QUALITY IN SPORT
*eISSN 2450-3118 · Open Access · Peer-reviewed*
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

**Cite as: MOKRACKA, Julia, KRĘCINA, Filip, KACZMAREK, Weronika, FITZ, Emilia, BRZEŹNIAK, Mikołaj, GIL, Kacper, DANIEK, Justyna, DRELICH, Krzysztof, KARBOWNICZEK, Aleksander and GRABARCZYK, Alicja. Optimal Exercise Prescription for Children and Adolescents with ADHD: A Narrative Review of Modality, Intensity and Dosage. Quality in Sport. 2026;59:72769. https://doi.org/10.12775/QS.2026.59.72769**

**ARTICLE TIMELINE**
Received: 28.05.2026. Revised: 20.06.2026. Accepted: 20.06.2026. Published: 21.06.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines: Medical Sciences; Health Sciences.
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Nauki medyczne; Nauki o zdrowiu. 

# Optimal Exercise Prescription for Children and Adolescents with ADHD: A Narrative Review of Modality, Intensity and Dosage

Julia Maria Mokracka[1] *

ORCID: https://orcid.org/0009-0009-1095-0273
E-mail: julia.mokracka@gmail.com
[1] Jagiellonian University Collegium Medicum, Krakow, Poland

Filip Kręcina[2]

ORCID: https://orcid.org/0009-0006-6950-2107
E-mail: filip.krecina@hotmail.com
[2] Students' Scientific Society, Department of Gynaecology and Obstetrics, Medical University of Silesia, 40-752 Katowice, Poland

Weronika Kaczmarek[1]

ORCID: https://orcid.org/0009-0005-1940-0682
E-mail: weronika.2002.kaczmarek@gmail.com
[1] Jagiellonian University Collegium Medicum, Krakow, Poland

Emilia Fitz[1]

ORCID: https://orcid.org/0009-0001-7048-7921
E-mail: emilia.fitz@onet.pl
[1] Jagiellonian University Collegium Medicum, Krakow, Poland

Mikołaj Brzeźniak[1]

ORCID: https://orcid.org/0009-0004-5121-6562
E-mail: mikolajbrzezniak12@gmail.com
[1] Jagiellonian University Collegium Medicum, Krakow, Poland

Kacper Gil[4]

ORCID: https://orcid.org/0009-0005-1385-1634
E-mail: gilkac101@gmail.com
[3] Ludwik Rydygier Specialist Hospital, Kraków, Poland

Justyna Daniek[6]

ORCID: https://orcid.org/0009-0006-8519-5573
E-mail: justynadank@gmail.com
[4] St. John Grande Hospital of the Brothers Hospitallers, Kraków, Poland

Krzysztof Drelich[5]

ORCID: https://orcid.org/0009-0007-3710-8380
E-mail: krzy.drelich@gmail.com
[5] University Hospital, Krakow, Poland

Aleksander Karbowniczek[2]

ORCID: https://orcid.org/0009-0006-1670-4696
E-mail: karbowniczek33@gmail.com
[2] Faculty of Medical Sciences in Katowice, Medical University of Silesia, Katowice, Poland

Alicja Grabarczyk[2]

ORCID: https://orcid.org/0009-0008-8651-3283
E-mail: alicjagrabarczyk515@gmail.com
[2] Students' Scientific Society, Department of Gynaecology and Obstetrics, Medical University of Silesia, Katowice, Poland

*** Corresponding Author:** Julia Maria Mokracka, E-mail: julia.mokracka@gmail.com

## Abstract

**Background.** ADHD is among the most common neurodevelopmental disorders in childhood, characterized by persistent inattention, hyperactivity, and impulsivity. While pharmacological treatment is effective, it is associated with adverse effects and limited efficacy for broader cognitive and motor difficulties. Physical activity has emerged as a promising adjunct, yet optimal exercise prescription parameters remain insufficiently defined.

**Aim.** To synthesize evidence on the effects of different exercise modalities on cognitive, behavioral, and motor functioning in children and adolescents with ADHD.

**Material and methods.** A literature search was conducted in PubMed and ScienceDirect (2016–2026). A total of 25 studies were included.

**Results.** All examined exercise types demonstrated beneficial effects across ADHD-related outcomes, though with distinct profiles. Aerobic and closed-skill exercise most consistently reduced core ADHD symptoms including inattention (SMD = −1.51) and hyperactivity/impulsivity (SMD = −1.60). Open-skill activities produced the largest improvements in executive functions (SMD = 1.96) and inhibitory control (SMD = 1.94). Mind-body exercise significantly improved attention (SMD = −0.97) but showed limited evidence for broader executive or behavioral effects. HIIT and VR-based exercise represent promising emerging modalities. Regarding dosage, moderate-to-

vigorous intensity and sessions of at least 60 minutes performed twice weekly were associated with the most robust outcomes. No single modality could be identified as definitively superior.

