



# Mastery in Tennis Skill Enhance Executive Functions in ADHD Children: A Psychosocial Perspective

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## Abstract

A common neurodevelopmental disorder with a childhood onset, Attention Deficit-Hyperactivity Disorder (ADHD) is characterized by developmentally inappropriate levels of impulsivity, hyperactivity, and/or inattention that can persist throughout life. The primary issues that children with ADHD encounter are caused by their incapacity to use their executive function or abilities to execute and engage in self-regulation. The different range of symptoms may lead to different management strategies. Although behaviour therapy, parental education and counselling, and the use of stimulants may be beneficial, a thorough treatment plan should also incorporate exercise, good sleep hygiene, and a balanced diet. Only a small number of researches have demonstrated the benefits of physical activity for children with ADHD. The objective of this paper is to provide light on the value of physical activity, specifically tennis, in improving the executive functions and psychosocial development of children with ADHD. The open-skilled sport of tennis demands a lot of neuromuscular and metabolic exertion. Tennis requires immediate assessments of a player's technique and strategy, and cognitive flexibility goes hand in hand with motor skills; these aspects of the game may help build executive functions. Tennis offers a range of opportunities for regular physical activity that improve ADHD children's attention, learning, memory, impulse control, problem-solving, and decision-making abilities, according to the research findings gathered. Therefore, today, tennis is regarded as the healthiest sport in the world since it fosters socialization, improves emotional control, and increases self-efficacy while lowering stress and anxiety.

**Keywords:** Neurodevelopment; Executive Function; Tennis; Exercise; Physical Activity; Children

## Abbreviations

ADHD: Attention Deficit-Hyperactivity Disorder; NHIS: National Health Interview Survey.

## Introduction

### ADHD Children

A common neurodevelopmental disorder with a childhood

onset, Attention Deficit-Hyperactivity Disorder (ADHD) is characterized by developmentally inappropriate levels of impulsivity, hyperactivity, and/or inattention that can persist throughout life [1]. ADHD is prevalent in the majority of cultures worldwide. According to the National Health Interview Survey (NHIS), 11.3% of kids between the ages of 5 and 17 received an ADHD diagnosis in 2020–2022. ADHD was more common in boys (14.5%) than in girls (8.0%), and this trend has been observed in children aged 5–11 and 12–17. Among both boys and girls, children aged 5 to

11 had a lower prevalence of ADHD (8.6%) than children aged 12 to 17 (14.3%) [2]. In India, ADHD is becoming more common. According to several studies, the prevalence of ADHD in kids and teenagers varies between 1.30 and 28.9% [3]. The nervous system of children with ADHD is different from that of neurotypical children. It controls behaviors that people find unacceptable, such as constant motion, poor impulse control, and distractibility. As a result, children and adolescents with ADHD have lower academic achievement, poorer relationships with their parents, siblings, and other people, and low self-esteem, low self-evaluation, negative emotions, and other negative effects [4,5]. It should be mentioned that research on ADHD focuses on the issues that the person has created as a result of the disorder. Raising a child with ADHD can be incredibly challenging for any parent. Effective intervention requires an understanding of ADHD's cascading effects. Childhood is a highly sensitive and critical period for executive function development due to development of the key cortex, the prefrontal cortex and late maturation [6,7]. The developmental curve of gray matter for the frontal lobe peaks at around age 12 [8]. Accordingly, the executive function undergoes a protracted development. During the period from 7 to 12, all sub-components of the executive function experience significant development, consistent with increased gray matter density in the brain [9]. Executive function development is more susceptible to external and environmental stimuli during this period, including participation in sports [10,11]. Numerous studies have demonstrated that physical activity enhances physiological markers, including muscular strength, bone health, cardio-respiratory functions, and metabolic biomarkers. These improvements increase physical fitness, lower the risk of cardiovascular disease and metabolic syndrome, and lessen psycho-social issues. Regular physical activity has been linked to improved brain functions, according to recent researches [10,12,7]. Consequently, it can be said that children with ADHD benefits more from physical activity that are discussed below.

