophic factors (BDNF, IGF-1, and VEGF) between exercisers and controls. The study also examined the effect of the amount of exercise on the relationship between the serum levels of neurotrophic factors and the cognitive functions of participants. The researchers used questionnaires to measure the amount of exercise in the past year and the annual average since age 11. Next, a trained nurse drew blood to determine the levels of neurotrophic factors. The participants also were administered a battery of tests (The Stroop Color-Word test and the Wisconsin Card Sorting Test), which are associated with specific brain functions of the frontal and medial-temporal lobe. The Stroop Color-Word test assesses inhibition and cognitive control processes regulated by the frontal lobe. The Wisconsin Card Sorting Test measures cognitive flexibility. The spatial memory task and the spatial associate learning tasks were tests of cognitive processes regulated by the medial-temporal lobe. A control task, tapping occipital lobe function, was also administered.

The researchers compared the effect of group differences on exercise dosage, serum levels of the neurotrophic factors, and cognitive functions while controlling for psychomotor speed. Correlational analyses were used to assess the relationship between the serum levels of neurotrophic factors with exercise dosage. The exercisers, relative to the controls, showed a much better performance on cognitive tasks that assessed frontal and medial-temporal lobe function. The exercisers demonstrated better performance with the Color Word test and with the Wisconsin Card Sorting test compared with the controls. With the WCST, the exercisers exhibited a higher accuracy rate, used fewer trials to complete the test, and provided more conceptual responses. In the spatial associative learning task, the exercisers had a higher memory score and increased response accuracy. Moderator variable analyses showed that the amount of exercise significantly interacted with neurotrophic factors in predicting an individual’s performance in the neuropsychological assessments associated with frontal and medial temporal lobe functions.

Verbough, Scherder, Van Lange, & Oosterlaan (2016), wanted to determine if elite and amateur soccer players would outperform non-athletes on neurocognitive measures. A total of 168 preadolescent children, aged 8-12 years, were recruited from primary schools, an amateur soccer club, and an elite soccer club. The sample included fifty-one boys not involved in any organized sports (non-athletes), forty-eight boys who regularly participated in sports (non-elite soccer players), and sixty-nine boys who participated very frequently in sports (elite soccer players). Non-athletes were recruited from elementary schools and were not involved in any organized sports; they were neither a members of a sports club, nor a participants in an extracurricular sports program at school. All of the participants were given neurocognitive measures that assessed inhibition, short term memory, working memory, and three types of attention. The types of attention were alerting, orienting, and executive attention. Data of the non-athletes were collected at elementary schools during regular school hours. Participants from both soccer player groups were tested prior to soccer training, and the non-athletes were tested on a day without physical education class. The researchers used a regression analysis which indicated that time spent in organized sports was positively associated with inhibition, short term memory, working memory, and lapses of attention. The researchers found that the elite soccer players outperformed both the non-elite soccer players and the non-athletes on inhibition. The researchers found that both soccer groups outperformed the non-athletes on the tests of short term memory, working memory, and attention.

Acute Exercise Studies

Acute exercise designs examine the immediate changes in cognitive functioning rather than the longer-lasting effects of chronic exercise. They examined differences in cognitive functioning upon completion of different types of exercise (Best, 2010). Chen at al., (2014) studied the effects of acute exercise on executive functions. Ninety-eight students in third, fourth and fifth grades participated in the study. The students were divided into exercise and control groups. Prior to implementation of an exercise activity, the students completed three computer based, neuropsychological assessments that involved working memory, inhibition, and shifting.

The participants in the experimental group then participated in an exercise activity group. The activity consisted of the children jogging in groups at a moderate intensity for thirty minutes on a playing field. After the exercise and when the participants recovered from the activity, they completed the same neuropsychological tests they had performed, pre-activity. To assess the performance of executive functions [2 (treatment: exercise versus control) x 2 (grade: third versus fifth) x 2 (time point: pre test versus post test)] ANOVAS were conducted separately for the inhibition, working memory, and shifting skills. Results showed that acute exercise facilitates multiple aspects of executive function. There were main effects for working memory and inhibition.

Chang, Tsai and Chen (2012) studied the effects of acute exercise on kindergartners' use of executive functions. The children were divided into two groups. One group was a low-intensity exercise group and one was a moderate-to high intensity group. Prior to the exercise activity, the children were given a neuropsychological assessment to test their effectiveness with an inhibition task. Next, the students participated in the exercise groups. The low-intensity group played soccer and emphasized soccer's coordinated movement in the lower extremities (dribbling and kicking) and included continuous walking. Exercise in the moderate group targeted similar actions with lower extremity movements coordinated with continuous running. The exercise program was instructed by a soccer-certified physical education teacher. After the exercise, the children were re-administered the inhibition task. The results showed that children had higher accuracy and faster reaction times on the inhibitory task following the coordinated exercise intervention. There were no significant differences between the low and moderate intensity groups, which suggests that exercise itself, regardless of intensity, facilitates improvement in the use of inhibition.

Pontifex, Saliba, Raine, Pichhietti, & Hillman (2013) wanted to examine the effect of a single bout of moderate-intensity aerobic exercise on preadolescent children diagnosed with ADHD, using objective measures of attention, brain neurophysiology, and academic performance. There were two groups of participants. One group was children diagnosed with ADHD and one group was composed of matched controls without ADHD diagnoses. All children received the exercise activity. The children were administered a pre-test of inhibition, a neuro-electric assessment, and a seated reading task. After the initial testing the students participated in the physical activity. The physical activity consisted of running on a treadmill for twenty minutes at a moderate intensity. After exercising, the children were given a posttest (Pontifex et al., 2013). The results showed that children diagnosed with ADHD and the match control group exhibited increased overall response accuracy and inhibitory control. Following the single session of exercise, both groups exhibited better scores on the reading activity (Pontifex et al., 2013).

Jager, Schmidt, Conzelman, and Roebers (2015), performed an acute exercise study with conditions involving aerobic exercise with a cognitive component. The sample consisted of 219 children who were distributed into four conditions. The four conditions that were compared included physical games with cognitive engagement, aerobic exercise without cognitive engagement, cognitive sedentary games, and a control condition, which was sedentary activity without cognitive engagement. Children were randomly assigned to one of the four experimental conditions. All conditions lasted twenty minutes and performance with tasks assessing executive capacities was assessed before (pre-test) and immediately after (post-test) the intervention. In the physical games condition with cognitive engagement, the children played three different cooperative and competitive physical games that required activation of one or more executive capacities such as keeping in mind different rules, updating these rules, and reacting appropriately to different rules. The aerobic exercise condition without cognitive engagement consisted of short tasks and games requiring different forms of running with different speeds. The cognitive requirements were minimized in this condition. In the cognitive games condition children played a card game, adapted from a game used in a long term intervention with the aim to improve EF in children. The game required the activation of all three EF dimensions and the level of the difficulty was increased twice during the game by introducing new rules. The control condition consisted of the children listening to an age appropriate story that lasted for fifteen minutes. In the remaining minutes of the session the children answered simple comprehension questions.

To investigate the effects of physical activity, cognitive engagement and the combination of these factors, an analysis of variance (ANOVA) was conducted. The main finding of the present study was that none of the acute PA interventions yielded positive effects on EF in the overall sample, but that the PA conditions yielded an improvement in updating in children with higher aerobic fitness and/or higher academic achievement. The researchers thought these findings could be due to the intensity of the PA, which was not adjusted to the individual level. Thus it could not be ensured that all individuals trained with an intensity that was neither too low nor too high. Additionally, the intensity was not steady throughout the interventions because the different games within one intervention varied in their intensities and short breaks between the games could not be avoided.

Kubesh et al., (2009), wanted to determine if a thirty minute physical exercise program would improve children's executive functions. The study consisted of eighty-one participants who were divided into a treatment group and a control group. In the control group the students took part exclusively in the investigation of the effects of a five minute movement break. In the treatment group the students took part exclusively in the investigation of the effects of a thirty minute exercise program. The exercise program consisted of a thirty minute predominately aerobic endurance exercise session. The treatment condition was executed by the physical education teachers and was focused on the exercise intensity of the student's individual performance. In the control condition, students were listening to a thirty- minute audio book. The movement break was also an aerobic endurance exercise session but with a duration of only five minutes. The study was performed as a randomized within-subject cross-over design. In the first week, students received an introduction to the computerized tasks to measure EF's. On the next day, participants were randomly assigned to the sports condition or to the control condition. During the day, EF's were measured three times: before and after the respective treatment and control condition, and after a following lesson in mathematics. One week later the students received the alternative condition. To assess cognitive functions, the researchers used neuropsychological tests that measured inhibition, working memory, and cognitive flexibility.

Results of the study (Kubesh et al., 2009) indicated that a single PE program of thirty-minutes leads to an improvement in the maintenance of on-task attention in the face of distraction. This in turn may support students' selective, sustained, and focused attention processes. However, improved ability to inhibit attention to distraction was only achieved during the thirty minute program and not achieved by a five minute movement program. This indicates that duration of the program seems to be crucial for the measured improvement in inhibitory attention processes. The tasks that measured working memory and flexibility were not influenced by either condition. The researchers hypothesized this because the tests that assessed these skills had fewer trials than the inhibition task which may have influenced the results. The researchers also further suggest that a possible increased synthesis of serotonin after the thirty-minute PE program may directly lead to an increased serotonergic tone. Study results suggest that a serotonergic modulation in the prefrontal cortex occurs simultaneously with decreased impulsivity to increased attentional selectivity.

