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Investigating the Effectiveness of Mindfulness Training on Sustained Attention, Self-Control, and Cognitive Flexibility in Children with Attention Deficit Hyperactivity Disorder (ADHD)

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A B S T R A C T

Purpose: This study aimed to investigate the effectiveness of mindfulness training on sustained attention, self-control, and cognitive flexibility in children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD).

Methods and Materials: The research employed a quasi-experimental design with a pretest–posttest–follow-up structure and a control group. A sample of 30 male students aged 8 to 12 years with a clinical diagnosis of ADHD was selected through purposive sampling from a private clinical population. Participants were randomly assigned to experimental (n=15) and control (n=15) groups. The experimental group received an 8-session mindfulness training protocol, each session lasting 90 minutes, based on developmentally appropriate exercises. Outcome measures included the Self-Control Scale (Tangney et al., 2004), the Continuous Performance Test (Rosvold et al., 1965) for sustained attention, and the Wisconsin Card Sorting Test (Grant & Berg, 1984) for cognitive flexibility. Data were collected at three time points: pretest, posttest, and a two-month follow-up, and analyzed using repeated measures ANOVA.

Findings: Results showed significant group-by-time interaction effects for all three outcome variables ($p < .001$). Self-control scores increased significantly in the experimental group from pretest to posttest and remained stable at follow-up. Measures of sustained attention improved significantly, as evidenced by reductions in omission and commission errors and shorter reaction times ($p < .001$). Cognitive flexibility also showed statistically significant gains, with decreases in perseverative and total errors and increases in correct category classification ($p < .001$). Bonferroni post hoc tests confirmed that most improvements persisted at follow-up, indicating durable intervention effects.

Conclusion: Mindfulness training is an effective and sustainable intervention for improving executive functions—specifically self-control, sustained attention, and cognitive flexibility—in children with ADHD, offering a promising non-pharmacological treatment pathway.

Keywords: *Mindfulness training, sustained attention, self-control, cognitive flexibility, children with Attention Deficit Hyperactivity Disorder (ADHD)*

1. Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder that significantly impairs various cognitive, emotional, and behavioral functions in children. Characterized by persistent patterns of inattention, hyperactivity, and impulsivity, ADHD often leads to academic underperformance, interpersonal difficulties, and reduced self-regulatory capacity (Wong et al., 2024; Zysset et al., 2023). Cognitive impairments associated with ADHD extend beyond core symptoms to include deficits in sustained attention, self-control, inhibitory functioning, and cognitive flexibility (Amorim & Marques, 2018; Cai et al., 2019; Unsworth & Robison, 2020). These cognitive weaknesses are foundational to many of the functional difficulties observed in children with ADHD, making them essential targets for intervention and rehabilitation.

A growing body of research has shifted focus toward executive functioning—particularly working memory, attentional control, and inhibitory regulation—as central to understanding the cognitive architecture of ADHD (Drechsler et al., 2020; Kuntsi et al., 2014). Inhibitory control and cognitive flexibility, as core executive functions, are essential for adaptive functioning in both academic and social contexts (Amorim & Marques, 2018; Dennis & Vanderwal, 2010). In particular, sustained attention—the ability to maintain focus over time—has been repeatedly shown to be impaired in children with ADHD, often serving as a predictor for long-term academic and behavioral outcomes (Fuermaier et al., 2022; Yıldırım Demirdöğen et al., 2022). Furthermore, cognitive flexibility, which enables individuals to shift between tasks or mental sets, is often compromised in this population, limiting their adaptability in dynamic learning environments (Dennis & Vanderwal, 2010; Van de Weijer-Bergsma et al., 2012). Together, these deficits contribute to the broader profile of cognitive dysfunction in children with ADHD and represent critical domains for early and effective intervention.

Traditional treatment approaches for ADHD—primarily pharmacological—have yielded moderate efficacy but are often accompanied by side effects and concerns about long-term use (Hosenbocus & Chahal, 2012; Zysset et al., 2023). In recent years, non-pharmacological strategies, especially those focusing on cognitive and behavioral training, have emerged as promising alternatives or adjuncts (Keshavarz Valian et al., 2023; Nejati, 2020). Among these, mindfulness-based interventions (MBIs) have gained empirical support as effective means of improving attention regulation, self-awareness, and executive functioning (Bögels et al., 2010; Van der Oord et al., 2012). Rooted in the intentional practice of present-moment awareness, mindfulness enhances attentional stability and emotional self-regulation, thereby addressing the core deficits found in ADHD (García-Rubio, 2021; Wong et al., 2023). Mindfulness helps to cultivate a non-reactive awareness of internal and external stimuli, which may, in turn, bolster self-control and reduce behavioral impulsivity (Zhang & Zhang, 2023; Zhang et al., 2017).

