CHOJNACKA, Barbara, OŻGA, Aleksandra, WĄTOR, Julia, WOŹNIACKA, Agnieszka, KRZESZOWIAK, Jerzy, BOBA, Barbara, PULANECKI, Tomasz, PODOLSKA, Alicja, BRYKSY, Sylwia and KOLANO, Patrycja. The Role of Physical Activity in Managing ADHD Symptoms in Children and Adolescents – Review of Current Literature. Quality in Sport. 2025;43:61248. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.43.61248
https://apcz.umk.pl/QS/article/view/61248

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 l.p. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 21.05.2025. Revised: 11.07.2025. Accepted: 11.07.2025. Published: 14.07.2025.

The Role of Physical Activity in Managing ADHD Symptoms in Children and Adolescents – Review of Current Literature

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Abstract
Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders seen in pediatric and adolescent psychiatry. The major symptoms are impulsivity, difficulties in sustaining attention and increased levels of motor activity. Emerging studies show that participating in physical activity may help improve ADHD symptoms.
Aim of the study: This review explores the influence of physical activity on ADHD symptoms in children and adolescents. We also try to highlight the potential therapeutic role of physical activity as a complementary intervention in ADHD management.

Materials and methods: An extensive search of the literature was performed in the PubMed database up to the year 2025.
Conclusions: This review's findings show that physical activity interventions benefit ADHD symptoms and executive functions in children and adolescents. Results of the studies showed that physical activity, especially organized closed-skill activities like running and aerobic training, enhanced the core ADHD symptoms (impulsivity, attention dysregulation, hyperactivity) the most, while open-skill activities that require real-time adaptation to environmental changes, had some effect on inhibitory control. What is more children and adolescents should participate in physical activities that they like in order to guarantee compliance and the durability of the intervention. Exercise should be included in the treatment plan for ADHD to offer holistic benefits, that not only addresses symptoms, but also enhances cognitive, behavioral, and emotional aspects of a child's life. Future work should include longitudinal research to explore the effects of physical activity on ADHD symptoms and the development of individualized exercise interventions tailored to individual symptoms profiles.

Keywords: „Attention deficit hyperactivity disorder", „ADHD", „Physical Activity", „Exercises", „Children", „Adolescents".

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) represents one of the most prevalent neurodevelopmental disorders in pediatric and adolescent psychiatry, with an estimated global prevalence exceeding 5% [1]. The epidemiological distribution of ADHD varies across different populations, particularly with regard to sex, as the female-to-male diagnosis ratio ranges from 1:3 to 1:16, depending on the country. However, boys are generally more frequently diagnosed than girls. The phenotypic presentation of ADHD differs between sexes, with factors such as variations in prosocial behaviors potentially contributing to the underdiagnosis of females [2]. Clinical manifestations of ADHD are commonly observed in school-aged children and often persist into adulthood. The core symptomatology of ADHD encompasses impulsivity, attentional dysregulation, and hyperactivity. These neurocognitive impairments influence executive functions, emotional regulation and behavioral responses, leading to challenges across multiple domains, including academic performance and social interactions [3-5].
The therapeutic approaches to ADHD can be categorized into pharmacological and non-pharmacological interventions. Non-pharmacological interventions have been extensively researched and comprise three principal modalities: psychological methods, complementary interventions and assistive devices [6,7].
An increasing number of studies indicate that physical activity exerts a positive influence on the symptomatology of ADHD. Research has demonstrated enhancements in neurobehavioral functions, including a reduction in impulsivity and hyperactivity, improved attentional control and better performance in tasks requiring executive functioning. [8,9]

In this article, we aim to provide a review of the current scientific literature exploring the influence of physical activity on the symptomatology of ADHD in children and adolescents. Our objective is to examine the extent to which various forms of exercise contribute to the mitigation of core ADHD symptoms, as well as their impact on cognitive functions, emotional regulation, and overall well-being. By analyzing recent research findings, we seek to highlight the potential therapeutic role of physical activity as a complementary intervention in ADHD management.

Neurobiological mechanisms of the impact of physical activity on ADHD

While the precise etiology of Attention Deficit Hyperactivity Disorder remains unclear, early theories suggesting impaired brain function were supported by findings indicating reductions in both the volume and functionality of gray and white matter. Additionally, research has proposed a dysregulation of dopamine (DA) and norepinephrine (NE) as a key neurobiological factor in ADHD, aligning with the pharmacological mechanisms of commonly prescribed medications. Especially stimulants such as methylphenidate and non-stimulants like atomoxetine are known to enhance dopamine and norepinephrine signaling within the prefrontal cortex, as a result improving cognitive and behavioral symptoms [10].

