

## **The Relationship Between Physical Activity and ADHD in Childhood and Preadolescence: A Systematic Literature Review**

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**Abstract**

Attention deficit hyperactivity disorder (ADHD) is defined by a persistent pattern of inattention and/or hyperactivity-impulsivity, impacting development and behavior from childhood. The objective of this work was to analyze the relationship between physical activity and the improvement of psychological symptoms in children and pre-adolescents with ADHD. The systematic literature review was carried out using the PRISMA methodology and, of the thirty articles analyzed from the PUBMED and Web of Science databases, six articles were selected, which covered studies from 2015 to 2022. Various practices such as swimming, target shooting and judo, showed significant benefits in reducing behavioral, cognitive and academic symptoms. However, limitations such as restricted samples and high dropout rates were observed. The results emphasize the importance of health professionals encouraging and prescribing physical activity to this population as a complementary treatment.

**Keywords:**

Attention Deficit Disorder with Hyperactivity; Child Psychiatry; Executive Function; Neurodevelopmental Disorders; Quality of Life

**1. Introduction**

Attention deficit hyperactivity disorder (ADHD) is characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity, which interferes with functioning or development. Symptoms begin in childhood, with the presence of several of them before the age of 12. Manifestations of the disorder must be present in more than one environment, and it is common for symptoms to vary depending on the context (American Psychiatric Association, 2014). The consequences of the disorder are being associated with an extensive set of negative results for affected individuals in the financial, social and educational spheres, which characterizes it as a major public health problem (Polanczyk et al., 2007).

The management of cognitive, behavioral and emotional impairment associated with ADHD is multimodal, including different areas of interventions, not limited to drug treatment and cognitive-behavioral therapy. It relies on the association of psychoeducational interventions through clear and precise information to the family about the disorder and, at the school level, focuses on academic performance (Ning & Wang, 2021). Difficulties in maintaining attention, disorganization and restlessness can affect performance in studies. Treatment with a speech therapist is also

recommended in specific cases where there is, simultaneously, Reading Disorder (Dyslexia) or Written Expression Disorder (Dysortography) (Machado-Nascimento et al., 2016). Furthermore, regular physical activity is an important treatment modality (American Psychiatric Association , 2014).

In recent years, researchers and clinicians have shown increasing interest in physical activity and exercise interventions for children with ADHD. The benefits of physical activity for mental health are a consolidated subject in scientific literature, including reducing the intensity of symptoms, improving cognitive capacity and quality of life (Bustamante et al., 2019). Furthermore, in patients with mental disorders, there is a high rate of physical comorbidities that are linked to genetic factors, side effects of pharmacological treatments and an inadequate lifestyle such as substance abuse, poor nutritional eating habits, problems sleeping and low levels of physical activity. Additionally, studies have shown that physical activity can significantly alleviate anxiety, depression and aggressive behavior, as well as improve mentality and social problems in children with ADHD (Zang , 2019).

Exercise may be beneficial for ADHD, especially by increasing activity in the prefrontal cortex which plays a role in executive functions and high-level motor control. Also, exercise contributes to neurochemical and neuroanatomical factors and increases cerebral blood flow. The reported positive effects can be classified as physical, behavioral, cognitive, emotional, spiritual and social (Halperin et al., 2014). Therefore, the objective of this work was to analyze the relationship between physical activity and the improvement of psychological symptoms in children and pre-adolescents with ADHD.

## **2. Methodology**

The bibliographic research of the systematic literature review on the impact of physical activity on ADHD symptoms in children and pre-adolescents focused on scientific productions published in journals indexed in the United States databases, National Library of Medicine (PUBMED) and Web of Science. This research was carried out in accordance with the methodological recommendations of the Preferred Statement Reporting Items for Systematic Reviews (PRISMA). The search for articles was carried out between August and September 2023.

In the databases, the descriptor used in the research was “Physical activity in improving ADHD symptoms” with the following filters: last 10 years, “full text” and “clinical trial”. Review articles,

incomplete texts and those without the full text in English were excluded. Identification was carried out by two examiners, independently.

After fully reading the selected articles, texts that discussed adolescents and adults, articles that compared physical exercise, those that compared physical activity with the use of medication, those that included more mental disorders in the same article, as well as articles without DOI and without presentation of results were excluded. The included articles are grouped in an Excel table (Table 1), including title, DOI, authors, year of publication, journal, country of research, database, objective, method, results and limitations.