Several studies have demonstrated the potential of MBIs in improving executive functions among children with ADHD. For instance, mindfulness training has been associated with enhanced sustained attention, improved inhibitory control, and increased behavioral self-monitoring (Van der Oord et al., 2012; Wong et al., 2023). In a randomized controlled trial comparing mindfulness-based training to cognitive-behavioral therapy, children who received mindfulness interventions showed comparable or superior improvements in attentional control and reduced behavioral problems (Wong et al., 2024). Such interventions not only target symptomatology but also offer tools for emotional regulation and metacognitive awareness, critical for long-term adaptive functioning (Bögels et al., 2010; Siebelink et al., 2022).

Beyond symptom reduction, mindfulness-based programs appear to positively influence neurocognitive networks related to executive functioning. Evidence from neuroimaging and neuropsychological studies indicates that mindfulness may strengthen the functional connectivity of salience and frontoparietal networks, thereby enhancing top-down cognitive control mechanisms (Cai et al., 2019; Zhang & Zhang, 2023). These findings suggest a potential neurobiological pathway through which mindfulness exerts its effects on attentional and cognitive control in children with ADHD. Furthermore, mindfulness interventions have demonstrated feasibility and acceptability in pediatric settings, especially when combined with parental involvement (Karami & Pourkamali, 2023; Lo et al., 2016), which is crucial given the developmental needs and environmental dependencies of this population.

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The integrative application of mindfulness and cognitive training has also been explored in various pilot trials and mixed-method studies. The NeuroMind study, for instance, outlines a combined protocol of mindfulness and cognitive exercises tailored to the specific needs of children with ADHD, highlighting the potential for synergistic effects (Badia-Aguarón et al., 2024). Similarly, studies involving family-based mindfulness programs emphasize the importance of including parents in the intervention process to maximize outcomes for both children and family dynamics (Lo et al., 2016; Wong et al., 2023). This is particularly relevant as parent-child relational factors and mindful parenting have been shown to influence the effectiveness of therapeutic interventions for ADHD (Bögels et al., 2010; Van der Oord et al., 2012).

In addition to attention-related outcomes, MBIs have shown efficacy in enhancing self-control and psychological flexibility, two domains that are often impaired in children with ADHD and are critical for their socio-emotional development (Karami & Pourkamali, 2023; Keshavarz Valian et al., 2023). Self-control, as defined by the ability to regulate impulses and delay gratification, is fundamental to behavioral adaptation in academic and peer contexts (Beh-Pajooh et al., 2012; Zhang & Zhang, 2023). Mindfulness practices, by fostering moment-to-moment awareness and acceptance, may provide children with greater capacity to pause and choose deliberate responses rather than acting impulsively (Cassar et al., 2022; Wong et al., 2024).

Despite the growing body of evidence, it is important to consider individual differences in treatment responsiveness. Factors such as comorbid anxiety, cognitive capacity, and emotional regulation skills can moderate the effectiveness of mindfulness interventions (Anning et al., 2024; Wong et al., 2023). For example, children with co-occurring separation anxiety may exhibit different cognitive processing styles that influence how they engage with mindfulness training (Anning et al., 2024). Additionally, the contextual implementation of these programs—whether in schools, clinics, or home settings—can influence outcome efficacy (García-Rubio, 2021; Tercelli & Ferreira, 2019).

This study seeks to contribute to the expanding literature on mindfulness-based approaches by investigating the effectiveness of an adapted mindfulness training program on sustained attention, self-control, and cognitive flexibility in children diagnosed with ADHD.

2. Methods and Materials

2.1. Study Design and Participants

The present study was applied in purpose and utilized a quasi-experimental method with a pretest–posttest–follow-up design and a control group. The statistical population included all children aged 8 to 12 years diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) who had referred to a private clinic during the 2023–2024 academic year. From this population, 30 male students diagnosed with ADHD were selected purposefully, based on inclusion criteria, and then randomly assigned into two groups: an experimental group (15 participants) and a control group (15 participants). At the beginning of the study, both groups underwent initial cognitive assessments as part of the pretest phase, which measured their levels of self-control, sustained attention, and cognitive flexibility. Following the pretest, only the participants in the experimental group received a rehabilitation-based mindfulness training program conducted over eight weekly sessions, each lasting approximately one hour, at the clinic. During this intervention period, the control group received no psychological treatment or intervention. After completing the sessions, both groups were re-evaluated immediately and again after three months for the follow-up phase, to assess the sustainability of any observed effects. The inclusion criteria for participation were: being between 8 and 12 years old, having an average intellectual ability as confirmed by their case files at the clinic, possessing a formal diagnosis of ADHD by a psychiatrist or clinical psychologist, showing no signs of other psychological disorders based on diagnostic and differential interviews in accordance with DSM-5 criteria, not taking medication, not receiving any concurrent psychological interventions, providing informed assent to participate in the study, and having at least basic computer literacy. The exclusion criteria were: missing more than three consecutive therapy sessions, receiving concurrent psychological, behavioral, or pharmacological interventions during the study, failure to complete the required assessments and assignments, and unwillingness to continue participation.