### ADHD and Brain's Executive Functions

The primary issues that children with ADHD face are related to their incapacity to use their executive function or abilities to execute and engage in self-regulation. Executive function can be defined as self-regulation abilities that include: a) directing our actions toward ourselves; b) altering our behavior from what it is; and c) altering our future in a significant way (increasing or decreasing the likelihood of subsequent consequences). According to Barkley, individuals with ADHD or ADD typically have difficulties with seven fundamental executive functions which are follows [13]:

**Inhibition or Self Restraint:** A key neurocognitive domain in ADHD is inhibition, also known as self-restraint. It refers to a group of interconnected cognitive processes that

support the capacity to either stop (action cancellation) or withhold (action restraint) an on-going response [14]. The main executive dysfunction in ADHD is thought to be a lack of response inhibition, which results in deficiencies in other executive functions.

**Self-directed Attention to Achieve Self Awareness:** Self-directed attention is the capacity to focus our attention on ourselves as well as our surroundings, enabling us to keep an eye on our behaviour and to stop it when it seems necessary in a new circumstance or after we have erred. Understanding our own thoughts, feelings, values, beliefs, and behaviours is made possible by this awareness, which also helps us to understand who we are, what we want, how we feel, and why we act in certain ways. For people with ADHD, self-awareness is a major challenge.

**Using self-directed visual imagery to attain hindsight and foresight (awareness of ourselves over time):** This is the capacity to identify and take into account time-related elements in a variety of tasks and activities with a superior comprehension of the length of time, the order of events, and the cyclical nature of time. Both foresight (looking ahead) and hindsight (looking backward in our own memory) rely on our visual senses and our ability to conjure up images of past experiences. This ability is referred to as "Non-Verbal working Memory," and it is a major shortcoming in people with ADHD.

**Using language to control ourselves:** Internalized speech, also known as self-directed speech, is an executive function that enables us to regulate our own actions. Internalized speech helps us stay on course toward our plans and goals by providing self-directed instructions that help us control and guide our behaviour. Since people with ADHD lag behind in following rules, talking to themselves, using rules to control their behavior, and eventually creating their own rules when faced with challenges, these skills can be referred to as rule-governed behaviour that is deficient.

**Self-directed emotion to better control them:** Children with ADHD are thought to be more emotional and occasionally immature. Their inability to control their emotions to fit the situation and their objectives or well-being is the cause of their emotionality, not the emotion itself. They are unable to control their initial reactions to situations, don't give themselves enough time to separate their feelings from facts (reacting too quickly), and ultimately regret their impulsive and raw emotional reactions. This is impairment in the top-down self-regulation of primary emotions. Their actions alienate people, which lead to rejection, social hostility, punishment, and ultimately the end of friendships.

**Using self-motivation to support and maintain goal-directed actions:** Self-motivation is what keeps us going when we are working toward our objectives. People with ADHD have a partially full or empty fuel tank, which makes it difficult for them to stay motivated and support themselves while working on a task. Lack of access to outside sources of motivation will cause them to become distracted from the task at hand not out of laziness, but rather due to a biological issue with the way the brain functions.

**Using self-directed play to solve problems and create solutions:** Problem solving is the mental capacity to analyse and synthesize on-going data in order to generate completely original concepts and guidelines that could lead to potential solutions. Children with ADHD struggle to solve problems or come up with goal-directed ideas because they are unable to analyse and synthesize information. It has also been suggested that children with ADHD who are smarter than average might be more creative than typical kids in some areas and less in others.

### Tennis as a Unique Sport

Tennis has historically met many special needs and has both aerobic and anaerobic characteristics, causing greater physical exhaustion that may impact mental and emotional functions. During the game, there are no clocks, timeouts, or substitutions. Players are unsure of how long they will be competing on the court, and matches can last anywhere from 45 minutes to several hours. For example, the opponent of a player in the following round might have had a simple match that lasted only forty-five minutes, while the other match might have lasted three hours. Players are left to fend for themselves during the match, with little to no coaching permitted. A lead might swiftly evaporate due to the increasing pressure created by the scoring system. Even with a significant advantage, players rarely feel safe, regardless of the score. Given the wide range of fine motor abilities needed for success, nervousness and anxiety are major factors in competition. Age, not height or weight, determines the competitive groups; short players compete against tall players, and small players compete against large players. In order for the player to make contact in the middle of the strings in a way that will cause the ball to move to the desired position on the opposing team's side of the court, their brain must perform hundreds of thousands of split-second computations [15].

