

Physical activity as a modulator of hyperactivity and calmness in children with ADHD: a narrative literature review

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Abstract

The aim of this study was to conduct a narrative literature review and synthesize the latest research from 2023-2026 on the role of physical activity in modulating attention-deficit/hyperactivity disorder (ADHD) symptoms and promoting calmness in children with ADHD. Searches were conducted in the PubMed, Scopus, Web of Science, PsycINFO, and SPORTDiscus databases. Empirical and review publications in child psychiatry, neuropsychology, physical activity science, and public health, covering the population of children diagnosed with ADHD, were analyzed. Both individual forms of physical activity and structured exercise programs were included, including aerobic exercise, coordination training, and activities requiring self-control and discipline, such as taekwondo. Their associations with hyperactivity, impulsivity, inhibitory control, attention, self-regulation, and ability to achieve calmness were assessed. Available evidence suggests that regular physical activity can positively impact executive function, reduce impulsivity, and alleviate symptoms of hyperactivity. The most consistent results concern improvements in inhibitory control, attention, and arousal regulation. Structured forms of exercise seem particularly promising because they combine motor engagement with elements of cognitive control. These results suggest that physical activity may be an important adjunct to therapy for children with ADHD, but future research is needed to precisely determine the optimal type, intensity, and duration of intervention.

Keywords: emotional regulation, executive function, self-control, exercise, child

Introduction

Attention deficit/hyperactivity disorder (ADHD) in children is a neurodevelopmental disorder. The clinical presentation includes difficulties with concentration, impulsivity, and hyperactivity, which can significantly impair the child's functioning in school, family, and peer environments. Hyperactivity and difficulty achieving a state of calmness are significant, which impedes behavioral control, emotion regulation, and effective participation in daily activities. Contemporary approaches to ADHD emphasize the role of executive function disorders, particularly inhibitory control, working memory, and self-regulation, as mechanisms underlying some of the difficulties observed in children with this diagnosis [1,2].

In recent years, there has been growing interest in the use of physical activity as a non-pharmacological or adjunctive component of ADHD therapy. This stems from the assumption that regular physical activity can affect not only a child's overall performance but also cognitive

and emotional processes crucial for behavioral control [2-4]. Positive effects of physical activity are also observed in symptoms related to impulsivity, hyperarousal, and difficulties with self-control [1,2].

A significant body of research suggests that physical activity may play an important role in modulating the processes responsible for calming children with ADHD, while scientific literature more often describes this phenomenon using terms such as emotion regulation, inhibitory control, reduced arousal, or improved executive functions. In this context, particularly important are the research findings demonstrating that physical exercise can improve inhibitory control and working memory, areas closely related to the ability to inhibit responses, reduce hyperactivity, and improve behavioral organization [1,4,5]. Physical activity may promote improved emotion regulation and reduce symptoms of anxiety and low mood in children with ADHD, further reinforcing its potential role in achieving greater calmness and psychomotor stabilization [6,7].

The effectiveness of exercise interventions may depend on the type of activity undertaken. Cognitively engaging exercises may be beneficial, i.e. those that, in addition to movement, require planning, response inhibition, coordination, and ongoing adjustment of behavior to the task. Exercises combining motor and cognitive components may provide more complex benefits than activities that solely promote general development [8-11].

Research indicates that the impact of physical activity on children with ADHD is not limited to core symptoms. The relationships between exercise and sleep, psychological well-being, resilience, school functioning, and behavioral health are also important. This is clinically significant because difficulties in calming children with ADHD rarely occur in isolation and are usually accompanied by emotion regulation disorders, tension, sleep problems, or impaired behavioral control. Therefore, physical activity can be considered not only as a way to reduce hyperactivity but also as a factor supporting the child's broader psychophysical self-regulation [6,12-14].

Aim of the work

The aim of the study is to provide a narrative review of scientific literature from 2023-2026 regarding the impact of physical activity on the severity of hyperactivity symptoms and self-regulatory processes in children with ADHD, with particular emphasis on emotional regulation, inhibitory control, and executive functions.

Methods

This work is a narrative literature review. A search for publications was conducted in the PubMed, Scopus, and Web of Science databases, covering the years 2023-2026. Study selection was based on the PICO model. The analysis included publications on children and adolescents with ADHD that assessed the impact of physical activity or exercise interventions on the severity of hyperactivity symptoms and indicators of self-regulation, including emotion regulation, inhibitory control, and executive functions.

Original studies, randomized controlled trials, observational studies, systematic reviews, and meta-analyses were included. Publications that focused exclusively on adults, papers unrelated to physical activity or exercise, study protocols, duplicates, and publications with unverifiable bibliographic data were excluded, as were studies whose endpoints did not address ADHD symptoms, executive function, self-regulation, emotion regulation, sleep, or cognitive or behavioral functioning.

The process of identifying, selecting, and including publications was illustrated using a simplified flow diagram inspired by the PRISMA 2020 guidelines (Figure 1). Given the narrative nature of the review, the flow diagram was used to organize the literature selection process and does not imply that the study constitutes a full systematic review.

A total of 35 publications consistent with the thematic scope of the study were included in the narrative synthesis. The analysis was descriptive and analytical in nature. The results were organized thematically, taking into account the main areas of impact of physical activity on children with ADHD: psychomotor hyperactivity, impulsivity, self-regulation, emotion regulation, executive functions, attention, working memory, sleep, and psychosocial functioning. Due to the heterogeneity of the studies, including differences in intervention types, duration, intensity, populations, and measurement tools used, a quantitative synthesis of the results was not conducted.

