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EVALUATION OF THE EFFECT OF COGNITIVE RETRAINING ON NEUROCOGNITIVE FUNCTIONING IN CHILDREN WITH ATTENTION DEFICIT/HYPERACTIVITY DISORDER (ADHD)

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***ABSTRACT*:**

Background: Attention-Deficit/Hyperactivity Disorder (ADHD) is a common neurodevelopmental disorder associated with deficits in attention, working memory, executive functioning, and behavioral regulation. Cognitive retraining has emerged as a promising non pharmacological intervention aimed at improving neurocognitive functioning in children with ADHD.

Aim: To evaluate the effect of cognitive retraining on neurocognitive functioning in children diagnosed with ADHD.

Methods: A prospective interventional pre–post study was conducted among 100 children aged 6–12 years diagnosed with ADHD. Participants underwent structured cognitive retraining sessions for eight weeks targeting attention, working memory, executive functioning, and inhibitory control. Neurocognitive assessments were conducted before and after intervention using standardized assessment tools. Statistical analysis was performed using paired t-test and Repeated Measures ANOVA.

Results: Significant improvement was observed in sustained attention, selective attention, working memory, executive functioning, and processing speed following cognitive retraining ($p<0.001$). Session-wise accuracy improved progressively from 54.82% to 84.92%. Overall neurocognitive scores increased significantly from 42.84 ± 6.92 to 61.72 ± 6.38 after intervention. Marked clinical improvement was observed in 61% of participants.

Conclusion: Cognitive retraining significantly enhances neurocognitive functioning in children with ADHD and may serve as an effective complementary non-pharmacological intervention for improving cognitive and behavioral outcomes.

***Keywords**: ADHD; Cognitive Retraining; Neurocognitive Functioning; Executive Function; Working Memory.*

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders affecting children worldwide. It is characterized by persistent symptoms of inattention, hyperactivity, and impulsivity that interfere with academic, social, emotional, and behavioral functioning. Children with ADHD often experience difficulties in sustaining attention, controlling impulses, organizing activities, and regulating behavior, which negatively affect their neurocognitive functioning and quality of life. Neurocognitive deficits associated with ADHD mainly involve impairments in executive functions such as working memory, cognitive flexibility, response inhibition, planning, and processing speed [1]. These impairments frequently lead to poor academic achievement, low self-esteem, interpersonal difficulties, and emotional disturbances during childhood and adolescence.

Globally, ADHD affects approximately 5–7% of school-going children, and its prevalence is steadily increasing in India due to greater awareness and improved diagnostic practices. Indian studies have indicated that many children with ADHD remain underdiagnosed and untreated, especially in rural and semi-urban settings. In addition to behavioral symptoms, children with ADHD commonly exhibit deficits in attention span, visuospatial skills, working memory, and executive functioning. Research conducted in India found that children with ADHD and learning disabilities demonstrated significantly poorer attention and visuoconstruction abilities compared to children without ADHD [2]. These neurocognitive impairments emphasize the need for interventions that focus not only on behavioral symptom reduction but also on cognitive enhancement.

Pharmacological treatments, particularly stimulant medications, have traditionally been the primary approach for managing ADHD symptoms. Although medications are effective in reducing hyperactivity and impulsivity, they may not adequately improve higher-order cognitive functions and can produce side effects such as sleep disturbances, appetite suppression, and irritability. Therefore, researchers and clinicians have increasingly emphasized non pharmacological interventions, including behavioral therapy, neurofeedback, cognitive remediation, and cognitive retraining techniques. Among these approaches, cognitive retraining has emerged as a promising intervention for improving neurocognitive functioning in children with ADHD.

Cognitive retraining refers to structured therapeutic exercises designed to improve cognitive processes such as attention, memory, executive functioning, problem-solving, and response inhibition. These interventions are based on the concept of neuroplasticity, which suggests that repeated cognitive exercises can strengthen neural pathways and improve brain functioning. Cognitive retraining programs may include computerized cognitive training, working memory exercises, concentration tasks, and attention-enhancement activities. Such interventions aim to improve information processing abilities and help children perform better in academic and social environments.