2.2. Measures

To assess self-control in the participants, the study used the Self-Control Scale developed by Tangney, Baumeister, and Boone in 2004. This tool was designed to measure individuals' ability to regulate behavior, emotions, thoughts, and impulses in pursuit of long-term goals. The questionnaire contains 36 items rated on a 5-point Likert

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scale ranging from 1 (not at all like me) to 5 (very much like me). The scale yields a total score, with higher scores indicating greater self-control. The original version includes subscales for controlling thoughts, controlling emotions, resisting temptations, breaking bad habits, and performance reliability. However, in practice, many studies report the total score rather than subscale scores due to the interrelatedness of self-control dimensions. The internal consistency of the original version has been reported to be high ($\alpha = 0.89$), and its construct and convergent validity have been confirmed through correlations with various measures of behavior and psychological functioning. Numerous studies have since verified the psychometric properties of the scale in different populations, including children, making it a reliable tool in assessing self-regulatory capabilities in clinical and developmental contexts.

Sustained attention was measured using the Continuous Performance Test (CPT), originally developed by Rosvold, Mirsky, Sarason, Bransome, and Beck in 1965. The CPT is a computerized assessment tool widely employed in clinical and research settings to evaluate attentional capacity and vigilance over time. During this test, participants are required to respond to specific target stimuli while inhibiting responses to non-targets, which enables the measurement of both attentional focus and impulse control. It records variables such as omission errors (failing to respond to a target), commission errors (responding to a non-target), reaction time, and variability in reaction time. The test has become a standard diagnostic tool in assessing attention-related disorders, especially ADHD. Its validity and reliability have been extensively documented in both child and adult populations. The CPT is especially valued for its sensitivity to attentional lapses and has been normed across multiple age groups, reinforcing its utility in clinical diagnosis and cognitive research.

Cognitive flexibility was assessed through the Wisconsin Card Sorting Test (WCST), developed by Grant and Berg in 1948 and later computerized for standardized administration. This neuropsychological test evaluates an individual's ability to display flexibility in the face of changing schedules of reinforcement. During the task, participants are required to match stimulus cards according to different sorting rules, which are periodically changed without warning. The participant must infer the new rule based on feedback and adapt their behavior accordingly. Measures include the number of categories completed, total errors, and perseverative errors (i.e., continuing to use a previous rule despite negative feedback). The WCST is widely recognized for its ability to assess executive functions, especially mental set-shifting and problem-solving ability. Its relevance in studies involving children with ADHD is well-established, as deficits in cognitive flexibility are considered core features of the disorder. Numerous validation studies have confirmed the WCST's construct and criterion validity, and the test-retest reliability has been reported to be satisfactory in pediatric and clinical populations.

2.3. Intervention

The intervention protocol consisted of a structured mindfulness training program delivered over eight consecutive weeks, with one session per week, each lasting approximately 90 minutes. The sessions were conducted in a private clinic setting and facilitated by a trained therapist with expertise in mindfulness-based interventions for children. The content of the sessions was based on the Mindful Attention Training framework developed by Zylowska (2012), which is specifically tailored for children with Attention Deficit Hyperactivity Disorder (ADHD). The program included age-appropriate exercises designed to enhance awareness of bodily sensations, thoughts, and emotions through activities such as mindful breathing, sensory awareness, and movement-based mindfulness. Each session incorporated experiential practices, guided meditations, interactive discussions, and storytelling to facilitate comprehension and engagement. Homework assignments were provided after each session to encourage daily mindfulness practice at home, often supported by parental guidance. The training emphasized nonjudgmental awareness, present-moment focus, and self-regulation, with progressive development of attention control and emotional regulation across sessions. Throughout the program, children were encouraged to recognize and disengage from automatic reactive patterns and to develop adaptive responses to distractions and impulses, fostering improvements in sustained attention, self-control, and cognitive flexibility.

2.4. Data Analysis

For data analysis, the study employed repeated measures analysis of variance (ANOVA) to examine changes in dependent variables—namely sustained attention, self-control, and cognitive flexibility—across the three time points: pretest, posttest, and follow-up. This statistical method allows for the detection of both within-subject

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changes over time and between-group differences in treatment effects. The significance level was set at $p < .05$. Assumptions of normality, sphericity, and homogeneity of variances were examined prior to conducting the main analyses. The statistical analysis was conducted using SPSS version 26, and effect sizes were reported alongside p-values to indicate the magnitude of differences observed.

3. Findings and Results

Table 1 presents the descriptive indices of the research variables.