Overall, the exercise studies showed that exercise had effects on executive functions. The studies demonstrated positive effects for working memory, inhibition, shifting, flexibility, sustained attention, and focused attention. All of the chronic exercise studies showed improvements in executive functioning; however, not all of the studies looked at the same domains of functioning. All of the chronic exercise studies involved a variety of sports activities such as soccer, basketball, running, and interactive activities. The study by Verbough et al., (2016) that compared two groups of athletes with different levels of intensity, it found effects for exercise on both groups in working memory and attention, but the elite athletes outperformed the other group on inhibition. This is the only study that evaluated different levels of athletic ability. Perhaps higher level athletic ability involves more practice and skill development of inhibition. It would have been interesting to see, had the other studies involved different levels of athletic ability and if that would have made a difference in the results. Only one of these chronic studies reviewed above assessed for improvement in flexibility. This study used an assessment tool that is well known and valid, but lengthy to administer, which could be a reason why other researchers chose not to evaluate flexibility skills. In the future it would be useful to learn if exercise effects flexibility in other settings and studies because this is a skill that is necessary for success in school and sports.

The acute exercise studies also showed an overall effect for inhibition, working memory and shifting. All of the acute studies that evaluated inhibition found effects, but the results were varied for working memory and shifting. The studies that found effects for inhibition had a commonality. All of these studies involved exercise components of a steady twenty to thirty minute aerobic activity with moderate intensity. It can be inferred from these results that student athletes who consistently exercise at a moderate intensity will further develop their inhibitory skills. In the study by Chen et al., (2015) that assessed working memory there were significant effects. This study also involved a steady thirty minute jogging activity at a moderate intensity. One of the studies reviewed previously assessed working memory and shifting. There were significant effects for shifting, but not for working memory. In this study the intensities of the different aerobic activities varied. Perhaps in this study the participants had more opportunities to practice shifting skills rather than working memory skills. It would have been interesting to see the results had the intensities of the activities been more equal and had working memory shown more significant results.

The research studies mentioned previously indicated that using exercise interventions and surveys of teachers and parents related to students' sports and physical exercise have demonstrated that these activities can play a large role in strengthening executive capacities. No studies, however, have reported on students' own perceptions regarding their executive capacities and the extent to which they believe that the use of these executive capacities are strengthened through participation in sports, or the extent to which they believe that playing sports enables them to transfer the use of executive capacities into the classroom to perform better with academic tasks. Considering that athletes spend a substantial amount of time in practice and games, their points of view are as important as those of teachers and parents. Students have not been asked if certain sports help them engage in different executive capacities and if they transfer them into other aspects of their lives. Students also spend a considerable amount of time engaging with peers and forming relationships and there are no reports on the extent to which they believe that playing sports enables them to transfer executive capacities in social aspects of their lives. Students can provide valuable, direct information on whether or not playing sports facilitates transferring these capacities in social settings.

Concussions

Concussions are an important topic of discussion because they are a common occurrence in contact sports, and they can have serious impact on the developing brain and brain functioning. Sports activities are a major cause of concussions and it has been estimated that 1.6-3.8 million concussions occur in sports and recreational activities each year in the United States (Virji-Babul et al., 2014). The risk of concussion in youth is of great concern because the brain is still developing in adolescence, and it is more susceptible to hypoxia, ischemia, and traumatic axonal injury. The frontal and temporal lobes appear to be the most vulnerable to injury, and damage to these areas is associated with impairment of executive function, learning, memory, and behavioral disturbances (Virji-Babul et al., 2014).

Definition of Concussions

There is no universal agreement on the definition of concussion, but it has been proposed that the term should not be used synonymously with mild traumatic brain injury (Khurana & Kaye, 2001). This is because concussion can be a serious injury that, particularly with repetitive occurrences, it may have longer-term neuropsychological effects. There also should be a clear distinction between concussion and post-concussion syndrome. In previous determinations of concussions, a loss of consciousness was a determinant, but it has become more widely accepted that a diagnosis of concussion does not require a loss of consciousness (Karlin, 2011).

Concussion refers to a sudden and transient alteration in consciousness induced by traumatic biomechanical forces transmitted directly or indirectly to the brain. The word is derived from the Latin concutere, meaning to “shake violently” (Khurana & Kaye, 2011). There may or may not be a loss of consciousness, although a concussion typically does involve some period of temporary amnesia. Concussions do not cause a loss of autobiographical information (one’s name or date of birth), concussive amnesia tends to be anterograde. Anterograde amnesia refers to the inability to retain new information (Moser et al., 2007). There can be some degree of retrograde amnesia (inability to recall moments prior to the impact or to recall events hours or some days before the injury), which often occurs initially but tends to resolve, usually within hours, in most patients (Moser et al., 2007). Although gross structural abnormalities on standard CT scan and MRI are typically absent in concussion, at a microscopic level there may be ultra-structural changes in the brain (Khurana & Kaye, 2011; Moser et al., 2007). The reason for this is that concussions are primarily a functional disturbance rather than a structural injury (Karlin, 2011).

Etiology of Concussions

The Consensus Statement on Concussions in Sports determined that concussions may be caused by a direct impact to the head or by an impact to another part of the body with an impulsive force transmitted to the head (Karlin, 2011; McCrory et. al, 2013). Contact sports and bicycle accidents account for the majority of concussions in children and adolescents. A distinguishing feature of sports-related concussions, compared with non-sports related concussions, is that they often result from lower-velocity impact (Karlin, 2011; Marar, Mcllvain, Fields & Comstock, 2012). Sports-related concussions are more often associated with disorientation or a relative impairment of conscious state rather than loss of consciousness (Marar et al., 2012; McCrory et. al, 2013). Risk factors for sports concussions include organized sports as opposed to leisure physical activities, actual games rather than practice sessions, and the sub-group of high school athletes compared with the college level subgroup (Khurana & Kaye, 2011; Marar et al., 2012).

Pathophysiology of Concussions

In a study in 1943, researchers studying concussions sustained in cycling accidents, found they were caused by a change in the rotational velocity of the head (Cairns and Holbourn, 1943; Khurana & Kaye, 2011). The researchers wrote that those patients who were wearing crash helmets sustained milder symptoms of concussion amnesia than those who were not wearing helmets. Their observations have remained accurate to the present time (Cairns and Holbourn, 1943; Khurana & kaye, 2011). From a biochemical perspective, concussions are thought to be due to rotational or angular acceleration forces applied to the brain causing neuronal shearing (Khurana & kaye, 2011; Moser et al., 2007)). During head impact- causing concussion, the brain is violently moved within the skull, causing damage to brain cells and blood vessels (Moser et al., 2007). This can disrupt brain chemicals responsible for brain function. Animal studies have shown that concussions cause an excess of potassium and calcium ions that can cause damage to the cells. These ions can cause the blood vessels within the brain to constrict, decreasing blood flow; consequently, the cells do not get the glucose necessary for normal brain function (Adirim, 2007; Moser et al., 2007).

There is increasing evidence that shows diffuse axonal injury after a concussion, but little is known about the consequence of such injury to functional brain networks, particularly in adolescents (Virji-Babul, 2014). However, new approaches such as diffusion tensor imaging are being developed to detect changes in the microstructural properties of the white matter in the brain following a concussion. Recent studies show that critical white matter regions in the frontal association and commissural pathways are highly susceptible to microstructural changes. These tracts are involved in key cognitive functions, such as executive function, attention, memory, and learning (Virji-Babul, 2014). What researchers know in the adult concussed population is that when their brains are in resting state, they are associated with decreased functional connectivity (Virji-Babul, 2014). It has been reported that interhemispheric connectivity is reduced in the primary visual cortex, the hippocampus, and dorsolateral prefrontal cortex (DLPFC). Researchers have reported that adults with mild traumatic brain injury showed decreased neurocognitive function (Khurana & Kaye, 2011; Virji-Babul, 2014). Reduced functional connectivity has also been reported in the posterior cingulate and parietal cortices during the resting state in concussed athletes (Khurana & Kaye, 2011; Virji-Babul, 2014;). In addition, reduced connections between the left DLPFC and the left parietal cortex were found in athletes who had multiple concussions (Khurana & Kaye, 2011; Virji-Babul, 2014). In contrast, task-related functional networks are associated with increased functional activities within bilateral DLPFC and parietal areas in adults, but with decreased activation in the same regions as adolescents (Khurana & Kaye, 2011; Virji-Babul, 2014). Although both resting state and task based activations have revealed important functional changes in brain networks, little is known about the relationships and network dynamics within these networks (Khurana & Kaye, 2011; Virji-Babul, 2014;).

