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Effectiveness of Working Memory Training Technique on On-Task Attention Problems in Classroom Assignments Among Third Grade Children with Attention-Deficit/Hyperactivity Disorder in District 10 of Tehran

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ABSTRACT

The present study aimed to improve working memory and enhance behavioral attention performance in children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). To this end, four third-grade male students from an elementary school in District 10 of Tehran, identified with ADHD, were selected through convenience sampling. The study employed a single-subject experimental design using baseline data and a working memory training strategy implemented over 12 sessions, followed by a four-session follow-up phase. The results indicated that the children showed improvement in classroom behavioral attention performance, and this progress remained stable during the four-session follow-up. Therefore, it is concluded that the working memory strategy had a significant effect on the behavioral performance of children with ADHD.

Keywords: instructional technique, working memory, Attention-Deficit/Hyperactivity Disorder (ADHD)

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Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent neurodevelopmental disorders in childhood, characterized by pervasive patterns of inattention, hyperactivity, and impulsivity that interfere with functioning across multiple contexts. Among the core deficits observed in children with ADHD, impairments in executive functions—particularly working memory and sustained attention—have received substantial empirical support as neuropsychological hallmarks of the disorder (1, 2). Working memory, which refers to the capacity to temporarily hold and manipulate information for cognitive tasks, plays a critical role in academic learning, behavioral regulation, and adaptive functioning (3, 4). Dysfunction in this cognitive domain may compromise goal-directed behavior and contribute to many of the challenges observed in children with ADHD.

Given the centrality of working memory impairments in ADHD, researchers have increasingly focused on cognitive training interventions targeting this function as a means of improving attentional control and executive performance. Working memory training has shown promise in not only enhancing cognitive performance in typically developing children but also in populations with neurodevelopmental disorders such as ADHD and specific learning disabilities (SLD) (1, 5). Empirical studies support the hypothesis that such training may lead to improvements in related cognitive processes, including sustained attention, inhibitory control, and metacognitive regulation (3, 6, 7).

Research indicates that ADHD is marked by impaired attentional control resulting from underdeveloped executive systems. These deficits affect children's ability to maintain task focus, resist distractions, and update goal-relevant information in working memory (8, 9). Consequently, interventions targeting these areas are vital for enhancing educational outcomes and self-regulation in affected children. Several studies have validated the effectiveness of structured cognitive rehabilitation programs, particularly computerized working memory training, in improving executive function profiles among school-aged children with ADHD (10, 11).

One robust approach to studying cognitive intervention outcomes in ADHD populations involves analyzing the distinct contributions of training regimens on both working memory and attention. For instance, research by Jaquerod et al. (2020) demonstrated that working memory training resulted in early attentional modulation during high-risk decision-making tasks in young adults with ADHD, suggesting the transfer effects of such training on higher-order executive functioning (12). Similarly, Borjali and Rostami (2021) showed that working memory training significantly improved various executive functions—including attentional flexibility and response inhibition—in adults with ADHD, further affirming the plasticity of cognitive systems across the lifespan (13).

In children, evidence also supports the idea that working memory training can facilitate notable changes in attention regulation and classroom behavior. In their randomized clinical trial, Azizi et al. (2020) reported significant enhancements in working memory, sustained attention, and short-term memory following cognitive-behavioral play therapy in children with specific learning disorders, underscoring the relevance of integrated cognitive and behavioral approaches (14). Moreover, studies have found that physical activity levels and motor interventions influence working memory outcomes. Baniasadi (2024) compared executive functioning in children with varying physical activity levels and found superior working memory performance in more active individuals, suggesting a role for embodied cognition in ADHD interventions (15).

The association between attentional deficits and academic underperformance is well documented, particularly in elementary education. Children with ADHD are often rated by teachers as exhibiting poor on-task behavior, inconsistent focus, and greater distractibility in classroom settings (1, 16). These impairments contribute to broader academic difficulties, as attention and working memory are strongly tied to learning processes such as mathematical reasoning, reading comprehension, and problem-solving (3, 17). For example, Afsharizadeh et al. (2020) found that working memory directly influenced mathematical reasoning, with the effect being mediated by crystallized intelligence and domain-specific knowledge. This suggests that interventions enhancing working memory may yield benefits not only for attention regulation but also for broader cognitive-academic achievement.