As the player runs in dynamic motion toward the ball, factors like ball speed, spin, height, and wind conditions must be taken into account. Therefore, it should come as no surprise that poor attention, anger, or anxiety can seriously impair balance and the ability to execute gross and fine motor skills. Rivalries can grow out of control and add significant

social and emotional pressure to succeed. As participants compete, spectators are in close proximity to them. Parents' expressions of contempt, delight, shame, or fear are visible to players. There are always opportunities for gamesmanship and cheating, which might put a lot of emotional strain on players. "In" and "out" decisions are separated by fractions of inches. The usage of video replay during professional matches has shown that even professional players frequently make mistakes when making online calls. A player's tennis identity may be seriously threatened by bad losses, such as losing to a player with a lower ranking. Girls can and often do beat guys their own age when they are in school (6-13), which causes strong feelings of shame and failure [15]. The facial emotions of wrath, disgust, disdain, fear, rage, and hubris are visible to players. There are very few, if any, sports that provide such a wide range of opportunities for psychological growth. These stressors unique to tennis constitute an exceptional domain of demands that can hasten self-regulation and self-control. From a learning and development standpoint, tennis is an especially appealing option because of this factor as well as the fact that players have a little chance of injury and may actually play the sport for the rest of their lives [15].

### ADHD Children and Tennis

Parents and educators may find it difficult to manage children with ADHD. But if they comprehend the problems that result from the emergence of ADHD symptoms, it would be a lovely adventure. As was previously noted, management strategies for executive dysfunctions of ADHD may change based on the variety of symptoms. Behaviour modification, parental counselling and education, and application of stimulants drugs could be effective, simultaneously application of regular outdoor games/sports could equally provide benefit in regulating the executive dysfunctions associated with ADHD [16-20]. Unquestionably, tennis offers a number of positive psychosocial developmental elements that support and manage executive function particularly those with ADHD [21,22]. Autonomy, mastery, and relatedness are three fundamental developmental pillars for children. These are the most critical needs for progressive self-determination, and they are equally significant for neuro-divergent children like ADHD as they are for neuro-typical children. The psychological urge to believe that our actions are self-initiated and self-endorsed—that is, that we pursue something because it is intrinsically fulfilling is known as autonomy. The need to be proficient and successful in our work is symbolized by mastery; children find immense satisfaction in the process of learning, developing, and gaining mastery. The strong human need to connect with others is symbolized by relatedness, which is prevalent in early children. Attachment, bonding, and a sense of belonging are essential components in the development of positive self-esteem [23].

According to numerous studies, Tennis has been shown to help children with ADHD with a variety of skills and behaviours as detailed below:

**Attention:** One of the key components of being a successful tennis player is having a high level of attention, focus, and concentration, all of which impact performance [24]. It is thought that a key component of success in athletics is the capacity to focus attention on the right stimuli and sustain it. This kind of selective attention is typically the foundation of tennis exercises that support learning, memory, problem-solving, and attention control. The person wouldn't be able to behave consistently toward many items in its surroundings if it didn't have this attention selectivity. Tennis is an open-skilled sport that needs quick decision-making under time constraints and the ability to use creativity and/or problem-solving techniques to adjust to constantly shifting task demands, which improves executive functions [25-27]. Research has indicated that teaching methods that encourage an external focus of attention result in better stroke accuracy and enhanced tennis skill acquisition, especially for younger players. This was demonstrated by tasks like as hitting tennis balls at a target, where exterior focus outperformed internal focus in terms of accuracy in both retention and transfer tests [27].

