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The Effect of Running Training on Improving Classroom Attention in Children with ADHD

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder characterized by symptoms of inattention, hyperactivity, and impulsivity that adversely affect children's academic performance and behavior in classroom settings. Current ADHD management strategies, primarily pharmacological and behavioral, have limitations, prompting the exploration of alternative interventions. This study investigates the effects of a 12-week structured running training program on improving classroom attention in children with ADHD. Thirty children aged 7 to 12 years participated in a single-group intervention study, with attention, behavior, mood, and physical fitness assessed at baseline, post-intervention, and follow-up. Results showed significant improvements in classroom attention, as evidenced by reduced scores on the Conners' Teacher Rating Scale-Revised (CTRS-R) and fewer errors on the Continuous Performance Test (CPT). Secondary outcomes indicated notable reductions in hyperactive-impulsive behaviors, anxiety, and depressive symptoms, as well as enhanced physical fitness. These findings suggest that structured running programs may be an effective non-pharmacological intervention for enhancing attention and behavior in children with ADHD. Further research should explore the long-term effects and underlying mechanisms of such interventions and investigate their integration into comprehensive ADHD management plans.

Keywords: ADHD, running training, physical activity

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder characterized by persistent patterns of inattention, hyperactivity, and impulsivity that significantly impact children's learning, social interactions, and daily activities. ADHD affects an estimated 5% to 10% of children worldwide, with a higher prevalence in boys compared to girls. The core symptoms of ADHD, including distractibility, difficulty in sustaining attention, excessive activity levels, and impulsive behaviors, are particularly problematic in classroom settings, where children are required to complete assignments, follow instructions, and engage in structured learning activities. These difficulties often result in lower academic achievement, increased rates of grade retention, and higher dropout rates (DuPaul & Stoner, 2014). Traditional classroom environments, which demand sustained periods of focused attention, present unique challenges for children with ADHD, underscoring the need for effective interventions that enhance their ability to

maintain attention and participate in learning.

Current management strategies for ADHD typically involve a combination of pharmacological and non-pharmacological treatments. Pharmacological treatments, primarily involving central nervous system stimulants such as methylphenidate and amphetamines, are the most commonly used interventions and have been shown to be effective in reducing core symptoms of ADHD (Banaschewski et al., 2018). However, these medications are often associated with side effects such as insomnia, appetite suppression, and potential cardiovascular risks, and they do not universally benefit all children (Cortese et al., 2013). The effects of medication are generally short-term and may not address the broader social, emotional, and cognitive challenges faced by children with ADHD.

Non-pharmacological treatments, including behavioral therapy, cognitive-behavioral therapy (CBT), parent training, and educational interventions, are often used either alone or in conjunction with medication. Behavioral interventions, such as contingency management and classroom behavior modification techniques, have demonstrated moderate effectiveness in improving behavioral outcomes (Daley et al., 2018). However, the effectiveness of these treatments can vary widely depending on individual differences, and they often require substantial resources, specialized training, and consistent implementation, which can limit their practicality and scalability in diverse educational settings. Despite the benefits of these approaches, there is an increasing recognition of the need for complementary or alternative interventions that can effectively address the core symptoms of ADHD while overcoming the limitations associated with current treatments. In this context, physical activity has emerged as a promising intervention due to its potential to improve cognitive functions such as attention, executive function, and behavioral control, which are often impaired in children with ADHD (Verret et al., 2012).

Aerobic exercise, particularly running, has gained considerable attention for its positive effects on cognitive function and mental health in children. Research has indicated that regular physical activity is associated with improvements in various cognitive domains, including attention, memory, and executive function, as well as reductions in anxiety and depression (Hillman et al., 2008; Donnelly et al., 2016). These cognitive benefits are believed to result from several physiological mechanisms, such as increased cerebral blood flow, enhanced neurogenesis, and the upregulation of neurotrophic factors like Brain-Derived Neurotrophic Factor (BDNF), which support neuronal growth and synaptic plasticity (Ratey & Loehr, 2011).