**Conclusions.** Physical activity is a safe and clinically meaningful adjunct to ADHD treatment. An individualized approach guided by symptom profile and adherence is recommended. Future RCTs should establish precise exercise prescription guidelines for pediatric ADHD populations.

**Key words:** ADHD; physical activity; exercise prescription; modality; intensity; dosage; children; adolescents; executive functions; aerobic exercise; mind-body exercise; HIIT.

## 1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by developmentally inappropriate and impairing levels of inattention, hyperactivity, and impulsivity, with symptoms occurring across settings and interfering with educational, social, and everyday functioning [23]. ADHD is among the most common neurodevelopmental disorders in childhood and adolescence, with prevalence estimated at 7.6% among school-aged children (aged 3–12 years) and 5.6% among adolescents (aged 12–18 years) in a recent meta-analysis of 61 studies — with considerable variability across studies attributable to differences in diagnostic criteria and methodology [23]. ADHD is associated with wide-ranging functional impairments including academic underachievement, disrupted peer relationships, reduced self-esteem, and elevated rates of comorbid anxiety, mood disorders, and conduct disorder [25].

While stimulant medications are effective in reducing core ADHD symptoms, their use is accompanied by well-documented adverse effects including weight loss, appetite suppression, abdominal pain, headaches, irritability, and tics — contributing to poor long-term adherence, with the majority of patients discontinuing medication within the first year [9]. Notably, symptoms typically return the next day once medication is stopped [9]. Furthermore, pharmacological treatment may not adequately address broader cognitive, behavioral, emotional, and motor difficulties associated with ADHD. These limitations have motivated growing interest in complementary, non-pharmacological interventions, among which physical activity has emerged as a particularly promising adjunct. Neurobiological plausibility for these effects is supported by exercise-induced changes in catecholaminergic activity and neuroplasticity — mechanisms that partially overlap with those of stimulant medications [8]. Accumulating evidence further suggests that exercise modality may substantially influence therapeutic outcomes, with different types of physical activity potentially producing distinct patterns of benefit across ADHD symptom domains [7, 14]. However, critical questions remain regarding which modalities, intensities, and dosage parameters produce the most meaningful outcomes — questions that the present review aims to address.

Despite this promise, children with ADHD are significantly less likely to engage in regular physical activity than their neurotypical peers [2], highlighting the particular importance of accessible and engaging exercise interventions for this population.

**Research Objective.** The objective of this narrative review is therefore to synthesize current evidence on the effects of different exercise modalities — including aerobic exercise, open-skill activities, mind-body practices, HIIT, and virtual reality-based exercise — on cognitive, behavioral, emotional, and motor functioning in children and adolescents with ADHD, with particular attention to modality-specific effects, optimal prescription parameters including intensity, duration, and frequency, neurobiological mechanisms, and clinical implications.

**Research Problems.** Do different exercise modalities produce distinct profiles of benefit in children with ADHD, and if so, which symptom domains respond most consistently to specific exercise types? What intensity, duration, and frequency parameters are associated with the most robust outcomes in this population? What neurobiological mechanisms underlie the effects of exercise on ADHD, and how do these differ across modalities? How might exercise prescription be tailored to individual symptom profiles?

**Research Hypotheses.** We hypothesize that exercise intensity, session duration, and regularity of participation represent the primary determinants of therapeutic outcomes in children with ADHD, with exercise modality playing a secondary but clinically relevant role. We further hypothesize that different modalities may produce distinct profiles of benefit across symptom domains — a question that warrants systematic examination to inform individualized exercise prescription.

## 2. Research materials and methods

### 2.1. Search Strategy

A narrative literature search was conducted using two electronic databases: PubMed and ScienceDirect. The search was performed using the following Boolean keyword string: (ADHD OR "attention deficit hyperactivity disorder") AND (exercise OR "physical activity" OR sport* OR "aerobic exercise") AND (child* OR adolescent* OR youth). The search was limited to publications in the English language between January 2016 and March 2026.

### 2.2. Inclusion and Exclusion Criteria

Studies were included if they: (1) involved children and/or adolescents aged 6–18 years with a confirmed ADHD diagnosis; (2) examined any form of structured physical activity or exercise intervention; (3) reported outcomes related to ADHD core symptoms, executive functions, cognitive performance, motor skills, or behavioral measures; and (4) were published in peer-reviewed English-language journals between 2016 and 2026. Eligible study designs included randomized controlled trials (RCTs), meta-analyses, systematic reviews, and narrative reviews. Studies exclusively involving adult populations (>18 years), animal models, or populations without an ADHD diagnosis were excluded.

### 2.3. Data Collection and Analysis

Following the initial database search, 25 studies were selected based on relevance to the research objectives, methodological quality, and coverage of key exercise prescription parameters. Studies were thematically organized according to exercise modality, intensity, duration, and measured outcomes to facilitate narrative synthesis.