A growing body of work has also explored how various rehabilitation paradigms, such as motor-based and mindfulness-based protocols, contribute to cognitive outcomes in ADHD. Hamidian et al. (2019) compared the effects of rhythmic movement training, working memory exercises, and their combination on selective attention and found that combined protocols had the most substantial impact on children with ADHD (7). Likewise, Mohseni Nasab et al. (2024) demonstrated the efficacy of mindfulness training in improving working memory, attentional control, and self-efficacy in patients with anxiety disorders—findings that may be extrapolated to ADHD populations, given the high comorbidity with internalizing conditions (18).

Cognitive training interventions have not only demonstrated short-term gains but have also exhibited durable effects when paired with reinforcement mechanisms or ecological applications. Asadi Rajani (2023) found that adolescents who had recovered from acute COVID-19 exhibited deficits in attention and working memory compared to neurotypical peers, reinforcing the idea that such executive functions are sensitive to biological disruption but amenable to targeted remediation (19). Furthermore, Sarshar et al. (2024) emphasized the importance of integrating emotional and social components into working memory interventions. Their cognitive-emotional-social training significantly enhanced academic performance and executive functioning in students with ADHD, pointing to the value of comprehensive training packages (16).

While these interventions are promising, the heterogeneity in ADHD symptomatology and individual differences in neurocognitive profiles suggest that not all children respond equally to the same form of working memory training. Hence, customized interventions and rigorous methodological designs are necessary to determine the effectiveness and generalizability of outcomes. Superbia-Guimarães et al. (2022), in their study on attentional orienting in working memory in children with ADHD, underscored how attentional lapses and failures in inhibitory control can be mitigated through structured training with adaptive difficulty (2).

From a clinical and pedagogical perspective, these findings hold practical implications for early intervention, especially during critical periods of neurocognitive development. Programs like PARS (Program for Attention Rehabilitation and Strengthening), as developed by Nejati (2021), show that systematic cognitive training can result in meaningful improvements in attention regulation and executive functions among children with ADHD (20). Similarly, studies on family-based rehabilitation have highlighted how parental involvement can amplify training efficacy by extending cognitive strategies to everyday contexts (5).

Furthermore, the role of technology in enhancing cognitive training programs has gained attention. Soleimani Oskouei et al. (2022) demonstrated that computer-based cognitive rehabilitation significantly improved attention, working memory, and response inhibition in students with reading disorders, suggesting that digital tools can be effective delivery platforms for executive function interventions (11).

These findings align with broader cognitive neuroscience models asserting the plasticity of executive systems and the potential for training-induced neural adaptation.

Despite the growing consensus on the benefits of working memory training for children with ADHD, further research is warranted to elucidate the mechanisms underlying observed improvements, the durability of training effects, and the role of individual differences such as age, comorbidities, and baseline executive functioning levels (6). Additionally, longitudinal studies are necessary to determine whether cognitive gains translate into long-term academic and behavioral success.

In light of this body of literature, the current study aims to evaluate the effectiveness of working memory training techniques on task-related attention performance in third-grade students diagnosed with ADHD.

Methods and Materials

Study Design and Participants

The participants in this study consisted of four third-grade male elementary school students. The sampling method was experimental and single-subject or within-group, following an A-B time-series design with a 12-day follow-up. The study was applied in nature and used convenience sampling, a method chosen for its accessibility and proximity to participants. In this design, observation or measurement is conducted over time with one unit, which can be an individual or a group. The first phase (A) is the baseline phase, and the second phase (B) is the intervention phase. In the baseline phase, the target behavior is observed under natural conditions, and results are recorded as frequency data or graphically. In the intervention phase, the experimenter applies a behavioral modification strategy to the target behavior, and the results are recorded by the participants in terms of frequency or graphically. The independent variable was working memory training (B), and the dependent variable was attention deficit (A). All four participants received working memory training in 12 sessions of 45 minutes each.