For children with ADHD, physical activity may be particularly beneficial in enhancing cognitive function and behavioral regulation. Meta-analyses and systematic reviews have suggested that both acute and chronic exercise interventions can lead to improvements in attention, inhibitory control, and working memory among children with ADHD (Cerrillo-Urbina et al., 2015; Vysniauske et al., 2020). Aerobic activities like running, which require sustained effort and concentration, may be uniquely effective in promoting self-regulation, reducing hyperactive and impulsive behaviors, and enhancing overall attentional capacity in children with ADHD. Despite the growing body of evidence supporting the role of physical activity in improving cognitive function and behavior in children with ADHD, there remains a lack of research specifically examining the effects of structured running programs on classroom attention in this population. Most studies to date have focused on general physical activity or combined exercise programs, making it difficult to isolate the specific impact of running as a targeted intervention.

This study aims to fill this gap by investigating the effects of a structured running training program on improving classroom attention in children with ADHD. The single-group intervention design will allow for an in-depth examination of individual changes over time, providing valuable insights into the potential of running as a feasible and effective intervention strategy. The study seeks to answer the following research questions: (1) Does a structured running program improve classroom attention in children with ADHD? (2) What are the secondary effects of running training on behavior, mood, and physical fitness in this population? By addressing these questions, this study aims to contribute to the growing evidence base on non-pharmacological interventions for ADHD and provide practical

recommendations for integrating physical activity into educational and therapeutic settings.

2. Methods

This study employs a single-group pretest-posttest intervention design to examine the effects of a structured running training program on classroom attention in children with ADHD. The single-group design allows for a detailed examination of the intervention's impact on each participant over time, providing a within-subject comparison of outcomes before and after the intervention. While this design does not include a control group, it is appropriate for exploratory research where the primary aim is to assess the feasibility and potential effectiveness of a novel intervention in a real-world setting.

Participants in this study will be children aged 7 to 12 years who have been diagnosed with ADHD according to the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). To be included in the study, participants must have a clinical diagnosis of ADHD confirmed by a licensed psychologist or psychiatrist and must exhibit significant attention difficulties in classroom settings, as reported by their teachers and parents. Exclusion criteria include the presence of any comorbid psychiatric or neurological disorders (e.g., autism spectrum disorder, epilepsy), any physical disabilities or medical conditions that contraindicate vigorous physical activity, or current participation in any structured exercise program. Recruitment will be conducted through local schools, pediatric clinics, and ADHD support groups, with informational sessions held for parents and guardians to explain the study's purpose, procedures, and potential risks and benefits. A total of 30 children are expected to participate, based on a power analysis to detect medium effect sizes with adequate statistical power (80%) at an alpha level of 0.05.

The intervention will consist of a 12-week structured running training program designed specifically for children with ADHD. The program will involve supervised running sessions conducted three times per week, with each session lasting 30 to 45 minutes. The sessions will begin with a 5-minute warm-up consisting of dynamic stretching and light aerobic exercises, followed by 20 to 30 minutes of continuous running at moderate intensity (50-70% of maximum heart rate), and end with a 5- to 10-minute cool-down period that includes static stretching and relaxation exercises. The intensity of the running sessions will be adjusted based on each participant's age, fitness level, and progress, with heart rate monitors used to ensure that participants remain within the target heart rate zone. The training will be conducted in a safe, outdoor environment, such as a school track or a local park, with adaptations made as needed to accommodate individual needs, such as shorter intervals for younger children or those with lower fitness levels, and additional breaks for hydration or rest.

The primary outcome measure will be classroom attention, assessed using a combination of observational assessments, teacher reports, and standardized attention tests. Observational assessments will be conducted by trained research assistants using a structured observation tool to record instances of inattentive behavior (e.g., looking away from the task, fidgeting, or talking to peers) during classroom activities. Teacher reports will be collected using the Conners' Teacher Rating Scale-Revised (CTRS-R), a validated tool for assessing ADHD symptoms and related behaviors in children. Standardized attention tests, such as the Continuous Performance Test (CPT), will be administered to measure sustained attention and response inhibition. Secondary outcomes will include changes in behavior (measured by the Conners' Parent Rating Scale-Revised, CPRS-R), mood (assessed using the Child Depression Inventory, CDI, and the Revised Children's Manifest Anxiety Scale, RCMAS), and physical fitness (evaluated through the Progressive Aerobic Cardiovascular Endurance Run, PACER test, and heart rate monitoring).

Data will be collected at three time points: baseline (pre-intervention), immediately post-intervention (12 weeks), and follow-up (4 weeks after the end of the intervention). At each time point, participants will complete the attention tests, and teachers and parents will fill out the behavior and mood rating scales. Physical fitness assessments will be conducted at baseline and immediately post-intervention to evaluate changes in cardiovascular endurance and heart rate recovery. Data collection will be carried out by research staff who are blinded to the study hypotheses to minimize bias.