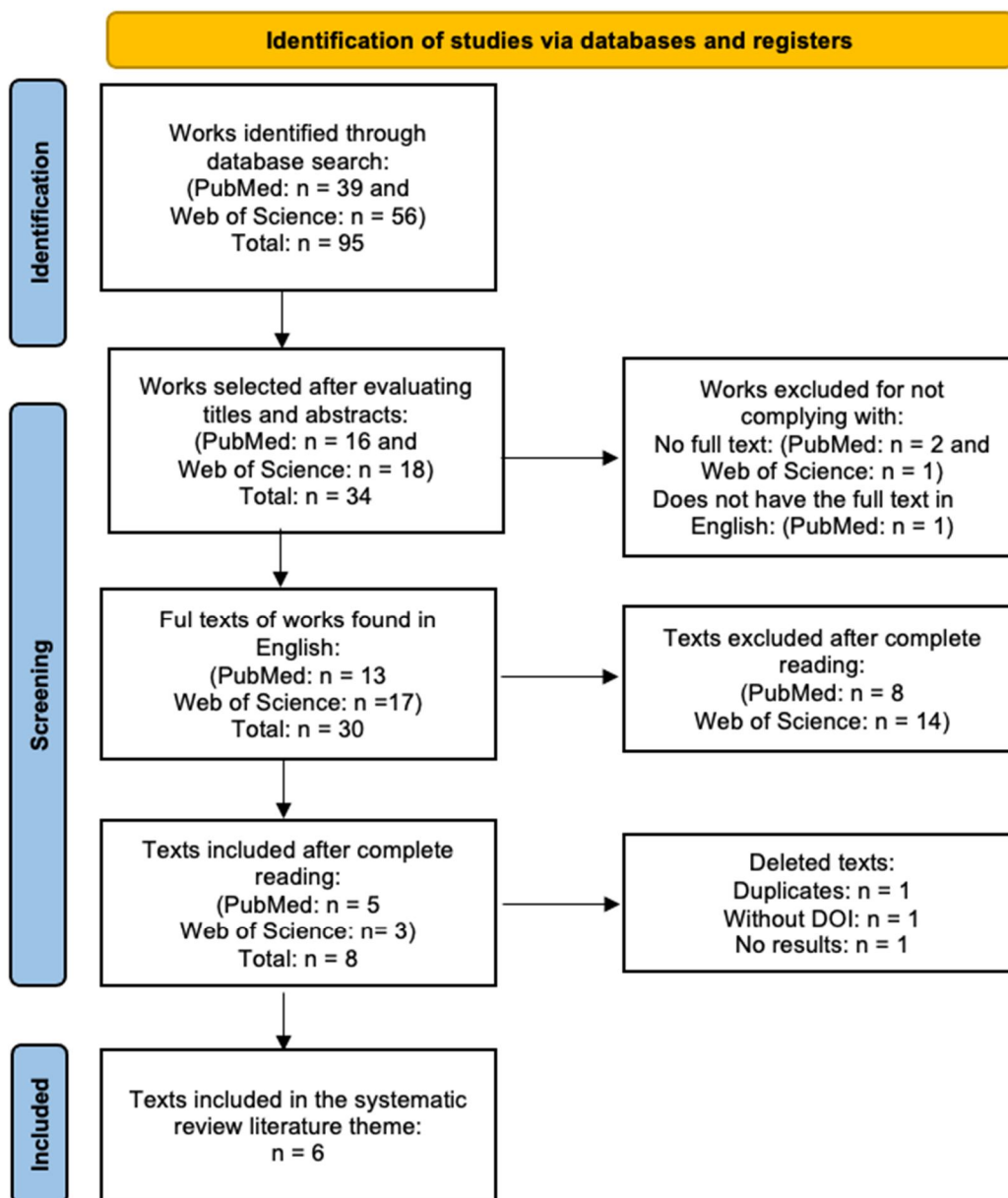
**Table 1.** Characterization of included articles: title, DOI, authors, year, journal, country, database, objective, methodology, results/conclusions and limitations.