Data Collection

The instruments used to identify children with Attention-Deficit/Hyperactivity Disorder (ADHD) included the Child Symptom Inventory (CSI-4), Conners' Teacher Rating Scale, the Jordan Attention Deficit Disorder Inventory (JADDI), and the Swanson, Nolan, and Pelham Questionnaire (SNAP-IV), all completed in teacher-report format. The working memory test was administered to selected children across three phases: baseline, intervention, and follow-up, and scores were obtained from their performance.

Child Symptom Inventory (CSI-IV): The CSI-IV is a behavioral rating scale initially developed by Sprafkin and Gadow based on DSM-III under the name SLUG for screening 18 emotional and behavioral disorders in children aged 5 to 12. In 1994, it was revised with the publication of DSM-IV and released as CSI-4. It includes a parent version with 112 items covering 11 major disorders and an additional group, and a teacher version with 87 items covering 9 major behavioral disorders. These disorders include ADHD, oppositional defiant disorder, conduct disorder, anxiety disorders, psychotic and mood disorders, and pervasive developmental disorders. Sections of the questionnaire are completed by teachers and parents. Section B of the parent form includes 8 questions, and Section C includes 14 questions (9 in the teacher form). Items are rated on a 4-point Likert scale: Never = 0, Sometimes = 0, Often = 1, Most of the time = 1. According to Hashemi et al. (2008), this questionnaire has high usability and comprehension, and technical psychiatric terms are simplified for parental understanding. In this study, Section A (questions 1–18) specific to ADHD was used for screening. A study by Farzad, Emamipour, and Vakil Ghahani (2011) on working children in Karaj validated the instrument, showing acceptable convergent validity with Kovacs' Depression Inventory. Internal consistency coefficients were 0.94 (parent form) and 0.96 (teacher form), with intercorrelations between subscales also significant. Sensitivity scores for ADHD, oppositional defiant disorder, and conduct disorder were 0.75, 0.89, and 0.89 respectively; specificity was 0.92, 0.91, and 0.90. Reliability coefficients were reported as 0.90 and 0.93 for parent and teacher forms respectively (Valiollah et al., 2011). According to Mohammad Esmaeil (2007), all parent form subscales—except social phobia—demonstrated acceptable reliability, and all subscales in both forms had adequate content validity (Mohammad Esmaeil & Alipour, 2002).

Conners' Teacher Rating Scale (CPRS): The CPRS consists of 38 items rated on a 4-point Likert scale: Never = 0, Rarely = 1, Often = 2, Very Often = 3. Items 1–21 assess classroom behavior; items 22–29 measure group participation; items 30–38 assess attitudes toward authority. A mean score of 1.5 or higher suggests ADHD. The total score ranges from 0 to 114; a score above 57 indicates attention problems. The scale was validated in Canada in 1998 by Conners et al. with Cronbach's alpha ranging from 0.76 to 0.94 for subscales. Test-retest reliability ranged from 0.47 (inattention) to 0.86 (conduct disorder). In Iran, the scale was translated and validated by Shaim et al. (2007), who reported an overall alpha of 0.86 for the full questionnaire. Conners et al. (1999) reported a reliability of 0.90.

Jordan Attention Deficit Disorder Inventory (JADDI): Developed by Dale Jordan in 1992, JADDI assesses attention problems in children. The teacher form requires teachers to rate students in two sections: 19 items for inattention, and 20 items for organization. The parent form mirrors the teacher version. Items are scored on a 4-point Likert scale: Never = 0, Sometimes = 1, Often = 2, Always = 3. Cronbach's alpha for the original test was 0.91; in the Persian version, it was 0.96 (Haj Heidari et al., 2024).

Swanson, Nolan, and Pelham Questionnaire (SNAP-IV, 1980): The SNAP-IV is an 18-item ADHD rating scale developed for parents and teachers, based on DSM criteria. It has two factors—Inattention (items 1–9) and Hyperactivity/Impulsivity (items 10–18). It is rated on a 4-point Likert scale: Never = 0, Rarely = 1, Often = 2, Very Often = 3. The instrument has demonstrated acceptable content, face, and criterion validity. Cronbach's alpha coefficients reported by Houshiari and Zamani (2007) exceeded 0.70.