Clinical Features of Concussions

The spectrum of concussions ranges from a player being dazed without a loss of consciousness, to an unconscious player who has had a seizure. Symptoms and signs from the time of impact (hyperacute) to the hours-to-days afterward (acute) or the first four weeks afterward (subacute) are defined as part of a concussion event (Adirim, 2007; Khurana & Kaye, 2011). The most common symptoms of concussion include headache, dizziness, nausea, vomiting, fatigue, and cognitive symptoms such as decreasing attention span, decreased concentration, decreased mental speed, and impaired short-term memory (Khurana & Kaye, 2011; Moser et al., 2007; Moser & Schatz, 2002). There also may be affective symptoms which include irritability, emotional lability, depression, and anxiety (Khurana & Kaye, 2011; Moser et al., 2007; Moser & Schatz, 2002;). This disruption may leave the brain more vulnerable to further serious injury if there is another impact to the head. There is a rare but devastating consequence of a second impact to the head after concussion, which is called second impact syndrome (Karlin, 2011). This happens primarily in adolescents and occurs when a concussed child or adolescent sustains a subsequent impact to the head before resolution of the first concussion. The result can be tragic because the child may die or suffer from permanent neurological damage. The more common result is in children who have persistence of concussive symptoms for more than four weeks (Karlin, 2011). The development of additional symptoms is defined as part of a post-concussive syndrome. This syndrome is highly variable in length and can last for a few months to several months. A number of the symptoms and signs of concussion and post-concussion syndrome may overlap (Karlin, 2011; Khurana & Kaye, 2011). Important symptoms to consider for post-concussive syndrome include significant feelings of anxiety and depression, a sense of isolation because of absence from social interactions, loss of control over one's own body and activity level, and possibly a fear of re-injury and long-term consequences (Karlin, 2011).

Epidemiology

It is estimated that 30-45 million children and adolescents participate in non-scholastic organized sports in the United States each year, and some children start participating in athletics as early as ages 3 and 4 (Adirim, 2011; Karmin, 2011). Karmin (2011), estimated that in the 2009-2010 school year, more than 7.6 million U.S adolescents participated in high school athletics. The Center for Disease Control (CDC) has estimated that concussions occur in 1.7 million children and adults a year, and that 20 % of these incidents are sports related. Children and adolescents overwhelmingly participate in sports more frequently than adults; they, therefore, sustain the majority of sports-related concussions (Barr, 2001; Karlin, 2011; Moser et al., 2007). In high school athletes, an estimated 300,000 head injuries occur annually, and 90% of these injuries are concussions. More than 100,000 of these injuries are sustained while playing high school football (Barr, 2001; Moser et al., 2007). In the United States, high schools sports with the highest incidences of concussions are football and ice hockey, followed by soccer, wrestling, basketball, field hockey, baseball, softball, and volleyball. By the start of high school, 53% of student athletes have reported a history of concussion (Barr, 2001; Karlin, 2011; Moser et al., 2007). It has been reported that 36% of collegiate athletes have a history of multiple concussions, and it has been estimated that concussions represent 8.9% of all high school and 5.8% of collegiate athletic injuries (Karlin, 2011).

The actual incidence of concussions in the pediatric population is likely to be underestimated and under-reported because of factors such as a lack of initial recognition by the athlete, parents, coaches, or trainers, a lack of follow-up in a medical setting, and the failure to report symptoms because of a fear of loss of playing time (Moser et al., 2007). One study found that nearly 70% of athletes reported symptoms suggestive of a concussion but that only 20% realized that they had sustained a concussion (Barr, 2001; Moser et al., 2007).

Marar et al., (2012), evaluated data from the National High School Sports-Related Injury Surveillance System, High School RIO (Reporting Information Online), an Internet-based sports injury surveillance system. Certified Athletic Trainers from high schools across the country, were recruited to participate in the study. The trainers logged onto the High School RIO Web site weekly throughout the academic year to report injury incidence and athletic exposure for twenty sports: football, soccer, volleyball, basketball, volleyball, softball, gymnastics, field hockey, lacrosse, swimming/diving, track/field, and cheerleading.

In the twenty sports studied over the course of the 2008-2010 school years, 14,635 injuries were reported, 1936 (13.2 %) of which were concussions. These injuries were sustained during the course of 7,780 athletic exposures, resulting in a concussion rate of 2.5 concussions per 10,000 athletic exposures. The majority of concussions resulted from participation in football (47.1 %), followed by girls soccer (8.2%), boys' wrestling (5.8%), and girls' basketball, (5.5%). Boys' volleyball was the only sport in which no concussions occurred. The rates of concussion were higher in competition than in practice for all sports except cheerleading, with this difference being significant in 13 of the 20 sports.

Summary of the Literature Review

Students use executive capacities on a daily basis to work through assignments, pay attention and learn in class, manage their responsibilities, engage in social activities with peers, and perform in sports. Executive capacities are necessary for engagement, organization, attention, and inhibition from distractions. When students are having difficulty in school it is often due to ineffective use of their executive capacities. There is a growing body of literature on what executive capacities are and how they develop in childhood and adolescence. In the past decade, research studies using exercise interventions and surveys of teachers and parents related to students' sports and physical exercise have demonstrated that these activities can play a large role in strengthening executive capacities. No studies, however, have reported on students' own perceptions regarding their executive capacities and the extent to which they believe that the use of these executive capacities are strengthened through participation in sports or the extent to which they believe that playing sports enables them to transfer the use of executive capacities into the classroom to perform better with academic tasks. Additionally, no studies have reported on whether or not there are perceived differences in the use and strengthening of executive capacities when comparing the responses of the athletes that play contact sports and the athletes that play non-contact sports.

Rationale for Survey

It is important for teachers and coaches to have an understanding of what executive capacities are, how they impact students in the classroom, and how physical activity makes physiological changes in the brain that may improve the use of executive capacities. When children and adolescents are playing sports, the areas of the brain that are responsible for executive capacities are activated. When they are playing sports they practice using the executive skills of inhibition, anticipation and shifting in conjunction with working memory to enhance concentration. By surveying the perceptions of student athletes and teachers about their executive capacities, it is possible to learn if they believe they also are applying, in the classroom, the executive capacities they are applying during participation in sports.

Research Questions

The current study was designed to explore student athletes' perceived beliefs about the relationship between playing sports and the use of executive capacities and also examine teachers' ratings of the executive capacities of student athletes. The focus of this study involves the executive capacities that are used to cue and direct the focusing and sustaining of attention, inhibiting impulsive responding, shifting, being flexible, and applying working memory.

The current study will address the following specific research questions:

1. Do students perceive a relationship between playing organized sports (OS) and the effective use of executive capacities?
   A. Do students perceive a relationship between OS. and the effective use of sustained attention?

B. Do students perceive a relationship between OS. and the effective use of focused attention?

C. Do students perceive a relationship between OS and the effective use of inhibition?

D. Do students perceive a relationship between OS and the effective use of shifting?

E. Do students perceive a relationship between OS and the effective use of flexibility?

F. Do students perceive a relationship between OS and the effective use of working memory?

2. Do the perceptions of the relationship between executive capacities and organized sports of those student athletes participating in contact required sports differ from the perceptions of those student athletes participating in contact non-required sports?

A. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of focused attention?

B. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of sustained attention?

C. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of inhibition?

D. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of shifting?

E. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of flexibility?

F. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of working memory?

3. Is there a difference in teacher reports of the effective use of executive functions between student athletes participating in contact required sports and student athletes participating in contact non-required sports?

A. Is there a difference between student athlete groups in teacher reports of effective use of focused attention?

B. Is there a difference between student athlete groups in teacher reports of effective use of sustained attention?

C. Is there a difference between student athlete groups in teacher reports o effective use of inhibition?

D. Is there a difference between student athlete groups in teacher reports of effective use of shifting?

E. Is there a difference between student athlete groups in teacher reports of effective use of flexibility?

F. Is there a difference between student athlete groups in teacher reports of effective use of working memory?

Hypothesis

It is hypothesized that student athletes perceive a relationship between playing organized sports and the effective use of executive capacities. It is hypothesized that teachers will report that student athletes exhibit effective use of executive capacities. It is also hypothesized that there will be a difference in self-reports of the effective use of executive capacities between athletes who participate in contact required sports and athletes participating in contact non-required sports. It is hypothesized that athletes participating in contact required sports will report less effective use of executive capacities because of the higher risk of concussions.

Chapter 3

METHODOLOGY

This chapter describes the methods that were used to conduct this study. The objective of the study was to investigate student athlete's perceptions of the relationship between playing sports and their executive functions. Analyses examined the relationships between type of sport (contact-required vs contact not-required sports) and teacher and student athlete perceptions of the level of effective use of executive functions.

Source of Archived Data

The study involved the use of archived data collected during the winter of 2016 and fall of 2017 as part of a school-based work project. The archived data consisted of surveys completed by student athletes and teachers from all sports teams at a high school. These students included any athlete on the freshman, junior varsity, and varsity teams. The sports teams included: soccer, football, swimming, track and field, cheerleading, baseball, softball, tennis, cross country, gymnastics, volleyball, field hockey, and lacrosse. The teachers and/or coaches of the students completed separate surveys. The athletic director by email, reached out to coaches and also invited, by email, any student athletes who were interested to complete the surveys. The email to the students gave a brief description of the survey, the date, place, and the time of the survey administration. Seventy students came to the survey administration. The survey administration and completion was held at the end of the school day in the gym. Each survey packet contained an arbitrary code number, a cover letter that described the purpose of the survey, and an approximate time for completion of the survey (about 25 minutes). The invitation provided information about the voluntary nature of the study, and the anonymous and confidential nature of the study (there were no questions requiring identifying information). There were no names or identifying information on the surveys. The athletic director distributed the teacher surveys via email, and reminder emails to return the surveys were sent out two weeks and one month after the initial invitation date. In the email to the teachers, the athletic director asked teachers and/or coaches to complete the survey based on four to five of their athletes, and were instructed that there should not be names or identifying information on survey. .