Title	Authors	Journal	Country/Year	Objective	Method	Results/Conclusion
A Randomized Trial of a Swimming-Based Alternative Treatment for Children with Attention Deficit Hyperactivity Disorder	Hattabi, S., Forte, P., Kukic, F., Bouden, A., Have, M., Chtourou, H., & Sorriell, A., Asma Bouden . Mona Have Hamdi Chtourou and Andrew Sortwell.	<i>International Journal of Environmental Research and Public Health</i>	Tunisia 2022	To investigate the impact of adapted swimming activity on cognitive functions, academic performance and related behavior of Tunisian children with ADHD.	The study was conducted on school children aged 9 to 12 years (n = 40, 5 female and 35 male) diagnosed with ADHD. They were randomly assigned to an experimental group (exercise intervention) or the control group. The Hayling test was used to assess cognitive performance, the Children Behavior Check List (CBCL) was used to assess ADHD-related behavior, and the change in reading and numeracy proficiency was assessed pre- and post-intervention.	The results revealed that there were significant improvements in behavior, the inhibition process and academic performance in the experimental group compared to the control group. These findings suggest that adapted swimming activity may have positive implications for cognitive function, behavior and academic performance. This research may provide preliminary support for alternative therapeutic interventions that could be utilized by professionals. Furthermore, the results support the active practice of recreational physical activities as a strategy to support children in overcoming ADHD disabilities.
Behavioral and neurocognitive effects of judo training on working memory capacity in children with ADHD: A randomized controlled trial	Ludya, S., Mücke, M., Leuenberger, R., Bruggisser, F., Pühse, U., Gerber, M., Capone-Mori, A., Kautler, C., Brotzmann, M., & Weber, P.	<i>NeuroImage: Clinical</i>	Switzerland and Germany, 2022	Effect of a judo training program targeting motor skills on behavioral and neurocognitive indices of working memory capacity in children with ADHD.	Children with ADHD aged 8 to 12 years (N = 57) were randomly allocated to a judo training group and a wait-list control group. The training program encompassed 120 min of judo per week over three months. Before and after the intervention period, participants completed a bilateral Change Detection task with low and high memory load conditions and the Movement Assessment Battery for Children-2 (MABC-2). The contralateral delay activity (CDA) elicited by the cognitive task was recorded using electroencephalography.	Compared to the control group, the judo training group showed a higher K-score on the Change Detection task and an increased negativity of the CDA on the high load condition following the intervention, when pretest scores (and confounders) were accounted for. In contrast, no group differences were found for MABC-2 score. In children with ADHD, judo training may complement the pharmacological treatment by increasing the effectiveness of working memory maintenance processes. On a behavioral level, this improvement is accompanied with an increased capacity to store visuospatial information.
The influence of participation in target-shooting sport for children with inattentive, hyperactive and impulsive symptoms – A controlled study of best practice	Månsson, A. G., Elmose, M., Dalsgaard, S., & Roessler, K. K.	<i>BMC Psychiatry</i>	Danmark, 2017	Examining if, and to which extent, target-shooting sport reduces parent- and teacher-reported severity of inattentiveness, hyperactivity, and impulsivity in children with attention difficulties, and if and to which extent, target-shooting sport improves the children's wellbeing and quality of life.	A mixed method approach is applied. A non-blinded, waiting list controlled study is combined with a case study, consisting of interviews and observations. The intervention consists of children practicing target-shooting sport, by attending a local shooting association, once a week for six months, during regular school hours. Data from questionnaires (ADHD-RS, SDQ, Kidscreen-27), as well as a computerized continued performance test (Qb test), measure the children's activity and attention. The study includes 50 children in an intervention group and 50 children in a waiting list control group. The Qb-test collects data from at least 20 children from the intervention group and at least 20 children from the waiting list control group. Data from the questionnaires and Qb-test is collected at baseline, and six months post intervention. In addition, a case study is carried out, consisting of interviews of at least five children from the intervention group, their parents, teachers and shooting instructors. Observations are carried out, when children are in school and while they are attending the local shooting association. The case study adds to an in-depth understanding of children's participation in target-shooting sports.	Preliminary findings from the initial sport project indicate, that participating children enjoys target-shooting sport, show on-going motivation, while at the same time increasing their ability to stay focussed on hitting the target. The unique characteristics of target-shooting sport, combined with theoretical knowledge on the subject of children with ADHD and preliminary project experience in the field, indicate beneficial effects of practicing target-shooting sport in local Danish shooting associations in children with symptoms of inattentiveness, hyperactivity and impulsivity.
Effects of physical activity on executive function and motor performance in children with ADHD. Research in Developmental Disabilities	Ziereis, S., & Jansen, P.	<i>Research in Developmental Disabilities</i>	Germany, 2015	Determine whether Physical activity improves cognitive performance in children with ADHD.	The study-design consisted of two experimental groups (EG1, n = 13; EG2, n = 14) and a wait-list control group (CG, n = 16). Participants in EG1 took part in a training which focused on the abilities ball handling, balance and manual dexterity. Participants in EG2 group were trained in sports without a specific focus. The children in the CG group received no intervention. Participants completed assessments of working memory (WM) and motor performance before, immediately after the first training week and one week after the last session.	The outcomes indicated that regular PA can be used as a complementary or alternative non-pharmacologic treatment for ADHD.
An Exercise Program Designed for Children with Attention Deficit/Hyperactivity Disorder for Use in School Physical Education: Feasibility and Utility.	Taylor, A., Novo, D., & Foreman, D.	<i>Healthcare</i>	United Kingdom, 2019	To examine the acceptability and the impact on symptoms of exercise at school designed for children with ADHD.	Twelve children (10-11 years), six with a diagnosis of ADHD and six with no diagnosis, undertook 40-min sessions of short-duration, mixed activities bi-weekly for eleven weeks. ADHD symptoms and exercise enjoyment were recorded before six and eleven weeks of intervention.	Teacher-reported data showed ADHD symptoms were significantly decreased in the children with ADHD, with a moderate to large effect size. There were no changes in the control group. All children indicated equal enjoyment of the exercise sessions. Specially designed exercise sessions stimulate and maintain engagement by children with ADHD and may reduce ADHD symptom levels in the school environment. The method that supports inclusive practice in physical education (PE) was successfully transferred to the study school and led by the usual class teacher. Children evaluated the exercises as acceptable and enjoyable for those with and without ADHD. This inclusive exercise method might help children manage ADHD symptoms.
A School-Based Physical Activity Intervention for Young Children: Are There Effects on Attention and Behavior?	Fedewa, A., Mayo, M. R., Ahn, S., & Erwin, H.	<i>Journal of Applied School Psychology</i>	United States, 2020	Examine the effectiveness of daily physical activity in relation to a sedentary treatment condition for improving the attention, behavior and executive function of children with or at-risk for ADHD.	Investigated the effects of a 16 week physical activity intervention in an elementary sample of typical-developing children as well as those at-risk for ADHD.	The findings indicated no significant relationship between the physical activity intervention and beneficial outcomes for student executive functioning or ADHD symptomology, although a moderator effect was found for low and high intensity on student executive functioning suggesting that low and high intensity physical activity may improve student executive functioning.