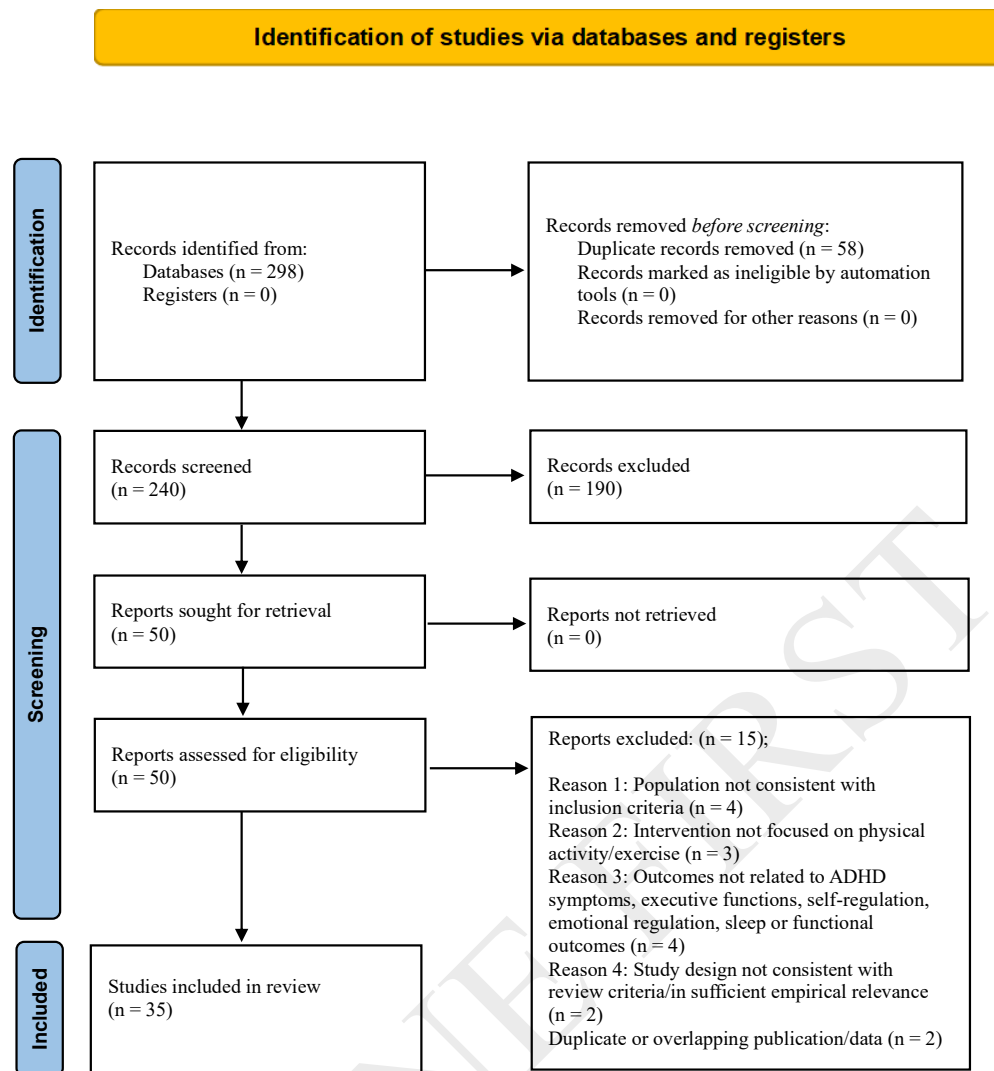


Figure 1. Simplified publication flow diagram inspired by the PRISMA 2020 guidelines

Notes: The diagram shows the process of identification, selection, full-text assessment, and inclusion of publications in the narrative synthesis

Literature review results

ADHD in children – characteristics of the problem

ADHD is a neurodevelopmental disorder, and its clinical presentation includes attention deficits, hyperactivity, and impulsivity, which can impact a child's functioning in school, family, and peer environments. Contemporary understanding of ADHD emphasizes deficits in self-regulation, inhibitory control, working memory, and other executive functions [1,2,5].

Hyperactivity in children with ADHD may be interpreted as a manifestation of difficulties modulating arousal and controlling responses to stimuli. These deficits impede

participation in school activities, performing tasks requiring concentration, and maintaining stable social relationships. Emotional difficulties (irritability, anxiety symptoms, depressive symptoms, emotion regulation disorders) are a significant aspect of the functioning of children with ADHD. These difficulties can exacerbate problems with concentration, impulsivity, and arousal regulation, limiting the child's ability to achieve a state of calmness. Therefore, current research in children with ADHD examines not only the core symptoms of the disorder but also executive functions, working memory, sleep quality, resilience, emotion regulation, and academic functioning [6,7,15,16]. Physical activity is a promising area of supportive intervention because it can influence neuropsychological mechanisms related to inhibitory control, attention, working memory, and emotional regulation [8-11,17,18].

Mechanisms of the possible influence of physical activity on ADHD symptoms

The potential impact of physical activity on ADHD symptoms in children should be considered from a multifactorial perspective, encompassing neurobiological, cognitive, emotional, and behavioral mechanisms. Literature indicates that regular, appropriately tailored physical activity can impact areas particularly important in the clinical picture of ADHD (inhibitory control, attention, working memory, emotion regulation, and level of psychomotor arousal). These mechanisms should be considered plausible and postulated, as the strength of the observed effects may depend on the type of activity, exercise intensity, program duration, participants' age, and their clinical profile [1,2,4].

One area under analysis is the impact of physical activity on executive functions. In children with ADHD, deficits in these functions are associated with difficulties in inhibiting reactions, planning actions, maintaining attention, and controlling impulsivity. Research suggests that physical activity, especially when conducted regularly and in a structured manner, can improve the efficiency of executive processes, which may translate into better behavioral organization, greater reaction control, and reduced hyperactivity and impulsivity [5,14,19]. Inhibitory control is particularly important, as this component is directly related to impulsivity and difficulty suppressing inappropriate reactions [1,20,21].