Tennis requires quick thinking and decision-making. It has been demonstrated that an external focus improves decision-making abilities during play, which is an essential component of tennis performance [27]. In their interactions with players, coaches can inadvertently create an internal concentration. Nonetheless, switching to teaching methods that encourage an external emphasis may greatly improve tennis skill acquisition and performance [24]. Another study has shown how beneficial a long-term racket-sport intervention is for improving children with ADHD's general performance, social behaviours, motor abilities, and executive functions, specifically selective attention [28]. Children with longer tennis training experiences have more opportunities to switch between different types of tasks and problem-solving strategies, which are necessary to enhance cognitive flexibility [30,31]. Also, tennis places great demand on attention-shifting ability due to the need for tennis players to focus attention on the opponent's actions and balls, shift attention among different objectives, and make accurate and fast corresponding accordingly in a dynamically changing, unpredictable, and externally paced environment [32,33]. For example, when playing tennis, players must be able to alter their focus under pressure, learn intricate movement patterns, and concentrate on the ball and opponent's position. Similar brain areas that regulate higher order cognitive functions (such cognitive flexibility) are thought to be activated by these activities [34,35].

**Individual Focus and Hyper Focus:** In ADHD, hyper focus

is a distinct cognitive state marked by a very high level of prolonged and intense focus on a particular task or activity. Hyper focus enables people with ADHD to fully engage in a task, which frequently results in increased productivity, even if conventional attention can be difficult for them. States that are frequently referred to as being "in the zone" are characterized by intense, prolonged attention and less distraction [36]. Less attention has been paid to how ADHD can benefit the individual when environmental characteristics (like structure) and cognitive profile (like hyper-focusing and high energy) are taken into account and interact [37]. Children who like to compete against themselves and use their hyper focus as strength, tennis can be an excellent option who also may have trouble managing their time and staying organized. According to studies, by encouraging physical activity and structuring activity in a positive way, children with ADHD can suppress their symptoms and learn to exhibit proper behaviour with the correct instruction [38,39]. Thus, Tennis helps them establish a sense of routine by offering structure in an entertaining and captivating way and with regular practice and match schedules in turn facilitate routine development. Children who follow this pattern can become more productive and have better habits, which will enhance their general well-being and time management abilities [15].

**Improve Executive Functions:** Exercise has a positive effect on the growing brain, which improves cognitive function [40]. Exercise has been shown to improve learning, memory, attention, impulse control, and problem solving in both adults and children, and it is also beneficial for children with ADHD [39]; prolonged periods of vigorous activity, which promotes cognitive development [15]. Tennis is thought to foster a lifetime of on-going brain growth by requiring awareness and strategic thinking, as well as by potentially creating new neural connections in the brain [41] and the players' demands necessitate critical thinking and problem-solving abilities, which stimulate the brain [10,12,7]. Children with ADHD can benefit from this mental activity by developing cognitive abilities linked to sound planning, problem-solving, and decision-making. When tennis players practice their hand-eye coordination, which is a type of ability of the entire body to complete a task by using their hands with information gained from their eyes without mental tensions or mistakes, and with minimal effort, they develop it significantly, just like in many other sports [42]. In a tennis ball drill, players must use their hands and bodies to accomplish a job by using visual cues about the ball's position and trajectory. Benefits include 1) coordination, as movement requires the use of the full body and visual cues to accomplish the task; 2) motor control, including gross motor (through court movement and ball striking) and fine motor (through angled volleys and fine-strategized drop shots); for example, throwing or tossing with the right direction

to give the best chance of catching the ball, especially if it's bouncing off a wall; and performing movements in the right directions and intensities to accomplish a task; and 3) visual tracking and anticipation, which is the process of acting on an object's visual information to forecast the remainder of its course. This is developed by determining how fast and how far to move in order to intercept the tennis ball based on its trajectory [43]. Developing acceleration, speed, leg strength, agility, and flexibility requires both active brain function and well-balanced body coordination [44, 45].