Working Memory Test: Developed by Daneman and Carpenter (1980), this test assesses children's working memory capacity and includes 27 sentences grouped into six sets (2 to 7 sentences per set). The test simultaneously measures the processing and storage components of working memory. In each trial, children listen to complex sentences and must (1) understand the meaning of each sentence, and (2) recall the final word of each sentence. Each correct answer is scored with 1 point for processing accuracy and 1 point for storage accuracy. With 27 sentences total, the maximum score for each component is 27, and the overall working memory score is the average of these two, expressed as a percentage. In a preliminary study by Asadzadeh (2004) on 84 psychology students at Allameh Tabataba'i University, a correlation of 0.88 was reported. Mojtabizadeh (2006) found a reliability of 0.87 using Kuder–Richardson formula. Asadzadeh (2004) also reported a split-half reliability of 0.85.

Data analysis

The study began with coordination with the Ministry of Education and the target school in District 10 of Tehran. Third-grade students were screened using the Conners and Swanson scales for ADHD. Among those identified with attention difficulties related to task completion, four students were selected. During the pre-test phase, research tools were administered. Over two weeks and four sessions, observations were conducted under baseline conditions (Phase A) without any training. One day after completing baseline observations and administering the Conners and Swanson questionnaires, teacher-made tests were conducted. The intervention phase involved applying the working memory training strategy. Attention frequency in class was recorded during all phases (baseline, intervention, follow-up). During the intervention and follow-up phases, teacher forms of the Swanson, Jordan, and Conners questionnaires were re-administered to assess attention and ADHD symptoms. Intervention-phase scores were based on students' correct responses in the working memory test.

Findings and Results

The primary objective of this study was to investigate the effect of working memory training on children with Attention-Deficit Disorder. The graphs related to each participant were analyzed qualitatively and the findings for each individual are presented below.

Table 1. Descriptive Scores of Attention and Concentration

Days	Phase A	Phase B	Follow-up	Phase A	Phase B	Follow-up	Phase A	Phase B	Follow-up	Phase A	Phase B	Follow-up
	Participant 1			Participant 2			Participant 3			Participant 4		
1	7.4	18.5	77.7	7.4	14.8	70.37	7.4	22.2	77.7	11.11	25.92	81.48
2	7.4	33.3	74.07	11.11	18.5	74.03	11.11	29.62	81.48	14.8	33.3	85.18
3	11.11	44.4	77.7	7.4	22.2	77.7	14.8	37.03	81.48	14.8	40.74	85.18
4	14.8	48.14	77.7	11.11	25.92	77.7	14.8	40.74	81.48	14.8	40.71	81.48
5		51.85			37.03			44.4			44.4	
6		55.5			44.4			51.85			48.14	
7		59.26			48.14			59.26			55.5	
8		62.96			55.5			62.96			59.26	
9		66.6			59.26			70.37			66.6	
10		66.6			62.96			74.07			70.37	
11		70.37			66.6			77.7			74.07	
12		70.37			70.37			81.48			77.7	

Since this was a single-subject, within-group experimental study, visual graph analysis, percentage of non-overlapping data (PND), and effect size were used to evaluate the potential outcomes of the intervention. For demographic evaluations, descriptive statistics such as mean and standard deviation were used for the studied variables. Mean, median, range, and stability envelope of the data were calculated for each condition to examine overlapping/non-overlapping data and effect size.

The *effect size* indicates the strength of the influence of the independent variables. According to Cohen (1988), an effect size of 0.02 is small, 0.15 is medium, and 0.35 is large. It is generally recommended to consider a minimum threshold of 0.15. The *stability envelope* consists of two parallel lines drawn above and below the median line, representing 20% or 25% of the median, added to and subtracted from it respectively. This envelope is plotted on the graph to determine the range within which data points fall. If 80% or more of the data points lie within ±20% of the median (i.e., within the stability envelope), the data are considered stable; otherwise, they are variable.

In visual analysis, changes due to the intervention are interpreted based on *level*, *trend*, and *variability* of the observations. The *level* refers to the magnitude of the dependent variable, the *trend* refers to the pattern over time (similar to slope), and *variability* refers to consistency or fluctuations in the dependent variable. A minimum of three data points is necessary to evaluate these components. Variability pertains to the baseline and follow-up phases, while trend pertains to the intervention phase. Stability in the baseline suggests the participant is ready for intervention, and stability in the follow-up phase suggests the treatment was effective. A steep slope in the intervention phase indicates treatment effectiveness and participant improvement.

