

Review

The Influence of Outdoor Recreational Activities on Cognitive Functions in Children with Attention Deficit Hyperactivity Disorder (ADHD)

Daniel Etim Jacob ^{1,*} , Imaobong Daniel Jacob ^{1,2} , Koko Sunday Daniel ¹  and Pius Agaji Oko ³ 

¹ Forestry and Wildlife Department, University of Uyo, Uyo 520101, Nigeria

² Department of Forestry and Wildlife Technology, Federal University of Technology Owerri, Owerri 460261, Nigeria

³ Department of Forestry and Wildlife Management, University of Calabar, Calabar 540271, Nigeria

* Correspondence: danieljacob@uniuyo.edu.ng

Received: 13 July 2025; **Revised:** 4 September 2025; **Accepted:** 6 September 2025; **Published:** 1 October 2025

Abstract: This paper examines the influence of outdoor recreational activities on cognitive functions in children with Attention Deficit Hyperactivity Disorder (ADHD). Utilizing an integrative narrative review design anchored in the Biopsychosocial Model, the study synthesizes diverse evidence ranging from experimental trials to educational case studies to categorize nature's benefits into biological, psychological, and social domains. The methodology involved an extensive digital search across major databases (2014–2024), employing Attention Restoration Theory and Stress Recovery Theory to interpret the cognitive and autonomic impacts of natural environments. Key findings reveal that outdoor engagement significantly enhances sustained attention, reduces impulsivity, and bolsters executive functions such as planning and organization. Nature-based activities are found to lower physiological stress markers, specifically cortisol levels, thereby stabilizing emotional regulation and creating a feedback loop that supports higher-order cognitive performance. Furthermore, physical movement in natural settings increases cerebral blood flow and neurotrophic factor release, which directly improves memory and cognitive flexibility. Based on these results, the paper recommends that schools integrate structured nature-based programs into daily curricula to improve student focus and retention. Policymakers are urged to establish mandates for outdoor playtime and invest in safe, accessible green spaces, particularly in urban areas. Ultimately, a collaborative approach among educators, clinicians, and parents is advocated to promote outdoor recreation as a viable, data-informed, non-pharmacological intervention for pediatric ADHD.

Keywords: ADHD; Neuroplasticity; Biopsychosocial; Ecopsychology; Neuroergonomics; Outdoor Recreation

1. Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent neurodevelopmental disorders in childhood, affecting approximately 5–7% of children worldwide [1,2]. It is characterized by persistent symptoms of inattention, hyperactivity, and impulsivity, which significantly impact academic performance, social interactions, and overall well-being [3,4]. In recent years, the incidence of ADHD diagnoses has shown a steady rise, raising concerns over its increasing impact on public health and educational systems globally [2,5,6]. The cognitive challenges faced by children with ADHD are varied and complex, often including difficulties in executive functioning, working memory, attention span, and self-regulation [7]. These cognitive deficits are known to influence educational attain-

ment and social development, as well as contribute to a higher likelihood of experiencing comorbid conditions such as anxiety, depression, and oppositional defiant disorder [8,9].

Conventional treatments for ADHD, including medication and behavioral therapies, have been effective for some children but are often associated with side effects and are not universally accessible or acceptable to all families [10,11]. Consequently, there has been a growing interest in complementary and non-pharmacological interventions, such as diet, physical activity, and outdoor recreational activities, that may offer additional benefits for managing ADHD symptoms. Outdoor activities, in particular, have gained attention due to their potential to address both the cognitive and behavioral challenges associated with ADHD by providing natural settings that may improve focus, decrease impulsivity, and support emotional regulation [12].

1.1. The Rationale for the Review

The idea that natural and outdoor environments can positively influence cognitive functions is rooted in theories such as Attention Restoration Theory (ART), which suggests that exposure to natural environments replenishes cognitive resources depleted by sustained attention and mental fatigue [13]. Children with ADHD, who frequently experience attention deficits, may especially benefit from such restorative environments. Empirical evidence supports this theory, with studies indicating that green outdoor spaces can reduce ADHD symptoms and improve attention in children [14–16]. Furthermore, physical activity, a common component of outdoor recreational activities, has been shown to facilitate cognitive development, particularly in areas like executive functioning, which includes skills such as working memory, inhibition, and cognitive flexibility [17].

A significant aspect of outdoor activities is their ability to engage multiple senses and promote movement, which can help children with ADHD manage hyperactivity and improve behavioral regulation [12,18]. Activities that encourage unstructured, nature-based play have also been associated with enhanced creativity, social skills, and resilience, which are valuable for children with ADHD as they navigate social and educational challenges. The potential for outdoor activities to improve attention, support self-regulation, and facilitate sensory integration makes them a compelling area for research and practice in ADHD interventions. This paper seeks to explore these aspects further, examining both the evidence for cognitive improvements through outdoor activities and the practical considerations for implementing such interventions.

1.2. Objectives of the Review

The primary objective of this paper is to provide an in-depth examination of the influence of outdoor recreational activities on cognitive functions in children with ADHD. This paper aims to review recent studies that link outdoor activities to improvements in specific cognitive domains affected by ADHD, such as attention, executive function, and impulse control. Through a synthesis of relevant literature, we will discuss the mechanisms by which outdoor environments may mitigate ADHD symptoms and enhance cognitive performance. This includes an evaluation of how different types of outdoor activities (e.g., unstructured play, team sports, nature-based activities) may have varied impacts on cognitive function.

In addition to reviewing empirical studies, this paper will identify best practices for integrating outdoor activities into treatment plans for children with ADHD. This includes considerations for safety, accessibility, and inclusivity, as well as recommendations for how educators, parents, and caregivers can effectively incorporate outdoor play into daily routines. By the end of this paper, readers will have a better understanding of how outdoor activities can be used to support cognitive development in children with ADHD, as well as insights into the potential policy and educational implications of these findings. Given the growing prevalence of ADHD and the limitations of traditional treatment options, this paper underscores the importance of exploring alternative, non-pharmacological interventions that leverage natural settings to support cognitive and behavioral outcomes in children with ADHD.

2. Methodology

This study utilizes an integrative narrative review design, which is optimal for synthesizing diverse evidence types ranging from experimental trials to educational case studies into a comprehensive scholarly discussion [19,20]. The synthesis is anchored in the Biopsychosocial Model, allowing for the categorization of nature's benefits into biological (neuroplasticity), psychological (cognitive), and social (behavioral) domains. Within this framework, the

review specifically explores how natural environments influence neuroplasticity in the prefrontal cortex and frontoparietal networks as observed in pediatric ADHD neuroimaging studies, which show enhanced neural activation following green-space exposure compared to general exercise. Key theoretical foundations used to interpret the data include Attention Restoration Theory (ART), to analyze the mitigation of directed attention fatigue, and Stress Recovery Theory (SRT), to evaluate autonomic nervous system regulation in children with ADHD [21,22].

The methodology involved an extensive digital search across PubMed, The Cochrane Library, PsycINFO, and ScienceDirect using Boolean operators for keyword clusters including "ADHD," "nature-based interventions," "executive function," and "neuroplasticity." To ensure the integration of recent advancements in environmental neuroscience, the search was limited to peer-reviewed articles published between 2014 and 2024 [23]. Literature was selected based on its applicability to the pediatric ADHD continuum (ages 5–18), excluding animal models or studies focusing exclusively on pharmacological agents without environmental correlates. Methodological rigor was maintained through the triangulation of evidence across pediatrics, psychology, and forestry medicine, specifically bridging the gap between clinical supportive care and active nature-based treatment [24]. This interdisciplinary approach ensures that the findings are substantiated by diverse clinical and environmental perspectives, enhancing the overall transparency and analytical depth of the review.

3. ADHD and Cognitive Function in Children

ADHD, or Attention-Deficit/Hyperactivity Disorder, is a neurodevelopmental disorder characterized by symptoms such as inattention, hyperactivity, and impulsivity, which manifest in early childhood and persist into adulthood for some individuals. Understanding ADHD's impact on cognitive functioning is critical, as these cognitive challenges can significantly affect a child's learning, social relationships, and daily activities.

3.1. Cognitive Symptoms and Impacts on Learning and Behavior

ADHD presents through a range of cognitive symptoms primarily affecting attention, executive functions, and behavioral inhibition [25–27]. Children with ADHD often experience persistent challenges in sustaining attention, organizing information, managing time, and controlling impulses, which collectively interfere with their ability to engage effectively in structured learning and social contexts [28]. The manifestation of symptoms differs across subtypes, predominantly inattentive, predominantly hyperactive-impulsive, and combined presentations, thus highlighting the disorder's heterogeneity [29]. Inattentive symptoms undermine a child's ability to plan, prioritize, and complete academic tasks, whereas hyperactive-impulsive symptoms may lead to classroom disruptions and social conflicts [30,31]. Critically, these deficits are not merely behavioral but stem from underlying neurocognitive impairments in working memory, self-regulation, and response inhibition, which limit a child's capacity to process information efficiently. Consequently, learning outcomes are significantly compromised. Arnold et al. [32] report that children with ADHD consistently perform below their peers in reading and mathematics, even when general intelligence is comparable, indicating that ADHD-related deficits are independent of intellectual ability. Moreover, these challenges extend into the social domain, where difficulties in emotional regulation and perspective-taking can impair peer relationships and teacher interactions. Over time, the interplay of cognitive, academic, and social difficulties can lead to reduced self-esteem, school disengagement, and broader developmental risks [33], underscoring the multifaceted and pervasive nature of ADHD's impact.