An important mechanism is the regulation of psychomotor arousal. Children with ADHD often experience difficulty adjusting their level of activation to situational demands (hyperactivity, psychomotor restlessness). Physical activity may be a potential factor modulating arousal and psychophysical tension. In this perspective, exercise is not merely a

form of “energy release” but can support processes responsible for behavioral stabilization and better adaptation of responses to environmental demands [3,12].

Another area is emotion regulation. In children with ADHD, emotional difficulties (excessive reactivity, low frustration tolerance, and difficulties in tension regulation) can exacerbate behavioral problems and hinder behavioral control. In this context, physical activity can support self-regulation not only by influencing cognitive processes but also by potentially contributing to emotional stabilization, reducing stress, and improving mental resilience [6,7,15].

The type of activity undertaken may be important. Interventions that engage motor and cognitive components are interesting (coordination training, complex exercises, exergaming, cognitive-motor programs, digital-motor interventions) [8,9,11]. Such activities require monitoring one’s responses, selective attention to stimuli, quickly adapting behavior, and maintaining concentration, thus potentially engaging motor and cognitive control processes simultaneously.

Physical activity can also impact attention and working memory, processes crucial to the daily functioning of children with ADHD. Improvements in these areas may indirectly promote better behavioral control, as the child is more effective at maintaining goal setting, processing information more efficiently, and inhibiting distracting stimuli more easily. Studies on aerobic exercise, coordination programs, and mixed interventions suggest possible improvements in working memory and sustained attention following exercise interventions [10,22-24].

Indirect mechanisms, such as sleep quality, psychological well-being, and behavioral functioning, should also be considered. Sleep disturbances, fatigue, reduced stress tolerance, and adaptive difficulties can exacerbate ADHD symptoms. Physical activity has a beneficial effect on sleep, reduced psychological tension, and overall well-being, and its secondary effects may include reduced hyperactivity and improved self-regulation [16,25,26].

Types of physical activity analyzed in studies

Studies on children with ADHD include diverse forms of physical activity, varying in structure, intensity, duration, implementation setting, and the degree of cognitive engagement. The interventions analyzed include aerobic exercise, coordination and complex exercises, cognitive-motor interventions, exergaming and technology-assisted activity, mixed programs, and structured sports activities. Individual forms of exercise may impact different aspects of

functioning in children with ADHD, but due to the heterogeneity of studies, comparing their effectiveness requires caution [2,12,14].

The most frequently analyzed group of interventions is aerobic exercise (running, walking, brisk walking, cycling, and general developmental exercises). Studies have linked these interventions to improved attention, working memory, inhibitory control, and overall cognitive functioning. Their advantage is ease of implementation in school and home environments, while effectiveness may depend on the frequency, intensity, duration of the program, and regularity of participation [4,20].

The second category comprises coordination exercises and complex movements requiring precision, motor control, and organization of action (tasks involving balance, movement rhythmization, visuomotor coordination, sequencing of actions, and rapid response to changing stimuli). These types of activities, in addition to their motor component, engage attention, planning, action monitoring, and reaction inhibition. Therefore, they may promote the improvement of selected executive functions and behavioral control, although their extent of advantage over simpler forms of activity requires further research [14,17].

Cognitive-motor interventions, i.e. programs combining physical activity with simultaneous cognitive load (tasks requiring concentration, stimulus selection, responding to instructions, decision-making, movement planning, and monitoring of performance accuracy), are important. These interventions directly engage processes often impaired in children with ADHD, particularly inhibitory control, attention, and working memory. Previous research suggests their potential usefulness in improving self-regulation and reducing impulsivity, but due to differences in protocols, a single optimal model for such training cannot be identified [9,11].

Technology-assisted forms of activity (exergaming, digital-motor programs) are frequently analyzed. Exergaming combines physical activity with an interactive digital environment, which may increase the attractiveness of the intervention and promote child engagement. Such activities can simultaneously engage attention, responsiveness, behavioral control, and motor coordination. Previous results indicate a possible improvement in selected aspects of cognitive functioning, particularly attention, and good acceptability of this form of intervention, but the number of studies in this area remains limited [8,18].

Another category comprises mixed programs, combining several types of physical activity in a single intervention (aerobic, coordination, strength, balance, general development, and cognitive-motor exercises). Their potential advantage is their multifaceted impact on physical fitness, cognitive functions, and behavioral control. At the same time, it is more

difficult to determine which program component is responsible for the observed effect, therefore, the results of mixed programs should be interpreted as the effect of the entire intervention, not a single type of exercise [24,27].

Some studies also analyzed structured sports and training activities (taekwondo, jump rope exercises, programs focused on specific motor skills). Their common characteristics include repetition, predictable structure, and the need to follow specific rules. Studies indicate possible benefits in attention, working memory, motor skills, and behavioral control, but conclusions should be drawn with caution due to differences in the intensity, duration, and scope of cognitive engagement of individual interventions [10,28] (Table 1).

Table 1. Types of physical activity analyzed in studies on children with ADHD

Type of physical activity	Characteristics of the intervention	Analyzed areas of functioning	References
Aerobic exercise	Running, walking, brisk walking, cycling, general physical exercises, moderate or high intensity training	Attention, working memory, inhibitory control, general cognitive functioning, arousal regulation	[4,9,20]
Coordination exercises and complex movements	Exercises requiring balance, visuomotor coordination, rhythmic movement, movement sequencing, and rapid responses to stimuli	Executive functions, behavioral control, organization of action, impulsivity, motor skills	[1,17,27]
Cognitive-motor interventions	Programs combining physical activity with tasks requiring concentration, planning, stimulus selection, decision-making, and reaction control	Inhibitory control, attention, working memory, self-regulation, core symptoms of ADHD	[9,11,24]
Exergaming and technology-assisted activity	Interactive forms of movement using digital games, virtual environments, or mobile technologies, often combining movement with cognitive stimuli	Attention, reaction time, behavior control, child engagement, acceptability of intervention	[8,18,32,33]
Mixed programs	Interventions combining various forms of exercise, e.g. aerobic, coordination, strength, balance, general conditioning, and cognitive-motor exercises	Executive functions, working memory, self-regulation, physical fitness, behavioral control	[24,29,35]
Strength and power exercises	Training focused on muscle strength, power, motor skills, and functional muscle strength	Motor skills, muscle strength, motor functionality	[27,30]