Tennis is a fast-paced sport that requires both quick decision-making and a great deal of patience to wait for the ideal opportunity to hit the ball. Assessing angles, geometry, and physics to achieve the best results is the foundation of tennis. Indeed, at any given moment in a tennis match, they are essential areas of expertise. Better off-court problem solving with appropriate impulse control results from having the ability to solve problems fast, or in real-time, on a tennis court. All of the noticeable or quantifiable improvements made by a skilled player are the consequence of the brain's higher cognitive functions, which are crucial to our daily lives and are typically regarded as executive functions [46,47]. Regular tennis players have been shown to have stronger bones, a stronger immune system, better grades, and higher academic achievement in subjects like reading, science, and math. They also have better behavioural self-regulation because their executive functions are well-developed [47-50]. Research has shown that children and adolescents with ADHD benefit from both acute (one burst of physical activity) and chronic (many times a week, over a long period of time) physical activity interventions in terms of cognitive function [51].

**Emotional Release and Control:** Tennis is regarded as a "mind game," requiring constant attention, confidence, and concentration. Tennis requires many difficult skills, particularly for those with ADD/ADHD. Tennis, on the other hand, is excellent for children with ADHD since it can gradually enhance these abilities and function as "physical therapy" for the brain [52-54]. Children might let out their fury or rage by hitting tennis balls. A child who plays tennis has numerous chances to speak their way through the flurry of lost balls, errors, and poor performance of intricate hand-eye coordination. Children need their parents' proximity and caring, have mood swings frequently, and are always looking to adults for validation, affirmation, and praise. When played in a joyful and encouraging setting, tennis can help self-regulate their mood swings and give them with a sense of detachment from their parents while also providing a constructive outlet for their demands for validation and reassurance [15]. Physical activity has been shown to significantly improve aggressive behaviours, social issues, anxiety, and depression in children with ADHD. As a result, it

has been recommended that children with ADHD incorporate physical exercise into their daily routines [55,56]. Children with ADHD, who are frequently prone to become easily agitated, losing their anger, or crying (for instance, yelling at a teammate who failed to pass the ball or crying after missing a shot), can benefit greatly from tennis as a form of physical activity [42,39]. More successful social interactions and the formation of friendships can result from participating in a shared, structured activity. This is especially true for kids who find it difficult to balance having fun and improving their game, which is something coaches typically teach them in training drills [15]. Tennis involves striking a delicate balance between concentrations and letting go of distracting ideas, which gradually improves body momentum and develops rhythm in constant action. Tennis players must be able to handle the pressure of competition and perform well under duress. Players eventually develop excellent mental toughness as a result of learning how to control their emotions, maintain composure under duress, and maintain concentrate on the task at hand [57].

**Develop Social Skills:** It is impossible to overstate the significance of social interaction in children's emotional and social development. Children's confidence, inventiveness, and social and emotional intelligence have all suffered as a result of staying inside and not interacting with their classmates. They can play tennis and make friends with other children their own age by interacting with them in person. They develop their interpersonal communication skills and mature on their own. Additionally, tennis is a fantastic tool to teach children life principles like strategy planning, quick thinking, accepting responsibility for one's actions, performing well under pressure, and accepting setbacks with dignity and successes with humility [15,21]. Children can develop their communication and teamwork skills by playing tennis doubles. "Now it's her/his turn," "be careful not to hurt anyone," "great job but don't swing so hard," and "how do you think your opponent feels" are just a few examples of how tennis can be a terrific tool for promoting moral development. Do you want to experience that emotion? Every group session offers countless chances to teach self-control, patience, kindness, respect for others, and the ability to resist violent impulses in order to hasten psychological growth [15]. While too much stress slows down development, too little stress slows down development, and the correct amount of stress promotes beneficial developmental changes. Tanking, quitting, sobbing, and temper tantrums are all excellent teaching moments. In order to excel in tennis, players must cooperate and communicate with one another. Improved communication is one of the biggest advantages of tennis workouts for groups. To keep the rally going and complete the drill successfully, players must effectively communicate with their teammates. This creates possibilities for social engagement and the

development and maintenance of relationships with others. Players gain greater communication skills from this, which they can use in other aspects of their lives [15]. Children with ADHD can learn critical social skills like problem-solving, communication, and teamwork by participating in a tennis program. Additionally, tennis can foster social and emotional growth, including resilience, self-confidence, emotional stability, and social support [57,52].