Several international studies have demonstrated the positive effects of cognitive retraining on children with ADHD. Research has shown that cognitive-motor rehabilitation significantly improves attention regulation, cognitive functioning, and behavioral symptoms in children with ADHD, with benefits extending beyond those achieved through medication alone [3]. Similarly, neurocognitive training interventions have been associated with improvements in executive functioning, classroom engagement, and academic performance among children with ADHD [4]. Studies have also found that working memory training and attention-enhancement exercises can reduce inattentiveness and improve classroom behavior in school-aged children diagnosed with ADHD [5]. In the Indian context, cognitive retraining interventions are still developing, and only a limited number of studies have examined their effectiveness. Indian researchers have highlighted the importance of concentration and coordination exercises in improving attention, working memory, and motor coordination among children with ADHD [6]. Furthermore, evidence suggests that cognitive retraining techniques targeting attentional processes can improve both attentional abilities and behavioral functioning in children diagnosed with ADHD [7]. Despite these promising findings, there remains limited Indian literature specifically focusing on the effects of cognitive retraining on neurocognitive functioning in children with ADHD. Most available studies are either small-scale or focused primarily on behavioral outcomes rather than detailed neurocognitive assessments.

Recent technological advancements have further enhanced the scope of cognitive retraining interventions. Computerized cognitive training programs, neurofeedback systems, and digital therapeutic games have shown encouraging results in improving working memory, sustained attention, and executive functioning among children with ADHD [8]. Research also indicates that cognitive training interventions may positively influence academic achievement, self-regulation, and adaptive functioning [9]. These findings support the growing recognition of cognitive retraining as an effective complementary therapeutic strategy for ADHD management. Neuroimaging and neuropsychological studies have additionally revealed that ADHD is associated with abnormalities in functional connectivity and cognitive processing networks within the brain. Cognitive retraining interventions may help strengthen these neural networks and improve neurocognitive efficiency through repeated mental exercises and behavioral practice [10]. Consequently, cognitive retraining has gained considerable importance as a non-invasive and child-friendly intervention for addressing neurocognitive deficits in ADHD.

The present study aimed to evaluate the effect of cognitive retraining on neurocognitive functioning in children with ADHD, with special emphasis on attention, working memory, executive functioning, processing speed, and response inhibition following structured cognitive intervention.

METHODOLOGY

1. Study Design

The study adopted a prospective interventional pre–post research design to evaluate the effects of cognitive retraining on neurocognitive functioning in children diagnosed with ADHD. Baseline and post-intervention neurocognitive assessments were conducted to identify changes in attention, working memory, executive

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functioning, and response inhibition following structured cognitive retraining sessions.

2. Study Setting

The study was conducted in the Department of Clinical Psychology and Child Guidance Services of a tertiary care teaching hospital and rehabilitation center in India. The setting provided specialized psychological assessment, ADHD evaluation, and cognitive retraining facilities in a structured and distraction-free therapeutic environment.

3. Study Duration

The study was conducted over a period of twelve months from January 2025 to December 2025. The duration included participant recruitment, baseline assessment, cognitive retraining intervention, post-intervention assessment, data collection, and statistical analysis.

4. Participants – Inclusion and Exclusion Criteria

Children aged 6–12 years diagnosed with ADHD according to ICD-10 criteria were included in the study. Participants were required to understand assessment instructions, have no previous cognitive retraining exposure, and provide parental consent and child assent. Children with intellectual disability, autism spectrum disorder, neurological disorders, severe psychiatric illness, sensory impairments, ongoing ADHD medication, or severe behavioral instability were excluded from the study.

5. Study Sampling

A purposive random sampling technique was employed in the study. Initially, purposive sampling was used to identify children fulfilling the inclusion criteria, following which simple random selection was performed among eligible participants. Recruitment continued until the required sample size was achieved.

6. Study Sample Size

The study included 100 children diagnosed with ADHD. The selected sample size was considered adequate for detecting statistically significant differences between baseline and post intervention neurocognitive scores and for assessing changes across multiple cognitive domains.

7. Study Groups

The study consisted of a single intervention group comprising children diagnosed with ADHD who underwent structured cognitive retraining. A pre–post design was followed in which each participant served as their own control during comparison of neurocognitive outcomes before and after intervention.