Table 1

Descriptive Statistics of Participants' Scores on the Research Variables Based on Group Membership and Assessment Phase

Component	Phase	Mindfulness Group Mean (SD)	Control Group Mean (SD)
Self-Control	Pretest	24.06 (2.63)	23.93 (2.65)
	Posttest	29.06 (2.56)	24.53 (2.44)
	Follow-up	31.13 (2.72)	23.20 (2.40)
Commission Errors	Pretest	13.60 (1.18)	13.80 (1.14)
	Posttest	7.80 (1.32)	13.01 (1.65)
	Follow-up	5.93 (1.75)	13.60 (1.18)
Omission Errors	Pretest	13.26 (1.03)	13.33 (1.34)
Sustained Attention	Posttest	10.46 (1.18)	13.06 (2.08)
	Follow-up	6.26 (2.08)	13.46 (1.40)
Reaction Time (ms)	Pretest	324.60 (8.82)	327.53 (8.59)
	Posttest	244.66 (7.47)	324.13 (7.29)
	Follow-up	220.66 (7.42)	327.40 (7.72)
Perseverative Errors	Pretest	8.66 (1.54)	8.53 (1.30)
	Posttest	5.61 (1.18)	8.87 (1.50)
	Follow-up	3.40 (1.12)	8.60 (1.90)
Total Errors	Pretest	21.80 (3.12)	22.93 (2.53)
Cognitive Flexibility	Posttest	12.93 (1.63)	22.13 (2.24)
	Follow-up	7.86 (1.55)	23.86 (2.64)
Number of Correct Categories	Pretest	2.26 (0.94)	2.66 (1.05)
	Posttest	5.80 (0.96)	2.26 (2.95)
	Follow-up	9.06 (1.71)	2.40 (1.05)

As shown in Table 1, the mean and standard deviation scores of the participants are presented for the variables of self-control, sustained attention (including commission errors, omission errors, and reaction time), and cognitive flexibility (including perseverative errors, total errors, and number of correct categories), based on group membership and the assessment phase. The results indicate noticeable differences in participants' scores from pretest to posttest and follow-up stages.

To ensure the appropriateness of using the parametric test of repeated measures analysis of variance (ANOVA), assumptions were first tested. The Shapiro-Wilk test was employed to assess the normality of data, and Levene's test was used to examine the equality of variances. The results of both tests were non-significant for all variables, indicating that the assumptions of data normality and homogeneity of variances were met.

To examine overall differences across the three assessment phases between the experimental and control groups, significance tests were first conducted, and the results are presented in Table 2.

Table 2

Significance Test Statistics for Research Variables

Test	F Value	df Hypothesis	df Error	Sig	Partial Eta Squared
Pillai's Trace	0.97	131.54	7	22	.001
Wilks' Lambda	0.02	131.54	7	22	.001
Hotelling's Trace	41.85	131.54	7	22	.001
Roy's Largest Root	41.85	131.54	7	22	.001

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As illustrated in Table 2, the Wilks' Lambda value is 0.02, which is significant at the $p \leq .01$ level. This indicates a statistically significant difference between the experimental and control groups across the three variables and at the three time points. To identify which specific variables and phases contributed to these differences, a repeated measures analysis of variance was conducted, and the results are reported in Table 3.

Table 3

Results of Repeated Measures ANOVA

Variable	Component	Source of Variation	Sum of Squares	df	Mean Square	F	p	Effect Size	Power
Self-Control	Self-Control	Pretest	60788.01	1	60788.01	6076.87	.001	.99	1
		Group	396.9	1	396.9	39.67	.001	.58	1
		Error	10.003	28					
Sustained Attention	Commission Errors	Pretest	11469.51	1	11469.51	5636.34	.001	.99	1
		Group	426.84	1	426.84	209.76	.001	.88	1
		Error	2.03	28					
	Omission Errors	Pretest	12203.37	1	12203.37	6185.13	.001	.99	1
		Group	243.37	1	243.37	123.35	.001	.81	1
		Error	1.97	28					
	Reaction Time	Pretest	7823402.5	1	7823402.5	49152.75	.001	.99	1
		Group	89428.54	1	89428.54	561.86	.001	.95	1
		Error	159.16	28					
Cognitive Flexibility	Perseverative Errors	Pretest	4708.9	1	4708.9	2945.98	.001	.99	1
		Group	162.67	1	162.67	101.77	.001	.78	1
		Error	1.59	28					
	Total Errors	Pretest	30544.04	1	30544.04	6778.002	.001	.99	1
		Group	1604.44	1	1604.44	356.04	.001	.92	1
		Error	4.5	28					
	Correct Categories	Pretest	1496.54	1	1496.54	1380.41	.001	.98	1
		Group	240.1	1	240.1	221.46	.001	.88	1
		Error	1.08	28					

As shown in Table 3, there are statistically significant differences ($p < .001$) in the scores for self-control, sustained attention (commission errors, omission errors, and reaction time), and cognitive flexibility (perseverative errors, total errors, and number of correct categories) across the three phases (pretest, posttest, and follow-up) within the experimental group. Additionally, there are statistically significant differences ($p < .001$) in these variables between the experimental and control groups.