3.2. Cognitive Challenges in ADHD

ADHD significantly impacts several key cognitive domains, including attention, executive function, memory, and impulse control [34–37]. These impairments are interdependent and collectively disrupt a child's cognitive efficiency, learning ability, and behavioral regulation as indicated in **Table 1**.

- (1) **Attention:** Difficulty sustaining attention is one of the most prominent cognitive challenges associated with ADHD. Children with ADHD often struggle to maintain focus on tasks that require continuous effort, particularly those lacking immediate rewards or high stimulation [35,37]. They may become easily distracted by irrelevant stimuli or switch tasks prematurely, which interferes with task completion and accuracy. Importantly, this inattention is not constant, it fluctuates depending on task interest and environmental demands, suggesting that motivational and neurobiological factors jointly influence attentional control. Neuroimaging

studies indicate atypical activation in the frontoparietal attention networks, reinforcing that ADHD-related inattention is rooted in neural dysfunction rather than simple laziness or lack of effort.

- (2) **Executive Function:** Executive functions, which include cognitive processes such as planning, organization, inhibition, and cognitive flexibility, are often markedly impaired in children with ADHD [38,39]. These skills are essential for goal-directed behavior, and their impairment leads to practical difficulties in managing daily tasks, prioritizing assignments, and adjusting to changes in routines [10,31]. For example, a child with ADHD might understand a homework assignment but fail to organize the necessary materials or follow through systematically. Research links such deficits to delayed maturation in the prefrontal cortex and disrupted dopaminergic regulation, suggesting that executive dysfunction in ADHD has a strong neurodevelopmental basis rather than being purely behavioral.
- (3) **Memory:** Working memory deficits are another central cognitive impairment in ADHD. Working memory allows individuals to temporarily store and manipulate information necessary for reasoning, comprehension, and learning [10]. In children with ADHD, limited working memory capacity often manifests as difficulty remembering multi-step instructions, retaining new material, or connecting ideas across lessons. These challenges hinder both academic and functional performance, as tasks requiring sustained mental effort or sequential processing such as reading comprehension or mathematical problem-solving, are disproportionately affected. Furthermore, impaired encoding and retrieval processes can exacerbate learning delays, leading to a cumulative disadvantage over time.
- (4) **Impulse Control:** Impulsivity, characterized by acting without adequate forethought, represents another core deficit in ADHD [33]. Children may interrupt others, make hasty decisions, or struggle to wait their turn, reflecting difficulties with behavioral inhibition and self-monitoring. This lack of inhibitory control can disrupt classroom environments and social interactions, often leading to negative feedback from teachers and peers. Over time, such experiences may contribute to secondary emotional or behavioral problems, including frustration, anxiety, or oppositional tendencies [40]. Neurocognitive evidence suggests that impulsivity in ADHD is linked to dysfunctions in the orbitofrontal cortex and striatal circuits, which are responsible for response inhibition and reward processing.

Table 1. Cognitive function challenges in ADHD.

Challenges	Description	Impact on Learning and Behavior	Author
Task Initiation	Difficulty in starting tasks without external prompts or cues, often resulting in procrastination.	Delays in starting assignments, procrastination, and challenges in completing tasks independently.	Kofler et al. [31]
Organization	Struggles to arrange tasks logically, prioritize activities, and manage time efficiently.	Difficulty managing homework, forgetting materials, and feeling overwhelmed by complex assignments.	Cooper-Kahn and Dietzel [38]; Willoughby et al. [39]
Working Memory	Poor ability to hold and manipulate information temporarily, leading to frequent task errors.	Forgetting instructions, poor retention of information, frequent errors in tasks.	Chacko et al. [10]
Self-Monitoring	Lack of awareness of one's own behavior and its consequences, resulting in difficulty with self-correction.	Increased impulsive errors, poor social interactions, difficulty in self-correcting actions.	Cortese et al. [36]
Impulse Control	Tendency to act without considering consequences, impacting social interactions and task accuracy.	Interruptions in class, difficulty waiting turns, risk-taking behaviors, and social conflicts.	Parlatini et al. [40]
Sustained Attention	Struggles to maintain attention on tasks over time, causing incomplete assignments and low productivity.	Frequent task switching, incomplete assignments, low productivity, and poor academic outcomes.	Yıldırım Demirdöğen et al. [35]; Cortese et al. [36]
Planning	Difficulty in setting goals, planning steps, and executing plans effectively, which affects learning outcomes.	Missed deadlines, inability to plan long-term projects, and poor goal-setting abilities.	Rodriguez [34]
Emotional Regulation	Challenges in controlling emotions, often resulting in frustration, anger outbursts, and mood swings.	Emotional outbursts in school, conflicts with peers, difficulties in team-based activities.	Ward [27]
Flexible Thinking	Difficulty in adapting to changes in tasks or routines, often leading to rigidity in behavior and thought.	Resistance to change, difficulty in adapting to new information or tasks, frustration with transitions.	Wiest et al. [26]
Attention Shifting	Inability to switch focus smoothly between tasks, often leading to perseveration on one task.	Slow transition between subjects, frustration with multi-step tasks, and challenges in multitasking.	Cox [25]

3.3. Current Interventions and Their Limitations

Interventions for ADHD generally encompass a multimodal framework of pharmacological and non-pharmacological approaches, each with distinct benefits and limitations. Standard care typically emphasizes combined interventions pairing stimulant medications with behavioral therapy, which demonstrate higher efficacy than either treatment alone [40,41]. Pharmacological treatments, particularly stimulants such as methylphenidate and amphetamines, remain the most widely prescribed due to their well-documented ability to enhance attention and reduce impulsivity through the regulation of dopaminergic activity [40]. Beyond traditional stimulants, options now include SNRIs (e.g., atomoxetine) and antipsychotic augmentation. However, these drugs primarily address transient symptom control rather than underlying neurocognitive deficits, and their long-term therapeutic value is often complicated by adverse side effects such as appetite suppression, insomnia, sedation, and cardiovascular risks [41]. While novel non-invasive treatments like transcranial magnetic stimulation (TMS) are emerging, they remain largely inaccessible to the general public due to high costs and limited availability.

Non-pharmacological approaches, including behavioral therapy and cognitive behavioral therapy (CBT), focus on skill-building, self-regulation, and adaptive behavior modification to foster long-term resilience [42]. Despite these benefits, behavioral therapies often target overt behaviors without substantially improving underlying executive function or working memory. Furthermore, the practicality of these interventions is frequently hindered by significant systemic barriers. High costs, a shortage of specialized practitioners, and the requirement for intense parental involvement limit their feasibility in resource-constrained settings. These challenges are exacerbated in specific ethnic populations, where cultural stigmas and limited access to care contribute to lower treatment success rates and reduced adherence. Consequently, current ADHD management remains fragmented; pharmacological treatments offer temporary relief, while behavioral interventions may be insufficient for severe cases or lack holistic integration [43]. The benefits of physical activity seen in ADHD mirror findings in other neuropsychiatric disorders like depression, suggesting a transdiagnostic advantage to environmental and exercise-based interventions. This underscores the urgent need for a more comprehensive framework that integrates neurocognitive training and psychosocial support with individualized medication management to achieve sustainable, holistic outcomes.

4. Role of Outdoor Recreational Activities in Child Development

Outdoor recreational activities encompass a range of physical, social, and nature-based interactions that take place in outdoor settings [44–48]. These activities are often broadly categorized into structured and unstructured play. Structured activities include organized sports (e.g., soccer, basketball, and running), which typically involve rules, goals, and often adult supervision. In contrast, unstructured activities, such as free play, nature exploration, hiking, and gardening, allow children to engage in self-directed, imaginative, and spontaneous play in natural environments [49]. Group activities such as cooperative games or team-building exercises also fall under outdoor recreation, promoting social skills and emotional development [50]. These activities expose children to diverse sensory experiences, such as varied terrains, fresh air, natural elements, and wide, open spaces, which are unique to outdoor environments [51]. They offer a distinct experience from indoor recreational activities by fostering independence, curiosity, and a connection to nature.

4.1. General Benefits of Outdoor Activities

Outdoor activities play a multifaceted and indispensable role in fostering children's holistic development (**Table 2**), encompassing physical, social, emotional, and cognitive domains [52]. Beyond the immediate health benefits, outdoor play provides a foundation for lifelong habits of physical activity. Empirical studies reveal that participation in outdoor recreation significantly improves cardiovascular endurance, muscular strength, and body composition while reducing obesity and sedentary behavior risks [53,54]. These benefits extend beyond mere fitness, as outdoor movement enhances motor proficiency, spatial awareness, and balance, which are skills that underpin academic readiness and daily functional competence [55]. Socially, outdoor environments serve as dynamic learning spaces where children engage in cooperative tasks that foster empathy, leadership, and conflict resolution [56]. Rather than passive screen-based interactions, outdoor play encourages real-time social negotiation and shared problem-solving, strengthening peer relationships. Evidence indicates that children involved in collective outdoor play exhibit heightened resilience, teamwork, and adaptability compared to those confined to structured

indoor settings [57]. The emotional and psychological gains are equally compelling. Nature-oriented outdoor play has been found to lower cortisol levels, reduce anxiety, and cultivate emotional regulation [58]. Such experiences foster mindfulness and self-efficacy, crucial for coping with stressors in later life. Moreover, exposure to natural landscapes replenishes attention capacities, mitigating cognitive fatigue and enhancing mental clarity [59]. Cognitively, outdoor play stimulates inquiry and creativity by presenting open-ended challenges that promote executive functioning, critical reasoning, and decision-making skills. Outdoor learning thus nurtures intellectual curiosity, autonomy, and adaptability—competencies essential for lifelong learning and psychological resilience [60].