An expanding amount of evidence suggests that moderate physical activity may exert positive effects on mental health by modulating neurotransmitter systems, stimulating the release of brain-derived neurotrophic factor (BDNF), and promoting neurogenesis [11,12]. Moreover, acute exercise have been found to influence dopamine and norepinephrine pathways in a manner similar to stimulant medications, potentially contributing to improvements in neurocognitive functioning among children with ADHD. [13]. Furthermore, aerobic exercise and moderate-intensity physical activity are thought to support brain plasticity, optimize neurotransmission associated with learning and memory, and enhance cerebral blood flow and oxygenation, ultimately contributing to the improvement of working memory. [14] Research indicates that engaging in regular physical activity, especially exercises that require attentional control, such as cognitive-motor skill training, not only strengthens working memory capacity but also enhances information processing speed and cognitive flexibility. [21] Physical activity also enhances the activation of the prefrontal cortex, a key brain region involved in regulating emotions, impulse control, and decision-making. By strengthening prefrontal cortex function, exercise may contribute to better emotional regulation, improved stress management, and greater behavioral control. [15,16] These benefits play a crucial role in improving both academic achievement and social competencies in children with ADHD.

Clinical evidence

This review encompasses systematic reviews, meta-analyses, and experimental studies, particularly randomized controlled trials, to evaluate the impact of physical activity interventions on children and adolescents diagnosed with ADHD. The study population includes individuals ≤18 years old with a confirmed ADHD diagnosis, ensuring relevance to developmental and cognitive outcomes. To maintain correct selection criteria, only full-text articles published in English in Pubmed were included. The review exclusively considers studies published between 2020 and 2025, ensuring an up-to-date analysis of recent advancements in the field.

The effect of physical activity on ADHD symptoms in children and adolescents has been assessed in several clinical trials and meta-analyses. The 2022 meta-analysis focused on synthesize the existing evidence on the impact of chronic exercise interventions (CEIs) on ADHD symptoms and executive functions EF domains in children and adolescents. The analysis included 22 randomized controlled trials in individuals aged 6 to 18 years. The findings indicated that CEIs had a small but significant effect on reducing core ADHD symptoms (SMD = -0.39, 95% CI: -0.64 to -0.14), with a particularly notable effect on inattention. Exercise interventions were classified as open-skill or closed-skill. Open-skill exercises, such as tai chi or basketball, demand higher cognitive engagement, as they involve executing complex movements and continuously adapting to dynamic and unpredictable task conditions. In contrast, closed-skill exercises, including walking, running, or jumping, consist of repetitive, structured movements that require minimal cognitive involvement and rely more on automatic motor execution. Closed-skill exercises produced the greatest improvements in ADHD core symptoms (SMD = -0.83, 95% CI: -1.30 to -0.35), whereas open-skill exercises did not demonstrate significant benefits. Additionally, CEIs had a moderate impact on executive functions (SMD = -0.68, 95% CI: -0.91 to -0.45), with a moderate-to-large effect on specific EF domains. Subgroup analysis revealed that the overall effects on core symptoms and EFs were not significantly influenced by factors such as age group (children vs. adolescents), session duration (≤50 min vs. >50 min), or total number of exercise sessions (<24 vs. ≥24 sessions). These findings suggest that CEIs provide small-to-moderate benefits for managing ADHD symptoms and improving executive functions in children and adolescents. Given the effectiveness of closed-skill exercises, structured and repetitive physical activities may serve as a valuable therapeutic approach for ADHD. [25]

Another meta-analysis of 15 randomized controlled trials, encompassing 734 children with ADHD, examined the impact of physical exercise interventions on core ADHD symptoms, motor skills, and executive functions. The findings indicated that physical exercise had a significant positive effect on attention (SMD = -0.60, 95% CI [-1.10, -0.11], $p < 0.01$), executive function (SMD = 1.22, 95% CI [0.61, 1.82], $p < 0.01$), and motor skills (SMD = 0.67, 95% CI [0.22, 1.12], $p < 0.01$). However, no statistically significant improvements were observed in hyperactivity, depression, social problems, or aggressive behavior. The variability in intervention duration and frequency was identified as a potential source of heterogeneity. These results suggest that physical activity interventions can be an effective non-pharmacological strategy for improving attention, executive functioning, and motor skills in children with ADHD. [17]

