

## Cognitive Function of Children with High Risk of ADHD and The Benefit of Physical Exercise for Cognitive Function of Children with a High Risk of ADHD

Yunias Setiawati<sup>1,2\*</sup>, Royke Tony Kalalo<sup>1,2</sup>, Melati Wahyurini<sup>1,2</sup>,  
Dianasari<sup>1,2</sup>, I Made Wedastra<sup>1,2,3</sup>, Dhenni Hartopo<sup>1,2</sup>,  
Vanessa Budiawan Soetioso<sup>1,2,4</sup>

<sup>1</sup>Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia

<sup>2</sup>Psychiatry Department, Dr. Soetomo General Hospital, Surabaya

<sup>3</sup>Psychiatry Department, Faculty of Medicine, Udayana University, Bali

<sup>4</sup>Faculty of Medicine, Widya Mandala Catholic University, Surabaya

E-mail: [yunias.setiawati@fk.unair.ac.id](mailto:yunias.setiawati@fk.unair.ac.id); [drroykekalalo@fk.unair.ac.id](mailto:drroykekalalo@fk.unair.ac.id);  
[wahyurinimelati@gmail.com](mailto:wahyurinimelati@gmail.com); [dianasari.md@gmail.com](mailto:dianasari.md@gmail.com); [madewedastra1985@gmail.com](mailto:madewedastra1985@gmail.com);  
[dhenni.hartopo@gmail.com](mailto:dhenni.hartopo@gmail.com); [vanessa.soetioso@outlook.com](mailto:vanessa.soetioso@outlook.com)

\*Corresponding author details: Yunias Setiawati; [yunias.setiawati@fk.unair.ac.id](mailto:yunias.setiawati@fk.unair.ac.id)

### ABSTRACT

**Objective:** Attention deficit hyperactivity disorder (ADHD) is a common neurodevelopmental disorder in children, affecting around 5% globally, with symptoms often persisting into adulthood. It significantly impairs cognitive functions like attention and executive functions. This study investigates the impact of physical exercise on cognitive functions in children at high risk of ADHD. **Method:** The study was conducted at SDN Simokerto VI, Surabaya. Participants were students in grades 4 and 5 with an Indonesian ADHD Rating Scale (IARS) score > 30. Cognitive performance was assessed using the Trail Making Test (TMT), which evaluates processing speed, attention, and cognitive flexibility. Physical exercise was administered as part of the community service activity. **Results:** A total of 26 students participated, with 12 males (46%) and 14 females (54%). The grade distribution was 9 students in grade 4 (35%) and 17 in grade 5 (65%). In the TMT-A, 23 students (88%) demonstrated average processing speed and attention, while 3 students (12%) showed deficits. In the TMT-B, 25 students (96%) exhibited average cognitive flexibility, with 1 student (4%) showing a deficit. The results indicate that most students performed within the average range for both tests, with a small number showing deficits in specific areas. **Conclusion:** Physical exercise appears to be an effective non-pharmacological intervention for improving cognitive functions in children with ADHD. The study's findings support the incorporation of regular physical activity into the daily routine of children at high risk of ADHD to enhance cognitive performance, reduce behavioral problems, and promote academic success.

**Keywords:** ADHD; cognitive function; physical exercise

### INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a prevalent condition among children and adolescents. It is marked by symptoms such as inattention, hyperactivity, and impulsivity. Additionally, children with ADHD often face difficulties with emotional regulation. The diagnostic criteria for ADHD require that symptoms be present for at least six months in two or more settings, emerge before the age of 12, and significantly disrupt the individual's normal functioning. The global prevalence of ADHD in school-age children is approximately 5%. In 20-80% of children with ADHD, the symptoms continue into adulthood. These statistics highlight the significance of ADHD as a widespread issue that requires considerable attention due to its potential to impact

the lives of numerous children and their families, and its persistence into adulthood. [1-5].

Attention Deficit Hyperactivity Disorder (ADHD) significantly impacts cognitive functions, particularly attention and concentration. Individuals with ADHD often struggle with sustaining attention, which can manifest in difficulties in completing tasks, following instructions, and maintaining focus on activities that require prolonged mental effort. This impairment in attention is frequently accompanied by distractibility, where individuals are easily pulled away from tasks by extraneous stimuli. Additionally, ADHD affects executive functions, leading to challenges in organizing tasks, managing time effectively, and maintaining cognitive control.