**Developing Resilience and Self-Assurance:** Executive functioning deficiencies in ADHD can significantly hinder daily functioning. Understanding these deficiencies puts parents in a much better position to help and support their child. One of the protective factors for developing resilience in ADHD is positive parenting [58]. The key elements needed for positive parenting of ADHD children are creating a stable and predictable family routine, demonstrating love, acceptance, and forgiveness in daily interactions, giving the children the chance to discover their “islands of competence,” and letting them fail while helping them learn from it and reducing the chance of a repeat failure [59]. ADHD is a self-regulation disorder that has a detrimental effect on organizing and planning, time management, thinking back on the past, and changing behaviour to achieve future objectives [13]. ADHD is a performance deficit rather than a knowledge deficit. This indicates that individuals with ADHD frequently possess the ability to execute a skill required for success but struggle consistently to apply that skill in the moment to achieve success [13]. Hard work is emphasized in tennis, and consistent practice and instruction help players maintain discipline in their pursuit of progress. Whether in life or tennis, the ability to bounce back from mistakes is essential. Stress is a normal aspect of daily life. As a result, playing tennis helps us cope with social, emotional, mental, and physical difficulties, which improves our ability to manage stress and anxiety [15,44,52]. Because they are out on their own and frequently call their own lines while playing, children who play tennis learn to accept responsibility for their actions, decisions, and mistakes and can start to manage these more effectively. These skills and strategies will also help them in life off the court. They receive training on how to handle stress, adjust to new circumstances and surroundings, and react to adversity all of which are frequently exacerbated when grades are close or they are losing [15].

Tennis improves children’s strategic and problem-solving abilities, which are thought to be difficult for children with ADHD, and helps them develop a sense of routine, discipline, and sportsmanship in both practice and competitive settings [47]. Children who participate in strength training can develop self-assurance and a goal-oriented mind-set. As players learn to concentrate on their strengths and strengthen their weaknesses, this optimistic outlook guarantees a positive outlook on life. Children with ADHD who succeed at tennis

develop self-esteem as a result of their increased confidence and sense of mastery [60]. Success in other spheres of life can result from this sense of accomplishment. Tennis may be the perfect activity for kids with ADHD because of the physical activity it offers, its capacity to lower stress levels, improve executive functioning abilities, and foster socialization and emotional growth [51-57]. Children with ADHD excel at tennis gain confidence and a sense of mastery that boosts their self-esteem [60]. This sense of achievement can lead to success in other areas of life. Given the physical activity it provides, its ability to reduce stress, enhance executive functioning, and promote psychosocial development, tennis may be the ideal physical activity for children with ADHD.

## Conclusion

In conclusion, children with ADHD may benefit greatly from playing tennis. It provides a mix of action and reaction, a mental and physical game where organization and self-control are crucial. It’s crucial to keep in mind that each child with ADHD is different, and it could take some trial and error to determine what suits each person best, even when practicing tennis. Although participating in physical activity has numerous advantages for children with ADHD, the disorder is neither treated nor cured by them. Rather, they may serve as a beneficial supplement to other conventional therapies. A child’s self-esteem, social skills, and physical fitness can all be enhanced by playing sports, which can serve as a positive alternative to being sedentary and help them concentrate on a particular task. Additionally, it helps children discover their own strengths and enhances their cognitive and decision-making skills. A child’s success depends on selecting the appropriate sport/physical activity for their needs. As discussed earlier, tennis provides a variety of opportunities for regular physical activity that enhance the attention, learning, memory, impulse control, problem-solving, and decision-making, planning and time management, better communication and support that foster self-confidence and resilience among children with ADHD. As a result, Tennis is thought to be the healthiest sport in the world because it promotes socialization, enhances emotional regulation, and boosts self-efficacy while reducing stress and anxiety in both children and adults. These benefits lead to a higher quality of life and self-efficacy irrespective of neuro-typical or neuro-divergent individuals. More longitudinal studies are required to explore and address the evidence based information into practice in the field.

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