Type of physical activity	Characteristics of the intervention	Analyzed areas of functioning	References
Structured sports activities	Activities with a defined structure and rules, such as taekwondo, jump rope exercises, or other sports programs that require discipline and movement control	Attention, working memory, behavioral control, motor skills, self-regulation	[10,28]
Short-term activities/acute effects	Single or short sessions of activity, e.g. walking, standing, or short-term exertion assessed immediately after completion	Short-term changes in executive function, attention, and arousal levels; limited ability to assess the durability of effects	[34]
Physical activity within the framework of 24-hour movement behavior	Analysis of compliance with recommendations regarding exercise, sleep, and sedentary behavior during the day	Behavioral health, ADHD symptoms, school functioning, mental well-being	[25,31]

Influence of physical activity on psychomotor hyperactivity

Hyperactivity, difficulty maintaining composure, and impulsivity are key components of the clinical picture of ADHD, impeding functioning in school, home, and social environments. Current research suggests that physical activity may play a role in modulating these symptoms, although the magnitude of the effect depends on the type of intervention, its duration, intensity, and method of outcome assessment [2,13,29]. Exercise interventions may promote improvement in the core symptoms of ADHD (hyperactivity and impulsivity). Some studies focus primarily on executive functions, attention, and inhibitory control, and improving these areas may indirectly translate into better behavioral control and reduced excessive motor responses [1,2,5,19].

Inhibitory control is particularly important because it is directly related to impulsivity and difficulty suppressing inappropriate responses. Physical activity, especially when conducted regularly and in a structured manner, can support processes responsible for behavior regulation; therefore, its effect on hyperactivity should be understood as a potential effect of improving self-control mechanisms [1,20,21].

The type of activity undertaken may be important. Interventions that simultaneously engage motor and cognitive components (coordination training, exergaming, cognitive-motor programs) may better activate processes responsible for reaction control, concentration, and organization of action. Therefore, they are considered promising in reducing impulsivity and

improving self-regulation, but their advantage over simpler forms of exercise requires further confirmation [8,9,11]. Aerobic exercise may also be useful due to its availability and possible beneficial relationship with arousal regulation, attention, and general behavioral control [4,20].

It is worth emphasizing that the reduction of psychomotor hyperactivity is not always assessed directly in studies. Many publications analyze changes in impulsivity, inhibitory control, executive functions, or attention, which are treated as indicators indirectly related to hyperactivity. This interpretation is justified but requires caution in drawing conclusions and indicates the need for further research using direct measures of psychomotor hyperactivity [6,13,22]. The effect of physical activity on hyperactivity may also be partially related to improved emotion regulation and psychological well-being, as emotional tension, frustration, and difficulties coping with environmental stimuli can exacerbate impulsivity and excessive motor activity [6,7,15].

Impact of physical activity on calmness, self-regulation, and emotional regulation

Physical activity can support self-regulation in children with ADHD, understood as the ability to control behavior, emotions, and arousal levels. This is important because ADHD difficulties also include impulsivity, emotional lability, and difficulty achieving a state of relative calmness. In research, the concept of “calmness” is rarely used as a distinct operational category; it is more often conceptualized indirectly through inhibitory control, emotion regulation, arousal modulation, and executive functions [1,6,13].

Available research suggests that physical activity can promote improved impulse control, response delay, and adapting behavior to situational demands [1,2,19]. In this context, its impact on calmness should not be understood as a simple “energy release” but as a possible effect of improving behavioral control mechanisms. Activities that simultaneously engage motor and cognitive components may be particularly important, as they require concentration, stimulus selection, response monitoring, and impulse inhibition [8,9,11].

Emotion regulation also remains an important area. In children with ADHD, increased emotional reactivity, low frustration tolerance, and difficulties in tension regulation may exacerbate hyperactivity and impulsivity. Physical activity may indirectly support emotional stabilization, reduction of tension, and improve psychological well-being, which promotes better behavioral control [6,7,15].

Indirect effects related to improved sleep, reduced fatigue, and improved school performance are also possible [16,25,26]. However, assessing the impact of physical activity

on calmness and self-regulation remains methodologically complex. Self-regulation is a multidimensional construct, and individual studies operationalize it differently, limiting the possibility of direct comparison of results. Therefore, conclusions regarding “calmness” should be formulated cautiously and based on more standardized assessment tools [1,6,13].

Factors influencing the effectiveness of intervention

The effectiveness of physical activity-based interventions for children with ADHD may depend on many interrelated factors, including both program characteristics and participant characteristics. Physical activity is not a homogeneous intervention; therefore, its potential impact on hyperactivity, self-regulation, executive functions, and emotion regulation may vary depending on the type of exercise, intensity, duration, frequency, degree of structure, and level of cognitive engagement [2,17,29].

The nature of the exercise intervention is an important factor. Current research suggests that programs combining motor and cognitive components are particularly effective because they can more strongly engage executive processes responsible for organizing behavior, concentration, and impulse inhibition [8,9,11]. A separate group comprises interventions focused on motor skills and muscle strength, including power exercises and traditional strength exercises, analyzed primarily in the context of motor functioning and physical fitness in children with ADHD [30]. Simpler forms of exercise can also contribute to improving attention, arousal regulation, and overall cognitive functioning, especially when implemented systematically and adapted to the child’s abilities [4,20].

The intensity, duration, and frequency of exercise may be important. Some studies indicate that moderate or higher intensity exercise may be associated with improved working memory, inhibitory control, and cognitive functioning, but the optimal intensity level is not clearly defined [20]. Excessive exercise intensity may limit motivation, increase fatigue, or hinder regular participation. Therefore, the selection of intensity should take into account the child’s age, physical fitness, and individual functioning profile. Similarly, regularity and longer program duration may promote more stable effects than single sessions, although available studies vary in terms of intervention length and outcome assessment [22,29,31].