To compare pairwise differences between measurement phases, the Bonferroni post hoc test was used. The results are presented in Table 4.

Table 4

Pairwise Comparisons of Variables Across the Three Measurements

Variable	Phases Compared	Mean Difference	Std. Error	Significance
Self-Control	Pretest–Posttest	-2.8	0.49	.001
	Pretest–Follow-up	-3.16	0.73	.001
	Posttest–Follow-up	-0.36	0.71	1.000
Commission Errors	Pretest–Posttest	3.3	0.28	.001
	Pretest–Follow-up	3.93	0.36	.001
	Posttest–Follow-up	0.63	0.27	.07
Omission Errors	Pretest–Posttest	1.53	0.32	.001
	Pretest–Follow-up	4.43	0.40	.001
	Posttest–Follow-up	1.9	0.53	.004
Reaction Time	Pretest–Posttest	41.66	3.12	.001
	Pretest–Follow-up	52.03	3.38	.001

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	Posttest–Follow-up	10.36	3.49	.018
Perseverative Errors	Pretest–Posttest	1.5	0.39	.002
	Pretest–Follow-up	2.6	0.43	.001
	Posttest–Follow-up	1.1	0.34	.012
Total Errors	Pretest–Posttest	4.83	0.66	.001
	Pretest–Follow-up	7.00	0.56	.001
	Posttest–Follow-up	2.16	0.55	.002
Correct Categories	Pretest–Posttest	-1.56	0.27	.001
	Pretest–Follow-up	-3.26	0.27	.001
	Posttest–Follow-up	-1.7	0.17	.001

According to the results presented in Table 4, there are statistically significant differences ($p < .01$) in self-control, sustained attention (commission errors, omission errors, and reaction time), and cognitive flexibility (perseverative errors, total errors, and number of correct categories) between the pretest and posttest, and between posttest and follow-up phases. However, there is no significant difference between posttest and follow-up scores for self-control and commission errors, indicating the stability of the intervention effects over time. Conversely, significant improvements were observed from posttest to follow-up in omission errors, reaction time, and cognitive flexibility measures (perseverative errors, total errors, and correct categories), suggesting continued gains in these areas during the follow-up period.

4. Discussion and Conclusion

The purpose of this study was to evaluate the effectiveness of mindfulness training on sustained attention, self-control, and cognitive flexibility in children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). The findings revealed that the mindfulness-based intervention significantly improved all three target cognitive domains. Specifically, children in the experimental group exhibited increased self-control, enhanced sustained attention (as evidenced by reductions in commission errors, omission errors, and reaction time), and better cognitive flexibility (as indicated by a reduction in perseverative errors and total errors and an increase in correct category classifications). These improvements were maintained during the two-month follow-up, indicating that the benefits of mindfulness training were not only immediate but also durable over time.

The results regarding improved self-control are consistent with findings from previous literature emphasizing the positive influence of mindfulness on behavioral regulation. For example, mindfulness-based programs help individuals cultivate a heightened awareness of present-moment experiences and reduce automatic, impulsive reactions, thereby fostering self-regulation (Beh-Pajooh et al., 2012; Karami & Pourkamali, 2023). In this study, the statistically significant improvement in self-control from pretest to posttest, which remained stable at follow-up, aligns with findings from (Wong et al., 2023) and (Siebelink et al., 2022), who reported that children with ADHD who underwent mindfulness interventions demonstrated better behavioral self-regulation and reduced impulsivity. This enhancement may be attributed to the nonjudgmental awareness developed during mindfulness training, which allows children to pause before reacting impulsively and to choose more adaptive behavioral responses.

The marked improvements in sustained attention also corroborate prior empirical findings that identify attention enhancement as a key outcome of mindfulness interventions. Participants in the experimental group showed significant reductions in both commission and omission errors, along with shorter reaction times, suggesting better vigilance and attentional control. These outcomes reflect the core function of mindfulness practice, which trains sustained, deliberate focus on stimuli while minimizing distractibility (Unsworth & Robison, 2020; Van de Weijer-Bergsma et al., 2012). In support of these findings, (Hong et al., 2022) used a virtual reality classroom task and similarly noted that mindfulness-based techniques improved attentional engagement in youth with ADHD. Moreover, the current study's use of the Continuous Performance Test (CPT) provides a validated behavioral measure of sustained attention, further reinforcing the reliability of the findings in line with cognitive-energetic models of attention regulation (Fuermaier et al., 2022; Yıldırım Demirdöğen et al., 2022).