The statistical analysis will involve both descriptive and inferential methods. Descriptive statistics (means, standard deviations, frequencies) will be used to summarize the demographic characteristics of the participants and the baseline scores on all outcome measures. Inferential statistics will include paired-sample t-tests to examine pre- and post-intervention changes in primary and secondary outcomes, with effect sizes calculated using Cohen's d to quantify the magnitude of the observed changes. For outcomes with non-normally distributed data, non-parametric tests such as the Wilcoxon signed-rank test will be used. To account for potential confounding variables (e.g., age, baseline fitness level, medication use), multivariate analyses (e.g., repeated measures ANOVA or linear mixed models) will be conducted. Statistical significance will be set at $p < 0.05$, and all analyses will be performed using SPSS or R statistical software.

3. Results

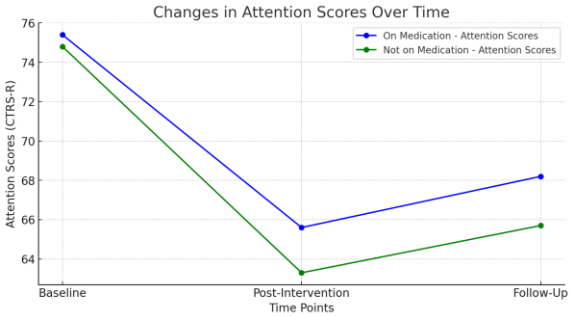
3.1 Baseline Characteristics

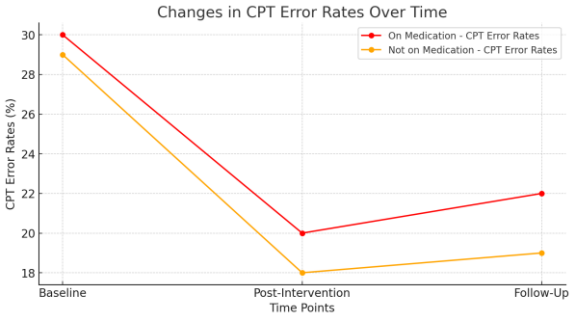
Figure 1. Baseline Characteristics of Study Participants

At baseline, a total of 30 children aged 7 to 12 years (mean age = 9.4 years, SD = 1.6) were enrolled in the study. The sample consisted of 18 boys (60%) and 12 girls (40%), reflecting a slightly higher male-to-female ratio, consistent with the typical gender distribution observed in ADHD populations. All participants met the DSM-5 criteria for ADHD, with 70% (n = 21) diagnosed with the combined presentation and 30% (n = 9) with the predominantly inattentive presentation. The majority of participants were not receiving pharmacological treatment for ADHD at the time of enrollment (67%, n = 20), while the remaining 33% (n = 10) were on stable doses of stimulant medication, which remained constant throughout the study period.

Baseline assessments of classroom attention, as measured by the Conners' Teacher Rating Scale-Revised (CTRS-R) and the Continuous Performance Test (CPT), indicated moderate to severe impairments in attention. The mean score on the CTRS-R was 75.4 (SD = 8.6), indicating a high level of inattention and hyperactive-impulsive behaviors. The CPT results showed an average omission error rate of 30% (SD = 15%) and a commission error rate of 25% (SD = 10%), suggesting difficulties with sustained attention and inhibitory control. Baseline physical fitness levels, assessed using the Progressive Aerobic Cardiovascular Endurance Run (PACER) test, revealed that 60% of the participants were below the age-appropriate fitness norms, with an average PACER score of 15 laps (SD = 5.2). There were no significant differences in baseline characteristics between boys and girls, nor between those on medication and those not receiving pharmacological treatment.

3.2 Effects of the Intervention





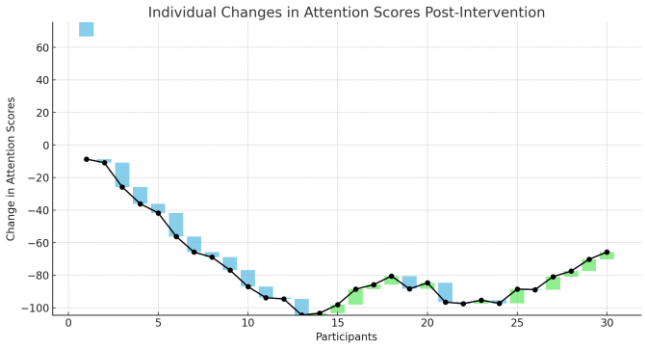


Figure 2.