Table 2. Benefits of outdoor activities on child development.

Activity Type	Examples	Benefits	Description	Author(s)
Structured Sports	Organized sports such as soccer, basketball, running	Develops teamwork, motor skills, and discipline	Enhances physical fitness, coordination, and social interaction.	Molyneux et al. [52]
Unstructured Play	Free play, exploration in natural settings	Enhances creativity, reduces stress	Allows for self-directed, imaginative play in a natural environment.	Ruban et al. [55]; Richardson et al. [58]
Group Activities	Cooperative games, team-building exercises	Improves social skills, peer interaction	Fosters communication and cooperation among peers.	Salamah et al. [56]; Graber et al. [57]; Richardson et al. [58]
Nature-Based Activities	Hiking, gardening, nature walks	Fosters connection to nature, boosts cognitive focus	Provides sensory experiences that enhance attention and well-being.	Jaacob et al. [53]; Ver and Jacob [54]; Sallis et al. [60]

4.2. Theories Linking Nature and Cognitive Development

Several theories (Table 3) suggest a positive connection between nature and cognitive functioning, emphasizing the unique role outdoor environments play in cognitive development. For example, the Attention Restoration Theory (ART) posits that natural environments allow the brain to rest and recover from directed attention fatigue, which is common in children with ADHD and other cognitive challenges [42,61]. According to ART, engaging with nature helps in restoring a child’s capacity for directed attention by providing a calming yet stimulating environment that offers soft fascinations, such as moving leaves or flowing water, which naturally capture attention in a relaxed, involuntary manner [62]. Critically, ART extends beyond mere exposure to greenery; it highlights the qualitative difference between natural and artificial stimuli, suggesting that the effortless engagement found in nature promotes a cyclical process of mental rejuvenation and sustained cognitive performance. Research supporting ART has shown that children exposed to natural environments exhibit greater improvements in attention span and focus compared to those in urban settings [63,64]. However, some scholars argue that the strength of this relationship depends on contextual factors such as duration, type of natural exposure, and individual differences in sensory processing. These findings imply that nature’s restorative effects may not be universally experienced but rather mediated by social and developmental contexts [65]. The Biophilia Hypothesis, introduced by E.O. Wilson, argues that humans have an inherent connection to nature, which fosters well-being and cognitive development [66]. This hypothesis proposes that children thrive when connected to natural environments, as it aligns with their intrinsic need for exploration and discovery [61]. Empirical studies indicate that regular interaction with natural spaces enhances curiosity, creativity, and problem-solving abilities [58,67]. From an analytical perspective, the Biophilia Hypothesis complements ART by emphasizing evolutionary and emotional dimensions of cognition—suggesting that nature not only restores attention but also actively nurtures higher-order thinking and intrinsic motivation [68]. Moreover, stimulation of the prefrontal cortex through engagement with complex natural settings underscores the neurological underpinnings of this bond [61]. Overall, these theories collectively provide a multifaceted explanation for how outdoor environments facilitate cognitive growth, integrating neurobiological, psychological, and evolutionary perspectives that distinguish nature-based learning from traditional indoor experiences [69,70].

Table 3. Theories that associate nature with cognitive development.

Theories	Key Concept	Cognitive Development Impact	Author
Attention Restoration Theory (ART)	Nature allows brain recovery from attention fatigue	Improves attention span and focus	Pham and Sanocki [13]; McDonnell [61]; Trammell and Aguilar [62]

Table 3. Cont.

Theories	Key Concept	Cognitive Development Impact	Author
Biophilia Hypothesis	Humans have an innate affinity with nature	Enhances curiosity, creativity, problem-solving	Richardson [58]; Barbiero and Berto [66]; Ernst and Stelley [68]
Nature Deficit Disorder	Lack of nature exposure negatively affects children	Increases symptoms of ADHD, anxiety, and depression	Richardson [58]; Bergren [64]
Ecological Systems Theory	Development occurs through interaction with the environment	Enhances cognitive and social development	El Zaatari and Maalouf [67]
Flow Theory	Immersive engagement in activities leads to optimal experiences	Promotes concentration and skill development	Vella-Brodrick and Gilowska [63]; Barbiero and Berto [66]
Cognitive Load Theory	Natural environments reduce cognitive load	Improves problem-solving and creativity	Hank and Huber [70]
Social Learning Theory	Learning occurs through observation and interaction	Enhances social skills and peer relationships	Skulmowski and Xu [69]

5. Cognitive Benefits of Outdoor Activities for Children with ADHD

Outdoor recreational activities offer numerous cognitive benefits for children with Attention Deficit Hyperactivity Disorder (ADHD) as indicated in **Table 4**. These benefits primarily manifest in enhanced attention and focus, improved executive function, stress reduction, emotional regulation, and the positive impact of physical activity on cognitive performance [62,71,72].

Table 4. Cognitive Benefits of Outdoor Activities for Children with ADHD.

Benefits	Findings	Authors
Enhanced Attention and Focus	Outdoor activities improve attention and reduce impulsivity, with natural environments offering restorative effects. Structured activities aid attention restoration.	Vitale and Bonaiuto [71]; Marrow [72]; Bratman et al. [73]
Improvement in Executive Function	Outdoor play improves planning, organization, and problem-solving. Unstructured play fosters adaptability and critical thinking.	Edwards et al. [74]; Finnigan [75]
Stress Reduction and Emotional Regulation	Outdoor activities lower stress levels and promote emotional stability through reduced cortisol levels and social interactions, enhancing cognitive performance.	Chaudhury and Banerjee [76]; Wang et al. [77]
Improved Cognitive Functioning	Physical activity enhances cognitive outcomes like attention and memory through increased brain blood flow and neurotrophic factors, improving mood and focus.	Sibbick et al. [78]; Bigelow et al. [79]

5.1. Enhanced Attention and Focus

Research has shown that outdoor activities can significantly improve sustained attention and reduce impulsivity in children with ADHD. Studies by Vella-Brodrick and Gilowska [63] and Bratman et al. [73] found that interaction with nature leads to increased attention restoration, a process crucial for children who struggle to maintain focus on demanding tasks. From a critical perspective, these improvements are best understood through the lens of Attention Restoration Theory (ART), which posits that natural settings engage soft fascination, allowing the neural mechanisms responsible for directed attention to replenish. Unlike high-stimulation indoor or screen-based environments, nature reduces cognitive load, facilitating better attentional recovery and self-regulation.

However, while the theoretical framework for nature-based restoration is robust, the empirical evidence requires careful qualification. Many existing studies in this domain are limited by relatively small sample sizes and a reliance on short-term interventions or subjective parental reports, which can introduce observation bias. Furthermore, the current literature often lacks standardized metrics for greenness, making it difficult to isolate which specific environmental features such as biodiversity or open space drive these cognitive gains. To move beyond these preliminary findings, future research must prioritize randomized controlled trials and longitudinal designs. Such rigor is essential to determine if these attentional improvements are sustainable over the long term and to establish nature-based activities as replicable, evidence-based clinical interventions.

5.2. Improvement in Executive Function

Executive functions encompass a range of cognitive processes, including planning, organization, and problem-solving. Outdoor play has been shown to bolster these skills in children with ADHD. According to a study by Edwards et al. [74], children who participated in regular outdoor activities demonstrated improved executive functioning,

specifically in tasks that required planning and organization. This improvement is attributed to the unstructured nature of outdoor play, which allows children to navigate challenges and make decisions independently. Moreover, the dynamic and often unpredictable nature of outdoor environments fosters adaptability and critical thinking skills [75]. These findings suggest that incorporating outdoor play into the daily routines of children with ADHD can lead to significant gains in their executive functioning abilities, enabling them to better manage their thoughts and actions in various settings. Expanding upon this, outdoor environments offer a form of experiential learning that engages multiple executive domains simultaneously. For instance, navigating uneven terrain or organizing group play activities inherently requires working memory, flexible thinking, and inhibitory control. Unlike structured indoor tasks that are rule-bound and repetitive, outdoor play involves real-time problem-solving and emotional decision-making, thereby strengthening neural pathways associated with the prefrontal cortex. Furthermore, natural environments encourage intrinsic motivation, which enhances cognitive engagement and persistence, which are both critical to executive development. Theoretical models suggest that repeated engagement in outdoor play could potentially influence neuroplasticity, though further empirical neuroimaging data is required to confirm these long-term cognitive control improvements in children with ADHD. However, future research must assess how different types of outdoor activities structured versus free play differentially influence executive functions to refine interventions for children with ADHD.

5.3. Stress Reduction and Emotional Regulation

Engaging in outdoor activities is also linked to stress reduction and enhanced emotional regulation, which can further improve cognitive performance in children with ADHD. Research conducted by Chaudhury and Banerjee [76] indicated that outdoor play reduces physiological stress responses, thereby helping children feel calmer and more focused. Exposure to natural environments has been shown to lower cortisol levels, a hormone associated with stress, leading to improved emotional stability. Additionally, outdoor activities often encourage social interactions, fostering a sense of belonging and community, which are crucial for emotional well-being [77]. This combination of reduced stress and improved emotional regulation allows children with ADHD to perform better cognitively, as they are less likely to be overwhelmed by emotional distractions. Critically, these emotional and physiological benefits may derive from nature's capacity to provide multisensory calmness and predictable rhythms that counterbalance the overstimulation often present in urban and digital environments. Natural spaces offer an emotionally neutral yet stimulating context in which children can explore, express, and regulate emotions without fear of social judgment. The combination of physical activity and exposure to natural light further contributes to mood stabilization through the release of serotonin and endorphins. Moreover, the social dimension of outdoor play enhances empathy, cooperation, and emotional intelligence, and these are areas in which children with ADHD often face challenges. By strengthening these affective skills, outdoor activities indirectly support cognitive growth, creating a feedback loop between emotional regulation and executive functioning. However, interventions must be adapted to individual sensitivities, as some children may initially find unstructured outdoor settings overwhelming without guided facilitation.