Cognitive flexibility, another essential executive function, was also significantly enhanced following the intervention. Improvements were evident in reduced perseverative errors and greater success in shifting mental sets, as measured by the Wisconsin Card Sorting Test. These findings are in agreement with (Amorim & Marques, 2018), who emphasized the role of mindfulness in promoting

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mental set-shifting and adaptability, which are crucial for effective problem-solving and learning. Furthermore, (Dennis & Vanderwal, 2010) demonstrated that training interventions that integrate mindfulness components can strengthen cognitive flexibility, allowing children with ADHD to better cope with environmental and task-related changes. Given that deficits in cognitive flexibility are associated with rigid thinking patterns and maladaptive responses, the observed post-intervention improvements are promising indicators of enhanced executive function among the participants.

The longitudinal strength of the study lies in its follow-up assessment, which demonstrated that the cognitive gains were not only significant immediately after the intervention but were also sustained two months later. This aligns with research by (Tercelli & Ferreira, 2019) and (Van der Oord et al., 2012), which supports the enduring nature of mindfulness-based gains when practices are consistently implemented. The follow-up results particularly affirm the internalization of mindfulness strategies, suggesting that the participants likely continued applying these skills independently, leading to persistent improvements.

These findings also reinforce the importance of developmentally tailored, non-pharmacological interventions for ADHD. Traditional pharmacotherapy, while effective in symptom suppression, often falls short in improving underlying cognitive mechanisms such as self-control and flexibility (Hosenbocus & Chahal, 2012). In contrast, mindfulness targets the neurocognitive roots of ADHD, offering a complementary approach that can function either as a standalone intervention or in conjunction with medication. This is further supported by studies such as (Wong et al., 2024) and (Lo et al., 2016), which underscore the unique contribution of mindfulness in shaping attentional processes and behavioral regulation, even when pharmacological treatment is present.

In terms of neurobiological explanations, the effectiveness of mindfulness in enhancing attention and cognitive control can be partially explained by its influence on brain networks involved in salience detection and executive function. Research indicates that mindfulness strengthens the interaction between the salience network and the frontoparietal control network, promoting more efficient cognitive processing (Cai et al., 2019). The modulation of these networks results in better stimulus discrimination, goal maintenance, and flexibility in adapting to changing demands—capacities that were demonstrably improved in the current study's participants. Such findings echo the observations of (Nejati, 2020) regarding the neurocognitive benefits of targeted interventions in children with ADHD.

Furthermore, the inclusion of mindfulness training in educational and clinical settings has demonstrated promising ecological validity. Programs that involve both children and their caregivers, such as the MYmind protocol used in (Wong et al., 2023), emphasize the importance of family dynamics and environmental support in maintaining intervention outcomes. While the current study did not explicitly incorporate parental training, the lasting post-treatment effects suggest that the child-focused mindfulness protocol was developmentally appropriate and engaging enough to produce long-term cognitive changes.

The findings also resonate with theoretical frameworks that conceptualize ADHD as a disorder of executive dysfunction rather than simply a behavioral condition. Executive functioning models of ADHD, such as those proposed by (Kuntsi et al., 2014) and (Drechsler et al., 2020), emphasize the role of inhibitory control, working memory, and flexibility in shaping attentional and behavioral outcomes. The present study's results substantiate this view and demonstrate that targeted mindfulness interventions can effectively address these foundational deficits, thereby offering an evidence-based approach for holistic ADHD management.

In addition, this study contributes to the growing literature on culturally and contextually adapted mindfulness interventions. As (Zhang et al., 2017) and (Karami & Pourkamali, 2023) suggest, cultural factors and individual differences must be considered when designing mindfulness programs for children. The protocol used here was specifically tailored to children's cognitive levels and attention spans, which may have contributed to the high adherence and effectiveness observed throughout the intervention period.

Despite the promising results, the present study is not without limitations. First, the sample size was relatively small and limited to a specific age range (8 to 12 years), which restricts the generalizability of the findings. Second, all participants were male, which omits the potential influence of gender differences in ADHD symptomatology and treatment responsiveness. Third, while the study employed validated cognitive assessments, it relied primarily on quantitative tools; the inclusion of qualitative data such as teacher or parent reports could have provided a more comprehensive understanding of behavioral changes. Finally, although follow-up data were collected two months post-intervention, a longer-term evaluation would be

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necessary to assess the durability of the cognitive improvements over extended periods.

Future research should seek to replicate this study with a larger and more diverse sample, including both genders and broader age ranges, to enhance external validity. Incorporating multi-informant assessments, such as parent, teacher, and clinician ratings, would offer a richer and more ecologically valid picture of behavioral change. It would also be beneficial to compare mindfulness interventions with other cognitive training methods or to explore the additive effects of combining mindfulness with pharmacological treatments. Future studies might also include neuroimaging techniques to better understand the underlying neural mechanisms through which mindfulness impacts cognitive control in children with ADHD. Lastly, evaluating the effects of mindfulness interventions when delivered in school environments could illuminate their practical implementation in real-world educational settings.