Data Source

The data in this study were collected using surveys created in order to gather information about the perceived relationship between student athletes' executive functions and playing sports. Survey data were used because they provided analyzable quantitative information. The student survey asked for basic demographic information including: number of years playing sports, number of seasons of playing sports, type of team they have played on, if they have been diagnosed with any learning disabilities, if they have had a sports related concussion, gender, grade level, and age. The surveys were divided into two separate groups, contact required and contact nonrequired. The contact sports were basketball, soccer, football, hockey, lacrosse, and field hockey. The contact nonrequired were baseball, tennis, swimming, track and field, cross country, gymnastics, and cheer leading. However, if a student indicated that he or she played two sports from both groups, such as cross country and basketball, that student was considered to be in the contact required group. In order to ensure the face validity of the survey three members of the dissertation committee, including two staff members at the

Philadelphia College of Osteopathic Medicine (PCOM), reviewed the questions. The survey contained questions on a Likert scale. The student survey was titled Sports Participation Questionnaire and assessed the students' beliefs on the relationship between playing sports and their executive functions. The teachers filled out a separate survey titled McCloskey Executive Functions Scale (MEFS). The questions requested that the teachers to simply rate each student's current executive functions ability. The MEFs questions were used with permission of the MEFS author and included only a subset of the items of the original MEFS.

The Sports Participation Question Questionnaire was created by the school psychologist at the high school and the author of the MEFS, Dr. McCloskey. The Sports Participation Questionnaire was divided into questions related to the executive functions of inhibiting, flexibly engaging, shifting, and holding and working with information in mind (working memory). These specific executive capacities were chosen because previous research showed results for these capacities. Dr. McCloskey had previously authored a MEFS self-report student version. The authors of the Sports Questionnaire wanted to formulate self-report questions that assessed a perception of a direct relationship between playing sports and the effective use of executive capacities. . The authors used the statements from the MEFS self-report, and placed the phrase, *playing sports helps me* in front of all the statements. For example, on the MEFS self-report, one of the statements for sustained attention was, "I sustain attention to others in social situations". In the Sports Participation Questionnaire, the statement was changed to, "Playing sports helps me sustain attention to others in social situations". The following sections describe the executive capacities that were included on the questionnaire.

Inhibiting: This section explored student beliefs on whether or not playing sports helps them wait for their turn more easily, helps them consider consequences before actions, helps them refrain from aggression, helps them avoid making inappropriate comments, helps them maintain emotional control in frustrating situations, and helps them maintain emotional control when disagreeing with others.

Flexibly engaging: This section explored student beliefs on whether or not playing sports helps the students to be more willing to try a different way do school tasks when they get stuck, helps them accept changes in relationships, and helps them with routines.

Shifting: This section explored student beliefs on whether or not playing sports helps the students to move from one school task to another without difficulty, and helps them change from one activity to another in social situations without difficulty.

Working memory: This section explored student beliefs on whether or not playing sports helps the students to keep information in mind for short periods of time when doing school tasks and helps them keep information in mind for short periods of time when talking with others.

Attention: This section explored student beliefs on whether or not playing sports helps the student alert their attention to a task, sustain that attention for extended periods of time, and ignore distractions while attending to that task.

The teacher report form of the MEFS addressed the same five executive capacities as those on the student questionnaire: inhibition, flexibly engaging, shifting, working memory and attention. The teacher report form was slightly different from the sports questionnaire because the teacher MEFS did not gather information on the relationship between playing sports and executive functions. It only had the teachers rate only the students' effective use of executive capacities. The first section of inhibition gathered information on the student's current skills in waiting for turns, considering consequences for action, maintaining emotional control, and refraining from aggression. The second section involved flexibly engaging, which gathered information on the students' skills of willingness to try a different approach to a task when they get stuck, accepting changes in school work, and accepting changes in their routines. The third section involved shifting, which gathered information on the students' skills of moving from one task to another without difficulty, and changing from one activity to another in social situations without difficulty. The fourth section examined working memory which gathered information on the students' skills of keeping information in mind for short period of time when doing school tasks and when talking with others. The fifth section gathered information on the student's ability to alert attention to a task and sustain attention for an extended period of time. The MEFS was normed on a national sample of more than 1,000 subjects and demonstrated strong reliability of consistently measuring the construct and strong validity of accurately measuring what it proposed to measure. The sample's demographics closely match those of the U.S population, and children with disabilities were included. The surveys used in this research study are included in Appendix B

Analyses

To examine research questions, descriptive and inferential statistics were conducted using the Statistical Package for the Social Sciences (SPSS). The survey and teacher report form item data are presented in frequency tables with descriptive statistics for each research question. In addition, an analysis of variance was conducted to analyze the relationships between student perceptions of the relationship between organized sports and executive functions and the type of sport played (contact required sport versus noncontact required sport).

Chapter 4

RESULTS

The purpose of this study was to examine student athletes' perceptions of the relationship between engaging in sports and effective use of executive capacities and to determine if perceptions varied, based on whether physical contact was a required part of the sport. The study also examined whether or not coaches reported differences in the effective use of executive capacities between athletes playing contact required sports (CRS) and athletes playing contact non-required sports (NCRS). Finally, student perceptions of the relationship between playing sports and effective use of executive capacities was compared with teachers' ratings of athletes' effectiveness of the use of executive capacities. Student athletes completed surveys that examined if they believed there was a relationship between playing sports and effectively using their executive capacities in other settings. The teachers completed surveys in which they rated student athletes' current use of executive capacities.

Characteristics of the Student Survey Respondents and Teacher Ratings

The data file used in this study consisted of the survey responses of 70 student athletes and the student ratings provided by 50 teachers and coaches. Student surveys in the data file originally were obtained from athletes in contact required sports (n=37), and athletes in contact nonrequired sports (n=33). The coach and teacher student ratings were provided by teachers who rated the executive capacities of CRS athletes (n=25), and the executive capacities of NCRS athletes (n=25) and were a subset of the students in the database that provided survey responses. The student survey respondents were males and females in grades 9 through 12. Characteristics of the student survey respondents and the students rated by coach and teacher raters are provided in Tables 4.1 through 4.16.

Table 4.1. *Student Survey Respondents by Type of Sport Participation, Gender and Age*

	Contact Sport Participation		Non-contact Sport Participation	
Age	Female	Male	Female	Male
14	1	7	4	3
15	3	4	4	3
16	5	6	9	3
17	4	6	6	1
18	0	1	0	0
Total	13	24	23	10

Table 4.2. *Student Survey Respondents by Type of Sport Participation, Gender and Grade*

	Contact Sport Participation		Non-contact Sport Participation	
Grade	Female	Male	Female	Male
9	1	9	6	4
10	2	3	3	2
11	6	6	8	4
12	4	6	6	0
Total	13	24	23	10

Table 4.3. *Student Survey Respondents by Type of Sport Participation, Gender and Number of Seasons Playing High School Sports*

Number of Seasons	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
1	7	6	5	0
2	4	12	10	5
3	1	0	7	4
4	1	6	1	1
Total	13	24	23	10

Table 4.4. *Student Survey Respondents by Type of Sport Participation, Gender and Number of Years of Participation*

Number of Years	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
1	1	5	4	0
2	1	2	4	3
3	3	4	5	1
4	0	0	2	0
5	2	2	2	0
6	4	11	6	6
Total	11	24	23	10

- Two females did not indicate how many years.

Table 4.5. *Student Survey Respondents by Type of Sport Participation, Gender and Incidence of Concussion*

Concussion Incidence	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
Yes	2	2	0	0
No	11	22	23	10
Total	13	24	23	10

Table 4.6. *Student Survey Respondents by Type of Sport Participation, Gender and Participation on Travel Team*

Travel Team Participation	Contact Sport Participation Female	Contact Sport Participation Male	Non-contact Sport Participation Female	Non-contact Sport Participation Male
Yes	2	2	0	3
No	11	22	23	7
Total	13	24	23	10

Table 4.7. *Student Survey Respondents by Type of Sport Participation, Gender and Participation on Club Team*

Club Team Participation	Contact Sport Participation Female	Contact Sport Participation Male	Non-contact Sport Participation Female	Non-contact Sport Participation Male
Yes	2	6	2	3
No	11	18	21	7
Total	13	24	23	10

Table 4.8. *Student Survey Respondents by Type of Sport Participation, Gender and Learning Disability Diagnosis*

Diagnosed Learning	Contact Sport Participation		Non-contact Sport Participation	
Disability	Female	Male	Female	Male
Yes	0	2	0	1
No	13	22	23	0
Total	13	24	23	10

Table 4.9. *Teacher Surveys Completed by Type of Sport Participation, Gender and Age of Students that Were Rated*

	Contact Sport Participation		Non-contact Sport Participation	
Age	Female	Male	Female	Male
14	1	3	3	0
15	3	3	4	2
16	5	2	9	1
17	4	4	6	0
18	0	0	0	0
Total	13	12	22	3

Table 4.10. *Teacher Surveys Completed by Type of Sport Participation, Gender and Grade of Students that Were Rated*

	Contact Sport Participation		Non-contact Sport Participation	
Grade	Female	Male	Female	Male
9	1	5	5	1
10	2	1	3	1
11	6	2	8	1
12	4	4	6	0
Total	13	12	22	3