Another factor is the degree of program structure. Children with ADHD often function better under conditions of clear rules, predictable organization, and repetitive activities. Therefore, structured, sequential interventions with clearly established rules may promote sustained attention, behavioral organization, and reduced impulsive reactions [10,28].

Participant characteristics, such as age, severity of ADHD symptoms, predominant difficulty profile, motor skill level, and co-occurring emotional problems, may also influence the effects of interventions. Children with predominant hyperactivity and impulsivity may respond to interventions differently than those with predominant attentional or emotional difficulties. Therefore, movement-based programs should be considered individualized interventions [2,12].

The program implementation environment and supportive environment may be crucial. School-based interventions can more easily fit into a child's daily routine and support functioning in educational settings. Digital and mobile programs, in turn, may increase the accessibility of interventions and enable the adaptation of exercises to the child's individual abilities [8,9,18,32]. Parental or guardian involvement can additionally promote regularity, motivation, and the transfer of intervention effects to daily functioning [33].

Evaluation of effectiveness depends on the selected endpoints. Some studies directly examine ADHD symptoms such as mobility and impulsivity, while others focus on attention, working memory, inhibitory control, executive functions, sleep, or emotion regulation. These differences make it difficult to compare results and identify the most effective type of physical activity [1,6,13].

Considering the heterogeneity of interventions and the factors influencing their effectiveness, Table 2 summarizes the main conclusions and practical recommendations regarding the use of physical activity in children with ADHD, with reference to the literature discussed in this review.

Table 2. Main conclusions and recommendations regarding the use of physical activity in children with ADHD with reference to the literature

Area	Key findings	Practical recommendations	References
Physical activity as an element of support for ADHD	Physical activity can support the functioning of children with ADHD, particularly in the areas of hyperactivity, impulsivity, executive function, and self-regulation. It should not be considered a standalone treatment for ADHD.	Include physical activity as a complement to a comprehensive support model that includes family, school, psychoeducation, behavioral interventions, and, if indicated, pharmacological treatment.	[3,12,29]
Executive functions and inhibitory control	The most consistent results relate to improvements in inhibitory control, attention, and working memory. Improving these processes	Prefer activities that require concentration, planning, responding to rules, and inhibiting reactions, e.g. coordination exercises, cognitive-motor	[1,5,13,21,35]

	may indirectly reduce impulsivity and hyperactivity.	exercises, or selected sports activities.	
Calmness and self-regulation	“Calmness” is rarely a self-measured endpoint. It is most often captured indirectly through self-regulation, inhibitory control, arousal regulation, emotional stabilization, and impulsivity reduction.	Use programs that are predictable, regular and adapted to the child’s abilities; avoid programs that are chaotic, overly demanding, or inappropriate to the child’s difficulty profile.	[1,6,7,13]
Emotion regulation and psychological well-being	Physical activity can support emotion regulation, tension reduction, mental resilience, and overall well-being, which may indirectly improve behavioral control.	Include activities that promote predictability, a sense of competence, and reduced tension, especially in children with severe emotional difficulties.	[6,7,15]
Type of physical activity	Interventions combining motor and cognitive components seem particularly promising, although current data do not allow us to indicate one optimal form of activity for all children with ADHD.	Select the activity according to the child’s profile: in the case of hyperactivity – exercises with rules and reaction control; in the case of attention deficits – tasks that involve concentration; in the case of emotional tension – predictable forms that strengthen the sense of agency.	[1,2,9,11,17]
Aerobic exercise	Aerobic exercise may be associated with improved attention, working memory, inhibitory control, arousal regulation, and overall cognitive functioning.	Use easily accessible forms of exercise, such as walking, running, cycling, or general physical exercises, especially in school and home environments.	[4,20,22]
Cognitive-motor and coordination interventions	Programs that simultaneously engage movement, attention, planning, and response inhibition may particularly support executive functions and self-regulation.	Include coordination exercises, sequential tasks, activities with rules, exercises requiring quick reactions, and adapting behavior to changing stimuli.	[9,11,24,17]
Exergaming and digital programs	Exergaming, mobile programs, and digital-movement interventions may enhance exercise appeal and engage attention, reaction speed, and behavioral control but require further validation.	Use technology to complement physical activity, especially when it improves motivation and accessibility, while also controlling screen time and program quality.	[8,9,18,32]
Sports and training activities	Structured sports activities such as taekwondo, jump rope exercises, power-based exercises, or motor skills training can support attention, working memory, behavioral control, and physical fitness.	Choose activities with clear rules, a repeatable structure, and possible degree of program structuring; avoid excessive emphasis on athletic performance.	[10,27,28,30]
Regularity, intensity and	The effects of interventions may depend on the regularity, intensity, duration, frequency,	Plan programs that are short, repeatable, realistic, and sustainable; adjust the intensity to	[2,17,20,29]

structure of the program	and degree of program structure. However, the optimal model is not clearly defined.	the child's age, fitness level, and exercise tolerance.	
Implementation environment and family support	School, home, and digital environments can play different roles in implementing physical activity. Family support can promote regularity and transfer the benefits into daily life.	Involve parents, teachers, and specialists in activity planning. At school, incorporate short, regular exercise breaks or structured exercises; at home, reinforce routines and motivation.	[25,31,33,34]
Limitations of the current evidence	The available studies are heterogeneous, often including small samples, short follow-up periods, different measurement tools, and intermediate outcome measures.	Formulate recommendations with caution; do not present physical activity as an intervention with equal effectiveness for all children with ADHD.	[3,13,17,29]
Directions for further research	Larger randomized controlled trials, longer follow-up periods, and more standardized outcome measures, including direct assessment of hyperactivity, impulsivity, self-regulation, and emotion regulation are needed.	Design studies that compare different types of activity, intensity, frequency, and duration of interventions and analyze which profiles of children benefit the most.	[1,13,29,35]

The recommendations presented in Table 2 should be interpreted with caution, as available studies vary in terms of intervention type, duration, intensity, age of participants, and assessment tools used. Physical activity can be considered as a supportive measure for children with ADHD, but its practical implementation should be individualized and integrated into a broader model of support.