#### 2.3.1. AI

Artificial intelligence tools were used exclusively to support language editing and improve the clarity, coherence, and readability of the manuscript. AI tools did not influence the selection of literature, critical analysis, interpretation of findings, or formulation of conclusions. All AI tools were used strictly as assistive instruments under human supervision. The authors take full responsibility for the content, originality, and scientific integrity of this narrative review.

## 3. Research results

### 3.1. Does Physical Activity Improve ADHD Symptoms? Overview of the Evidence

The first and most fundamental question addressed by the literature is whether physical activity produces meaningful improvements in ADHD symptoms and associated cognitive functioning. Evidence from meta-analyses and systematic reviews consistently indicates that physical activity is associated with improvements in executive functions [6], emotional and behavioral outcomes such as anxiety, depression, and social functioning [10], as well as positive associations with cognitive and behavioral outcomes across both medicated and unmedicated children [9].

However, the magnitude and specificity of these effects vary. It is important to note that executive functions — while closely related to ADHD — are not themselves diagnostic core symptoms under DSM-5 criteria; core symptoms refer specifically to inattention and hyperactivity/impulsivity. While beneficial effects on executive functions and emotional and behavioral comorbidities are consistently reported, improvements in core symptoms appear less robust and, in some analyses, do not reach statistical significance [10]. Furthermore, whether exercise acts additively alongside medication, operates through overlapping mechanisms, or modulates pharmacological treatment response in children with ADHD remains an open question [9].

### 3.2. Exercise Modality

A substantial body of evidence indicates that exercise modality matters — different types of physical activity appear to produce distinct patterns of benefit across cognitive, behavioral, and motor domains in children with ADHD [7, 14]. However, apparent differences in effect sizes across modalities partly reflect differences in the quantity and quality of available research, and should not be interpreted as a definitive ranking. With this caveat, the following sections examine the evidence for each major modality in turn.

An important practical consideration highlighted by Grahn [17] is that children with ADHD report structured environments, supportive interactions with coaches, and enjoyment of activities as central to sustained participation. This serves as a reminder that the most effective exercise type in practice is often the one the child will actually adhere to — and that engagement and enjoyment are themselves therapeutic variables [17].

### 3.3. Aerobic Exercise

Aerobic exercise — encompassing activities such as running, cycling, swimming, and treadmill training — is characterized by sustained physical effort that elevates heart rate and engages the cardiovascular system over extended periods [1]. Among all exercise modalities studied in ADHD, aerobic exercise currently has the most extensive evidence base, having been examined across both acute and chronic intervention designs [1]. Reviewing predominantly pediatric studies, Den Heijer et al. [1] found that cardio exercise produced consistent acute improvements in executive functions,

particularly inhibitory control and reaction time. Chronic aerobic training was additionally associated with broader improvements in attention and behavioral regulation [1].

Importantly, evidence reviewed by Chan et al. [8] suggests that even a single session of moderate-intensity aerobic exercise may produce cognitive benefits lasting up to 60 minutes post-exercise, supporting the strategic scheduling of physical activity before cognitively demanding tasks such as lessons or homework [8]. The acute benefits of exercise are further supported by Zhao et al. [13], whose three-level meta-analysis of 12 studies found that a single exercise session produced a small but statistically significant improvement in executive function in children and adolescents with ADHD ($g = 0.17$, 95% CI [0.05, 0.29]) [13].

Taken together, current evidence suggests that aerobic exercise remains one of the most extensively supported exercise approaches for children and adolescents with ADHD, particularly when delivered regularly at moderate or submaximal vigorous intensity over longer intervention periods.

### 3.4. Open-Skill and Closed-Skill Exercise: Comparative Effects

Exercise modalities can be broadly categorized into open-skill and closed-skill activities, depending on the cognitive and environmental demands imposed during movement execution. Open-skill exercises — such as football, basketball, tennis, and martial arts — are performed in dynamically changing environments that require continuous adaptation, decision-making, visuospatial processing, and inhibitory control. In contrast, closed-skill exercises — including running, cycling, swimming, and treadmill training — involve repetitive, predictable movement patterns performed in stable environments, with minimal real-time decision-making demands [1, 14].

Increasing evidence suggests that this distinction may be clinically relevant in ADHD. Zhu et al. [14], in a network meta-analysis of 59 studies involving 1,757 participants, found that open-skill activities produced the largest improvements in overall executive functions (SMD = 1.96) and inhibitory control (SMD = 1.94). The authors proposed that the continuous cognitive engagement required during open-skill exercise may enhance attentional regulation, cognitive flexibility, and response inhibition in children with ADHD [14].