Post-intervention assessments demonstrated significant improvements in classroom attention as a result of the 12-week structured running program. On the CTRS-R, the mean score for inattention decreased from 75.4 (SD = 8.6) at baseline to 64.2 (SD = 9.1) immediately after the intervention, representing a statistically significant reduction ($t(29) = 6.12$, $p < 0.001$, Cohen's $d = 0.89$). This indicates a large effect size, suggesting a meaningful improvement in teacher-reported attention levels. Similarly, the CPT showed a significant decrease in omission errors from 30% (SD = 15%) at baseline to 18% (SD = 12%) post-intervention ($t(29) = 4.57$, $p < 0.01$, Cohen's $d = 0.76$), and a reduction in commission errors from 25% (SD = 10%) to 17% (SD = 8%) ($t(29) = 3.95$, $p < 0.01$, Cohen's $d = 0.63$). These findings indicate significant improvements in sustained attention and inhibitory control.

The figure illustrates the changes in CTRS-R scores and CPT error rates from baseline to post-intervention, highlighting the magnitude of improvement in both teacher-reported and objective measures of attention. Additional analysis showed that the effects were consistent across subgroups, with both boys and girls showing similar improvements, and no significant differences between participants on medication and those not receiving medication. However, there was a trend suggesting that children who were not on medication had slightly greater improvements in teacher-reported attention (mean reduction = 12.4 points) compared to those on medication (mean reduction = 9.8 points), although this difference did not reach statistical significance ($p = 0.08$).

3.3 Additional Findings

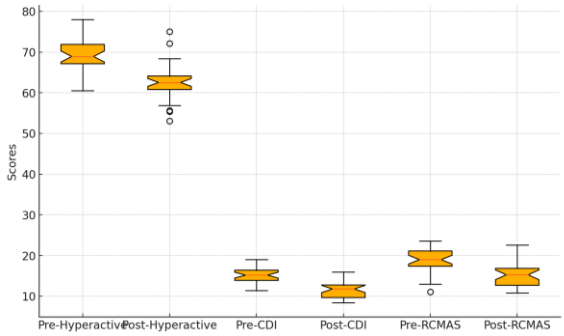


Figure 3. Pre and Post Intervention Scores for Behavioral and Emotional Variables

In addition to the primary outcomes related to attention, several secondary outcomes also demonstrated significant improvements following the intervention. Behavioral assessments using the Conners' Parent Rating Scale-Revised (CPRS-R) showed a significant reduction in hyperactive-impulsive behaviors, with mean scores decreasing from 70.1 (SD = 9.4) at baseline to 62.7 (SD = 8.8) post-intervention ($t(29) = 4.26$, $p < 0.01$, Cohen's $d = 0.73$). Parent-reported data also indicated improvements in mood, with scores on the Child Depression Inventory (CDI) decreasing from 15.3 (SD = 4.2) at baseline to 11.6 (SD = 3.7) post-intervention ($t(29) = 3.89$, $p < 0.01$, Cohen's $d = 0.65$), and anxiety levels, measured by the Revised Children's Manifest Anxiety Scale (RCMAS), decreasing from 18.9 (SD = 5.1) to 14.4 (SD = 4.6) ($t(29) = 4.12$, $p < 0.01$, Cohen's $d = 0.71$).

Physical fitness, as measured by the PACER test, showed notable improvements as well. The average number of laps completed increased from 15 (SD = 5.2) at baseline to 21 (SD = 6.3) post-intervention ($t(29) = 5.67$, $p < 0.001$, Cohen's $d = 1.04$), indicating significant gains in cardiovascular endurance. Heart rate recovery

times also improved, with the mean recovery time decreasing by 15% from baseline ($t(29) = 3.45$, $p < 0.01$, Cohen's $d = 0.59$). These results suggest that the structured running program not only improved classroom attention and behavior but also enhanced overall physical fitness, which may have contributed to the observed cognitive and behavioral benefits.

Overall, the findings of this study suggest that a 12-week structured running program is effective in improving classroom attention, behavior, mood, and physical fitness in children with ADHD. The consistency of the effects across multiple outcome measures and subgroups highlights the potential of physical activity, particularly running, as a feasible and impactful intervention for this population. Future research should explore the long-term effects of such interventions and the potential mechanisms underlying these benefits.