Table 4.11. *Teacher Surveys Completed by Type of Sport Participation, Gender and Number of Seasons Playing High School Sports of Students that Were Rated*

	Contact Sport Participation		Non-contact Sport Participation	
Number of Seasons	Female	Male	Female	Male
1	7	5	5	0
2	4	5	9	1
3	1	0	7	1
4	1	2	1	1
Total	13	12	22	3

Table 4.12. *Teacher Surveys Completed by Type of Sport Participation, Gender and Number of Years of Participation of Students that Were Rated*

Number of Years	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
1	1	4	4	0
2	1	0	4	0
3	3	1	5	1
4	0	0	2	0
5	2	2	2	0
6	4	5	6	2
Total	13	12	22	3

Table 4.13. *Teacher Surveys Completed by Type of Sport Participation, Gender and Incidence of Concussion of Students that Were Rated*

Concussion Incidence	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
Yes	2	2	0	0
No	11	10	22	3
Total	13	12	22	3

Table 4.14. *Teacher Surveys Completed by Type of Sport Participation, Gender and Participation on Travel Team of Students that Were Rated*

Travel Team Participation	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
Yes	2	0	0	1
No	11	12	22	2
Total	13	12	22	3

Table 4.15. *Teacher Surveys Completed by Type of Sport Participation, Gender and Participation on Club Team of Students that Were Rated*

Club Team Participation	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
Yes	2	1	1	2
No	11	11	21	1
Total	13	12	22	3

Table 4.16. *Teacher Surveys Completed by Type of Sport Participation, Gender and Learning Disability Diagnosis of Students that Were Rated*

Diagnosed Learning Disability	Contact Sport Participation		Non-contact Sport Participation	
	Female	Male	Female	Male
Yes	0	0	0	1
No	13	12	22	2
Total	13	12	22	3

Research Question 1: Do student perceive a relationship between playing organized sports (OS) and the effective use of executive capacities?

Research Question 1a: Do students perceive a relationship between OS. and the effective focusing and sustaining of attention?

Table 4.17 shows the percentage of students that endorsed the survey response options of Strongly Agree and Agree for the four survey items that assessed focusing and sustaining attention. For each question, more than 70 percent of the students responded that they agreed or strongly agreed that participation in sports helped them to focus and sustain attention in both academic and social situations.

Table 4.17. *Percentages of Students that Strongly Agreed or Agreed that Sports Participation Helped Them Focus and Sustain Attention*

Arena of Involvement	Executive Capacity	Survey Item	Percent Strongly Agree	Percent Agree	Percent Agree or Strongly Agree
Academic	Focus	Playing sports helps me focus attention on school tasks.	37.1	41.4	78.5
Self/Social	Focus	Playing sports helps me focus attention on others in social situations.	30.0	42.9	72.9
Academic	Sustain	Playing sports helps me sustain attention for school tasks until a task is completed.	30.0	51.4	81.4
Self/Social	Sustain	Playing sports helps me sustain attention to others in social situations.	25.9	47.1	73.0

Research Question 1b: Do students perceive a relationship between OS and the effective use of inhibition?

Table 4.18 shows the percentage of students that endorsed the survey response options of Strongly Agree and Agree for the seven survey items that assessed inhibition. For these 7 items, the percentage of student responses indicating that they agreed or strongly agreed ranged from 61.4% for the item “playing sports helps me wait for my turn more easily” to 83.4% for the item “playing sports helps me consider the consequences before saying or doing things I may regret.”

Table 4.18 *Percentages of Students that Strongly Agreed or Agreed that Sports Participation Helped Them with Inhibition*

Arena of Involvement	Executive Capacity	Survey Item	Percent Strongly Agree	Percent Agree	Percent Agree or Strongly Agree
Self/Social	Inhibit	Playing sports helps me wait for my turn more easily.	24.3	37.1	61.4
Self/Social	Inhibit	Playing sports helps me consider the consequences before saying or doing things I may regret.	41.4	42.9	84.3
Self/Social	Inhibit	Playing sports helps me refrain from acts of physical	34.3	38.6	72.9

		aggression.			
Self/Social	Inhibit	Playing sports helps me avoid making inappropriate or thoughtless comments (for example, name-calling, insulting, inappropriately tattling on others).	30.0	40.0	70.0
Self/Social	Inhibit	Playing sports helps me maintain emotional control in frustrating situations.	31.4	47.1	78.6
Academic	Inhibit	Playing sports helps me maintain emotional control when doing challenging school work.	24.3	40.0	64.3
Self/Social	Inhibit	Playing sports helps me maintain emotional control when disagreeing with others.	30.0	38.6	68.6

Research Question 1c: Do students perceive a relationship between OS and the effective use of flexibility?

Table 4.19 shows the percentage of students that endorsed the survey response options of Strongly Agree and Agree for the four survey items that assessed flexibility.

For each item, more than 70 percent of the students responded that they agreed or strongly agreed that participation in sports helped them with being flexible.

Table 4.19 *Percentages of Students that Strongly Agreed or Agreed that Sports Participation Helped Them with Being Flexible*

Arena of Involvement	Executive Capacity	Survey Item	Percent Strongly Agree	Percent Agree	Percent Agree or Strongly Agree
Academic	Flexible	Playing sports helps me be more willing to try a different way to do school tasks when I get stuck.	25.7	45.7	71.4
Self/Social	Flexible	Playing sports helps me accept a good idea when it is what most others in a group want to do.	21.4	54.3	75.7
Academic	Flexible	Playing sports helps me accept changes in school work or school routines without getting upset about it.	25.7	52.9	78.6
Self/Social	Flexible	Playing sports helps me accept changes in a person I know or accept unfamiliar	32.9	41.4	74.3

		persons without getting upset.			

Research Question 1d: Do student athletes perceive a relationship between playing organized sports and the effective use of shifting?

Table 4.20 shows the percentage of students that endorsed the survey response options of Strongly Agree and Agree for the two survey items that assessed shifting. Responses indicated that students perceived a greater benefit from sports when shifting in social situations (77.1%) than when shifting with academic tasks (68.6%).

Table 4.20 *Percentages of Students that Strongly Agreed or Agreed that Sports Participation Helped Them with Shifting*

Arena of Involvement	Executive Capacity	Survey Item	Percent Strongly Agree	Percent Agree	Percent Agree or Strongly Agree
Academic	Shifting	Playing sports helps me move from one school task to another without difficulty.	37.1	41.4	68.6
Self/Social	Shifting	Playing sports helps me change from one activity to another in social situations without difficulty.	25.7	51.4	77.1

Research Question 1e: Do student athletes perceive a relationship between playing organized sports and the effective cueing of working memory?

Table 4.21 shows the percentage of students that endorsed the survey response options of Strongly Agree and Agree for the two survey items that assessed working memory. More than 70 percent of the students responded that they agreed or strongly agreed that participation in sports helped them with the effective cueing of working memory in both academic and social situations.

Table 4.21 *Percentages of Students that Strongly Agreed or Agreed that Sports Participation Helped Them with Cueing Working Memory*

Arena of Involvement	Executive Capacity	Survey Item	Percent Strongly Agree	Percent Agree	Percent Agree or Strongly Agree
Academic	Working Memory	Playing sports helps me keep information in mind for short periods of time when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that were just given by the teacher.)	30.0	42.9	72.9

Self/Social	Working Memory	Playing sports helps me keep information in mind for short periods of time when talking with others. (For example, can follow and participate in a longer conversation.)	30.0	47.1	77.1

Research Question 2: Do the perceptions of the relationship between executive capacities and organized sports of CRS athletes differ from the perceptions of NCRS athletes?

To examine the difference in perceptions of the relationship between executive capacities and organized sports of CRS athletes and NCRS athletes, an analysis of variance (ANOVA) was conducted. The analyses used composite scores for attention (focusing and sustaining combined), inhibition, flexibility, shifting, and working memory for comparisons instead of individual items.

For the composite scores of attention, inhibition, flexibility, shifting, and working memory, there were no significant differences between CRS and NCRS athletes' levels of positive endorsement of the benefits of OS for effective use of executive functions. Table 4.22 shows the results of the ANOVA.

Table 4.22 *ANOVA Results Comparing CRS and NCRS Athletes' Perceptions of the Benefits of Organized Sports on the Effective Use of Executive Functions*

		Sum of Squares	Df	Mean Square	F	Sig
ATNCOM	Between Groups	7.601	1	7.601	3.807	.055
	Within Groups	135.771	68	1.997		
INHIBCOM	Between Groups	.785	1	.785	.086	.770
	Within Groups	619.515	68	9.111		
FLESHCOM	Between Groups	1.074	1	1.074	.067	.796
	Within Groups	1083.912	68	15.940		
WMCOM	Between Groups	.785	1	.785	.276	.601
	Within Groups	193.515	68	2.846		

*ANTOM stands for Attention Combined, INHIBCOM means Inhibition Comined, FLEXCOM means Flexibility and Shifting Combined, and WMCOM means Working Memory Combined.

Individual comparisons for each survey item also were conducted to determine if specific items within each composite may reflect different levels of endorsement between CRS and NCRS athletes.

Research Question 2a. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective focusing and sustaining of attention?

Table 4.23 shows the comparisons of percentages, by individual item, of CRS and NCRS athletes that Strongly Agreed or Agreed that sports participation helped them focus and sustain attention. Although a greater proportion of CRS athletes than NCRS athletes positively endorsed three of the four items, these differences were not statistically significant.