Clinicians and educators should consider integrating structured mindfulness training into therapeutic and educational programs for children with ADHD. Such interventions can serve as viable alternatives or supplements to medication, particularly for families seeking non-pharmacological options. When implementing mindfulness programs, it is essential to use developmentally appropriate practices and provide consistent reinforcement to ensure skill retention. Moreover, incorporating parent training and involvement may enhance the transfer of mindfulness skills to home and social environments. Overall, mindfulness-based approaches offer a practical, cost-effective, and evidence-supported method for improving core cognitive functions in children with ADHD.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the study and participated in the research with informed consent. The ethics committee of Islamic Azad University, Science and Research Branch, approved this study with ethics code IR.IAU.R.REC.1403.022.

References

Amorim, W. N., & Marques, S. C. (2018). Inhibitory control and cognitive flexibility in children with attention-deficit/hyperactivity disorder. *Psychology & Neuroscience*, *11*(4), 364. https://doi.org/10.1037/pne0000156

Anning, K. L., Langley, K., Hobson, C., De Sonneville, L., & Van Goozen, S. H. (2024). Inattention symptom severity and cognitive processes in children at risk of ADHD: the moderating role of separation anxiety. *Child Neuropsychology*, *30*(2), 264-288. https://doi.org/10.1080/09297049.2023.2190964

Badia-Aguarón, T., Royuela-Colomer, E., Pera-Guardiola, V., Vergés-Balasch, P., Cebolla, A., Luciano, J. V., & Huguet Miguel, A. (2024). Combining mindfulness and cognitive training in children with attention deficit hyperactivity disorder: study protocol of a pilot randomized controlled trial (the NeuroMind study). *Frontiers in psychology*, *15*, 1291198. https://doi.org/10.3389/fpsyg.2024.1291198

Beh-Pajooh, A., Fatemi, S. M., Bonab, B. G., Alizadeh, H., & Hemmati, G. (2012). The impact of a self-control training program on enhancement of social skills in students with ADHD. *Psychology*, *3*(8), 616-620. https://doi.org/10.4236/psych.2012.38094

Bögels, S. M., Lehtonen, A., & Restifo, K. (2010). Mindful parenting in mental health care. *Mindfulness*, *1*, 107-120. https://doi.org/10.1007/s12671-010-0014-5

Cai, W., Griffiths, K., Korgaonkar, M. S., Williams, L. M., & Menon, V. (2019). Inhibition-related modulation of salience and frontoparietal networks predicts cognitive control ability and inattention symptoms in children with ADHD. *Molecular Psychiatry*. https://doi.org/10.1016/j.biopsych.2019.03.593

Cassar, L., Fischer, M., & Valero, V. (2022). *Keep calm and carry on: The short-vs. long-run effects of mindfulness meditation on (academic) performance*.

Dennis, J. P., & Vanderwal, J. S. (2010). The cognitive flexibility inventory: instrument development and estimates of reliability

E-ISSN: 2980-9681

and validity. *Cognitive therapy and research*, *34*(3), 241-253. https://doi.org/10.1007/s10608-009-9276-4

Drechsler, R., Brem, S., Brandeis, D., Grünblatt, E., Berger, G., & Walitza, S. (2020). ADHD: Current concepts and treatments in children and adolescents. *Neuropediatrics*, *51*(05), 315-335. https://doi.org/10.1055/s-0040-1701658

Fuermaier, A. B., Tucha, L., Guo, N., Mette, C., Müller, B. W., Scherbaum, N., & Tucha, O. (2022). It takes time: vigilance and sustained attention assessment in adults with ADHD. *International journal of environmental research and public health*, *19*(9), 5216. https://doi.org/10.3390/ijerph19095216

García-Rubio, C. (2021). *Effectiveness and mechanisms of action of the mindfulness-based interventions in the school context* Autonomous University of Madrid].

Hong, N., Kim, J. J., Kwon, J. H., Eom, H., & Kim, E. (2022). Effect of distractors on sustained attention and hyperactivity in youth with ADHD using a mobile virtual reality school program. *Journal of Attention Disorders*, *26*(3), 358-369. https://doi.org/10.1177/1087054720986229

Hosenbocus, S., & Chahal, R. (2012). A review of executive function deficits and pharmacological management in children and adolescents. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *21*(3), 223.

Karami, M., & Pourkamali, T. (2023). The effectiveness of mindfulness-based cognitive therapy on psychological flexibility and resilience in patients with irritable bowel syndrome. *Journal of New Psychological Research*, *18*(69), 211-219.

Keshavarz Valian, N., Hassanzadeh, S., Kashani, V., Lial, A., & Asaseh, M. (2023). The effectiveness of neuropsychological skills training on self-control and social competence in children with attention deficit/hyperactivity disorder. *Applied Psychological Research*, *14*(3), 85-201.