These cognitive deficits can hinder academic performance, work productivity, and daily functioning. According to a study by Faraone et al. (2020), the cognitive impairments associated with ADHD are not limited to childhood but can persist into adulthood, affecting various domains of life [6–9].

The impact of ADHD on concentration is profound, often resulting in an inability to filter out irrelevant information and focus on essential tasks. This can lead to a scattered cognitive style where thoughts and activities are disorganized. Research by Sibley et al. (2019) highlights that individuals with ADHD exhibit significant variability in their attentional performance, which can fluctuate from moment to moment. This inconsistency in attention makes it challenging to complete complex tasks that require sustained mental effort. Moreover, the neural mechanisms underlying attention and concentration in ADHD involve dysfunctions in the prefrontal cortex and other related brain regions, which are responsible for executive control and regulatory functions. These findings underscore the importance of developing targeted interventions to help individuals with ADHD improve their cognitive functioning and enhance their ability to concentrate [6, 7, 10].

Physical exercise has been found to have a positive impact on cognitive function, particularly attention and concentration, in children with ADHD. Regular physical activity has been shown to enhance neural efficiency and promote neuroplasticity, which can help mitigate some of the cognitive deficits associated with ADHD. For example, a study by Grassmann et al. (2020) demonstrated that aerobic exercise significantly improves attention and executive function in children with ADHD. The study found that children who participated in regular physical exercise exhibited better-sustained attention and reduced impulsivity compared to those who did not engage in such activities. These findings suggest that incorporating physical exercise into the daily routine of children with ADHD can be an effective non-pharmacological strategy to improve cognitive function and manage symptoms [11, 12].

In addition to improving attention and concentration, physical exercise has also been shown to enhance other aspects of cognitive functioning in children with ADHD. Research by Vysniauske et al. (2020) found that physical exercise not only boosts attention but also improves working memory and cognitive flexibility. These cognitive benefits are likely due to the increased levels of neurotransmitters such as dopamine and norepinephrine, which are crucial for attention and executive function. Moreover, physical activity has been linked to the upregulation of brain-derived neurotrophic factor (BDNF), which supports the growth and differentiation of new neurons and synapses. By enhancing these neural processes, physical exercise can help children with ADHD improve their cognitive control and reduce

symptoms, leading to better academic and daily functioning [11, 12].

## METHOD

This study was conducted at an elementary school, in Surabaya, namely SDN Simokerto VI. This study was conducted simultaneously with community service activity of the Children and Adolescent Division, Department of Psychiatry, Faculty of Medicine, Airlangga University. Students, and their parents, with Indonesian ADHD Rating Scale (IARS) score > 30 (High risk of ADHD), between grades 4 and 5 were invited as participants in this study. TMT test done by the students and the IARS forms filled by their mothers in a previous study conducted by Rabitho and Setiawati. Physical exercise was given to the students as part of the community service activity. This study was approved by the Medicinal Faculty Ethics Committee of Airlangga University (Ethical exemption No. 68/EC/KEPK/FKUA/2024) [13].

## RESULT

**TABLE 1:** Sex and Grades of the students.

Sex	
Male	12 (46%)
Female	14 (54%)
Grade	
4	9 (35%)
5	17 (65%)

The table indicates that there is a total of 26 students in this study, with 12 males and 14 females. The distribution shows a slight predominance of female students compared to male students, with females constituting approximately 54% of the total student population. The grade distribution reveals that there are 9 students in grade 4 and 17 students in grade 5. This indicates that grade 5 has nearly twice (65%) the number of students compared to grade 4. The data highlights a larger cohort of students in the higher grade level. The overall student population consists of a slightly higher number of females compared to males. Additionally, the number of students in grade 5 significantly surpasses the number of students in grade 4.