Table 4.23

Comparison of Percentages of CRS and NCRS Student Athletes that Strongly Agreed or Agreed that Sports Participation Helped Them Focus and Sustain Attention

			Percent Agree or Strongly Agree			
Arena of Involvement	Executive Capacity	Survey Item	Contact Sport (n = 37)	Non-contact Sport (n = 33)	Fisher z	Level of Significance
Academic	Focus	Playing sports helps me focus	81.1	75.8	.54	.588

		attention on school tasks.				
Self/Social	Focus	Playing sports helps me focus attention on others in social situations.	81.1	63.6	1.38	.169
Academic	Sustain	Playing sports helps me sustain attention for school tasks until a task is completed.	81.1	81.8	-.08	.937
Self/Social	Sustain	Playing sports helps me sustain attention to others in social situations.	78.4	66.7	1.1	.271

Research Question 2b. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of inhibition?

Table 4.24 shows the comparisons of percentages, by individual items, of CRS and NCRS athletes that Strongly Agreed or Agreed that sports participation helped them with inhibition. Although some of the comparisons reflected differences between the groups of 15 percentage points or more, none of the comparisons reflected a statistically significant difference.

Table 4.24

Comparison of Percentages of CRS and NCRS Student Athletes that Strongly Agreed or Agreed that Sports Participation Helped Them with Inhibition

Arena of Involvement	Executive Capacity	Survey Item	Percent Agree or Strongly Agree		Fisher z	Level of Significance
			Contact Sport (n = 37)	Non-contact Sport (n = 33)		
Self/Social	Inhibit	Playing sports helps me wait for my turn more easily.	62.2	60.6	.13	.893
Self/Social	Inhibit	Playing sports helps me consider the consequences before saying or doing things I may regret.	81.1	87.9	--	--
Self/Social	Inhibit	Playing sports helps me refrain	78.4	66.7	1.10	.271

		from acts of physical aggression.				
Self/Social	Inhibit	Playing sports helps me avoid making inappropriate or thoughtless comments (for example, name-calling, insulting, inappropriately tattling on others).	78.4	60.6	1.62	.105
Self/Social	Inhibit	Playing sports helps me maintain emotional control in frustrating situations.	83.8	72.7	1.13	.260
Academic	Inhibit	Playing sports helps me maintain emotional control when doing challenging school	67.6	60.6	.61	.544

		work.				
Self/Social	Inhibit	Playing sports helps me maintain emotional control when disagreeing with others.	75.7	60.6	1.36	.175

Research Question 2c. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of flexibility?

Table 4.25 shows the comparisons of percentages, by individual item, of CRS and NCRS athletes that Strongly Agreed or Agreed and that sports participation helped them with flexibility. There were no statistically significant differences between the two groups in terms of the proportions of athletes positively endorsing each item.

Table 4.25

Comparison of Percentages of CRS and NCRS Student Athletes that Strongly Agreed or Agreed that Sports Participation Helped Them with Being Flexible

Arena of Involvement	Executive Capacity	Survey Item	Percent Agree or Strongly Agree		Fisher z	Level of Significance
			Contact Sport (n = 37)	Non-contact Sport (n = 33)		

Academic	Flexible	Playing sports helps me be more willing to try a different way to do school tasks when I get stuck.	70.3	72.7	--	--
Self/Social	Flexible	Playing sports helps me accept a good idea when it is what most others in a group want to do.	81.1	69.7	1.11	.267
Academic	Flexible	Playing sports helps me accept changes in school work or school routines without getting upset about it.	81.1	75.8	.54	.588
Self/Social	Flexible	Playing sports helps me accept changes in a person I know or	73.0	75.8	--	--

		accept unfamiliar persons without getting upset.				

Reseearch Question 2d. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of flexibility?

Table 4.26 shows the comparisons of percentages, by individual items, of CRS and NCRS athletes that Strongly Agreed or Agreed that sports participation helped them with shifting. Although a greater proportion of CRS athletes than NCRS athletes positively endorsed these items, the differences were not statistically significant.

Table 4.26

Comparison of Percentages of CRS and NCRS Student Athletes that Strongly Agreed or Agreed that Sports Participation Helped Them with Shifting

Arena of Involvement	Executive Capacity	Survey Item	Percent Agree or Strongly Agree		Fisher z	Level of Significance
			Contact Sport (n = 37)	Non-contact Sport (n = 33)		
Academic	Shifting	Playing sports helps me move from one school	73.0	63.6	.84	.401

		task to another without difficulty.				
Self/Social	Shifting	Playing sports helps me change from one activity to another in social situations without difficulty.	81.1	72.7	.83	.406

Research Question 2e. Is there a difference between student athlete groups in perceptions of the relationship between OS and the effective use of working memory?

Table 4.27 shows the comparisons of percentages, by individual items, of CRS and NCRS athletes that Strongly Agreed or Agreed that sports participation helped them with effective cueing of working memory. Although a greater proportion of CRS athletes than NCRS athletes positively endorsed these items, the differences were not statistically significant.

Table 4.27

Comparison of Percentages of CRS and NCRS Student Athletes that Strongly Agreed or Agreed that Sports Participation Helped Them with Cueing Working Memory

Arena of Involvement	Executive Capacity	Survey Item	Percent Agree or Strongly Agree: Contact Sport (n = 37)	Percent Agree or Strongly Agree: Non-contact Sport (n = 33)	Fisher z	Level of Significance
Self/Social	Working Memory	Playing sports helps me keep information in mind for short periods of time when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that	81.1	63.6	1.64	.101

		were just given by the teacher.)				
Self/Social	Working Memory	Playing sports helps me keep information in mind for short periods of time when talking with others. (For example, can follow and participate in a longer conversation.)	81.1	72.7	.83	.406

Research Question 3. Is there a difference in teacher ratings of the effective use of executive functions between student athletes participating in contact required sports and student athletes participating in contact non-required sports?

To examine the difference in teacher ratings of the executive capacities of CRS and NCRS athletes, an ANOVA was conducted. The analyses used composite scores for attention (focusing and sustaining combined), inhibition, flexibility, shifting, and working memory for comparisons instead of individual items.

For the composite scores of attention, inhibition, flexibility shifting, and working memory, there were no significant differences between teacher ratings of CRS and NCRS athletes' executive capacities. Table 4.28 shows the results of the ANOVA.

Table 4.28 *ANOVA Results Comparing Teacher Ratings of CRS and NCRS Athletes' Effective Use of Executive Functions*

		Sum of Squares	Df	Mean Square	F	Sig
ATNCOM	Between Groups	9.680	1	9.680	2.857	.097
	Within Groups	162.40	48	3.388		
INHIBCOM	Between Groups	36.980	1	36.980	2.090	.155
	Within Groups	849.440	48	17.697		
FLESHCOM	Between Groups	40.500	1	40.500	3.649	.062
	Within Groups	532.720	48	11.098		
WMCOM	Between Groups	.980	1	.980	.527	.471

	Within Groups	89.200	48	1.858

Individual comparisons for each survey item also were conducted to determine if specific items within each composite may reflect different levels of teacher ratings of executive capacities between CRS and NCRS athletes. For each student athlete group, frequency counts of the teacher ratings indicating executive strengths were obtained for each item. These frequency counts were compared to determine if the difference between them was statistically significant.

Research Question 3a: Is there a significant difference in teacher ratings of the effective focusing and sustaining of attention between CRS and NCRS athletes?

Table 4:29 shows the comparisons, by individual item, of percentages of CRS and NCRS athletes rated by teachers as demonstrating executive strengths when required to focus and sustain attention. Although a greater proportion of NCRS athletes than the CRS athletes were rated as having executive strengths when required to focus and sustain attention, these differences were not statistically significant.

Table 4:29 *Comparison of the percentage of CRS and NCRS Athletes rated by Teachers as having an Executive Strength when Required to Focus and Sustain Attention*

Arena of Involvement	Executive Capacity	Survey Item	Percent Rated as Executive Strength		Fisher z	Level of Significance
			Contact Sport (n = 50)	Non-contact Sport (n = 50)		
Academic	Focus	Focuses attention on school tasks.	76	84	-.048	.0683
Self/Social	Focus	Focuses attention on others in social situations.	76	76	---	----
Academic	Sustain	Sustains attention for school tasks until a task is completed.	68	80	-.621	.535
Self/Social	Sustain	Sustains attention to others in social situations.	76	76	----	------

Research Question 3b. Is there a difference between student athlete groups in teacher reports of effective use of inhibition?

Table 4.30 shows the comparisons, by individual item, of percentages of CRS and NCRS athletes rated by teachers as demonstrating executive strengths when required to inhibit. Although some of the comparisons reflected differences between groups of 12 percentage points or more, none of the comparisons reflected a statistically significant difference.