By contrast, closed-skill activities — many of which were aerobic in nature — demonstrated particularly strong effects on core ADHD symptoms, including inattention (SMD = −1.51) and hyperactivity/impulsivity (SMD = −1.60), while also improving working memory (SMD = 1.21) [14]. These findings suggest that structured repetitive aerobic exercise may be especially beneficial for children with prominent inattentive and hyperactive/impulsive symptoms.

Importantly, these findings should not be interpreted as establishing a definitive hierarchy of exercise modalities. Rather, they suggest that different forms of exercise may target partially distinct cognitive and behavioral domains. Open-skill activities may be particularly effective for enhancing executive functioning and cognitive flexibility, whereas closed-skill aerobic exercise may exert stronger effects on core ADHD symptomatology. This distinction supports a more individualized approach to exercise prescription in children and adolescents with ADHD. Consequently, exercise selection in ADHD may benefit from considering the child's predominant symptom profile, cognitive difficulties, and individual preferences.

### 3.5. Mind-Body Exercise

Mind-body exercises (MBE) constitute a distinct category of physical intervention encompassing practices such as yoga, tai chi, Pilates, dance, and mindfulness-based movement programs —

activities that integrate physical effort with breath regulation, attentional focus, and conscious movement awareness [16]. Mindfulness may be especially relevant in ADHD because it directly targets attention regulation and impulse control — capacities centrally impaired in the disorder — by strengthening the ability to observe internal and external stimuli without reacting impulsively to them [24]. Peng et al. [16], in a systematic review and meta-analysis across five databases, found that mind-body exercise significantly improved attention in individuals with ADHD (SMD = −0.97, $p < 0.05$), but found no statistically significant evidence for improvements in executive function, emotional regulation, or hyperactivity/impulsivity [16].

Lee et al. [24], in a systematic review and meta-analysis of 11 randomized controlled trials, found that mindfulness-based interventions produced relatively large effects on overall ADHD symptoms ($g = 0.77$) — assessed through parent-rated behavioral questionnaires reflecting broader functional improvements in daily behavior — and moderate effects on children's mindfulness skills ($g = 0.43$) and parental stress ($g = 0.40$). Effects on externalizing and internalizing behavioral problems were negligible [24]. Compared to other intervention approaches, mind-body exercise may be particularly relevant during childhood, when cognitive and emotional self-regulation are still developing, as mindfulness practices and attentional focus training may help children gradually strengthen attentional control and behavioral regulation [16]. These characteristics support a complementary role for mind-body exercise alongside pharmacological and behavioral treatments. However, definitive conclusions remain limited by the moderate methodological quality of the primary studies, underscoring the need for larger and better-controlled trials [16, 24].

### 3.6. High-Intensity Interval Training

High-intensity interval training (HIIT) involves repeated bouts of vigorous exercise at ≥80–90% maximum heart rate, interspersed with recovery periods at lower intensities. This time-efficient format typically lasts approximately 20 minutes and is considered particularly suitable for children with ADHD given its adaptability to their naturally sporadic, high-intensity activity patterns [8, 18]. Poon et al. [18], in a systematic review of 13 studies involving 453 participants with special educational needs including ADHD, found that HIIT generally improved body composition, physical fitness, cardiometabolic biomarkers, mental health, and cognitive performance. Chan et al. [8] provided more specific evidence, reporting that a single 20-minute HIIT session significantly improved cognitive function and sustained attention in boys with ADHD aged 7–15 years. Furthermore, longer HIIT programs were associated with additional benefits including improved motor coordination, self-confidence, and interpersonal relationships [8]. These findings suggest that both short and extended HIIT protocols may offer meaningful benefits for children with ADHD, though the evidence base for HIIT specifically in ADHD remains more limited compared to aerobic exercise.

### 3.7. Virtual Reality-Based Exercise

Virtual reality (VR)-based exercise represents an emerging intervention modality that combines physical activity with computer-generated environments simulating real-world experiences, delivered through devices ranging from fully immersive headsets to screen-based platforms [19]. This modality may be particularly suited for children with ADHD because VR-based exercises inherently require inhibitory control and task-switching, thereby stimulating brain regions involved in executive functions while simultaneously maintaining engagement through interactive virtual environments [19]. Sun et al. [19], in a systematic review of 6 studies involving 192 participants with ADHD, found positive effects across inhibitory control, attention, working memory,

switching, and planning, with sessions exceeding 30 minutes associated with more consistent outcomes [19]. Given its inherently engaging format, VR-based exercise may be especially valuable for children with ADHD who show low motivation or poor adherence to conventional exercise programs [19]. Both fully immersive and screen-based semi-immersive VR interventions yielded comparable results. Yet the current evidence base remains too limited for firm clinical conclusions, and further well-controlled trials are needed.