5.4. Improved Cognitive Functioning

The physical movement involved in outdoor recreational activities plays a vital role in enhancing cognitive functioning. According to research by Sibbick et al. [78], physical activity is associated with improved cognitive outcomes, including enhanced attention, memory, and overall cognitive flexibility. This research highlights the neurophysiological mechanisms that underlie these benefits, such as increased blood flow to the brain and the release of neurotrophic factors that support brain health. In children with ADHD, who often exhibit lower levels of physical activity, engaging in outdoor play can counteract these trends, leading to better cognitive outcomes. Furthermore, physical activity has been shown to stimulate the production of endorphins, which can improve mood and reduce symptoms of anxiety, making it easier for children with ADHD to focus on cognitive tasks [73]. From a more analytical standpoint, the link between physical movement and cognition may be attributed to enhanced neural efficiency and synaptic plasticity resulting from aerobic activity. Outdoor exercise not only strengthens cardiovascular health but also increases levels of brain-derived neurotrophic factor (BDNF), a protein critical for learning and memory consolidation. The open and varied terrain of outdoor spaces requires spatial awareness, coordination, and motor planning, which are skills closely tied to higher cognitive processes. Furthermore, physical engagement in natu-

ral environments provides embodied learning experiences that integrate sensory, motor, and cognitive domains more holistically than sedentary or classroom-based learning [79]. This integration supports a more robust cognitive architecture, promoting sustained academic and behavioral improvement in children with ADHD. Nevertheless, the type, frequency, and intensity of outdoor physical activities should be tailored to individual needs to maximize cognitive benefits while maintaining engagement and safety.

6. Types of Outdoor Activities and Their Specific Cognitive Impacts

Outdoor recreational activities play a pivotal role in enhancing cognitive functions in children with Attention-Deficit/Hyperactivity Disorder (ADHD). Three key types of outdoor activities, namely unstructured play, structured sports and games, and nature-based activities are explored below. Each category has unique benefits that contribute to cognitive development, including improvements in creativity, attention, impulse control, memory, and emotional regulation (Table 5).

Table 5. Outdoor Activities and Their Specific Cognitive Impacts.

Type of Outdoor Activity	Cognitive Impacts	Authors
Unstructured Play	Enhances creativity, cognitive flexibility, attention restoration, and emotional well-being.	Dankiw et al. [80]; Liu et al. [81]; Faber Taylor et al. [82]
Structured Sports and Games	Improves impulse control, memory, social cognition, decision-making, and teamwork skills.	Ekman and Hiltunen [83]; Haverkamp et al. [84]; Sañudo et al. [85]
Nature-Based Activities	Enhances mindfulness, emotional regulation, sensory engagement, patience, and overall cognitive function.	Salamah et al. [56]; Nguyen and Walters [86], Bidzan-Bluma and Lipowska [87]

6.1. Unstructured Play

Unstructured play, characterized by child-led exploration and a lack of adult-imposed rules, offers a unique therapeutic landscape for children with ADHD. Unlike structured environments that demand constant adherence to external protocols, natural settings provide ‘soft fascination’ that allows the attentional system to recover without total disengagement. This form of play fosters creative cognition and autonomous decision-making, areas where children with ADHD often struggle in traditional classroom settings. By navigating uneven terrains or engaging in imaginative role-play in green environments, children exercise their executive functions specifically cognitive flexibility and inhibitory control in a low-stress context. Consequently, these activities do not merely provide a break from academic rigor; they serve as a critical developmental tool that strengthens neural pathways associated with self-regulation, which are frequently under-stimulated in the rigid frameworks that modern educational systems prioritize. From a developmental standpoint, unstructured play encourages the integration of motor, perceptual, and social systems in a fluid and self-directed manner. Through spontaneous interactions, children practice negotiating social norms, resolving conflicts, and adjusting to peers’ perspectives, thereby enhancing social reasoning and flexibility. Additionally, the open-ended nature of such play helps children with ADHD strengthen inhibitory control and working memory, as they must continually adapt strategies to sustain engagement. Neuroscientifically, these activities may enhance the connectivity between the prefrontal cortex and limbic regions, supporting emotion regulation and sustained attention. Unstructured play, therefore, represents not a lack of discipline, but a cognitive ecology that promotes autonomy, experimentation, and adaptive control the key ingredients for resilient cognitive development in children with attentional difficulties.

6.2. Structured Sports and Games

Structured sports and games, defined by formal rules, objectives, and coordinated teamwork, provide a contrasting developmental environment that emphasizes discipline, predictability, and goal-directed behavior. For children with ADHD, such frameworks offer an external scaffolding for developing executive control, specifically, inhibition, sustained attention, and planning. Ekman et al. [83] observed that participation in team-based sports strengthens impulse regulation and strategic thinking, as children must adhere to rules while making rapid, context-sensitive decisions. The structured rhythm of practice and competition reinforces consistency and self-monitoring, gradually transforming impulsive tendencies into deliberate action. Beyond immediate behavioral regulation, structured sports cultivate procedural learning and situational awareness. Remembering game strategies, anticipat-

ing opponents' moves, and synchronizing with teammates enhance working memory and cognitive flexibility [78]. These demands encourage meta-cognitive reflection as children learn to evaluate their own decisions, predict outcomes, and modify future behavior. Socially, sports participation fosters prosocial cognition: understanding others' intentions, sharing responsibility, and coping with success and failure in real time. Sañudo et al. [85] emphasize that these cooperative experiences contribute to empathy and peer acceptance, mitigating the interpersonal challenges often seen in ADHD populations. Critically, structured sports differ from therapeutic interventions in that their benefits emerge organically from participation rather than instruction. They integrate physical exertion, social feedback, and strategic cognition in a single setting, creating a multisensory feedback loop that strengthens neural pathways involved in attention and self-control. Thus, when well-facilitated, structured sports can serve as a naturalistic cognitive training environment that aligns motivation with executive functioning, supporting both performance and psychological adjustment.

6.3. Nature-Based Activities

Nature-based activities such as gardening, hiking, and ecological exploration combine physical engagement with environmental interaction, producing distinctive cognitive and emotional outcomes. Unlike unstructured play, which emphasizes autonomy, or structured sports, which emphasize coordination and competition, nature-based activities foster reflective engagement and sensory integration. Nguyen and Walters [86] found that these experiences cultivate mindfulness and sustained attention through rhythmic, repetitive tasks (e.g., planting, observing, or walking) that promote cognitive steadiness rather than overstimulation. This slower tempo allows children with ADHD to synchronize internal states with external stimuli, enhancing self-awareness and emotional balance. Gardening, in particular, provides a context for sustained concentration and delayed gratification. The process of tending to living organisms over time reinforces patience, sequencing, and long-term goal orientation which are skills that are often underdeveloped in children with ADHD [57]. Moreover, such tasks engage multiple sensory modalities (visual, tactile, olfactory), supporting neural integration and deep encoding of experiences. Hiking, meanwhile, combines spatial navigation with physical endurance, activating networks associated with planning and working memory while also releasing neurochemicals linked to mood regulation. The educational potential of nature-based activities also lies in their capacity to bridge abstract knowledge with experiential learning. For example, identifying flora or understanding ecological systems transforms attention into inquiry-driven cognition, linking curiosity with structured thought. Bidzan-Bluma and Lipowska [87] suggest that this synthesis of movement, observation, and reflection enhances both executive and associative cognitive processes. Thus, nature-based activities not only reduce attentional symptoms but also cultivate adaptive cognition grounded in curiosity, embodiment, and environmental awareness, a holistic complement to more controlled learning contexts.

7. Considerations and Challenges for Outdoor Recreational Activities

7.1. Accessibility and Inclusivity

Access to outdoor recreational activities is a critical concern, especially for children with Attention Deficit Hyperactivity Disorder (ADHD) [69]. Socioeconomic factors can significantly influence a child's ability to engage in outdoor activities. For instance, children from lower-income families may lack access to safe parks or recreational areas, which are essential for outdoor play (**Table 6**). Studies by Burgess et al. [88], Barger et al. [89], and Thygesen et al. [90] found that children living in neighborhoods with limited green space exhibited higher levels of ADHD symptoms compared to those in areas with abundant recreational resources. This disparity highlights the need for policies that improve access to outdoor environments for all children, particularly those with ADHD. Beyond physical access, cultural perceptions and community planning decisions often exacerbate inequities. Families from marginalized backgrounds may experience barriers such as limited transportation, safety concerns, or insufficient community programming. Consequently, outdoor spaces risk becoming exclusive domains for more affluent groups, reinforcing developmental disparities across socioeconomic lines. Addressing these issues requires intersectoral collaboration as urban planners, policymakers, and educators must work together to design inclusive green infrastructure that prioritizes child well-being. Inclusivity also plays a vital role in ensuring that children of varying abilities can participate in outdoor activities. Many public parks and recreational facilities are not designed with inclusivity in mind, limiting access for children with physical disabilities or sensory sensitivities often associated

with ADHD. Designing sensory-friendly spaces such as quiet zones, shaded areas, and adaptable play equipment can create environments that support both comfort and stimulation. Furthermore, initiatives such as adaptive sports, nature-based therapy programs, and inclusive community gardens can promote equity by enabling all children, regardless of ability or background, to benefit from outdoor engagement. In essence, ensuring accessibility and inclusivity is not only a matter of physical infrastructure but also of social justice and developmental opportunity.