Table 4:30 *Comparison of the percentage of CRS and NCRS Athletes rated by Teachers as having an Executive Strength when Required to Effectively Inhibit*

Arena of Involvement	Executive Capacity	Survey Item	Percent Rated as Executive Strength: Contact Sport (n = 50)	Percent Rated as Executive Strength: Non-contact Sport (n = 50)	Fisher z	Level of Significance
Self/Social	Inhibit	Waits for my turn more easily.	68	80	-.621	.535
Self/Social	Inhibit	Considers the consequences before saying or	64	56	.436	.663

		doing things I may regret.				
Self/Social	Inhibit	Refrains from acts of physical aggression.	88	80	.405	. .686
Self/Social	Inhibit	Does not make inappropriate or thoughtless comments (for example, name-calling, insulting, inappropriately tattling on others).	60	64	-.216	.829
Self/Social	Inhibit	Maintains emotional control in frustrating situations.	56	72	-.857	.391
Academic	Inhibit	Maintains emotional control when doing challenging school work.	68	80	-.621	.535
		Maintains				

Self/Social	Inhibit	emotional control when disagreeing with others.	68	56	.649	.516

Research Question 3c. Is there a difference between student athlete groups in teacher reports of effective use of shifting?

Table 4:31 shows the comparisons, by individual item, of percentages of CRS and NCRS athletes rated by teachers as demonstrating executive strengths when required to shift. Although a greater proportion of NCRS athletes than the CRS athletes were rated as having executive strengths when required to shift, the differences were not statistically significant.

Table 4:31 *Comparison of the percentage of CRS and NCRS Athletes rated by Teachers as having an Executive Strength when Required to Effectively Use Shifting*

Arena of Involvement	Executive Capacity	Survey Item	Percent Rated as Executive Strength		Fisher z	Level of Significance
			Contact Sport (n = 50)	Non-contact Sport (n = 50)		
Academic	Shifting	Moves from one school task to	60.0	68	-.429	.668

		another without difficulty.				
Self/Social	Shifting	Changes from one activity to another in social situations without difficulty.	48	76	-1.514	.13

Research Question 3d. Is there a difference between student athlete groups in teacher reports of effective use of flexibility?

Table 4.32 shows the comparisons, by individual item, of percentages of CRS and NCRS athletes rated by teachers as demonstrating executive strengths when required to use flexibility. Although a greater proportion of NCRS athletes than the CRS athletes were rated as having executive strengths when required to use flexibility on three out of the four items, these differences were not statistically significant.

Table 4:32 *Comparison of the percentage of CRS and NCRS Athletes rated by Teachers as having an Executive Strength when Required to Effectively Use Flexibility*

Arena of Involvement	Executive Capacity	Survey Item	Percent Rated as Executive Strength		Fisher z	Level of Significance
			Contact Sport (n = 37)	Non-contact Sport (n = 33)		
Academic	Flexible	Willing to try a different way to do school tasks when I get stuck.	96	76	-.207	. .836
Self/Social	Flexible	Accepts a good idea when it is what most others in a group want to do.	76	80	-.205	.838
Academic	Flexible	Accepts changes in school work or school routines without getting	76	80	-.205	.838

		upset about it.				
Self/Social	Flexible	Accepts changes in a person I know or accept unfamiliar persons without getting upset.	64	84	-1.468	.142

Research Question 3e. Is there a difference between student athlete groups in teacher reports of effective use of working memory?

Table 4.33 shows the comparisons, by individual item, of percentages of CRS and NCRS athletes rated by teachers as demonstrating executive strength when required to cue working memory. Although a greater proportion of CRS athletes than the NCRS athletes were rated as having executive strengths when required to cue working memory, these differences were not statistically significant.

Table 4:33 *Comparison of the percentage of CRS and NCRS Athletes rated by Teachers as having an Executive Strength when Required to Effectively Cue Working Memory*

Arena of Involvement	Executive Capacity	Survey Item	Percent Rated as Executive Strength		Fisher z	Level of Significance
			Contact Sport (n =	Non-contact Sport (n =		

			37)	33)		
Self/Social	Working Memory	Can keep information in mind for short periods of time when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that were just given by the teacher.)	72	64	.422	.673
Self/Social	Working Memory	Can keep information in mind for short periods of time when talking with others. (For example, can follow and	80	68	.621	.535

		participate in a longer conversation.)				

Chapter 5

Discussion

Summary of the Findings

With regard to the first research question, "Do student athletes perceive a relationship between playing organized sports and effective use of their executive capacities?" the results indicated that a large majority of student athletes positively endorsed the benefits of organized sports for effective use of executive capacities. Frequency distributions for the individual survey items in the composites attention, flexibility, shifting, inhibition, and working memory were examined. The results of the item analyses indicated that a large majority of the athletes agreed or strongly agreed that playing organized sports helped them with the effective use of their executive capacities. The highest percentage of positive endorsements were obtained for the executive capacities used to cue and direct attention, flexibility and working memory.

With regard to the second research question, "Do the perceptions of the relationship between executive capacities and organized sports of CRS athletes differ from the perceptions of NCRS athletes?", the results indicated there were no statistically significant differences between CRS and NCRS athletes' levels of positive endorsement of the benefits of OS for effective use of executive functions.

With regard to the third research question, "Is there a difference in teacher ratings of the effective use of executive functions between CRS and NCRS athletes? ", analyses indicated that there were no statistically significant differences between teacher ratings of CRS and NCRS athletes' executive capacities. The frequency distribution for the individual teacher survey items in the composites, attention, flexibility, shifting, inhibition, and working memory were examined. Although the literature indicates that CRS athletes are more likely than NCRS to experience concussions, and that concussions often result in less effective use of executive capacities, the ratings provided by the coaches and teachers in this study did not indicate any perceived differences in the use of executive capacities of CRS and NCRS athletes as a group.

Significance of the Findings

The findings of this study are consistent with previous findings such as those reported by Best, (2010), i.e., that playing sports helps students use their executive capacities effectively and that the increase in effectiveness is seen in additional settings such as the classroom. It can be inferred from the results that a large majority of the student athletes included in this study believe that playing sports helps them focus and sustain their attention on school tasks until their completion. The student athletes also positively endorsed the fact that playing sports helps them to hold and manipulate information in mind for short periods of time while doing school tasks, transition to different activities, problem solve, and understand another point of view in a variety of situations. These student responses support the neuropsychological research by Ratey and Hagerman, (2010), and it is a possibility that as a result of exercise, increased levels of neurotransmitters are enhancing the effective use of executive functions. It can be implied that increased levels of dopamine are enhancing the focus of attention to facilitate learning and that increases in norepinephrine are reducing distractibility and are enhancing memory to assist in learning. If the findings in the literature are correct and the perceptions of this group of student athletes are accurate, then the repeated activation of executive capacities that occurs during practice is causing the synapses in the brains of these student athletes to grow and make stronger connections. Consistent with the perceptions of most students, most of the teachers' ratings indicated that student athletes were demonstrating effective performances when required to use their executive capacities.

For a majority of the survey items, a higher percentage of CRS athletes than NCRS athletes offered positive endorsements, and there are a few possible explanations for these results. However, there were no significant differences between the groups and the results should be interpreted with caution. When looking at the framework of the different sports, NCRS athletes were on highly individualized teams such as cross-country, track and field, and swimming. In contrast, the CRS athletes participate in group-oriented sports. The CRS athletes engage in cooperative play much more frequently and are potentially developing more effective executive capacities as a result. Since the athletes are required to constantly engage in cooperative play with their teammates, it motivates them to excel in their skills for themselves and for their teammates. Additionally, in the contact required sports such as soccer, football, and basketball, the athletes are both actively competing against an adversary and cooperating with teammates to reach their goals instead of competing against a clock or working toward a personal best. The nature of contact required sports requires much more frequent and repeated use of executive capacities which may have led to better developed skills. According to Best (2010), sports such as soccer, basketball, and football, require complex cognition in order to cooperate with teammates, anticipate the behavior of teammates and opponents, employ strategies, and adapt to ever-changing task demands.

It is interesting to note that despite the higher risk of concussions, the CRS athletes did not perceive any difficulties with the use of their executive capacities. The teacher reports, in fact, did not indicate significantly less effective use of executive capacities among the CRS athletes.

Limitations

There are several limitations related to the present study. First, the study focused on high school students; therefore, the study cannot be generalizable to younger students. The study was conducted in one high school with a medium-sample size, which also limits the generalizability of the study. Additionally, the degree of participation in sports varied greatly among the students. Some of the students played on multiple teams, such as their school's varsity team and on competitive club teams in their town; and there were other students who played on only one of the high school's freshman, junior varsity or varsity teams. Considering the fact that students are playing at different levels and are practicing the use of executive functions to varying degrees, this may have impacted the results of the study. There also was a lot of variability in the number of seasons and the number of years the athletes reported playing sports. Athletes who play more often and have played for a long time may demonstrate greater executive strengths than athletes who are beginners. This variability may have influenced the results of the study.

As with any survey responder, bias is a possible limitation because student participants reported on their own perceptions and beliefs about their executive functions capacities. It is possible the athletes succumbed to social desirability bias in order to appear more competent in their abilities. Another possibility is that adolescents sometimes have weak self-awareness and their responses may not have reflected a perspective that could be supported in an objective manner. Additionally, with regard to the teacher surveys, the teachers were of varying ages, varying teaching experience and years of training. Another point of consideration is that coaches are extremely and personally invested in their athletes and their sports teams. They may have endorsed the athletes with executive strength because they want to demonstrate not only the importance of the sports programs but also the fact that their athletes are very skilled. These factors may have influenced their judgments about the effectiveness of athletes' use of executive functions.

Direct standardized measures of executive functions may be more valid and may give more accurate characterizations of executive functions capacities, but the collection of such data was not feasible for this study. Another limitation was that the research study did not take a longitudinal approach to the study and evaluated teacher and student perceptions at one of point time. The study might have reflected significant differences in ratings if the teachers had rated the students throughout the school year.