Limitations of available research

This review identifies a number of limitations that hinder a clear assessment of the effectiveness of interventions regarding the impact of physical activity on the functioning of children with ADHD. The most important problem remains the heterogeneity of studies, including differences in populations, types of physical activity, program duration, exercise intensity, session frequency, and methods of effect assessment. These differences limit the ability to directly compare results and draw clear conclusions regarding the optimal intervention model [2,17,29].

One limitation is the heterogeneity of the analyzed exercise programs [4,8,9]. Individual programs differed in structure, session length, number of sessions per week, and total duration. It is difficult to determine whether the observed benefits result from physical activity itself or from specific features of a particular program. The diversity of measurement tools and endpoints remains a problem. Some studies directly assessed symptoms of hyperactivity and impulsivity, while others focused on executive functions, attention, working memory, emotion regulation, sleep, or general psychosocial functioning [1,6,13].

Concepts such as “calmness”, “self-regulation”, or “improved functioning” are sometimes operationalized differently. Some conclusions regarding the effects of physical activity on hyperactivity and self-regulation are based on indirect measures (inhibitory control, working memory) rather than direct measurement of the child’s behavior. Such interpretation requires methodological caution [13,19,22].

Another limitation is the small sample size in some intervention studies. Small study groups limit the statistical power of analyses, hinder generalization of results, and increase the risk of sample-specific effects [8,10,15]. This problem is significant in pilot studies and preliminary analyses of newer forms of intervention, which, despite promising results, require further validation in larger and better-controlled trials [9,11,18]. Some studies analyze acute effects (after short forms of activity), which provides data on immediate cognitive responses but is of limited value for assessing the long-term effectiveness of the program [34].

The heterogeneity of the participant population also influences the interpretation of results. Studies include children of different ages, with varying symptom severity, different profiles of cognitive and emotional difficulties, and sometimes with different pharmacological treatment status or co-occurring developmental and behavioral difficulties [2,12]. These factors may modify a child’s response to physical activity but are not always sufficiently controlled. Consequently, it is difficult to determine which groups of children may benefit most from specific forms of intervention.

The scarcity of long-term studies remains a limitation. Although some publications indicate beneficial effects of exercise interventions immediately after their completion, the sustainability of these changes in the long term is much less frequently analyzed [20,26]. This is important from the perspective of clinical, educational, and family practice, as the actual usefulness of interventions depends not only on short-term effects but also on their sustainability.

Another limitation is the uneven methodological quality of the available studies [1,6,13,35]. Not all studies use the same diagnostic criteria, randomization, control groups, or

standardized measurement procedures. Consequently, the strength of evidence varies, and the results of studies with limited control of confounding variables should be interpreted with caution [3,29].

Practical implications

Physical activity can be considered as a supportive element in the functioning of children with ADHD, particularly in the areas of hyperactivity, self-regulation, inhibitory control, attention, and emotion regulation. It should not be treated as an alternative to standard forms of treatment (psychoeducational and behavioral interventions, school support, pharmacological treatment). It is more appropriate to consider it as a component of a comprehensive support model that can complement existing therapeutic and educational interventions [3,12,29].

From a practical perspective, regular, structured interventions tailored to the child's abilities are particularly important. Physical activity programs should have a clearly defined course, predictable rules, appropriately selected intensity, and a graduated level of difficulty. This is important because children with ADHD often function better in structured conditions that facilitate anticipation of subsequent steps, maintenance of attention, and reaction control. Interventions that are chaotic, excessively intense, or inappropriate to the child's level of ability can limit motivation and hinder systematic participation [2,10,28].

Activities that engage both motor and cognitive components may be particularly useful (coordination exercises, tasks requiring rapid response to stimuli, cognitive-motor programs, selected forms of martial arts, exergaming, digital-motor interventions). Such activities can support attention, inhibitory control, organization of behavior, and self-regulation, as they require concentration, planning, stimulus selection, and adapting behavior to task rules [8,9,11,18]. However, this does not mean that simple forms of activity (walking, running, cycling, general physical exercises) are without value. They may be easier to implement in school and home environments and may be beneficially associated with attention, arousal regulation, and overall cognitive functioning [4,20].

A significant practical implication is the need to individualize a physical activity program. The selection of activities should take into account the child's age, symptom severity, predominant difficulty profile, motor skill level, motivation, and the presence of coexisting emotional or behavioral problems. Children with predominant hyperactivity and impulsivity may benefit from forms of exercise that require inhibition of reactions and compliance with

rules. Children with attention difficulties may benefit from exercises that engage cognitive control, while children with increased emotional tension should benefit from predictable activities that enhance a sense of competence and promote tension reduction [6,7,15].

The environment in which the intervention is implemented is crucial. School can be a natural setting for implementing short, regular forms of physical activity, especially when they are incorporated into the daily routine and do not require specialized equipment. Home-based, mobile, and digital programs can increase the accessibility and attractiveness of interventions, especially when the family supports regular exercise. Exergaming and digital-motor solutions can be useful for increasing child engagement, but they should be used in a controlled manner and tailored to the child's needs [8,9,32,34]. From a family perspective, it is important that physical activity be incorporated into a daily routine and not treated as a one-time intervention. Parents and caregivers can support children by establishing predictable activity times, choosing forms of exercise consistent with the child's preferences, fostering engagement, and avoiding excessive pressure on athletic performance. Strengthening the sense of agency and competence may be particularly important, as negative experiences associated with physical activity may reduce motivation for further participation [19,25,33].