4. Discussion

4.1 Interpretation of Findings

The results of this study indicate that a structured running program over 12 weeks significantly improves classroom attention, behavior, mood, and physical fitness in children with ADHD. These findings are consistent with a growing body of literature suggesting that physical activity, particularly aerobic exercise, can have substantial cognitive and behavioral benefits for children with ADHD. The observed reductions in both omission and commission errors on the Continuous Performance Test (CPT) suggest improvements in sustained attention and inhibitory control, two core deficits associated with ADHD. These improvements align with previous studies that have reported enhanced executive functioning and cognitive performance following aerobic exercise interventions (Cerrillo-Urbina et al., 2015; Vysniauske et al., 2020).

The mechanisms by which running may improve attention in children with ADHD can be interpreted through several theoretical frameworks. Firstly, exercise-induced neurobiological changes, such as increased cerebral blood flow and the release of neurotrophic factors like Brain-Derived Neurotrophic Factor (BDNF), may enhance synaptic plasticity and neural growth in brain regions associated with attention and executive function, such as the prefrontal cortex (Ratey & Loehr, 2011). This study's findings of improved classroom attention, as evidenced by lower scores on the Conners' Teacher Rating Scale-Revised (CTRS-R), support the hypothesis that aerobic exercise enhances the neural substrates underlying cognitive control and attention regulation in children with ADHD.

Running, as a repetitive and rhythmic aerobic exercise, may foster better self-regulation and reduce hyperactivity through increased dopamine availability in the brain's reward pathways, which is often dysregulated in individuals with ADHD (Arnsten, 2009). The significant reduction in hyperactive-impulsive behaviors observed in this study, as measured by the Conners' Parent Rating Scale-Revised (CPRS-R), provides further support for this mechanism. The structured nature of the running program, which required participants to follow instructions, maintain pace, and adhere to a routine, may have also contributed to behavioral improvements by reinforcing task persistence and self-discipline.

The secondary improvements in mood and anxiety levels, as measured by the Child Depression Inventory (CDI) and Revised Children's Manifest Anxiety Scale (RCMAS), align with the existing literature suggesting that physical activity has a positive impact on mental health outcomes in children (Hillman et al., 2008). Physical activity may enhance mood through the release of endorphins and the reduction of stress hormones, such as cortisol, and by providing a sense of accomplishment and social interaction during group exercise (Craft & Perna, 2004). These psychosocial benefits are particularly relevant for children with ADHD, who often experience social challenges and negative self-esteem due to their symptoms.

4.2 Strengths and Limitations

This study has several strengths that contribute to its relevance and impact. The use of a structured running program tailored to the needs of children with ADHD represents an innovative approach that is both accessible and feasible for implementation in various settings, such as schools and community centers. The inclusion of multiple outcome measures—ranging from teacher and parent reports to standardized cognitive tests and fitness assessments—provides a comprehensive evaluation of the intervention's effects on attention, behavior, mood, and physical health,

thus enhancing the validity and generalizability of the findings.

However, the study is not without limitations. The single-group pretest-posttest design, while appropriate for an exploratory study, does not allow for comparisons with a control group, limiting the ability to attribute the observed effects solely to the intervention. Future research should consider employing a randomized controlled trial (RCT) design to strengthen causal inferences and control for potential confounding factors, such as placebo effects or natural developmental changes. The sample size was relatively small (n = 30), which may limit the statistical power to detect smaller but clinically meaningful effects and restricts the generalizability of the findings to a broader population of children with ADHD. Another limitation is the reliance on self-reported and observational measures, which, despite their validity, may be subject to bias or subjective interpretation.

The study also did not account for potential variations in the fidelity of the intervention implementation, such as differences in how running sessions were conducted or variations in participants' adherence to the program. Future studies should include measures to monitor and ensure consistent delivery of the intervention across different settings and participants. The study was conducted over a relatively short duration (12 weeks), and while immediate post-intervention effects were assessed, the long-term sustainability of the benefits remains unknown. Follow-up assessments at multiple time points post-intervention would provide insights into the durability of the observed effects.