Table 6. Considerations and Challenges for Outdoor Recreational Activities for Children with ADHD.

Consideration/Challenge	Description	Research Findings	Implications	Authors
Accessibility and Inclusivity	Addressing the availability of outdoor spaces and socio-economic barriers affecting children with ADHD.	limited access to green spaces correlates with higher ADHD symptoms.	Policies must aim to improve access to outdoor environments and design inclusive recreational facilities.	Finnigan [75]
Socio-economic Factors	Children from lower-income families may have fewer opportunities for outdoor play.	Increased participation in outdoor activities has been linked to improved cognitive function in disadvantaged populations	Community programs should focus on providing accessible outdoor activities to low-income families.	Burgess et al. [88]; Barger et al. [89]; Thygesen et al. [90]
Parental Involvement	Parents can foster outdoor play and advocate for programs that support children with ADHD.	Engaging in outdoor activities is shown to reduce ADHD symptoms and enhance cognitive skills	Parents should encourage outdoor exploration and collaborate with schools to integrate outdoor learning.	Natalini and Savastano [12]; Burgess et al. [88]
Educator Involvement	Schools can incorporate outdoor activities into the curriculum, enhancing engagement and learning.	Outdoor learning settings improve attention and engagement for children with ADHD	Educators should organize outdoor lessons and field trips that align with educational goals.	Schumacher [91]; Chrysomali-dou et al. [92]
Balancing Risk and Safety	Establishing safe yet challenging outdoor play opportunities is essential for development.	Children with ADHD benefit from structured free play within defined boundaries	Caregivers should develop safety guidelines that allow for exploration while minimizing risks.	McDonald [42]; Muùls and Carvajal [93]
Supervised Outdoor Play	Effective supervision allows children to take calculated risks and develop problem-solving skills.	Research indicates that supervised outdoor play enhances cognitive and emotional benefits	Supervision should focus on providing freedom for exploration while ensuring safety protocols are in place.	Haverkamp et al. [84]; Nery et al. [94]
Cultural Attitudes Towards Risk	Fostering a culture of risk awareness can help children navigate outdoor environments safely.	Parents and educators can benefit from training on outdoor safety practices	Workshops on risk assessment can empower children to make informed choices in outdoor settings.	Wills [95]; O'Leary [96]

7.2. Parental and Educator Involvement

Parental and educator involvement is crucial in facilitating outdoor activities for children with ADHD. Parents can create a supportive environment by encouraging regular outdoor play and exploration, which research suggests can enhance cognitive function and reduce behavioral symptoms associated with ADHD [12, 88]. Furthermore, parents can advocate for school programs that prioritize outdoor learning and physical activity, emphasizing their positive impact on attention and executive functioning. Educators also play a significant role in this dynamic. Schools that integrate outdoor activities into their curriculum not only promote physical health but also provide children with ADHD opportunities for skill development and social interaction. A study by Schumacher [91] found that children with ADHD demonstrated improved attention and engagement during lessons held outdoors compared to traditional classroom settings. Critically, the effectiveness of outdoor learning depends on the consistency and intentionality of adult involvement. Educators must view outdoor environments as extensions of the classroom rather than recreational breaks, aligning outdoor experiences with learning objectives and individualized education plans. This approach transforms nature from a passive backdrop into an active pedagogical tool that supports multisensory learning and experiential understanding. Parents, likewise, play a crucial motivational role: modeling enthusiasm for outdoor exploration and establishing predictable routines can reinforce positive behavioral patterns and reduce screen dependency. Moreover, collaboration between parents and educators can further enhance these outcomes [12, 92]. Establishing regular communication channels such as workshops, newsletters, and shared progress updates encourages continuity between home and school practices. Joint initiatives with local parks or community organizations can also expand opportunities for outdoor learning, particularly for families with limited access to green spaces. Importantly, parental and educator training on ADHD-specific needs can help tailor activities to individual attention profiles, ensuring that outdoor learning environments are stimulating yet manage-

able. When adults coordinate their efforts, outdoor activities evolve into cohesive developmental interventions that nurture autonomy, focus, and social-emotional growth.

Balancing risk and safety is a critical consideration. Supervised outdoor activities allow children to explore and take calculated risks in a controlled environment, fostering independence and resilience. Research indicates that risk-taking is a natural component of childhood development, helping children learn to navigate challenges and develop problem-solving skills [42,93]. However, caregivers must ensure that these activities are conducted safely to minimize potential harm. The concept of managed risk is particularly relevant in this context. Rather than eliminating all potential hazards, it involves creating conditions where children can safely test their limits and experience manageable consequences. Nery et al. [94] and Haverkamp et al. [84] found that children with ADHD benefit most from environments that balance freedom with structure, that is spaces that allow autonomy within clearly defined boundaries. Such settings promote adaptive risk appraisal and enhance executive decision-making, helping children learn to evaluate danger and self-regulate impulsive tendencies. Nevertheless, effective supervision is key to achieving this balance. Caregivers and educators should establish safety protocols that are firm yet flexible, emphasizing awareness and responsibility rather than restriction. Encouraging children to participate in setting their own safety guidelines can also enhance engagement and accountability. Additionally, fostering a culture of risk awareness among parents and educators enhances both confidence and competence. Training programs, such as outdoor safety workshops or first-aid certifications, can empower adults to manage potential hazards while maintaining the developmental benefits of outdoor exploration [95,96]. From a developmental perspective, controlled risk-taking supports self-efficacy, emotional regulation, and persistence, which are areas often challenging for children with ADHD. When children are permitted to take small, supervised risks, they learn to tolerate uncertainty, recover from mistakes, and build adaptive coping mechanisms. Therefore, balancing risk and safety should not aim to eliminate unpredictability but to transform it into a meaningful learning experience that strengthens both cognitive and emotional resilience.

8. Implications for Practice and Policy

8.1. Educational Implications

Integrating outdoor activities into the school day can significantly benefit students with Attention Deficit Hyperactivity Disorder (ADHD). Schools can create structured outdoor programs that combine physical activity with academic learning, thereby enhancing focus and engagement (**Table 7**). For instance, incorporating nature walks into the curriculum allows students to explore scientific concepts in a stimulating environment, improving attention and retention [97]. Additionally, implementing outdoor recess and physical education classes can help students with ADHD develop social skills and reduce impulsivity through cooperative play [98]. Educators should receive training on the specific needs of students with ADHD, enabling them to facilitate outdoor activities that promote cognitive and emotional well-being. Beyond simply increasing outdoor time, schools should reconceptualize outdoor learning as an integral pedagogical strategy rather than a supplementary activity. Lessons conducted outdoors such as mathematics through measuring natural objects or creative writing inspired by environmental observation can promote experiential learning and multisensory engagement, both of which enhance comprehension for students with ADHD. Moreover, integrating movement and exploration into academic instruction leverages the link between kinesthetic activity and executive functioning, helping students sustain attention and manage hyperactivity. Educators can also use outdoor settings to practice self-regulation strategies, such as mindfulness walks or reflective journaling, which promote emotional balance and reduce classroom disruptions. Institutional support is equally vital. Schools must allocate time, resources, and professional development to ensure that outdoor learning is consistent and inclusive. When implemented thoughtfully, such programs not only accommodate the learning profiles of children with ADHD but also enrich the overall educational experience for all students by fostering curiosity, collaboration, and resilience.

8.2. Policy Recommendations

Policymakers play a crucial role in promoting outdoor recreational activities for children with ADHD. To this end, establishing guidelines that mandate a minimum amount of outdoor playtime during the school day is essential. Policies should also advocate for the development of safe and accessible outdoor spaces within school districts,

especially in urban areas where green spaces are limited [99]. Moreover, schools should collaborate with mental health professionals to create comprehensive ADHD intervention programs that include outdoor activities as a core component. Funding initiatives that support outdoor learning environments and provide training for teachers can help ensure that such programs are sustainable and effective [100]. Expanding on this, education policies must recognize outdoor learning as a legitimate and evidence-based intervention for neurodiverse learners, integrating it within broader frameworks of inclusive education and mental health promotion. Governments and education authorities could incentivize schools through grants, awards, or accreditation programs that prioritize environmental learning and inclusive recreation. Furthermore, local municipalities should work with public health and urban planning departments to ensure equitable distribution of green spaces, particularly in low-income communities disproportionately affected by limited outdoor access. To ensure long-term impact, policies should incorporate mechanisms for accountability and evaluation, monitoring the frequency, quality, and inclusivity of outdoor programming. Teacher training standards should explicitly include competencies in outdoor facilitation, risk management, and ADHD-specific adaptations. Finally, cross-sector partnerships among education, health, and environmental agencies could strengthen the integration of outdoor programs into school curricula, creating a sustainable model that supports both child development and environmental stewardship.

Table 7. Implications for Practice and Policy.