### 3. Results

Initially, the search identified 95 articles using the descriptor “Physical activity in improving ADHD symptoms”, with 39 in the PUBMED database and 56 in the Web of Science database. After a thorough evaluation of titles and abstracts, 34 articles were selected, 16 from PUBMED and 18 from Web of Science. Of these, three were excluded for not having a full text and one for not having a full text in English. Resulting in 30 articles for in-depth analysis.

**Figure 1.** Scheme of the method of identification, selection, eligibility and inclusion of articles, adapted according to the PRISMA Flow recommendation Diagram.



After fully reading the pre-selected articles, eight articles were excluded from the PUBMED database and 14 from the Web of Science database, as they did not meet the eligibility criteria described in the methodology, resulting in eight articles. Of these, one article was excluded for being duplicated in the databases and one for not having a DOI. Figure 1 refers to the flow diagram, which summarizes the selection process for the present study.

The six selected articles were classified and grouped in an Excel table in ascending order of year of publication, containing title, DOI, authors, year of publication, periodical, country of research, database (Table 1). The studies were published between the years 2015 and 2022. The research countries were Tunisia (1), Switzerland and Germany (1), Germany (1), Denmark (1), United Kingdom (1) and the United States of America (1).

#### **4. Discussion**

All but one of the articles included in this systematic review covered a wide range of training interventions aimed at improving executive function and quality of life in children and pre-adolescents aged up to 14 years diagnosed with ADHD. Some interventions directly aimed at improving cognitive functions, academic performance, behavior, memory capacity and exercise acceptability. The other study, by Månsson et al., (2017) involved well-being and quality of life, and was therefore included in this review. All the articles were clinical trials, related to improving the symptoms of the disorder with the practice of physical exercise. The vast majority of articles concluded that physical activity provides benefits in reducing symptoms, which showed an improvement in the performance of executive function in these children. It can be used as an adjuvant non-pharmacological treatment, suggesting long-term benefits.