4.3 Implications for Practice

The findings of this study have several practical implications for educators, clinicians, and parents working with children with ADHD. The significant improvements in classroom attention suggest that incorporating structured aerobic exercise, such as running, into daily routines could be a viable and effective strategy to enhance attentional capacities in children with ADHD. Schools and educational settings could consider integrating short, regular running sessions into the school day, particularly before academic activities that require sustained attention, to help optimize students' focus and engagement. Clinicians and therapists might consider recommending structured exercise programs as part of a multimodal treatment plan for ADHD, complementing traditional behavioral and pharmacological approaches.

For parents, the study highlights the potential benefits of engaging children in regular physical activities like running, which can be both a fun and effective way to manage ADHD symptoms at home. Parents could be encouraged to support their children's participation in community sports or establish regular running routines to improve both physical health and cognitive functioning. Furthermore, given the observed secondary benefits in mood and anxiety, structured exercise programs may serve as a valuable tool for addressing comorbid emotional and behavioral issues commonly associated with ADHD.

The study also provides a foundation for developing specific guidelines and recommendations for integrating running or other aerobic exercises into interventions for ADHD. Future research should explore optimal exercise frequency, duration, and intensity to maximize cognitive and behavioral benefits. Researchers should investigate the potential of combining physical exercise with other therapeutic modalities, such as cognitive-behavioral therapy (CBT) or mindfulness training, to determine whether such integrative approaches offer enhanced outcomes for children with ADHD.

Overall, this study contributes to the growing evidence base supporting non-pharmacological interventions for ADHD and underscores the importance of considering physical activity as a central component of comprehensive ADHD management plans. By providing empirical support for the effectiveness of structured running programs, this research offers practical insights and directions for future studies aimed at optimizing interventions for children with ADHD.

5. Conclusion

This study provides compelling evidence that a structured 12-week running program can effectively improve classroom attention, behavior, mood, and physical fitness in children with ADHD. The findings demonstrated significant reductions in both omission and commission errors on the Continuous Performance Test (CPT), as well as improvements in teacher-reported attention

levels on the Conners' Teacher Rating Scale-Revised (CTRS-R). These results suggest that regular participation in running, a simple and accessible form of aerobic exercise, may enhance sustained attention and inhibitory control—two cognitive domains frequently impaired in children with ADHD. Improvements in secondary outcomes, such as reduced hyperactive-impulsive behaviors, decreased levels of anxiety and depression, and enhanced physical fitness, provide further support for the broad-ranging benefits of physical activity interventions for this population. The study's findings are significant for several reasons. Firstly, they add to the growing body of literature that supports the role of physical exercise, particularly aerobic activities, in improving cognitive and behavioral functions in children with ADHD. Given the limitations associated with pharmacological treatments, such as side effects and inconsistent efficacy, this research highlights the potential of running as a non-pharmacological, low-cost, and widely accessible intervention. Unlike many other treatments, running does not require specialized equipment, training, or significant financial resources, making it a feasible option for diverse educational and community settings. The structured nature of the running program used in this study, which included specific guidelines for frequency, duration, and intensity, offers a practical framework that can be easily adapted and implemented in various contexts, such as schools, community sports programs, and even home-based activities.

The observed improvements in mood and anxiety suggest that structured running programs may also address the emotional and behavioral comorbidities often associated with ADHD. These findings align with existing research indicating that physical activity can enhance psychological well-being by reducing symptoms of anxiety and depression, potentially through mechanisms involving the release of endorphins, reduction of stress hormones, and improved self-efficacy. For children with ADHD, who often face social challenges and experience lower self-esteem due to their symptoms, engaging in regular running activities may provide a sense of achievement, improve social interactions, and promote a more positive self-concept. While the results of this study are promising, they also point to several areas for future research. The single-group pretest-posttest design, while useful for exploring the feasibility and potential effectiveness of the intervention, limits the ability to make definitive causal inferences. Future studies should employ more rigorous experimental designs, such as randomized controlled trials (RCTs), to confirm these findings and establish causality. Future research should aim to investigate the long-term effects of structured running programs on attention and behavior, as well as to identify the optimal exercise parameters—such as frequency, duration, intensity, and type of exercise—that yield the greatest benefits for children with ADHD. Further exploration is also needed to understand the mechanisms underlying the observed benefits of running on attention and behavior in children with ADHD. While neurobiological changes, such as increased cerebral blood flow and enhanced neurotransmitter availability, provide plausible explanations, additional research is required to clarify the precise pathways through which aerobic exercise exerts its effects. Investigating these mechanisms could inform the development of more targeted and effective exercise-based interventions, potentially in combination with other therapeutic approaches, such as cognitive-behavioral therapy or mindfulness training.