Kuntsi, J., Pinto, R., Price, T. S., Van Der Meere, J. J., Frazier-Wood, A. C., & Asherson, P. (2014). The separation of ADHD inattention and hyperactivity-impulsivity symptoms: pathways from genetic effects to cognitive impairments and symptoms. *Journal of abnormal child psychology*, *42*(1), 127-136. https://doi.org/10.1007/s10802-013-9771-7

Lo, H. H., Wong, S. Y., Wong, J. Y., Wong, S. W., & Yeung, J. W. (2016). The effect of a family-based mindfulness intervention on children with attention deficit and hyperactivity symptoms and their parents: design and rationale for a randomized, controlled clinical trial (Study protocol). *BMC psychiatry*, *16*, 1. https://doi.org/10.1186/s12888-016-0773-1

Nejati, V. (2020). Cognitive rehabilitation in children with attention deficit-hyperactivity disorder: transferability to untrained cognitive domains and behavior. *Asian Journal of Psychiatry*, *49*, 101949. https://doi.org/10.1016/j.ajp.2020.101949

Siebelink, N. M., Bögels, S. M., Speckens, A. E., Dammers, J. T., Wolfers, T., Buitelaar, J. K., & Greven, C. U. (2022). A randomized controlled trial (MindChamp) of a mindfulness-based intervention for children with ADHD and their parents. *Journal of Child Psychology and Psychiatry*, *63*(2), 165-177. https://doi.org/10.1111/jcpp.13430

Tercelli, I., & Ferreira, N. (2019). A systematic review of mindfulness-based interventions for children and young people with ADHD and their parents. *Global Psychiatry*, *2*(1), 79-95. https://doi.org/10.2478/gp-2019-0007

Unsworth, N., & Robison, M. K. (2020). Working memory capacity and sustained attention: a cognitive-energetic perspective. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(1), 77-103. https://doi.org/10.1037/xlm0000712

Van de Weijer-Bergsma, E., Formsma, A. R., de Bruin, E. I., & Bögels, S. M. (2012). The effectiveness of mindfulness training on behavioral problems and attentional functioning in adolescents with ADHD. *Journal of Child and Family Studies*, *21*, 775-787. https://doi.org/10.1007/s10826-011-9531-7

Van der Oord, S., Bögels, S. M., & Peijnenburg, D. (2012). The effectiveness of mindfulness training for children with ADHD and mindful parenting for their parents. *Journal of Child and Family Studies*, *21*, 139-147. https://doi.org/10.1007/s10826-011-9457-0

Wong, S. Y. S., Chan, S. K. C., Yip, B. H. K., Wang, W., Lo, H. H. M., Zhang, D., & Bögels, S. M. (2023). The effects of mindfulness for youth (MYmind) versus group cognitive behavioral therapy in improving attention and reducing behavioral problems among children with ADHD and their parents: a randomized controlled trial. *Psychotherapy and psychosomatics*, *92*(6), 379-390. https://doi.org/10.1159/000534962

Wong, S. Y. S., Chan, S. K. C., Yip, B. H. K., Wang, W., Lo, H. H. M., Zhang, D., & Bögels, S. M. (2024). The effects of mindfulness for youth (MYmind) versus group cognitive behavioral therapy in improving attention and reducing behavioral problems among children with ADHD and their parents: a randomized controlled trial. *Psychotherapy and psychosomatics*, *92*(6), 379. https://doi.org/10.1159/000534962

Yıldırım Demirdöğen, E., Esin, İ. S., Turan, B., & Dursun, O. B. (2022). Assessing sustained attention of children with ADHD in a class flow video task. *Nordic journal of psychiatry*, *76*(7), 497-506. https://doi.org/10.1080/08039488.2022.2064545

Zhang, A., & Zhang, Q. (2023). How could mindfulness-based intervention reduce aggression in adolescent? Mindfulness, emotion dysregulation and self-control as mediators. *Current Psychology*, *42*(6), 4483-4497. https://doi.org/10.1007/s12144-021-01778-5

Zhang, D., Chan, S. K. C., Lo, H. H. M., Chan, C. Y. H., Chan, J. C. Y., Ting, K. T., & Wong, S. Y. S. (2017). Mindfulness-based intervention for Chinese children with ADHD and their parents: a pilot mixed-method study. *Mindfulness*, *8*, 859-872. https://doi.org/10.1007/s12671-016-0660-3

Zysset, A., Robin, D., Albermann, K., Dratva, J., Hotz, S., Wieber, F., & von Rhein, M. (2023). Diagnosis and management of ADHD: a pediatric perspective on practice and challenges in Switzerland. *BMC pediatrics*, *23*(1), 103. https://doi.org/10.1186/s12887-023-03873-x

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