A different meta-analysis from 2021 focused on randomized controlled trials and quasi-experimental designs that implemented exercise interventions and assessed executive functions through neurocognitive tasks. Out of 314 initially identified studies, 31 full texts were independently reviewed for eligibility, leading to 21 studies being included in the systematic review and 15 studies undergoing meta-analysis. The results demonstrated that exercise interventions significantly improved executive functions in children and adolescents with ADHD (SMD = 0.611, 95% CI [0.386 to 0.836], $p < 0.01$). A moderate-to-large effect was observed in inhibitory control and cognitive flexibility. Further subgroup analysis revealed that intervention intensity and the frequency of exercise sessions (acute vs. chronic) significantly influenced outcomes, whereas the type of exercise intervention had a lesser impact.

These observations suggest that chronic, moderate-intensity exercise interventions should be incorporated into ADHD treatment strategies to enhance executive functions. [18]

The 2023 systematic review and meta-analysis were conducted to examine the impact of physical activity interventions on attention problems in school-aged children with ADHD. A total of 10 studies met the inclusion criteria and were incorporated into the meta-analysis. The findings demonstrated that physical activity interventions had a moderate effect on improving attention problems in children with ADHD (SMD = -0.48, 95% CI: -0.85, -0.07, $p < 0.05$). Further subgroup analysis revealed that the effectiveness of physical activity was moderated by intervention type, frequency, rather than factors such as the physical activity environment in which they took place or single-session duration. These results suggest that cognitively engaging physical exercises are particularly effective in enhancing attention in children with ADHD. Specifically, interventions incorporating cognitive engagement, conducted fewer than three times per week, yielded the most significant improvements. However, given the variability in ADHD symptomatology, interventions should be tailored to individual needs, with careful assessment of each child's specific cognitive and behavioral profile before implementing an exercise program. [19]

Another systematic review and meta-analysis from 2024 assess the impact of aerobic exercise therapy on executive functions (EFs) in children aged 6 to 12 years diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). After screening for eligibility, nine RCTs were included in the systematic evaluation. The results showed that aerobic exercise significantly enhanced executive functions, with moderate-to-large effect sizes observed in inhibitory control (SMD = 0.83, 95% CI [0.37–1.29], $p = 0.0005$), cognitive flexibility (SMD = 0.65, 95% CI [0.37–0.93], $p < 0.00001$), and working memory (SMD = 0.48, 95% CI [0.02–0.95], $p = 0.04$). Subgroup analysis revealed that the effectiveness of aerobic exercise on inhibitory control and cognitive flexibility was influenced by factors such as intervention type, duration, intensity, and medication use. The most beneficial parameters for executive function improvement included moderate-intensity aerobic exercise performed 60–90 minutes per session, over a period of 6–12 weeks. Additionally, the use of medication appeared to further enhance the intervention's effectiveness. These findings suggest that aerobic exercise therapy is an effective non-pharmacological intervention for improving executive functions in children with ADHD, particularly in inhibitory control, cognitive flexibility, and working memory. While the results indicate a clinically meaningful impact, the study's limitations should be considered when applying these findings in clinical practice. [20]

To explore the impact of physical exercise interventions on anxiety, depression, and emotional regulation in children diagnosed with ADHD the systematic review and meta-analysis from 2025 was performed. The meta-analysis included 18 randomized controlled trials (RCTs) with 830 participants, revealing that physical exercise had a significant positive impact on anxiety (SMD = -0.58, $p < 0.05$), depression (SMD = -0.57, $p < 0.05$), and emotional regulation (SMD = 1.03, $p < 0.05$) in children with ADHD. Further subgroup analysis indicated that exercise performed at high frequency over a short duration, were most effective in reducing anxiety symptoms. Improvements in emotional regulation were most pronounced when programs featured a combination of exercise modalities, a longer intervention period, moderate-to-high frequency, shorter individual sessions, and low intensity.