The data were interpreted using visual line graph analysis as shown in Figure 1. This includes examining *level*, *trend*, and *variability* in the baseline, intervention, and follow-up phases, and comparing them across conditions. The *level* reflects the relative value of attention (dependent variable); the *trend* indicates whether the data pattern suggests improvement or deterioration; and *variability* shows the amount of fluctuation in the data. Visual analysis was conducted at two levels: *intra-condition analysis* and *inter-condition analysis*. Intra-condition analysis examines the data change pattern within a single phase (e.g., baseline or intervention), while inter-condition analysis compares level, trend, and variability between two adjacent phases.

Next, we calculated the *percentage of non-overlapping data* (PND) and *percentage of overlapping data* (POD). To calculate PND, when the goal of the intervention is to increase a variable (attention), the highest baseline data point is identified, and the number of intervention data points above that value is counted. If the goal is to decrease a variable, the lowest baseline point is used, and the number of intervention data points below it is counted. For POD, the number of data points equal to or below the highest baseline point is counted. A higher PND or a lower POD between adjacent conditions suggests a more effective intervention.

To support the hypothesis that working memory training improves classroom attention skills in third-grade children with ADHD, the findings from visual analysis across the three phases—baseline, intervention, and follow-up—were used to compute effect sizes and compare conditions, as illustrated in Figure 1.