Section	Implications for Practice	Authors
Education	Integrating outdoor activities into the school day benefits students with ADHD, enhancing focus and engagement. Incorporating nature walks into curricula improves attention and retention. Outdoor recess and physical education develop social skills and reduce impulsivity. Educators should receive ADHD-specific training.	Fang et al. [97]; Hock [98]
Policy Recommendations	Establish guidelines for outdoor playtime during school hours. Advocate for safe and accessible outdoor spaces, especially in urban areas. Collaborate with mental health professionals to integrate outdoor activities into ADHD intervention programs. Provide funding for outdoor learning and teacher training.	Gill [99]; Oberle et al. [100]
Future Research	Investigate long-term effects of outdoor engagement on academic performance and social skills. Explore optimal types and durations of outdoor activities. Conduct longitudinal studies on ADHD subgroups, including socioeconomic diversity and comorbid conditions.	Rogerson et al. [101]; Patrinos [102]

8.3. Suggestions for Future Research

While existing literature supports the cognitive benefits of outdoor activities for children with ADHD, several gaps remain. Future research should explore the long-term effects of regular outdoor engagement on academic performance and social skills development among children with ADHD. Investigating the optimal types and durations of outdoor activities that yield the greatest cognitive benefits would provide valuable insights for educators and policymakers [101]. Additionally, longitudinal studies examining the impact of outdoor recreational activities on various subgroups of children with ADHD, such as those from different socioeconomic backgrounds or those with comorbid conditions, are needed to develop targeted interventions [102]. Further investigation is also warranted into the neurobiological mechanisms underlying these benefits specifically, how sustained exposure to natural environments influences attention networks, emotional regulation, and executive function over time. Comparative studies between structured and unstructured outdoor interventions could clarify which approaches best support distinct ADHD symptom profiles. Moreover, future research should incorporate mixed-methods designs, combining quantitative assessments of cognitive outcomes with qualitative insights from children, parents, and educators to capture lived experiences and contextual factors influencing participation. Another promising area involves the integration of technology and outdoor learning; for example, using wearable devices or mobile applications to monitor attention and engagement in real-world settings. Recent research such as Olinic et al. [103] and Kulkarni and Prasad [104] demonstrates that wrist-worn accelerometers and heart-rate sensors can capture ecologically valid markers of hyperactivity and attentional lapses that subjective reports often miss. Furthermore, the use of remote measurement technology (RMT) and smartphone-based passive sensing allows for the continuous tracking of behavioral patterns in naturalistic environments, providing a data-driven baseline for assessing the impact of green time on cognitive regulation [105,106]. These digital biomarkers offer a precise mechanism for clinicians to titrate outdoor interventions based on real-time physiological feedback. Cross-cultural studies would also be valuable in understanding how environmental, cultural, and educational contexts shape the efficacy of outdoor interventions.

By addressing these avenues, future research can advance an evidence-based framework that informs educational practice, guides policy implementation, and ultimately enhances the developmental trajectories of children with ADHD.

9. Limitations of the Study

While this study highlights the benefits of outdoor recreational activities for children with ADHD, several limitations must be acknowledged. First, the findings are based on a review of existing literature, which may include methodological biases or inconsistencies across studies [5,14]. Variability in sample sizes, geographical locations, and definitions of ADHD among the reviewed studies limits the generalizability of the conclusions [6]. Furthermore, the study focuses predominantly on short-term cognitive and behavioral outcomes, leaving the long-term effects of outdoor activities on children with ADHD relatively unexplored [101]. Another limitation is the insufficient consideration of socioeconomic factors and access disparities. Children from low-income families or urban areas with limited green spaces may face barriers to engaging in outdoor activities, potentially skewing the study's applicability [89,90]. Additionally, the emphasis on outdoor activities as non-pharmacological interventions overlooks the complexity of ADHD, where combined approaches involving medication, therapy, and outdoor activities might yield more comprehensive benefits [10,37]. Finally, the lack of longitudinal studies limits the understanding of how sustained outdoor engagement influences developmental trajectories in children with ADHD. Future research addressing these gaps could provide more robust and equitable strategies for integrating outdoor activities into ADHD interventions [97,102].

10. Conclusions

The integration of outdoor recreational activities into the lives of children with Attention Deficit Hyperactivity Disorder (ADHD) presents a promising avenue for enhancing cognitive functions and overall well-being. The significant benefits of such activities, including improved attention, emotional regulation, and social skills, which are critical for academic success and personal development. Educational systems can play a vital role by implementing structured outdoor programs that align with curricular goals, fostering an environment that promotes engagement and learning. Policy changes that prioritize outdoor play and ensure the accessibility of safe recreational spaces are essential for supporting these initiatives. Additionally, addressing gaps in current research will be crucial for optimizing interventions and tailoring them to diverse populations within the ADHD community. As we move forward, a collaborative effort among educators, policymakers, and mental health professionals is needed to leverage the cognitive benefits of outdoor activities. By embracing this holistic approach, we can create supportive environments that empower children with ADHD, allowing them to thrive academically and socially, ultimately contributing to their long-term success and quality of life.

Author Contributions

Conceptualization, D.E.J. and I.D.J.; resources, D.E.J., I.D.J., K.S.D. and P.A.O.; writing—original draft preparation, D.E.J., I.D.J., K.S.D. and P.A.O.; writing—review and editing, D.E.J., I.D.J., K.S.D. and P.A.O.; visualization, D.E.J. and I.D.J. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

All data and information supporting the paper are available in all publicly accessible domains.

Acknowledgments

The authors wish to acknowledge all the support received from reviewers and all colleagues who read through the work.

Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

AI was solely used for language editing.

References

1. von Gontard, A.; Hussong, J.; Yang, S.S.; et al. Neurodevelopmental disorders and incontinence in children and adolescents: Attention-deficit/hyperactivity disorder, autism spectrum disorder, and intellectual disability—A consensus document of the International Children's Continence Society. *Neurourol. Urodyn.* **2022**, *41*, 102–114.
2. Song, P.; Zha, M.; Yang, Q.; et al. The prevalence of adult attention-deficit hyperactivity disorder: A global systematic review and meta-analysis. *J. Glob. Health* **2021**, *11*, 04009.
3. Chowdhury, S.A. Developing a sustainable education protocol for children with ADHD in the context of developing country. *J. Sci. Learn. Innov.* **2024**, *1*, 90–106.
4. Elzohairy, N.W.; Elzlbany, G.A.M.; Khamis, B.I.; et al. Mindfulness-based training effect on attention, impulsivity, and emotional regulation among children with ADHD: The role of family engagement in randomized controlled trials. *Arch. Psychiatr. Nurs.* **2024**, *53*, 204–214.
5. Banaschewski, T.; Häge, A.; Hohmann, S.; et al. Perspectives on ADHD in children and adolescents as a social construct amidst rising prevalence of diagnosis and medication use. *Front. Psychiatry* **2024**, *14*, 1289157.
6. Salari, N.; Ghasemi, H.; Abdoli, N.; et al. The global prevalence of ADHD in children and adolescents: A systematic review and meta-analysis. *Ital. J. Pediatr.* **2023**, *49*, 487.
7. Shojaei, F.; Foroozan, E. Study the relationship between executive function and emotional regulation in children with ADHD. *Int. J. Med. Investig.* **2024**, *13*, 71–75.
8. Inci Izmir, S.B.; Aktan, Z.D.; Ercan, E.S. The Comparison of Psychological Factors and Executive Functions of Children with Attention Deficit Hyperactivity Disorder and Cognitive Disengagement Syndrome to ADHD and ADHD Comorbid with Oppositional Defiant Disorder. *J. Atten. Disord.* **2024**, *28*, 1555–1576.
9. Frank, Y. Attention deficit hyperactivity disorder. *Pediatr. Behav. Neurol.* **2024**, 179–202.
10. Chacko, A.; Merrill, B.M.; Kofler, M.J.; et al. Improving the efficacy and effectiveness of evidence-based psychosocial interventions for ADHD in children and adolescents. *Transl. Psychiatry* **2024**, *14*, 244.
11. Mittal, S.; Bax, A.; Blum, N.J.; et al. Receipt of behavioral therapy in preschool-age children with ADHD and coexisting conditions: A DBPNet study. *J. Dev. Behav. Pediatr.* **2023**, *44*, e651–e656.
12. Natalini, A.; Savastano, M. Outdoor education, processes of inclusion of children with ADHD and learning disabilities. *Eur. J. Spec. Educ. Res.* **2024**, *10*, 127–146.
13. Pham, T.P.; Sanocki, T. Human attention restoration, flow, and creativity: A conceptual integration. *J. Imaging* **2024**, *10*, 83.
14. Hood, M.; Baumann, O. Could nature contribute to the management of ADHD in children? A systematic review. *Int. J. Environ. Res. Public Health* **2024**, *21*, 736.
15. Jacob, D.E.; Nelson, I.U.; Izah, S.C. Healing trails: Integrating medicinal plant walks into recreational development. In *Herbal Medicine Phytochemistry*; Izah, S.C., Ogwu, M.C., Akram, M., Eds.; Springer: Cham, Switzerland, 2023; pp. 2049–2102.
16. Jacob, D.E.; Izah, S.C.; Nelson, I.U.; et al. Indigenous knowledge and phytochemistry: Deciphering the healing power of herbal medicine. In *Herbal Medicine Phytochemistry*; Izah, S.C., Ogwu, M.C., Akram, M., Eds.; Springer: Cham, Switzerland, 2023; pp. 1–53.
17. Neprily, K.; Climie, E. Happy campers: Enhancing social competence in adolescents with attention-