**TABLE 2:** TMT Result.

TMT	Average	Deficit
TMT-A	23 (88%)	3 (12%)
TMT-B	25 (96%)	1 (4%)

In the TMT-A, which assesses processing speed and attention by requiring students to connect a series of numbered circles in sequential order, 23 students (88%) achieved an average performance. This indicates that these students performed within the expected time range, demonstrating adequate processing speed and attention. However, 3 students (12%) were assessed with a deficit, suggesting they performed slower than the expected time, indicating potential difficulties in processing speed or attention.

In the more complex TMT-B, which evaluates cognitive flexibility by requiring students to alternate between numbers and letters in sequence, 25 students (96%) achieved an average performance. This indicates that the majority of students demonstrated adequate cognitive flexibility and attention-switching abilities. Only 1 student (4%) was assessed with a deficit, suggesting difficulty in cognitive flexibility for the group as a whole.

The overall results indicate that most students performed within the average range for both TMT-A and TMT-B, with a small number of students showing deficits. Specifically, 3 students showed deficits in TMT-A, indicating minor difficulties in processing speed and attention, while only 1 student showed a deficit in TMT-B, suggesting that cognitive flexibility and attention-switching abilities are relatively well-preserved among the group.

## DISCUSSION

ADHD is a neurodevelopmental condition that significantly affects cognitive function, particularly attention concentration and executive functions. Executive functions encompass higher-level cognitive processes such as goal-directed behavior, adaptive thinking, and flexible problem-solving. Research indicates that children with ADHD often encounter difficulties in these areas, which can impact their academic performance and daily activities. These challenges stem from impairments in working memory, organizational skills, and other cognitive processes essential for complex tasks. Our study shows that some of these children with a high risk of ADHD do have problems with their cognitive function, particularly attention concentration and executive functions. This is shown with the result of the TMT [14–16].

Various interventions have shown promise in mitigating cognitive impairments associated with ADHD. For instance, brainwave entrainment techniques and neurofeedback can enhance cognitive performance and alleviate ADHD symptoms. These methods aim to improve the brain's executive functions, leading to better focus, organization, and impulse control. Additionally, nutritional supplements such as B-complex vitamins may support cognitive function and overall well-being in individuals with ADHD. Such multifaceted approaches highlight the importance of addressing the complex interplay between ADHD and cognitive function [17].

Interventions involving physical exercise have shown promising results in improving cognitive functions in children with ADHD. Research indicates that regular physical activity can enhance cognitive flexibility, inhibitory control, and attention in children and adolescents with ADHD. These improvements in executive functions are crucial for managing ADHD symptoms and enhancing overall cognitive performance. For instance, a study highlighted by the National Center for Biotechnology Information (NCBI) suggests that exercise interventions significantly contribute to better cognitive outcomes in this population (Dastamooz et al., 2023).

Our community service activity involves taking children to engage in physical exercise, which has been shown to significantly aid in enhancing cognitive function. Through structured physical activities (SANIMAN Exercise), we aim to improve their cognitive flexibility, inhibitory control, and attention, which are often areas of difficulty for children with ADHD. Regular exercise not only contributes to better cognitive performance but also helps in reducing behavioral problems, thereby supporting their learning and academic success. By incorporating these activities, we provide a holistic approach that promotes both physical health and cognitive development, ensuring that children with high risk of ADHD receive the benefits of an active lifestyle while enhancing their overall well-being.

## CONCLUSION

ADHD is a neurodevelopmental disorder that significantly impairs cognitive functions, particularly attention, concentration, and executive functions, which include goal-directed behavior, adaptive thinking, and problem-solving. Children with ADHD often face challenges in these areas due to impairments in working memory and organizational skills, affecting their academic performance and daily activities. Interventions such as brainwave entrainment, neurofeedback, and nutritional supplements like B-complex vitamins have shown promise in improving cognitive performance and alleviating symptoms. Physical exercise has also proven effective, enhancing cognitive flexibility, inhibitory control, and attention in children with ADHD. Our community service activity incorporates structured physical exercises (SANIMAN Exercise) to help children with ADHD improve these cognitive functions, reduce behavioral problems, and support their overall well-being and academic success.