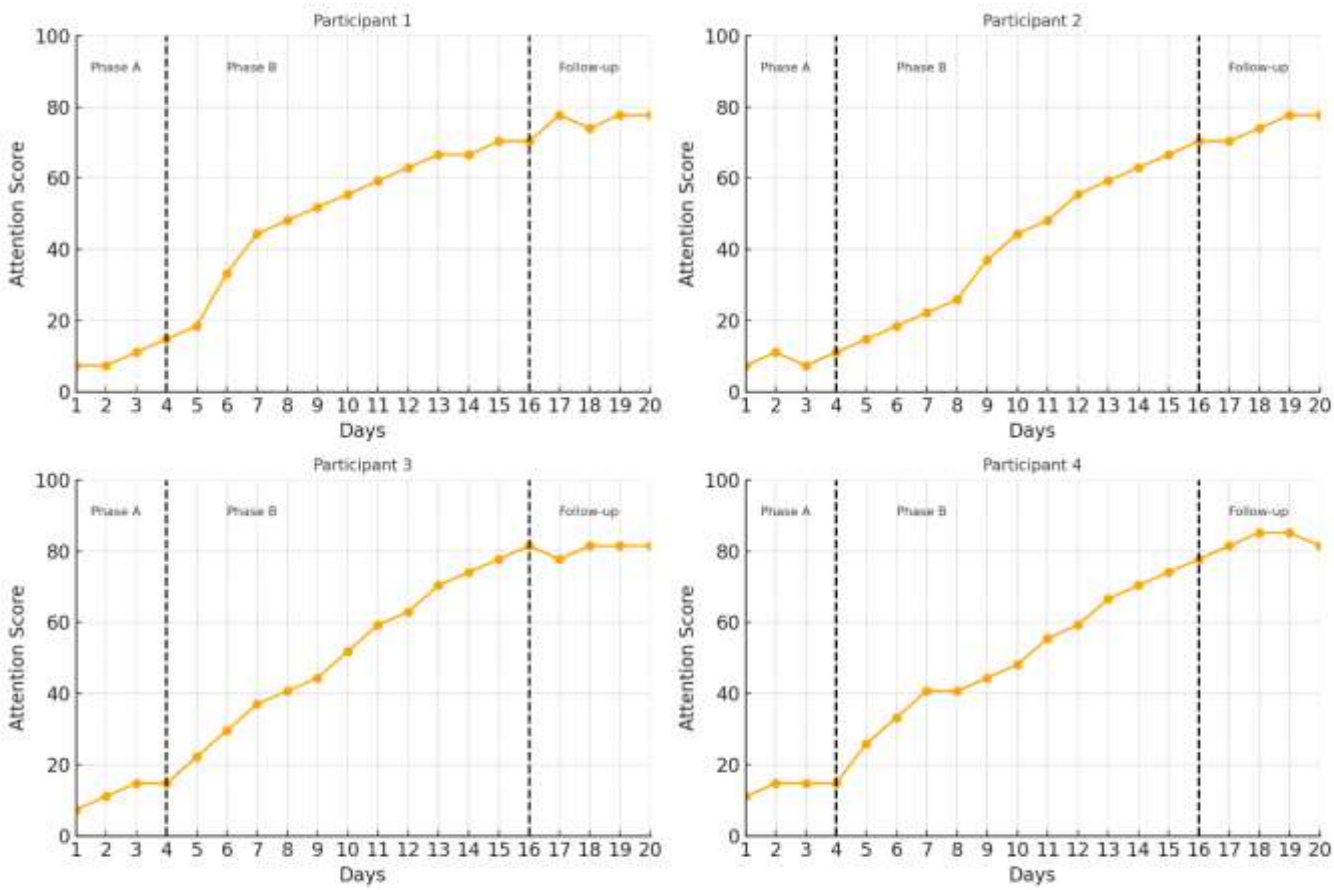

Figure 1. Visual Analysis Results of the Effect of Working Memory Strategy Training on Classroom Task Attention

According to Figure 1, the trend of change during the intervention phase was upward for all participants, indicating improvement. The stability observed during the baseline phase supports the appropriate timing for initiating the intervention, and the continued stability during the follow-up phase confirms the effectiveness of the intervention.

To examine intra-condition and inter-condition data analyses and data trends in each condition, both absolute and relative level changes were calculated. Relative level change is determined by the difference between the medians of the first and second halves of data within a given condition. Absolute level change is calculated as the difference between the first and last data point in each condition. The "split-half" method was used for these calculations, which involves dividing the data of each condition into two halves and then computing the median for each half. The intra- and inter-condition analysis for the classroom attention variable is presented in Table 2, which shows that participants exhibited effective improvement in classroom attention during both the intervention and follow-up phases following working memory training. Indicators such as percentage of non-overlapping data (PND), percentage of overlapping data (POD), and Cohen's *d* were reported for the entire group. Stability envelope calculations for all four participants indicated that their data during the baseline and follow-up phases were 100% stable.

Table 2. Statistical Data of the Four Participants on Classroom Attention and Concentration

Phase	Participant 1	Participant 2	Participant 3	Participant 4
A – Mean	10.17	9.25	12.02	13.87

B – Mean	53.98	43.80	54.30	53.05
Follow-up – Mean	76.79	74.95	80.53	83.33
A – SD	3.54	2.14	3.54	1.84
B – SD	15.90	19.77	19.68	16.80
Follow-up – SD	1.80	3.50	1.89	2.13
A – Median	9.25	9.25	12.95	14.80
B – Median	57.38	46.27	55.50	68.48
Follow-up – Median	77.70	75.86	81.48	83.33
Median 1	7.40	24.06	9.25	12.95
Median 2	12.95	66.11	14.80	14.80
Stability %	100%	100%	100%	100%
Intra-condition Analysis	+5.55	+20.33	+1.81	+1.84
Inter-condition Analysis	Increase	Increase	Increase	Increase
PND	100%	100%	100%	100%
POD	0%	0%	0%	0%
Cohen's *d*	1.52	0.88	1.14	1.17
Total Effect Size	1.15			

In the statistical analysis section, the mean and standard deviation for each of the four participants in the baseline, intervention, and follow-up phases are presented in Table 2. The standardized mean difference (effect size) was used to evaluate the impact of working memory training on the improvement of attention skills in third-grade students. This is considered the best quantitative method for computing effect size in single-subject experimental research.

According to Table 2, for Participant 1, the mean increased from 10.17 in the baseline phase to 53.98 in the intervention phase, and this increase continued to 76.79 in the follow-up phase. The standardized mean difference was 2.09, and the effect size was 1.52, indicating that working memory training had a positive effect on this participant's classroom attention skills.

For Participant 2, the mean rose from 9.25 (baseline) to 43.80 (intervention) and reached 74.95 in follow-up. The standardized mean difference was 1.20, and the effect size was 0.88, showing a positive impact of the intervention on classroom attention strategies.