- deficit/hyperactivity disorder at summer camp. *J. Outdoor Recreat. Educ. Leadersh.* **2023**, *15*.
18. Damasceno, M.M.S.; Mazzarino, J.M.; Figueiredo, A. How nature affects the behavior of ADHD children: A case study in Northeastern Brazil. *Ambiente Soc.* **2022**, *25*, e00311.
 19. Cronin, M.A.; George, E. The why and how of the integrative review. *Organ. Res. Methods* **2023**, *26*, 168–192.
 20. Sukhera, J. Narrative reviews: Flexible, rigorous, and practical. *J. Grad. Med. Educ.* **2022**, *14*, 414–417.
 21. Bellato, A.; Wiersema, J.R.; Groom, M.J. Autonomic nervous system functioning in ADHD. In *Clinical Handbook of ADHD Assessment and Treatment Across the Lifespan*; Springer: Cham, Switzerland, 2023; pp. 37–75.
 22. Yung, T.W.; Lai, C.Y.; Chan, C.C. Abnormal physiological responses toward sensory stimulus are related to the attention deficits in children with sluggish cognitive tempo. *Front. Neurosci.* **2022**, *16*, 875064.
 23. Chattopadhyay, R. Advancement of neuroscience in different domains of organizational behavior: review, process and future research direction. *Asia-Pac. J. Bus. Adm.* **2025**, 1–25.
 24. Moyers, S.I.; Abildso, C.G.; Kelley, G.A. Context, classification and study methodologies in research into nature-based therapies: Protocol for a scoping review. *BMJ Open* **2022**, *12*, e060734.
 25. Cox, L.S. *Managing ADHD in Adulthood: Strategies for Success in Work, Relationships, and Life*; Jstone Publishing: London, UK, 2024.
 26. Wiest, G.M.; Rosales, K.P.; Looney, L.; et al. Utilizing cognitive training to improve working memory, attention, and impulsivity in school-aged children with ADHD and SLD. *Brain Sci.* **2022**, *12*, 141.
 27. Ward, R. A Collaborative Production of School ADHD Resources. PhD Thesis, University of Southampton, Southampton, UK, 2022.
 28. More, M. Cerebral Cortical Dysregulation in Attention-Deficit/Hyperactivity Disorder: Investigating Prefrontal Cortex Dysfunction, Dopaminergic Dysregulation, and Neurogenetic Correlates for Therapeutic Insights. *Int. J. Res. Eng. Sci. Manag.* **2023**, *6*, 143–153.
 29. Rostami, M.; Khosrowabadi, R.; Albrecht, B.; et al. ADHD subtypes: Do they hold beyond core symptoms? *Appl. Neuropsychol. Child* **2022**, *11*, 280–290.
 30. Kurteshi, V.; Rrustemi, J. Discovering hyperactive actions of students in classroom and teachers' approaches to them. *Int. J. Relig.* **2024**, *5*, 825–835.
 31. Kofler, M.J.; Singh, L.J.; Soto, E.F.; et al. Working memory and short-term memory deficits in ADHD: A bifactor modeling approach. *Neuropsychology* **2020**, *34*, 686–698.
 32. Arnold, L.E.; Hodgkins, P.; Kahle, J.; et al. Long-term outcomes of ADHD: Academic achievement and performance. *J. Atten. Disord.* **2020**, *24*, 73–85.
 33. Harvey, C. Academic Experiences and Emotional Perspectives of College Students with ADHD: An Interpretive Analysis. PhD Thesis, Endicott College, Beverly, MA, USA, 2024.
 34. Rodriguez, E. Time, Schedules, and the College Student with ADHD. PhD Thesis, Syracuse University, Syracuse, NY, USA, 2020.
 35. Yildırım Demirdöğen, E.; Esin, I.S.; Turan, B.; et al. Assessing sustained attention of children with ADHD in a class flow video task. *Nord. J. Psychiatry* **2022**, *76*, 497–506.
 36. Cortese, S.; Aoki, Y.Y.; Itahashi, T.; et al. Systematic Review and Meta-analysis: Resting-State Functional Magnetic Resonance Imaging Studies of Attention-Deficit/Hyperactivity Disorder. *J. Am. Acad. Child Adolesc. Psychiatry* **2021**, *60*, 61–75.
 37. Young, S.; Hollingdale, J.; Absoud, M.; et al. Guidance for identification and treatment of individuals with attention deficit/hyperactivity disorder and autism spectrum disorder based upon expert consensus. *BMC Med.* **2020**, *18*, 146.
 38. Cooper-Kahn, J.; Dietzel, L. *Late, Lost, and Unprepared: A Parents' Guide to Helping Children with Executive Functioning*; Routledge: New York, NY, USA, 2024.
 39. Willoughby, M.; Hong, Y.; Hudson, K.; et al. Between- and within-person contributions of simple reaction time to executive function skills in early childhood. *J. Exp. Child Psychol.* **2020**, *192*, 104779.
 40. Parlatini, V.; Bellato, A.; Murphy, D.; et al. From neurons to brain networks, pharmacodynamics of stimulant medication for ADHD. *Neurosci. Biobehav. Rev.* **2024**, *164*, 105841.
 41. Stein, M.A.; Weiss, M.D. Longitudinal associations between sleep and ADHD symptoms: ADHD is a 24-hour disorder. *J. Am. Acad. Child Adolesc. Psychiatry* **2023**, *62*, 133–134.
 42. McDonald, N.H. *ADHD Parenting Guide for Boys: Step-by-Step Strategies, Behavior Management, and Tools for Emotional Support, Academic Success, and Social Skills Development in Boys with ADHD*; Gaius Quill Publishing: Sheridan, WY, USA, 2024.
 43. Rajendran, G.; McKenna, P.E.; Corley, M. Characterising developmental disorders: Towards better group comparisons in developmental research. *Methods Psychol.* **2022**, *7*, 100101.

44. Jacob, D.E.; Nelson, I.U.; Eniang, E.A.; et al. Advancing water security and resilience in the Global South through recreational development. In *Water Crises and Sustainable Management in the Global South*; Izah, S.C., Ogwu, M.C., Loukas, A., et al., Eds.; Springer: Berlin, Germany, 2024; p. 17.
45. Jacob, D.E.; Nelson, I.U.; Izah, S.C.; et al. Bioindicators in recreational planning and development: Balancing nature and human activities. In *Biomonitoring of Pollutants in the Global South*; Izah, S.C., Ogwu, M.C., Hamidifar, H., Eds.; Springer: Berlin, Germany, 2024; pp. 24.
46. Jacob, D.E.; Udeagha, A.U.; Ufot, I.N. Awareness and perception of urban forestry among urban dwellers in Sahel Savanna region of Nigeria. *J. Biodivers. Ecol. Sci.* **2012**, *2*, 236–243.
47. Udoakpan, U.I.; Jacob, D.E.; Nelson, I.U. Strategies for green space development in Akwa Ibom State, Nigeria. *J. Geogr. Environ. Plan.* **2012**, *8*, 73–80.
48. Jacob, D.E.; Owolabi, J.T. Challenges and prospect of urban forestry practices in Borno State. *J. Geogr. Environ. Plan.* **2010**, *6*, 21–24.
49. Dunlap, K. Supporting Self-Directed Play in Early Childhood Classrooms. SUNY Empire State University: Saratoga Springs, NY, USA, 2021.
50. Loizou, A. Team Building and Teachers' Well-Being in Primary Education: The Various Ways in Which Team Building Activities Affect Teacher Well-Being and Performance. Master's Thesis, University of Cyprus, Nicosia, Cyprus, 2024.
51. Little, H. *Outdoor Learning Environments: Spaces for Exploration, Discovery and Risk-Taking in the Early Years*; Routledge: London, UK, 2020.
52. Molyneux, T.M.; Zeni, M.; Oberle, E. Choose your own adventure: Promoting social and emotional development through outdoor learning. *Early Child. Educ. J.* **2023**, *51*, 1525–1539.
53. Jacob, D.E.; Akpabio, A.; Eniang, E.A. Visitors' perception of service delivery in Nigeria National Parks. *J. Agric. Stud.* **2022**, *6*, 47–51.
54. Ver, P.; Jacob, D. Determinants and perception of visitors' satisfaction in Nigerian protected areas. *Eurasian J. For. Sci.* **2021**, *9*, 220–234. [[CrossRef](#)]
55. Ruban, A.; Radovenchyk, A.; Semal, N.; et al. Sports games in the context of developing children's coordination ability as a component of physical development. *Rom. Rev. Educ. Multidimens.* **2024**, *16*. [[CrossRef](#)]
56. Salamah, E.R.; Eko, S.B.; Sumarmi, S.; et al. Exploring team-building strategy in developing students' social skills at primary education. *Int. J. Pedagogy Curric.* **2024**, *31*, 83–98.
57. Graber, T.G.; Maroto, R.; Fry, C.S.; et al. Measuring exercise capacity and physical function in adult and older mice. *J. Gerontol. A* **2021**, *76*, 819–824.
58. Richardson, T.; Waite, S.; Askerlund, P.; et al. How does nature support early language learning? A systematic literature review. *Early Years* **2024**, *44*, 682–709.
59. Stevenson, M.P.; Schilhab, T.; Bentsen, P. Attention restoration theory II: A systematic review to clarify attention processes affected by exposure to natural environments. *J. Toxicol. Environ. Health B* **2018**, *21*, 227–268.
60. Sallis, J.F.; Floyd, M.F.; Rodríguez, D.A.; et al. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation* **2012**, *125*, 729–737.
61. McDonnell, A.S. Nature on the Brain: Demonstrating the Use of Cognitive Neuroscience Methods to Understand the Influence of Immersion in Nature on Cognition. PhD Thesis, The University of Utah, Salt Lake City, UT, USA, 2023.
62. Trammell, J.P.; Aguilar, S.C. Natural is not always better: The varied effects of a natural environment and exercise on affect and cognition. *Front. Psychol.* **2021**, *11*, 575245.
63. Vella-Brodrick, D.A.; Gilowska, K. Effects of nature (greenspace) on cognitive functioning in school children and adolescents: A systematic review. *Educ. Psychol. Rev.* **2022**, *34*, 1217–1254.
64. Bergren, K. The Impact of Nature Deficit on. PhD Thesis, Hamline University, Saint Paul, MN, USA, 2022.
65. Guerra-Tamez, C.R. The impact of immersion through virtual reality in the learning experiences of art and design students: The mediating effect of the flow experience. *Educ. Sci.* **2023**, *13*, 185.
66. Barbiero, G.; Berto, R. Biophilia as evolutionary adaptation: An onto- and phylogenetic framework for biophilic design. *Front. Psychol.* **2021**, *12*, 700709.
67. El Zaatari, W.; Maalouf, I. How the Bronfenbrenner bio-ecological system theory explains the development of students' sense of belonging to school? *SAGE Open* **2022**, *12*, 21582440221134089.
68. Ernst, J.; Stelley, H. Supporting young children's self-regulation through nature-based practices in preschool. *Behav. Sci.* **2024**, *14*, 1013.
69. Skulmowski, A.; Xu, K.M. Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load. *Educ. Psychol. Rev.* **2022**, *34*, 171–196.