The research covered several countries, with a prevalence being observed on the European continent, including Denmark, Germany, Switzerland and the United Kingdom (REFS). In addition to these, research from Tunisia and the United States of America was also included. With regard to the locations where the research was carried out, it was observed that the majority of them took place in school environments, including schools with special children and which require special educational programs. Furthermore, there was research that was developed through direct recruitment in child and youth psychiatric clinics. Therefore, it can be observed that this theme is gaining more and more relevance in the scope of the scientific area. Regarding the place of publication of the articles, all were published in scientific journals that cover the topics of public

health, diseases of the central nervous system, psychiatry, school psychology, health and interdisciplinary research.

Articles by authors Fedewa et al. (2020), Taylor et al. (2019); Ziereis & Jansen (2015) presented a similarity in their methodology, proposing diversified physical exercise programs, not limited to a single modality. Taylor et al. (2019) and Ziereis & Jansen (2015) concluded that physical activity has positive effects on the executive functions of children with ADHD, and can also be an effective complement to medication. Furthermore, they showed that physical activity sessions are acceptable and enjoyable for children. With this, the results found can be transferred to other schools and carried out by teachers for application in the school routine. In contrast, Fedewa et al. (2020), concluded that there was no improvement in the symptomatology of the disorder in children, and furthermore, there was no significant effect of the intervention on parents' and teachers' measures related to executive function, although previous research has found physical activity to be a useful, long-term alternative intervention to improve motor, cognitive, social and behavioral functioning in these cases.

Hattabi et al. (2022) addresses the impact of swimming on the adaptation of cognitive functions, academic performance and behavior of Tunisian children with ADHD. Children were randomly assigned to the experimental group or control group, and the Hayling test was used to evaluate performance, the Children's test Behavior Check List (CBCL) to assess ADHD-related behavior, and change in reading and numeracy proficiency was assessed pre- and post-intervention. Significant results were observed, suggesting that low-intensity aerobic swimming, performed three times a week, may be an effective therapeutic intervention. They concluded that the educational system can promote the benefits of frequent swimming sessions for students with ADHD.

Ludyga et al. (2022) also specifically address the relationship between an exercise modality and the impacts on ADHD symptoms. This article explored the impact of a judo training program for 120 minutes per week for three months. The sessions focused on learning and refining techniques, but also included fun activities for children. The article also found promising results in which benefits can be observed at a behavioral and neurocognitive level, given that practice increases the number of items that can be stored in working memory. It is concluded that judo can complement pharmacological treatment by increasing the effectiveness of the working memory maintenance processes.

Therefore, Månsson et al., (2017) aimed to investigate whether target practice decreases the intensity of symptoms of inattention, hyperactivity and impulsivity, as reported by teachers and

parents in children with ADHD. Furthermore, they analyzed the extent to which this sport contributes to the quality of life and well-being of children. The approach involves children participating in target practice once a week for six months during regular school hours, while also taking quizzes to measure performance. The results suggest that the individuals evaluated enjoyed target shooting as a sport, observing beneficial effects on motivation and ability to maintain focus, indicating the usefulness of this sport for children with ADHD.

The research analyzed has limitations, notably the restricted size of the sample studied, challenges in comparing results and also the absence of a control group with an alternative intervention. Furthermore, they noticed a high dropout rate in some groups, both due to changes in school hours and the attractiveness of a different activity. Another obstacle encountered was the distribution of genders, which were not equal between the groups and could have effects on the final results, since sex moderates the effects caused by physical exercise. Additionally, there was a restriction on the domains investigated, causing a lack of conclusion about the relationship between planning capacity and motor performance. Finally, the effect of the intervention may be influenced by the participants' expectations, as in some studies the selection was from a waiting list control group, instead of an active control group.

The articles suggest improvements for future studies, such as expanding the studies to multiple schools and improving the recruitment process to obtain more significant results. In addition, they recommend projects that allow the participation of all children and use larger sample sizes to ensure representativeness and robust comparisons. They also suggest the use of broader assessment tools to explore executive function and its multiple subdomains in children with ADHD. They also highlight the need to carry out research comparing effective non-pharmacological and pharmacological interventions to help children with the disorder.