Participant 3 showed an increase in mean score from 12.02 (baseline) to 54.30 (intervention), continuing to 80.53 in follow-up. The standardized mean difference was 1.57, and the effect size was 1.14, indicating that working memory training positively affected behavioral attention in the classroom.

For Participant 4, the mean increased from 13.87 (baseline) to 53.05 (intervention), and further to 83.33 (follow-up). The standardized mean difference was 1.61, and the effect size was 1.17, demonstrating a positive effect of working memory training on classroom attention.

The group-wide standardized mean difference effect size was calculated to be 1.58, which confirms that working memory training had a significant positive effect on the improvement of behavioral attention in the classroom across all participants. The upward trend observed during the intervention phase also supports the effectiveness of the working memory strategy in enhancing behavioral attention among third-grade students. Additionally, the PND for all participants was 100%, and the total effect size for the group was 1.15—considered a large effect—indicating a substantial impact of working memory training on improving attention skills in all four children. Based on these findings, the research hypothesis is confirmed. Thus, it can be concluded that working memory training positively affects classroom attention skills in third-grade children with Attention-Deficit/Hyperactivity Disorder (ADHD).

Discussion and Conclusion

The purpose of this study was to evaluate the effectiveness of working memory training techniques on improving classroom attention among third-grade male students diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). Using a single-subject experimental design with multiple phases (baseline, intervention, and follow-up), the findings demonstrated a consistent and significant upward trend in attentional scores across all four participants following the implementation of the working memory intervention. The improvements observed in the intervention phase were maintained through the follow-up sessions, as indicated by high post-training attention scores and 100% data stability in follow-up conditions. These results offer strong empirical support for the utility of structured working memory training in enhancing on-task classroom behavior in children with ADHD.

The visual analysis indicated substantial growth in attention scores immediately after the transition from the baseline to the intervention phase, suggesting that the training program produced rapid cognitive engagement and behavioral gains. All four participants exhibited a notable positive slope in attention performance during the intervention period, which stabilized during the follow-up phase, indicating lasting effects of the cognitive training. The high percentage of non-overlapping data (PND = 100%) and the large group effect size (d = 1.15) further confirm the clinical significance of the intervention. These findings align with previous studies emphasizing the pivotal role of working memory in attention regulation and executive functioning in children with ADHD (10, 13, 21).

Several explanations can account for the observed improvements. First, working memory serves as a central executive mechanism that governs attentional allocation, inhibitory control, and the updating of goal-relevant information. By systematically engaging students in tasks that stimulate these processes, the training likely activated neurocognitive pathways associated with attention modulation. This is consistent with neurocognitive models that posit a strong overlap between working memory and attention networks (3, 6). The results mirror the findings by Zhao (2024), who reported significant improvements in attention regulation and emotion management in children with ADHD after working memory training (8). Likewise, Jaquerod et al. (2020) found that ADHD patients undergoing working memory training displayed better attentional modulation in risky decision-making contexts, confirming the generalizability of such interventions beyond academic domains (12).

The observed behavioral improvements may also reflect increased metacognitive awareness and self-regulation. According to Scheibe et al. (2023), metacognitive cues embedded in working memory tasks can reduce math anxiety and improve problem-solving skills by promoting attentional control and regulated information processing (3). Similarly, Wiest et al. (2022) showed that targeted cognitive training led to measurable improvements in impulsivity, attention, and working memory in school-aged children with ADHD and specific learning disorders (1). These findings suggest that engaging children in focused, cognitively demanding tasks reinforces sustained attention through top-down control mechanisms.

Additionally, the results of the current study confirm prior evidence suggesting that attentional control can be effectively rehabilitated through non-pharmacological means. For instance, Haqnazari et al. (2022) demonstrated that computerized working memory programs significantly enhanced both working memory and sustained attention in male students, supporting the practical application of cognitive rehabilitation in educational settings (10). Similarly, Soleimani Oskouei et al. (2022) found that computer-based cognitive rehabilitation improved executive functions such as attention, working memory, and response inhibition among students with reading disorders, indicating that cognitive training yields transdiagnostic benefits (11).