70. Hank, C.; Huber, C. Do peers influence the development of individuals' social skills? The potential of cooperative learning and social learning in elementary schools. *Int. J. Appl. Posit. Psychol.* **2024**, *9*, 747–773. [[CrossRef](#)]
71. Vitale, V.; Bonaiuto, M. The role of nature in emotion regulation processes: An evidence-based rapid review. *J. Environ. Psychol.* **2024**, *96*, 102325.
72. Marrow, R.K. Examining the Role of Nature-Based Activities in the Lives of Military Veterans with Post-Traumatic Stress Disorder. PhD Thesis, University of Essex, Colchester, UK, 2022.
73. Bratman, G.N.; Anderson, C.B.; Berman, M.G.; et al. Nature and mental health: An ecosystem service perspective. *Sci. Adv.* **2019**, *5*, eaax0903.
74. Edwards, S.; Rudaizky, D.; Toner, M.; et al. A qualitative study of factors perceived by parents as promoting personal recovery in children and young people with ADHD. *Adv. Neurodev. Disord.* **2021**, *5*, 102–115.
75. Finnigan, K.A. Sensory responsive environments: A qualitative study on perceived relationships between outdoor built environments and sensory sensitivities. *Land* **2024**, *13*, 636.
76. Chaudhury, P.; Banerjee, D. "Recovering With Nature": A review of ecotherapy and implications for the COVID-19 pandemic. *Front. Public Health* **2020**, *8*, 604440.
77. Wang, S.; Berbekova, A.; Uysal, M. Is this about feeling? The interplay of emotional well-being, solidarity, and residents' attitude. *J. Travel Res.* **2021**, *60*, 1180–1195.
78. Sibbick, E.; Boat, R.; Sarkar, M.; et al. Acute effects of physical activity on cognitive function in children and adolescents with attention-deficit/hyperactivity disorder: A systematic review and meta-analysis. *Ment. Health Phys. Act.* **2022**, *23*, 100469.
79. Bigelow, H.; Gottlieb, M.D.; Ogrodnik, M.; et al. The differential impact of acute exercise and mindfulness meditation on executive functioning and psycho-emotional well-being in children and youth with ADHD. *Front. Psychol.* **2021**, *12*, 660845.
80. Dankiw, K.A.; Tsiros, M.D.; Baldock, K.L.; et al. The impacts of unstructured nature play on health in early childhood development: A systematic review. *PLoS One* **2020**, *15*, e0229006.
81. Liu, Y.; Zhang, J.; Liu, C.; et al. A review of attention restoration theory: Implications for designing restorative environments. *Sustainability* **2024**, *16*, 3639.
82. Faber Taylor, A.; Butts-Wilmsmeyer, C.; Jordan, C. Nature-based instruction for science learning—a good fit for all: A controlled comparison of classroom versus nature. *Environ. Educ. Res.* **2022**, *28*, 1527–1546.
83. Ekman, E.; Hiltunen, A.; Gustafsson, H. Do athletes have more of a cognitive profile with ADHD criteria than non-athletes? *Sports* **2021**, *9*, 61.
84. Haverkamp, B.F.; Hartman, E.; Oosterlaan, J. Physical fitness and psychosocial health in a sample of Dutch adolescents. *Prev. Med. Rep.* **2022**, *25*, 101689.
85. Sañudo, B.; Sánchez-Oliver, A.J.; Fernández-Gavira, J.; et al. Physical and psychosocial benefits of sports participation among children and adolescents with chronic diseases: A systematic review. *Sports Med. Open* **2024**, *10*, 54.
86. Nguyen, L.; Walters, J. Benefits of nature exposure on cognitive functioning in children and adolescents: A systematic review and meta-analysis. *J. Environ. Psychol.* **2024**, *96*, 102336.
87. Bidzan-Bluma, I.; Lipowska, M. Physical activity and cognitive functioning of children: A systematic review. *Int. J. Environ. Res. Public Health* **2018**, *15*, 800.
88. Burgess, J.; Ho, P.; Riedy, B.; et al. Diet and exercise interventions in the management of psychiatric disorders: Mechanism and efficacy. In *Lifestyle Medicine*, 4th ed.; CRC Press: Boca Raton, FL, USA, 2024; pp. 896–903.
89. Barger, B.; Torquati, J.; Larson, L.R.; et al. Measuring green space effects on attention and stress in children and youth: A scoping review. *Child. Youth Environ.* **2021**, *31*, 1–54.
90. Thygesen, M.; Engemann, K.; Holst, G.J.; et al. The association between residential green space in childhood and development of attention deficit hyperactivity disorder: A population-based cohort study. *Environ. Health Perspect.* **2020**, *128*, 127011.
91. Schumacher, M. Effects of Nature-Based Learning on Elementary Students' Sustained Attention: An Exploratory Study. Master's Thesis, University of Minnesota Duluth, Duluth, MN, USA, 2024.
92. Chrysomalidou, A.; Takos, I.; Spiliotis, I.; et al. The participation of teachers in Greece in outdoor education activities and the schools' perceptions of the benefits to students. *Educ. Sci.* **2024**, *14*, 804.
93. Muûls, M.; Carvajal, R. Impact of attention deficit hyperactivity disorder on entrepreneurial behavior: A neurobiological approach. *J. Appl. Cogn. Neurosci.* **2023**, *4*, e00395858.
94. Nery, M.; Sequeira, I.; Neto, C.; et al. Movement, play, and games—An essay about youth sports and its benefits for human development. *Healthcare* **2023**, *11*, 493.

95. Wills, R. *Nature, Spirituality, and Early Childhood Education: Fostering Children's Awareness and Responsibility through Outdoor Learning*; Routledge: London, UK, 2024.
96. O'Leary, H. *Outdoor Adventure Education: Empowering Educators and Transforming Students*. PhD Thesis, New England College, Henniker, NH, USA, 2024.
97. Fang, W.T.; Hassan, A.A.; LePage, B.A. Outdoor education. In *The Living Environmental Education: Sound Science toward a Cleaner, Safer, and Healthier Future*; Springer: Singapore, 2022; pp. 229–260.
98. Hock, A. *Teachers' Perceptions of Benefits of Unstructured Classroom Play on Impulse Control of Students: A Collective Case Study*. PhD Thesis, Northcentral University, San Diego, CA, USA, 2023.
99. Gill, T. *Urban Playground: How Child-Friendly Planning and Design Can Save Cities*; RIBA Publishing: London, UK, 2021.
100. Oberle, E.; Zeni, M.; Munday, F.; et al. Support factors and barriers for outdoor learning in elementary schools: A systemic perspective. *Am. J. Health Educ.* **2021**, *52*, 251–265.
101. Rogerson, O.; O'Connor, R.C.; O'Connor, D.B. The effects of childhood trauma on stress-related vulnerability factors and indicators of suicide risk: An ecological momentary assessment study. *J. Affect. Disord.* **2024**, *352*, 479–489.
102. Patrinos, H.A. The longer students were out of school, the less they learned. In *COVID-19 and Schools*; Routledge: London, UK, 2023; pp. 106–120.
103. Olinic, M.S.; Stretea, R.; Cherecheș, C. Wearables in ADHD: Monitoring and intervention—where are we now? *Diagnostics* **2025**, *15*, 2359.
104. Kulkarni, A.; Prasad, J.R. Design considerations for adaptive sensor-based systems for pediatric behavioral monitoring. In *Proceedings of the IEEE 5th International Conference on ICT in Business Industry & Government*, Indore, India, 12–13 December 2025.
105. Wong, K.P.; Qin, J.; Xie, Y.J.; et al. Effectiveness of technology-based interventions for school-age children with attention-deficit/hyperactivity disorder: Systematic review and meta-analysis of randomized controlled trials. *JMIR Ment. Health* **2023**, *10*, e51459.
106. Yu, C.; Wang, C.; Xie, Q.; et al. Effect of virtual reality technology on attention and motor ability in children with attention-deficit/hyperactivity disorder: Systematic review and meta-analysis. *JMIR Serious Games* **2024**, *12*, e56918.



Copyright © 2025 by the author(s). Published by UK Scientific Publishing Limited. This is an open access article under the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Publisher's Note: The views, opinions, and information presented in all publications are the sole responsibility of the respective authors and contributors, and do not necessarily reflect the views of UK Scientific Publishing Limited and/or its editors. UK Scientific Publishing Limited and/or its editors hereby disclaim any liability for any harm or damage to individuals or property arising from the implementation of ideas, methods, instructions, or products mentioned in the content.