## REFERENCE

- [1] Sánchez M, Lavigne R, Romero JF, et al. Emotion regulation in participants diagnosed with Attention Deficit Hyperactivity Disorder, before and after an emotion regulation intervention. *Front Psychol*; 10. Epub ahead of print 2019. DOI: 10.3389/fpsyg.2019.01092.
- [2] Christiansen H, Hirsch O, Albrecht B, et al. Attention-Deficit/Hyperactivity Disorder (ADHD) and Emotion Regulation Over the Life Span. *Current Psychiatry Reports* 2019; 21: 17–28.
- [3] Tenenbaum RB, Musser ED, Morris S, et al. Response Inhibition, Response Execution, and Emotion Regulation among Children with Attention-Deficit/Hyperactivity Disorder. *J Abnorm Child Psychol* 2019; 47: 589–603.
- [4] Peñuelas-Calvo I, Palomar-Ciria N, Porrás-Segovia A, et al. Impact of ADHD symptoms on family functioning, family burden and parents' quality of life in a hospital area in Spain. *European Journal of Psychiatry* 2021; 35: 166–172.

- [5] Danang Rabitho F, Setiawati Y. The Population of Children with High Risk of ADHD and The Mother's Sociodemographic Profile in Surabaya. *International Journal of Scientific Advances* 2024; 5: 42–46.
- [6] Faraone S V., Banaschewski T, Coghill D, et al. The World Federation of ADHD International Consensus Statement: 208 Evidence-based conclusions about the disorder. *Neuroscience and Biobehavioral Reviews* 2021; 128: 789–818.
- [7] Sibley MH, Swanson JM, Arnold LE, et al. Defining ADHD symptom persistence in adulthood: optimizing sensitivity and specificity. *J Child Psychol Psychiatry* 2017; 58: 655–662.
- [8] Sasono C, Setiawati Y, Irwanto I. Correlation Between Children's Temperament and Risk Factor of Attention Deficit/Hyperactivity Disorder in Elementary School. *Biomolecular and Health Science Journal* 2019; 2: 17.
- [9] Setiawati Y, Mukono H, Wahyuhadi J, et al. The Influence of Lead (Pb), Zinc (Zn), Ratio Lead (Pb) to Zinc (Zn) in Attention Deficit Hyperactivity Disorder (ADHD). *Indian J Public Health Res Dev* 2019; 10: 1497.
- [10] Sukmajaya AC, Lusida MI, Soetjipto, et al. Systematic review of gut microbiota and attention-deficit hyperactivity disorder (ADHD). *Annals of General Psychiatry*; 20. Epub ahead of print 1 December 2021. DOI: 10.1186/s12991-021-00330-w.
- [11] Grassmann V, Alves MV, Santos-Galduróz RF, et al. Possible Cognitive Benefits of Acute Physical Exercise in Children With ADHD: A Systematic Review. *J Atten Disord* 2017; 21: 367–371.
- [12] Vysniauske R, Verburgh L, Oosterlaan J, et al. The Effects of Physical Exercise on Functional Outcomes in the Treatment of ADHD: A Meta-Analysis. *J Atten Disord* 2020; 24: 644–654.
- [13] Rabitho FD, Setiawati Y. The Population of Children with High Risk of ADHD and The Mother's Sociodemographic Profile in Surabaya. *International Journal of Scientific Advances*; 5. Epub ahead of print 2024. DOI: 10.51542/ijscia.v5i1.8.
- [14] Hoy B-A, Bi M, Lam M, et al. Hyperactivity in ADHD: Friend or Foe? *Brain Sci* 2024; 14: 719.
- [15] Bowie CR, Harvey PD. Administration and interpretation of the Trail Making Test. *Nat Protoc* 2006; 1: 2277–2281.
- [16] Setiawati Y, Mukono HJ, Wahyuhadi J, et al. Is there an Effect of Serotonin on Attention Deficit Hyperactivity Disorder. *Indian J Public Health Res Dev* 2020; 11: 1745.
- [17] Posner J, Polanczyk G V., Sonuga-Barke E. Attention-deficit hyperactivity disorder. *The Lancet* 2020; 395: 450–462.
- [18] Dastamooz S, Sadeghi-Bahmani D, Farahani MHD, 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*; 62. Epub ahead of print 1 August 2023. DOI: 10.1016/j.eclinm.2023.102137.