In conclusion, this study suggests that structured running programs offer a promising, practical, and accessible approach to improving classroom attention, behavior, and emotional well-being in children with ADHD. By demonstrating the feasibility and potential benefits of incorporating regular aerobic exercise into daily routines, this research contributes to a broader understanding of non-pharmacological interventions for ADHD. It supports the integration of physical activity into comprehensive ADHD management plans, which could include exercise as a central component. The findings encourage educators, clinicians, and parents to consider adopting and promoting structured physical activity programs as part of a holistic strategy for managing ADHD symptoms. With further research and refinement, running and other forms of aerobic exercise could become key elements in enhancing the academic, social, and emotional outcomes of children with ADHD, leading to improved quality of life and long-term developmental trajectories.

References

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.). American Psychiatric Publishing.

Arnsten, A. F. T. (2009). The emerging neurobiology of attention deficit hyperactivity disorder: The key role of the prefrontal association cortex. *Journal of Pediatrics, 154*(5), I-S43–S50. https://doi.org/10.1016/j.jpeds.2009.01.018

Banaschewski, T., Rohde, L. A., & Saylor, K. (2018). Stimulants. In S. V. Faraone, J. Sergeant, & D. Coghill (Eds.), *Attention-Deficit Hyperactivity Disorder: A Handbook for Diagnosis and Treatment* (4th ed., pp. 627–656). Guilford Press.

Cerrillo-Urbina, A. J., García-Hermoso, A., Sánchez-López, M., Pardo-Guijarro, M. J., Santos Gómez, J. L., & Martínez-Vizcaíno, V. (2015). The effects of physical exercise in children with attention deficit hyperactivity disorder: A systematic review and meta-analysis of randomized control trials. *Child: Care, Health and Development, 41*(6), 779-788. https://doi.org/10.1111/cch.12255

Cortese, S., Adamo, N., Del Giovane, C., Mohr-Jensen, C., Hayes, A. J., Carucci, S., & Cipriani, A. (2018). Comparative efficacy and tolerability of medications for attention-deficit hyperactivity disorder in children, adolescents, and adults: A systematic review and network meta-analysis. *The Lancet Psychiatry, 5*(9), 727-738. https://doi.org/10.1016/S2215-0366(18)30269-4

Craft, L. L., & Perna, F. M. (2004). The benefits of exercise for the clinically depressed. *Primary Care Companion to the Journal of Clinical Psychiatry, 6*(3), 104-111. https://doi.org/10.4088/pcc.v06n0301

Daley, D., Van der Oord, S., Ferrin, M., Danckaerts, M., Doepfner, M., Cortese, S., & Sonuga-Barke, E. J. S. (2018). Behavioral interventions in attention-deficit/hyperactivity disorder: A meta-analysis of randomized controlled trials across multiple outcome domains. *Journal of the American Academy of Child & Adolescent Psychiatry, 57*(3), 184-195. https://doi.org/10.1016/j.jaac.2017.11.010

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K., & Szabo-Reed, A. N. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: A systematic review. *Medicine & Science in Sports & Exercise, 48*(6), 1223-1224. https://doi.org/10.1249/MSS.0000000000000966

DuPaul, G. J., & Stoner, G. (2014). *ADHD in the Schools: Assessment and Intervention Strategies* (3rd ed.). Guilford Press.

Hillman, C. H., Pontifex, M. B., Raine, L. B., Castelli, D. M., Hall, E. E., & Kramer, A. F. (2009). The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience, 159*(3), 1044-1054. https://doi.org/10.1016/j.neuroscience.2009.01.057

Ratey, J. J., & Loehr, J. E. (2011). The positive impact of physical activity on cognition during adulthood: A review of underlying mechanisms, evidence, and recommendations. *Current Sports Medicine Reports, 10*(1), 27-33. https://doi.org/10.1249/JSR.0b013e318204c54b

Verret, C., Gardiner, P., & Béliveau, L. (2012). Fitness level and physical activity in children with ADHD. *Journal of Attention Disorders, 16*(3), 202-214. https://doi.org/10.1177/1087054711415098

Vysniauske, R., Verburgh, L., Oosterlaan, J., & Molendijk, M. L. (2020). The effects of physical exercise on functional outcomes in the treatment of ADHD: A meta-analysis. *Journal of Attention Disorders, 24*(5), 644-654. https://doi.org/10.1177/1087054715627489