These outcomes highlight the therapeutic potential of physical exercise as an intervention for emotional and psychological well-being in children with ADHD. The results suggest a dose-response relationship, with the type, intensity, frequency, and duration of physical activity playing a crucial role in determining its effectiveness. [22]

A different systematic review encompassing 59 examined the effects of physical activity on executive functions (EFs) and ADHD-related symptoms. A total of 44 studies involving 1,757 participants were eligible for meta-analysis. The findings demonstrated that all forms of physical activity contributed to EF enhancement (SMD = 1.15, 95% CI: 0.83 to 1.46). Among these, open-skill exercises, which require rapid adaptation to dynamic and externally paced environments, yielded the most pronounced improvements. Further analysis revealed distinct effects depending on the type of activity: open-skill exercises were most effective in enhancing inhibitory control, while closed-skill activities, particularly those based on aerobic training, had a slightly higher probability of improving working memory. Additionally, multi-component physical exercise appeared to be the most beneficial for cognitive flexibility. In terms of ADHD symptom reduction, closed-skill exercises dominated by aerobic activity proved to be particularly advantageous. These interventions showed greater efficacy in reducing hyperactivity and impulsivity as well as inattention. The results highlight the potential of physical activity as a non-pharmacological intervention for ADHD management, emphasizing its role in improving both cognitive and behavioral functioning. Moreover, to ensure long-term adherence and effectiveness, it is recommended that children and adolescents engage in physical activities that they find most enjoyable. [4]

In another 2022 study was examined whether a structured judo training program designed to improve motor skills could positively impact behavioral and neurocognitive markers of working memory in children with ADHD. The study included 57 children aged 8 to 12 years diagnosed with ADHD, who were randomly assigned to either a judo training group or a wait-list control group. The intervention consisted of 120 minutes of judo training per week over a three-month period. Before and after the intervention, participants completed a bilateral Change Detection task under varying memory load conditions and were assessed using the Movement Assessment Battery for Children-2 (MABC-2). Additionally, contralateral delay activity (CDA), a neurophysiological marker of working memory, was measured via electroencephalography (EEG). Results showed that, following the intervention, children in the judo training group exhibited a higher K-score on the Change Detection task, indicating improved working memory capacity compared to the control group. Furthermore, an increase in CDA negativity in high-load conditions suggested enhanced neurocognitive processing for working memory maintenance. However, no significant differences were observed between groups in the MABC-2 assessment of motor function. These findings suggest that judo training may serve as an effective complementary intervention for ADHD, supporting working memory maintenance processes and enhancing visuospatial information storage. Given its non-pharmacological nature, structured physical training such as judo may represent a valuable addition to traditional ADHD treatment strategies. [24]

A different study from 2022 explored the effects of an adapted swimming program on cognitive function, academic performance, and behavioral regulation in Tunisian school children aged 9 to 12 years (n = 40; 5 girls, 35 boys) diagnosed with ADHD. Participants were randomly assigned to either an experimental group (engaging in structured swimming sessions) or a control group. To evaluate outcomes, the Hayling Test was used to measure cognitive performance, the Children Behavior Check List assessed behavioral symptoms, and reading and numeracy skills were examined both before and after the intervention. Following 12 weeks of structured swimming training, children in the experimental group demonstrated significant improvements in behavioral regulation, inhibitory control and academic achievement, compared to those in the control group. These evidence shows that adapted swimming may serve as an effective intervention for enhancing cognitive abilities, self-regulation, and school performance in children with ADHD. [23]

A randomized control trial from 2021 included 29 children diagnosed with ADHD, who were randomly assigned to either an intervention group or an active control group. The intervention group underwent Balance-Based Attentive Rehabilitation of Attention (BARAN), while the control group participated in aerobic exercise and running sessions, both lasting 12 to 15 sessions. The outcomes demonstrated that BARAN significantly improved working memory, cognitive flexibility, and inhibitory control. Additionally, ADHD-related symptoms showed improvement in both home and school settings, suggesting that balance-based training may have widespread benefits beyond motor coordination. These results indicate that integrating balance-focused tasks with cognitive training enhances executive function performance in children with ADHD. The study highlights the therapeutic potential of combining sensorimotor exercises with cognitive engagement, offering a new, non-pharmacological approach to managing ADHD symptoms. [26]