### 3.8. Motor Skills

Motor impairments constitute a common yet frequently overlooked dimension of ADHD, affecting approximately 30–52% of children diagnosed with the disorder [22]. Deficits span both gross and fine motor domains — including coordination, handwriting, balance, and movement accuracy [22] — and motor development in children with ADHD has been estimated to lag by nearly two years relative to neurotypical peers [21, 22]. These impairments affect academic performance, self-esteem, and social participation, yet are often insufficiently addressed by pharmacological treatment, with stimulant medication sometimes failing to normalize fine motor performance [22].

Wang et al. [21], in a three-level meta-analysis of 9 studies, demonstrated that long-term exercise interventions significantly improved motor skills in children with ADHD ($g = 0.72$, 95% CI [0.31–1.14], $p = 0.001$). Lelong et al. [22] further reported that multi-session fine motor training interventions were generally effective in children aged 4–12 years, with physical activity components frequently accompanying successful interventions. Collectively, these findings suggest that movement-based interventions represent an important complementary strategy in the management of ADHD-related motor impairments.

### 3.9. Neurobiological Mechanisms

The neurobiological mechanisms underlying exercise effects in ADHD help explain both its therapeutic value and the differences observed across modalities. The catecholamine hypothesis proposes that acute exercise — a single structured session — transiently increases dopamine and noradrenaline availability within prefrontal circuits involved in attention, inhibitory control, and working memory [1, 8] — partially paralleling, though less potently, the mechanisms of stimulant medications [1]. Additionally, aerobic exercise increases brain blood flow and circulation, enhancing metabolic activity and activating the central nervous system — effects particularly relevant to the prefrontal deficits characteristic of ADHD [8]. Furthermore, moderate-to-high intensity aerobic exercise may stimulate lactate production, which in turn may promote BDNF synthesis — and with regular training, this may contribute to sustained neuroplastic adaptations supporting executive functioning [1, 8]. These findings are corroborated by Caponnetto et al. [20], who similarly demonstrated a significant association between physical exercise and BDNF levels and neuronal plasticity [20].

Mind-body exercise appears to operate through distinct neurobiological pathways. Chan et al. [8] noted that perceptual-motor training and meditation may promote neuroplasticity in nerve cells and synaptic connections, and that strengthening the sensorimotor base contributes to improvements in attention [8]. Peng et al. [16] further proposed that the sustained attentional focus, breathing control, and conscious movement regulation characteristic of mind-body practices may strengthen self-regulatory capacities through prefrontal modulation rather than neurochemical activation [16]. These mechanisms may help explain why mind-body exercise shows specific effects on attention but limited impact on broader executive function.

Collectively, exercise benefits in ADHD likely arise through multiple interacting neurobiological pathways, with different modalities targeting partially distinct but clinically relevant dimensions of the disorder.

### 3.10. Exercise Prescription Parameters: Current Evidence

Regarding exercise intensity, Liang et al. [5] classified interventions as light (60% HRmax), moderate (65–75% HRmax), moderate-to-vigorous, or vigorous (>75% HRmax), and found moderate intensity to be the most consistently effective across 21 studies [5]. Zhang and Li [12], in a meta-analysis focused exclusively on vigorous-intensity interventions — defined as exercise performed at >75% of maximum heart rate — found that submaximal effort within that range, rather than maximal exertion, produced the most consistent improvements in inhibitory control across 10 studies [12]. These findings are not fully consistent, but collectively suggest that moderate-to-vigorous intensity represents a practical target range, with the optimal threshold yet to be definitively established.

Wang et al. [11], in a meta-analysis of 11 studies involving 713 children with ADHD, found a significant overall improvement in inhibitory function (SMD = 0.78, $p < 0.001$). Subgroup analyses further identified longitudinal open-skill exercise lasting at least 60 minutes per session, performed twice weekly, as producing the most robust improvements in inhibitory control [11].

Notably, Liang et al. [5] found that intervention intensity and session duration significantly moderated exercise outcomes, whereas exercise type did not — suggesting that how exercise is performed may matter more than what type of exercise is chosen [5]. Consistently, Liu et al. [15] demonstrated significant improvements in inhibitory control ($g = 0.60$) and working memory ($g = 0.51$) across different exercise types in school-aged children with ADHD, regardless of modality [15]. This finding has an important practical implication: children may be encouraged to engage in physical activities they personally enjoy, as long as appropriate intensity and duration are maintained. Taken together, sessions of 30–60 minutes at moderate-to-vigorous intensity represent the most evidence-based dosage parameters currently available.

### 3.11. Clinical Implications

The evidence reviewed in this article supports positioning physical activity as a safe, accessible, and clinically valuable adjunct to established ADHD treatments. Catalá-López et al. [3] demonstrated that the combination of behavioral therapy and stimulant medication remains the most effective therapeutic approach for ADHD; physical activity should therefore be considered a complementary rather than replacement intervention [3].