## **5. Conclusion**

The present systematic literature review examined six articles developed that evaluated the relationship between physical activity and improvement in symptoms related to ADHD in children and pre-adolescents. The diversity in physical activity practices, which includes everything from swimming to target shooting, revealed an improvement in behavioral, cognitive and academic performance. These findings indicate that physical activity can be used as an adjuvant non-pharmacological treatment, suggesting long-term benefits. The results highlight the importance of professionals encouraging and prescribing physical activity to this population as a complementary



treatment. Finally, there is evidence that studies on this topic will remain the focus of research in the field of health promotion.

## 6. References

American Psychiatric Association . (2014). DSM-5. Artmed Editora.

Bustamante, EE, Santiago-Rodriguez, ME, Ramer , JD, Balbim , GM, Mehta , TG, & Frazier, SL (2019). PHYSICAL ACTIVITY AND ADHD: EVIDENCE ON DEVELOPMENTAL TRAJECTORIES, TRANSIENT AND DURABLE NEUROCOGNITIVE EFFECTS, AND REAL-WORLD APPLICATIONS. *Think En Movement : Revista de Ciencias Del Ejercicio Y La Salud* , 17(1), e34662. <https://doi.org/10.15517/pensaarmov.v17i1.34662>

Fedewa , A., Mayo, M.R., Ahn , S., & Erwin, H. (2020). A School-Based Physical Activity Intervention for Young Children: Are There Effects on Attention and Behavior? *Journal of Applied School Psychology* , 37 (4), 391–414. <https://doi.org/10.1080/15377903.2020.1858380>

Halperin, J.M., Berwid , O.G., & O'Neill, S. (2014). Healthy Body, Healthy Mind? *Child and Adolescent Psychiatric Clinics of North America* , 23(4), 899–936. <https://doi.org/10.1016/j.chc.2014.05.005>

Hattabi , S., Forte, P., Kukic , F., Bouden , A., Have, M., Chtourou , H., & Sortwell , A. (2022). A Randomized Trial of a Swimming-Based Alternative Treatment for Children with Attention Deficit Hyperactivity Disorder. *International Journal of Environmental Research and Public Health* , 19 (23), 16238. <https://doi.org/10.3390/ijerph192316238>

Ludyga , S., Mücke , M., Leuenberger , R., Bruggisser , F., Pühse , U., Gerber, M., Capone-Mori, A., Keutler , C., Brotzmann , M., & Weber, P. (2022). Behavioral and neurocognitive effects of judo training on working memory capacity in children with ADHD: A randomized controlled trial. *NeuroImage : Clinical* , 36, 103156. <https://doi.org/10.1016/j.nicl.2022.103156>

Machado-Nascimento, N., Melo and Kümmer , A., & Lemos, SMA (2016). Speech-language pathology alterations in Attention Deficit Hyperactivity Disorder: systematic literature review. *CoDAS* , 28(6), 833–842. <https://doi.org/10.1590/2317-1782/20162015270>

Månsson , AG, Elmoose , M., Dalsgaard, S., & Roessler, K. K. (2017). The influence of participation in target-shooting sport for children with inattentive, hyperactive and impulsive symptoms – A controlled study of best practice. *BMC Psychiatry*, 17. <https://doi.org/10.1186/s12888-017-1283-5>

Ning, K., & Wang, T. (2021). Multimodal Interventions Are More Effective in Improving Core Symptoms in Children With ADHD. *Frontiers in Psychiatry* , 12. <https://doi.org/10.3389/fpsy.2021.759315>

Polanczyk , G., de Lima, MS, Horta, BL, Biederman , J., & Rohde , LA (2007). The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry* , 164(6), 942–948. <https://doi.org/10.1176/ajp.2007.164.6.942>

Taylor, A., Novo, D., & Foreman, D. (2019). An Exercise Program Designed for Children with Attention Deficit/Hyperactivity Disorder for Use in School Physical Education: Feasibility and Utility. *Healthcare* , 7 (3), 102. <https://doi.org/10.3390/healthcare7030102>

Zang, Y. (2019). Impact of physical exercise on children with attention deficit hyperactivity disorders. *Medicine*, 98(46), e17980. <https://doi.org/10.1097/md.00000000000017980>

Ziereis , S., & Jansen , P. (2015). Effects of physical activity on executive function and motor performance in children with ADHD. *Research in Developmental Disabilities* , 38(1), 181–191. <https://doi.org/10.1016/j.ridd.2014.12.005>