The practical application of physical activity requires caution in interpreting its effects. It should not be assumed that every form of activity affects all ADHD symptoms to the same degree. Evaluation of effects should take into account specific intervention goals (reducing impulsivity, improving concentration, better emotion regulation, reducing psychomotor tension, improving school functioning). In clinical and educational practice, it is advisable to monitor behavioral symptoms and the child's functioning in everyday situations [1,13,35].

When implementing physical activity as a support tool for children with ADHD, it is important to consider the program's safety and acceptability. Exercises should be tailored to the child's age, health, fitness level, and psychophysical abilities. Consultation with a specialist is recommended for comorbidities, significant motor limitations, or severe emotional difficulties. The program should be gradual, realistic, and sustainable in the long term, as overly demanding interventions can lead to withdrawal, overload, or a negative attitude toward physical activity [12,29,30].

Conclusions

Physical activity can be a valuable element supporting the functioning of children with ADHD, particularly in the areas of hyperactivity, impulsivity, inhibitory control, self-regulation, and emotion regulation. Regular, structured programs tailored to the child's abilities seem justified, especially when combining a movement component with cognitive demands. Physical activity should not be considered a standalone method of treating ADHD but rather a complement to a comprehensive model of support encompassing family, school, behavioral interventions, and pharmacological treatment [1,3,29].

Caution is warranted when interpreting "calmness", as this concept is rarely directly operationalized in research. Most often, its meaning can be related to self-regulation, inhibitory control, arousal modulation, emotional stabilization, and impulsivity reduction. Therefore, assessing the impact of physical activity on calmness requires the use of more standardized and comparable measurement tools [6,13].

The current state of knowledge does not allow for the identification of a single optimal form of physical activity for all children with ADHD. Further research should include larger samples, longer follow-up periods, more standardized endpoints, and direct comparisons of different types of interventions, their intensity, frequency, and duration [13,17].

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References:

1. Wang M, Yang X, Yu J, Zhu J, Kim HD, Cruz A. Effects of physical activity on inhibitory function in children with attention deficit hyperactivity disorder: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2023; 20(2): 1032. <https://doi.org/10.3390/ijerph20021032>
2. Zhu F, Zhu X, Bi X, Kuang D, Liu B, Zhou J, et al. Comparative effectiveness of various physical exercise interventions on executive functions and related symptoms in children and adolescents with attention deficit hyperactivity disorder: a systematic review and network meta-analysis. *Front Public Health*. 2023; 11: 1133727. <https://doi.org/10.3389/fpubh.2023.1133727>
3. Dastamooz S, Sadeghi-Bahmani D, Farahani MHD, Wong SHS, Yam JCS, Tham CCY, et al. The efficacy of physical exercise interventions on mental health, cognitive function, and ADHD symptoms in children and adolescents with ADHD: an umbrella review. *EClinicalMedicine*. 2023; 62: 102137. <https://doi.org/10.1016/j.eclinm.2023.102137>
4. Yang G, Liu Q, Wang W, Liu W, Li J. Effect of aerobic exercise on the improvement of executive function in children with attention deficit hyperactivity disorder: a systematic review and meta-analysis. *Front Psychol*. 2024; 15: 1376354. <https://doi.org/10.3389/fpsyg.2024.1376354>
5. 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>
6. Song Y, Jia S, Wang X, Wang A, Ma T, Li S, et al. Effects of physical exercise on anxiety depression and emotion regulation in children with attention deficit hyperactivity disorder: a systematic review and meta-analysis. *Front Pediatr*. 2025; 12: 1479615. <https://doi.org/10.3389/fped.2024.1479615>
7. Ontiveros N, Wiklund CA, Ohlss A, Ekblom Ö. The role of physical activity in the association between ADHD and emotional dysregulation. *J Affect Disord*. 2025; 376: 68-75. <https://doi.org/10.1016/j.jad.2025.01.127>
8. Ji H, Wu S, Won J, Weng S, Lee S, Seo S, et al. The effects of exergaming on attention in children with attention deficit/hyperactivity disorder: randomized controlled trial. *JMIR Serious Games*. 2023; 11: e40438. <https://doi.org/10.2196/40438>