Current findings additionally support a more individualized approach to exercise prescription in ADHD. Different exercise modalities may be appropriate for different symptom profiles and functional difficulties. Aerobic and closed-skill exercise may be particularly suitable for children with prominent inattentive and hyperactive/impulsive symptoms [14], whereas open-skill activities may better support executive functioning and cognitive flexibility [7]. Mind-body interventions may represent useful adjuncts for children experiencing attentional instability [16], while VR-based exercise and HIIT formats may help increase engagement among children less motivated by traditional exercise programs [18, 19].

Motor impairments, affecting up to 52% of children with ADHD, represent an additional therapeutic target that is often insufficiently addressed in standard pharmacological management [21, 22].

Exercise interventions capable of simultaneously supporting cognitive, behavioral, and motor functioning may therefore provide particular clinical value.

Schools and extracurricular environments represent especially important settings for implementing exercise-based interventions. Importantly, the child's preferences, enjoyment, and willingness to participate regularly should remain central considerations in exercise selection, as long-term adherence likely represents one of the strongest determinants of therapeutic benefit in real-world practice [17]. Physical activity thus represents not only a therapeutic tool but also a means of supporting broader physical health, social functioning, and cognitive development in children with ADHD [20].

## 4. Discussion

This narrative review synthesized evidence published between 2016 and 2026 regarding the effects of physical activity on ADHD-related outcomes in children and adolescents. Overall, the reviewed literature consistently suggests that exercise is associated with improvements across multiple domains relevant to ADHD, including attention, executive functioning, behavioral regulation, and motor skills. At the same time, considerable heterogeneity across studies continues to limit definitive conclusions regarding the optimal modality and dosage of exercise interventions.

One of the most clinically relevant findings emerging from the current literature is that different exercise modalities appear to produce partially distinct profiles of benefit rather than uniformly equivalent effects. Open-skill activities, characterized by continuous environmental adaptation and executive engagement, appear particularly associated with improvements in executive functions and inhibitory control [7, 14]. In contrast, closed-skill aerobic exercise demonstrates stronger associations with reductions in core ADHD symptoms such as inattention and hyperactivity/impulsivity [14]. Mind-body interventions appear to exert more selective effects on attentional regulation and self-regulatory processes, while evidence for broader executive or behavioral effects remains less consistent [16, 24].

Two independent network meta-analyses included in this review yielded partially different findings regarding the optimal exercise modality for improving inhibitory control. Zhu et al. [14] identified open-skill activities as the most effective, whereas Ouyang et al. [7] reported the strongest effects for mind-body movement interventions. However, this discrepancy most likely reflects differences in exercise classification between the two analyses, as Ouyang et al. included highly cognitively engaging activities such as taekwondo within the mind-body category. Importantly, both analyses consistently favored exercise modalities combining physical activity with continuous attentional and executive demands over more repetitive forms of exercise. Collectively, these findings support the concept that the degree of cognitive engagement during movement may represent a key determinant of executive-function improvements in ADHD, while also highlighting the need for caution when attempting to establish a definitive hierarchy of exercise modalities [7, 14].

Emerging modalities — particularly HIIT and VR-based exercise — represent promising but methodologically immature areas of evidence. Their potential advantages related to time efficiency and motivational engagement may be especially relevant for children with ADHD, who frequently experience difficulties maintaining long-term participation in conventional forms of physical activity [18, 19]. These findings are particularly concerning given that adolescents with ADHD remain significantly less likely to engage in regular physical activity than their neurotypical peers [2]. Wang et al. [4] further demonstrated that only 6.5% of adolescents with ADHD simultaneously

met all components of the 24-hour movement guidelines — which recommend at least 60 minutes of moderate-to-vigorous physical activity daily, less than 2 hours of recreational screen time, and 9–11 hours of sleep [4]. Together, these findings highlight an important public health challenge. Importantly, low motivation and reduced engagement in physical activity are not merely behavioral choices in this population — they reflect core neurobiological features of ADHD, including dysregulation of dopamine-mediated reward processing [8]. This reality further highlights the importance of individualized, engaging, and accessible exercise interventions that account for the specific motivational profile of children with ADHD.

The neurobiological findings discussed across the included studies provide important mechanistic support for exercise as a therapeutic adjunct in ADHD. Acute exercise appears to transiently enhance catecholaminergic activity within prefrontal circuits involved in executive control, while chronic exercise may additionally promote neuroplastic adaptations involving BDNF signaling and cerebral blood flow [1, 8, 20]. Different exercise modalities may simultaneously engage partially distinct neurocognitive systems, potentially explaining their differing cognitive and behavioral effects.