Implication for Practice

The first intent of this study was to examine students' beliefs that playing sports helps them effectively use executive function capacities. The second intent of the study was to determine if there was a difference in student perceptions and teacher reports between athletes engaged in contact-required sports and athletes engaged in contact non-required sports. It was hypothesized that students do believe that playing sports helps them, as student athletes, effectively use their executive capacities in other arenas such as academics. It was also hypothesized that students in contact-required sports would report less effective use of executive functions than students in contact non-required sports. The information gathered from the student athletes and teachers is something that should be explored further. The study has illustrated that students believe that playing sports can have a meaningful influence on adolescents' effective use of their executive capacities and it was revealed that students do see a positive relationship between playing sports and their use of effective executive capacities in their academics and peer relationships. This is valuable information for teachers, parents, and families because effective use of executive functions is largely responsible for paying attention in class, studying, engaging with peers, forming relationships, and planning for the future. Teachers and parents are constantly looking for ways to motivate their students and enable them to succeed in sports and in academics. The literature base and results from this study can be used for professional developments presented to educators to illustrate how encouraging students involved in sports and physical activity will improve and aid in the development of their executive capacities in academics, social settings, and future aspirations. Resources on executive functions and how physical exercise influences cognition should be readily available to teachers so they can educate their students on the fact that playing sports promotes their success in multiple facets of their lives.

Next Steps

There is also further research that can be developed from this study. Student athletes and teachers were eager to participate in this study and provided extremely valuable information. This study involved the self-reports of athletes from a variety of sports and levels of play. The student athletes who participated in the study consisted of those athletes who are involved in travel, club, freshman, junior varsity, and varsity teams. Typically athletes who play in varsity, travel and club are of a higher caliber and can be exceptional athletes. It would have been interesting to proceed with further surveys to determine if athletes of a higher caliber report more effective use of executive capacities.

The study could also have been furthered and expanded in a few different ways. The surveys were administered in the middle of the school year; a second survey at the end of the school year might have provided additional information. It would have been interesting to determine if students reported increased effective use of executive capacities as the school year progressed and they had further practice of these capacities. Their frontal lobes are developing over time and perhaps with repeated practice and further development, their executive capacities will flourish.

Another method for research would be to administer direct neuropsychological test batteries that assess the self-regulation executive functions to the student athletes, along with the surveys. The students can be administered the direct assessments and surveys prior to the sports season's beginning. The results from the direct assessments could be compared with their impressions of their effective use of executive capacities. At the end of the season, a second direct assessment would be administered to determine if their capacities had improved over time and if possible concussions or head injuries influenced their use of executive capacities. This would provide valuable, direct measures of a students' executive capacities. This would be extremely valuable because teachers and coaches would have an objective measure of the athletes' capacities.

Further, future research also could consider coaches' knowledge of concussions and the impact that concussions have on a child's brain and development. This study did not acknowledge their knowledge of concussions, and this is an area that would provide more detailed information on how to detect concussions and how to treat them proactively.

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Appendices

Appendix A

Dear Student,

You are invited to complete this anonymous survey regarding your participation in sports and how you feel about school. Do not put your name or any identifiers on the documents you fill out. The purpose is to gather information regarding beliefs if playing sports helps students perform well in school and with their peers. This survey is completely voluntary. If you have any questions regarding this survey, you can ask me any question and I will be happy to answer them for you! You can also contact and ask questions to Mr. Andolina(Athletic Director) if you have any questions.

Sincerely,

Rebecca Edelsberg

MS.Ed. School Psychologist

Appendix B

Student Survey

Sports Participation Questionnaire

What is your age? _____

What is your grade level? ______

What is your gender? _____

How many seasons a year do you play a sport? _____

What sports do you play or engage in? Check all that apply

Baseball_____

Softball____

Basketball _____

Tennis _____

Track and field _____

Cross Country _____

Gymnastics _____

Swimming _____

Volleyball _____

Field hockey _____

Lacrosse _____

Cheer leading _____

Football _____

Soccer_____

Hockey_____

Other______

How many years have you played sports in school (include elementary and middle school years)?

1year _____

2-years___

3 years _____

4-years____

5 years _____

6 or more years _____

Do you play on a club sport team?

Do you play on a travel team?

Have you ever been diagnosed with a learning disability? Yes_____No_____

Have you ever been diagnosed with a sports related concussion? Yes-___ No____

For each statement below, circle the option that best describes you:
SA = Strongly Agree A = Agree NS = Not Sure D = Disagree DA = Disagree

FOCUSING ATTENTION					
Playing sports helps me focus attention on school tasks.	S A	A	N S	D	SD
Playing sports helps me focus attention on others in social situations.	S A	A	N S	D	SD
SUSTAINING ATTENTION					
Playing sports helps me sustain attention for school tasks until a task is completed.	S A	A	NS	D	SD
Playing sports helps me sustain attention to others in social situations.	S A	A	NS	D	SD
INHIBITING					
Playing sports helps me wait for my turn more easily.	S	A	NS	D	SD

	A				
Playing sports helps me consider the consequences before saying or doing things I may regret.	S A	A	NS	D	SD
Playing sports helps me refrain from acts of physical aggression.	S A	A	NS	D	SD
Playing sports helps me avoid making inappropriate or thoughtless comments (for example, name-calling, insulting, inappropriately tattling on others).	S A	A	NS	D	SD
Playing sports helps me maintain emotional control in frustrating situations.	S A	A	NS	D	SD
Playing sports helps me maintain emotional control when doing challenging school work.	S A	A	NS	D	SD
Playing sports helps me maintain emotional control when disagreeing with others.	S A	A	NS	D	SD
FLEXIBLY ENGAGING					
Playing sports helps me be more willing to try a different way to do school tasks when I get stuck.	S A	A	NS	D	SD
Playing sports helps me accept a good idea when it is what most others in a group want to do.	S A	A	NS	D	SD
Playing sports helps me accept changes in school work or school routines without getting upset about it.	S A	A	NS	D	SD
Playing sports helps me accept changes in a person I know or accept unfamiliar persons without getting upset.	S A	A	NS	D	SD

SHIFTING					
Playing sports helps me move from one school task to another without difficulty.	SA	A	NS	D	SD
Playing sports helps me change from one activity to another in social situations without difficulty.	SA	A	NS	D	SD
HOLDING and WORKING WITH INFORMATION IN MIND					
Playing sports helps me keep information in mind for short periods of time when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that were just given by the teacher.)	SA	A	NS	D	SD
Playing sports helps me keep information in mind for short periods of time when talking with others. (For example, can follow and participate in a longer conversation.)	SA	A	NS	D	SD

Teacher Survey

Sport:____________________

For each statement below, think about the student and circle the option that best describes this student:

5	AA	Always or almost always does this on his or her own. Does not need to be prompted or reminded (cued) to do it.
4	F	Frequently does this on own without prompting
3	S	Seldom does this on own without being prompted, reminded, or cued to do so.
2	AP	Does this only after being prompted, reminded, or cued to do it.

1	DA	Only does it with direct assistance. Requires much more than a simple prompt or cue to be able to get it done in situations that require it.
0	UA	Unable to do this, even when direct assistance is provided.

FOCUSING ATTENTION						
Focuses attention on school tasks.	AA	F	S	AP	DA	UA
Focuses attention on others in social situations.	AA	F	S	AP	DA	UA
SUSTAINING ATTENTION						
Sustains attention for school tasks until a task is completed.	AA	F	S	AP	DA	UA
Sustains attention to others in social situations.	AA	F	S	AP	DA	UA
INHIBITING						
Waits for turn.	AA	F	S	AP	DA	UA
Considers the consequences before saying or doing things he or she may regret.	AA	F	S	AP	DA	UA
Refrains from acts of physical aggression.	AA	F	S	AP	DA	UA
Does not make inappropriate or thoughtless comments (for	A	F	S	AP	DA	UA

example, name-calling, insulting, inappropriately tattling on others).	A					
Maintains emotional control in frustrating situations.	AA	F	S	AP	DA	UA
Maintains emotional control when doing challenging school work.	AA	F	S	AP	DA	UA
Maintains emotional control when disagreeing with others.	AA	F	S	AP	DA	UA
FL**EXIBLY ENGAGING**						
Willing to try a different way to do school tasks when he or she gets stuck.	AA	F	S	AP	DA	UA
Accepts a good idea when it is what most others in a group want to do.	AA	F	S	AP	DA	UA
Accepts changes in school work or school routines without getting upset about it.	AA	F	S	AP	DA	UA
Accepts changes in a person he or she knows or to accept unfamiliar persons without getting upset.	AA	F	S	AP	DA	UA
SHIFTING						
Moves from one school task to another without difficulty.	AA	F	S	AP	DA	UA
Changes from one activity to another in social situations without difficulty.	AA	F	S	AP	DA	UA

HOLDING and WORKING WITH INFORMATION IN MIND						
Can keep information in mind for short periods of time when doing school tasks. (For example, can add 3 or more numbers without pencil and paper; can remember directions that were just given by the teacher.)	AA	F	S	AP	DA	UA
Can keep information in mind for short periods of time when talking with others. (For example, can follow and participate in a longer conversation.)	AA	F	S	AP	DA	UA