9. Zhao L, Agazzi H, Du Y, Meng H, Maku R, Li K, et al. A digital cognitive-physical intervention for attention-deficit/hyperactivity disorder: randomized controlled trial. *J Med Internet Res*. 2024; 26: e55569. <https://doi.org/10.2196/55569>
10. Huang Z, Li L, Lu Y, Meng J, Wu X. Effects of rope skipping exercise on working memory and cardiorespiratory fitness in children with attention deficit hyperactivity disorder. *Front Psychiatry*. 2024; 15: 1381403. <https://doi.org/10.3389/fpsyt.2024.1381403>
11. Zhu FL, Dong ZH, Lu HY, Kuang DQ, Xu BH, Yang L, et al. Integrated cognitive-motor exercise for core symptoms and executive functions in children with attention deficit hyperactivity disorder: a randomized clinical trial. *World J Pediatr*. 2026; 22: 435-450. <https://doi.org/10.1007/s12519-026-01019-4>
12. Martín-Rodríguez A, Herrero-Roldán S, Clemente-Suárez VJ. The role of physical activity in ADHD management: diagnostic, digital and non-digital interventions, and lifespan considerations. *Children (Basel)*. 2025; 12(3): 338. <https://doi.org/10.3390/children12030338>
13. Zhang Z, Bo X, Liu K, Su J, Zhu Y, Yang S. Effects of exercise on hyperactivity/impulsivity and inhibitory control at behavioral and electrophysiological levels in ADHD: a systematic review and meta-analysis. *J Atten Disord*. 2026; 30(5): 677-693. <https://doi.org/10.1177/10870547251404197>
14. Li D, Wang D, Cui W, Yan J, Zang W, Li C. Effects of different physical activity interventions on children with attention-deficit/hyperactivity disorder: a network meta-analysis of randomized controlled trials. *Front Neurosci*. 2023; 17: 1139263. <https://doi.org/10.3389/fnins.2023.1139263>
15. Liang X, Xu RH, Zhao M, Qu L, Shum DHK. Impact of a physical exercise intervention on psychological resilience and mental ill-being in medical-naïve children with attention-deficit/hyperactivity disorder: a pilot randomised controlled trial. *Psychol Health Med*. 2024; 29(10): 1764-1775. <https://doi.org/10.1080/13548506.2024.2407449>
16. González-Devesa D, Sanchez-Lastra MA, Outeda-Monteagudo B, Diz-Gómez JC, Ayán-Pérez C. Effectiveness of exercise on sleep quality in attention deficit hyperactivity disorder: a systematic review and meta-analysis. *Children (Basel)*. 2025; 12(2): 119. <https://doi.org/10.3390/children12020119>
17. 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(12): e71069. <https://doi.org/10.1002/brb3.71069>
18. 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: 139. <https://doi.org/10.1186/s12984-025-01671-3>
19. Li D, Miao C, Wang D, Li C. Effect of physical activity interventions on executive functions in school-age children with ADHD: a meta-analysis of randomized controlled trials. *J Affect Disord.* 2025; 378: 175-190. <https://doi.org/10.1016/j.jad.2025.01.155>
20. Zhang R, Li H. 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: 104. <https://doi.org/10.1186/s13052-025-01924-w>
21. Wang H, Wang S, Cheng G. A multilevel meta-analysis of the effects of exercise interventions on inhibitory control in children with ADHD. *Front Psychiatry.* 2026; 17: 1742882. <https://doi.org/10.3389/fpsy.2026.1742882>
22. Li D, Li L, Zang W, Wang D, Miao C, Li C, et al. Effect of physical activity on attention in school-age children with ADHD: a systematic review and meta-analysis of randomized controlled trials. *Front Physiol.* 2023; 14: 1189443. <https://doi.org/10.3389/fphys.2023.1189443>
23. Cheng G, Song C, Hong X. The impact of physical activity on working memory in children with ADHD: a meta-analysis. *Front Psychiatry.* 2025; 16: 1578614. <https://doi.org/10.3389/fpsy.2025.1578614>
24. He C, Huang H, Guo S, Peng X, Huan M, Shi L, et al. The effects of combined exercise on working memory in children with attention-deficit/hyperactivity disorder: a randomized controlled trial. *J Sci Med Sport.* 2026; 29(2): 177-184. <https://doi.org/10.1016/j.jsams.2025.09.010>
25. Parnes M, Gonzalez E, Tran N, Stein MA, Mendoza J, Tandon P. Adherence to 24-hour movement guidelines and behavioral health in children with attention deficit hyperactivity disorder in the United States. *J Phys Act Health.* 2025; 22(9): 1143-1152. <https://doi.org/10.1123/jpah.2024-0497>
26. Porfirio GB, Bardella MC, Oliani MM, Moraes C. The impact of physical activity on cognitive, behavioral, and academic performance in children with ADHD: a systematic

- review. *Dement. Neuropsychol.* 2026; 20: e20250339. <https://doi.org/10.1590/1980-5764-dn-2025-0339>
27. 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: 497. <https://doi.org/10.1186/s12887-025-05857-5>
28. Song X, Wang D, Wang D, Chen C, Wang Z. The effect of taekwondo structured training on attention in 7-8-year-old children: a randomized controlled trial. *BMC Sports Sci Med Rehabil.* 2026; 18: 130. <https://doi.org/10.1186/s13102-026-01570-7>
29. Zheng R, Huang S, Yang J, Zhao P, Li E. The therapeutic effects of physical activity on children with attention deficit hyperactivity disorder: a systematic review and meta-analysis. *Medicine (Baltimore).* 2025; 104(16): e42063. <https://doi.org/10.1097/MD.00000000000042063>
30. Tascioglu EN, Karademir S, Kara K, Tonak HA, Kara OK. Effectiveness of power exercises compared to traditional strength exercises on motor skills, muscle performance and functional muscle strength of children with attention deficit hyperactivity disorder: a single-blind randomized controlled trial. *Dev Neurorehabil.* 2024; 27(1-2): 17-26. <https://doi.org/10.1080/17518423.2024.2345335>
31. Li J, Chen Y, Herold F, Logan NE, Brown DMY, Haegele JA, et al. Linking 24-hour movement behaviour guidelines to core symptoms and school engagement of youth with moderate/severe ADHD. *J Affect Disord.* 2025; 372: 422-430. <https://doi.org/10.1016/j.jad.2024.12.039>
32. Zhu F, Kuang D, Zhu X, Xu B, Lin S, Chen J, et al. Efficacy of a mobile health with tailored personalized exercise rehabilitation program for ADHD children: randomized controlled trial. *J Affect Disord.* 2025; 387: 119495. <https://doi.org/10.1016/j.jad.2025.119495>
33. Wang J, Xiao L, Zhang J, Wen X, Shi Y, Chen Y, et al. Assessment of the impact of exercise therapy combined with family intervention on attention and executive function in children with attention deficit and hyperactive disorder. *BMJ Paediatr Open.* 2025; 9(1): e003234. <https://doi.org/10.1136/bmjpo-2024-003234>
34. Barudin-Carreiro A, Camhi SM, Stanish HI, Wright JA. Acute effects of walking and standing on executive function in children with attention deficit/hyperactivity disorder: a feasibility study. *Children (Basel).* 2024; 11(3): 341. <https://doi.org/10.3390/children11030341>

35. Liu R, Wen Z, Han D, Wang J. Effects of exercise interventions on executive function in school-aged children with ADHD: a systematic review and meta-analysis. BMC Public Health. 2025; 25: 3265. <https://doi.org/10.1186/s12889-025-24335-2>

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