Several limitations of the current literature should be acknowledged. Considerable heterogeneity exists across studies with respect to exercise protocols, intensity, duration, participant characteristics, medication status, and outcome measures. Many primary studies additionally remain limited by relatively small sample sizes, moderate methodological quality, lack of active control groups, and short follow-up periods. As a result, precise dose-response relationships and long-term sustainability of exercise-induced benefits remain insufficiently understood. Future research should prioritize adequately powered randomized controlled trials with standardized exercise protocols, objective neuropsychological outcome measures, and longitudinal follow-up to better define modality-specific effects and individualized exercise prescription strategies for children and adolescents with ADHD.

## 5. Conclusions

Physical activity represents a safe, accessible, and clinically meaningful adjunct to standard ADHD treatment in children and adolescents. Current evidence suggests that exercise may improve multiple domains relevant to ADHD, including attention, executive functioning, behavioral regulation, and motor skills.

Although different exercise modalities appear to produce partially distinct profiles of benefit, the existing literature does not support a definitive hierarchy of exercise types. Rather, the available evidence supports a more individualized approach in which exercise selection is guided by symptom profile, enjoyment, accessibility, and long-term adherence.

Overall, regular moderate-to-vigorous physical activity should be considered a valuable component of multimodal ADHD management [5, 11]. Future research should focus on standardized, high-quality randomized controlled trials capable of clarifying modality-specific effects and establishing precise exercise prescription guidelines for pediatric ADHD populations.

## Supplementary Materials

Not applicable.

## Author Contributions

Conceptualization: Julia Maria Mokracka, Filip Kręcina. Methodology: Julia Maria Mokracka, Filip Kręcina, Weronika Kaczmarek. Investigation and data collection: Julia Maria Mokracka, Filip Kręcina, Weronika Kaczmarek, Emilia Fitz, Mikołaj Brzeźniak, Kacper Gil, Justyna Daniek, Krzysztof Drelich, Aleksander Karbowniczek, Alicja Grabarczyk. Writing – original draft: Julia Maria Mokracka, Filip Kręcina, Emilia Fitz, Mikołaj Brzeźniak. Writing – review and editing: Kacper Gil, Justyna Daniek, Krzysztof Drelich, Aleksander Karbowniczek, Alicja Grabarczyk. Supervision: Julia Maria Mokracka.

## Funding

This research received no external funding.

## Institutional Review Board Statement

Not applicable.

## Informed Consent Statement

Not applicable.

## Data Availability Statement

Not applicable.

## Acknowledgements

This research has not received any administrative or technical support.

## Conflicts of Interest

The authors declare no conflict of interest.

## Declaration of Artificial Intelligence Use

The authors declare that artificial intelligence (AI) tools were used exclusively to support language editing and improve the clarity, coherence, and readability of the manuscript. AI tools did not influence the selection of literature, the critical analysis and synthesis of sources, the interpretation of findings, or the formulation of conclusions. The authors take full responsibility for the content, originality, and scientific integrity of this narrative review.

## References

1. Den Heijer AE, Groen Y, Tucha L, et al. Sweat it out? The effects of physical exercise on cognition and behavior in children and adults with ADHD: a systematic literature review. J Neural Transm (Vienna). 2017;124(Suppl 1):3-26. https://doi.org/10.1007/s00702-016-1593-7

2. Mercurio LY, Amanullah S, Gill N, Gjelsvik A. Children With ADHD Engage in Less Physical Activity. J Atten Disord. 2021;25(8):1187-1195. https://doi.org/10.1177/1087054719887789

3. Catalá-López F, Hutton B, Nuñez-Beltrán A, et al. The pharmacological and non-pharmacological treatment of attention deficit hyperactivity disorder in children and adolescents: A systematic review with network meta-analyses of randomised trials. PLoS One. 2017;12(7):e0180355. https://doi.org/10.1371/journal.pone.0180355

4. Wang C, Szabo A, Morozova N, Sit CHP. Adherence to 24-Hour Movement Guidelines and Associations with Flourishing and School Engagement in Adolescents with ADHD. Int J Environ Res Public Health. 2022;19(4):2132. https://doi.org/10.3390/ijerph19042132

5. Liang X, Li R, Wong SHS, Sum RKW, Sit CHP. The impact of exercise interventions concerning executive functions of children and adolescents with attention-deficit/hyperactive disorder: a systematic review and meta-analysis. Int J Behav Nutr Phys Act. 2021;18(1):68. https://doi.org/10.1186/s12966-021-01135-6

6. Song Y, Fan B, Wang C, Yu H. Meta-analysis of the effects of physical activity on executive function in children and adolescents with attention deficit hyperactivity disorder. PLoS ONE. 2023;18(8):e0289732. https://doi.org/10.1371/journal.pone.0289732

7. Ouyang J, Hu Y, Xia Y, Sheng Y. Effects of Six Types of Exercise Interventions on Inhibitory Control, Executive Function, and Gross Motor Skills in Children with ADHD: A Network Meta-Analysis of 26 Randomized Controlled Trials. Brain Behav. 2025;15:e71069. https://doi.org/10.1002/brb3.71069