A key strength of the present findings is the alignment with developmental neuroscience research, which suggests that executive functions are malleable during childhood and respond well to targeted training. Baniasadi (2024) found significant differences in working memory performance between children with high and low physical activity, implying that executive systems can be influenced by behavioral context and environmental engagement (15). Similarly, Mohseni Nasab et al. (2024) observed improvements in working memory and attention in individuals with anxiety disorders following mindfulness training, further affirming the efficacy of structured cognitive interventions across populations (18).

The practical relevance of this study is further underscored by the fact that all data points during the follow-up phase remained within the stability envelope, showing no decline in performance. This sustained effect implies that the training had not only immediate but also enduring impacts on attentional behavior, which is crucial for educational outcomes. Consistent with the results of Nejati (2021), whose PARS program significantly improved executive functioning in children with ADHD, the present findings suggest that working memory training can serve as a viable tool for classroom-based interventions (20).

Moreover, studies by Sarshar et al. (2024) have emphasized the importance of socio-emotional integration in cognitive training. Their research showed that incorporating emotional and social elements into working memory interventions led to improvements in academic performance and executive functions in children with ADHD (16). Although the present study did not include emotional or social training elements, the behavioral improvements observed suggest that cognitive-only programs still offer substantial benefits. However, future studies could explore whether combining working memory training with socio-emotional components could amplify treatment outcomes.

While the current results are promising, they must be interpreted within the framework of prior literature that identifies heterogeneity in ADHD manifestations and responses to intervention. For instance, Asadi Rajani (2023) showed that adolescents recovering from acute COVID-19 displayed attentional and working memory deficits distinct from neurotypical peers, indicating that individual baseline differences may influence cognitive training outcomes (19). Similarly, Spaniol and Danielsson (2022) highlighted variability in executive function profiles among children with intellectual disabilities, further supporting the need for individualized intervention planning (6).

The evidence from this study also resonates with earlier findings emphasizing the necessity of incorporating family and contextual factors into cognitive interventions. Ghasemi et al. (2019) designed a family-based cognitive rehabilitation program that improved sustained attention and social skills in children with intellectual disabilities, demonstrating that ecological validity and environmental reinforcement play crucial roles in maximizing treatment outcomes (5). While the current study was conducted in a controlled school setting, extending training beyond the classroom may enhance long-term maintenance of gains.

Lastly, our findings contribute to a growing consensus that working memory is not only trainable but also a powerful predictor of attentional capacity and adaptive classroom behavior. Azizi et al. (2020) demonstrated that working memory interventions significantly impacted attention and short-term memory in children with specific learning disorders (14), while Hamidian et al. (2019) showed that a combination of working memory and rhythmic training produced optimal outcomes in children with ADHD (7). These studies, along with the present research, support the view that executive functions are modifiable and central to improving attentional deficits in neurodivergent youth.

Despite its strengths, this study is not without limitations. The sample size was limited to four participants, restricting the generalizability of the findings to broader populations. Although single-subject designs allow for intensive analysis of individual behavioral change, they lack the statistical power of larger randomized controlled trials. Furthermore, the intervention was applied in a relatively short time span, and the follow-up period was brief. This restricts conclusions about the long-term durability of the observed effects. The exclusive focus on male students also limits the ability to infer outcomes for female students with ADHD, who may exhibit different attentional profiles.

Future studies should aim to replicate these findings with larger and more diverse samples, including children of varying ages, genders, and cognitive profiles. Longer follow-up durations are needed to assess the sustainability of training effects over time. Moreover, comparative studies evaluating different types of cognitive interventions—such as mindfulness-based training, neurofeedback, or motor-based exercises—can offer insight into which modalities yield the greatest benefits for specific executive domains. Integrating multimodal assessments, such as neuroimaging or teacher behavioral ratings, may also provide a more comprehensive understanding of training impact.

Educators and school psychologists should consider implementing structured working memory training programs as part of classroom-based intervention strategies for students with ADHD. These programs can be embedded into daily routines, either through computerized platforms or paper-based tasks tailored to the cognitive level of each child. Collaboration with parents, special educators, and mental health professionals will ensure continuity between home and school settings. Given the evidence for durability and efficacy, working memory training can be an effective, low-cost, and non-pharmacological tool to improve classroom engagement and academic outcomes for children struggling with attention deficits.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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