Furthermore, the Randomized Controlled Trial from 2024, which aimed to evaluate the effectiveness of BrainFit, an original digital intervention that integrates cognitive training with physical exercise, in reducing ADHD symptoms and enhancing executive functions (EFs) in school-aged children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). A 4-week prospective randomized controlled trial was conducted, enrolling 90 children aged 6 to 12 years who met diagnostic criteria for ADHD and were receiving care at an ADHD outpatient clinic. Participants were randomly assigned to either the BrainFit intervention group (n = 44) or a waitlist control group (n = 46). The intervention comprised twelve 30-minute sessions, administered via iPad over four weeks (three sessions per week, supervised by trained staff). Results indicated that the BrainFit intervention group experienced significantly greater reductions in ADHD symptoms compared to the control group ($\beta = -12.203$, 95% CI –17.882 to –6.523; $P < .001$). Improvements were observed across multiple ADHD symptom domains, including inattention, hyperactivity/impulsivity and oppositional defiant behaviors. Additionally, significant enhancements were noted in executive function indices. Importantly, no severe adverse effects related to the intervention were reported. These findings support the efficacy of BrainFit as an innovative, technology-driven intervention that combines cognitive and physical training to improve core ADHD symptoms and executive functions. [27]

A 2022 randomized controlled trial examined the effects of table tennis training on writing skills and executive functions in children with ADHD. The study included 48 participants who were randomly assigned to one of three groups: actual table tennis training, simulated table tennis using a practice game or a control group without additional training. The intervention lasted 12 weeks, and participants in the table tennis groups participated in three 1-hour sessions per week. Outcomes were assessed using computerized handwriting assessment, the Color-Word Stroop Test, and the Wisconsin Card Sorting Test (WCST). Results indicated that both table tennis interventions significantly improved writing skills, reaction time, and automaticity of writing skills. Additionally, both intervention groups showed improvements in Stroop test scores, suggesting improved cognitive control and attention regulation. However, only the real table tennis group showed significant improvement in the WCST, indicating greater benefits in cognitive flexibility and problem-solving compared to the control and game training groups. These results support the use of motor coordination interventions, such as table tennis, as a nonpharmacological treatment strategy for handwriting difficulties and executive dysfunction in children with ADHD. [28]

Conclusions

The findings from this review highlight the positive impact of physical activity interventions on ADHD symptoms and executive functions in children and adolescents. That confirms the conclusions reached so far from the 2019 and 2021 meta-analysis. [29, 30]. Across multiple systematic reviews, meta-analyses and randomized controlled trials, physical exercises - particularly structured, closed-skill, such as running and aerobic training activities produced the greatest improvements in ADHD core symptoms (impulsivity, attentional dysregulation, hyperactivity), while open-skill exercises, which require real-time adaptation to changing environments, have shown notable effects on inhibitory control. [24] Regardless of exercise type, physical activity interventions contributed to enhancing executive functions. [4] Subgroup analyses suggest that intervention duration, intensity, and frequency influence outcomes, with moderate-intensity aerobic training conducted over 6–12 weeks, for 60–90 minutes per session, emerging as the most beneficial for executive function improvement [20].

The therapeutic potential of physical activity extends beyond symptoms management. Structured exercise programs also enhance academic performance, motor skills, and emotional regulation [22]. Adapted swimming and balance-based interventions were particularly effective in improving behavioral control and self-regulation [23], while digital movement-based interventions, such as BrainFit, demonstrated promising technology-driven solutions for ADHD management [27].

Although these are promising findings, study methodologies, intervention protocols, and sample sizes vary, such that the results may not be generalizable. Future work should also include longitudinal studies to look at the long term effects of physical activity on ADHD symptoms and also examine specific exercise interventions designed for each symptom profile.

In conclusion, physical activity is an effective non-pharmacological strategy for symptom management, as well as for enhancing executive functions and quality of life in children and adolescents. To enhance the longevity of the adherence and the efficacy of the physical activities, they should be interesting and fitted to the preferences of the individuals. [4] Integrating structured exercise programs into ADHD treatment strategies may provide holistic benefits beyond symptoms reduction, contributing to cognitive, behavioral, and emotional development.

Disclosure

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All authors have read and agreed with the published version of the manuscript.

Funding Statement:
The study did not receive special funding.

Institutional Review Board Statement:
Not applicable.

Informed Consent Statement:
Not applicable.

Data Availability Statement:
Not applicable.

Conflict of Interest Statement:
The authors declare no conflicts of interest.

Acknowledgements:
Not applicable.

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