8. Chan YS, Cheng CP, Li TM, et al. Effects of physical exercise on attention and executive functions in children with ADHD: an updated systematic review and meta-analysis. Biomed J. 2022;45(2):265-270. https://doi.org/10.1016/j.bj.2021.11.011

9. Song MK, Lauseng D, Lee S, Nordstrom M, Katch V. Enhanced Physical Activity Improves Selected Outcomes in Children With ADHD: Systematic Review. West J Nurs Res. 2016;38(9):1155-1184. https://doi.org/10.1177/0193945916649954

10. Zang Y. Impact of physical exercise on children with attention deficit hyperactivity disorders: evidence through a meta-analysis. Medicine. 2019;98(46):e17980. https://doi.org/10.1097/MD.0000000000017980

11. Wang C, Li R, Wong SHS, Sum RKW, Sit CHP. Effects of exercise on inhibitory function in children and adolescents with ADHD: a systematic review and meta-analysis. Int J Environ Res Public Health. 2023;20(2):1032. https://doi.org/10.3390/ijerph20021032

12. Zhang L, Li X. Effect of vigorous-intensity exercise on the working memory and inhibitory control among children with attention deficit hyperactivity disorder: a systematic review and meta-analysis. Ital J Pediatr. 2025;51(1):104. https://doi.org/10.1186/s13052-025-01924-w

13. Zhao L, Lu H, Yang Q, Zhang D. Intervention effect of a single exercise session on executive function in children and adolescents with attention deficit hyperactivity disorder: a three-level meta-analysis. BMC Pediatr. 2025;25(1):519. https://doi.org/10.1186/s12887-025-05846-8

14. Zhu F, Zhu X, Bi X, et al. Comparative effectiveness of various physical exercise interventions on executive functions and related symptoms in children and adolescents with ADHD: A systematic review and network meta-analysis. Front Public Health. 2023;11:1133727. https://doi.org/10.3389/fpubh.2023.1133727

15. Liu B, Zhang X, Li Y, et al. Effects of exercise interventions on inhibitory control and working memory in children with ADHD: a meta-analysis of randomized controlled trials. BMC Public Health. 2025;25:3265. https://doi.org/10.1186/s12889-025-24335-2

16. Peng J, Wang W, Wang Y, Hu F, Jia M. Effects of mind-body exercise on individuals with ADHD: a systematic review and meta-analysis. Front Psychiatry. 2024;15:1490708. https://doi.org/10.3389/fpsyt.2024.1490708

17. Grahn M. Children with ADHD and ASD in organized physical activity: a qualitative meta-synthesis. Int J Qual Stud Health Well-being. 2025;20:2524460. https://doi.org/10.1080/17482631.2025.2524460

18. Poon ETC, Wongpipit W, Sun F, Tse ACY, Sit CHP. High-intensity interval training in children and adolescents with special educational needs: a systematic review and narrative synthesis. Int J Behav Nutr Phys Act. 2023;20(1):13. https://doi.org/10.1186/s12966-023-01421-5

19. Sun JL, Chaw XJ, Fresnoza S, Kuo HI. Effects of virtual reality-based exercise intervention in young people with attention-deficit/hyperactivity disorder: a systematic review. J Neuroeng Rehabil. 2025;22(1):139. https://doi.org/10.1186/s12984-025-01671-3

20. Caponnetto P, Casu M, Amato M, et al. The Effects of Physical Exercise on Mental Health: From Cognitive Improvements to Risk of Addiction. Int J Environ Res Public Health. 2021;18(24):13384. https://doi.org/10.3390/ijerph182413384

21. Wang C, You Y, Zhou J. The impact of long-term exercise on motor skills in children with ADHD: a three-level meta-analysis. BMC Pediatr. 2025;25(1):497. https://doi.org/10.1186/s12887-025-05857-5

22. Lelong M, Zysset A, Nievergelt M, et al. How effective is fine motor training in children with ADHD? A scoping review. BMC Pediatr. 2021;21(1):490. https://doi.org/10.1186/s12887-021-02916-5

23. 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(1):48. https://doi.org/10.1186/s13052-023-01456-1

24. Lee YC, Chen CR, Lin KC. Effects of Mindfulness-Based Interventions in Children and Adolescents with ADHD: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Int J Environ Res Public Health. 2022;19(22):15198. https://doi.org/10.3390/ijerph192215198

25. Wanni Arachchige Dona S, Badloe N, Sciberras E, Gold L, Coghill D, Le HND. The Impact of Childhood Attention-Deficit/Hyperactivity Disorder (ADHD) on Children's Health-Related Quality of Life: A Systematic Review and Meta-Analysis. J Atten Disord. 2023;27(6):598-611. https://doi.org/10.1177/10870547231155438