8. Study Parameters

Primary parameters assessed in the study included attention span, working memory, executive functioning, and response inhibition. Secondary parameters included processing speed, response consistency, task persistence, visual scanning efficiency, and behavioral engagement during intervention sessions.

9. Study Procedure

After obtaining ethical approval and informed consent, baseline neurocognitive assessment was conducted using standardized tools. Participants then underwent structured cognitive retraining sessions over eight weeks focusing on attention, working memory, executive functioning, and inhibitory control. Post-intervention assessments were conducted using the same assessment measures.

10. Study Data Collection

Data collection was carried out at baseline and post-intervention stages. Demographic details, clinical information, and neurocognitive scores were recorded systematically. Session-wise variables including accuracy, omission errors, commission errors, response time, fatigue signs, and behavioral engagement were documented using structured case record forms.

11. Data Analysis

Data were analyzed using IBM Statistical Package for the Social Sciences (SPSS). Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize variables. Paired t-tests and Repeated Measures ANOVA were applied to compare pre- and post-intervention neurocognitive scores. Statistical significance was considered at $p < 0.05$.

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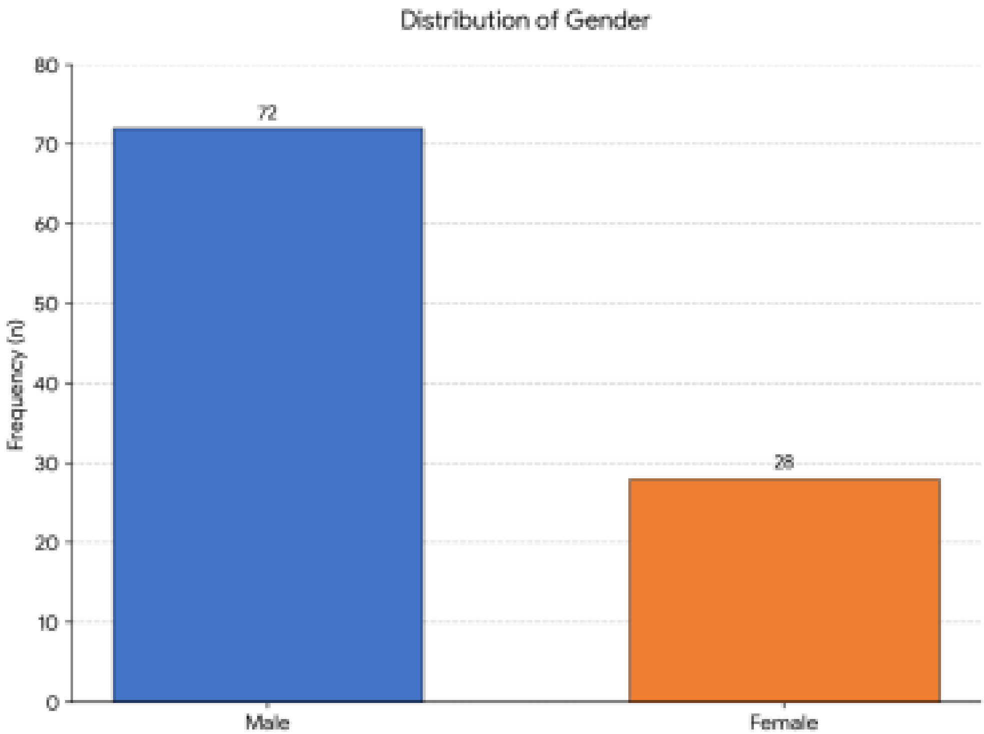
12. Ethical Considerations
Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study. Written informed consent from parents and assent from children were obtained before participation. Confidentiality of participant information was maintained using coded identification numbers, and participation remained voluntary throughout the study.

RESULTS

1. Gender Distribution of Study Participants
The majority of study participants were males (72%) compared to females (28%), and the gender distribution was statistically significant (p<0.001). This finding indicates a higher prevalence of ADHD among male children in the present study population (Table 1).

Table 1: Gender Distribution of Study Participants (n = 100)

Gender	Frequency (n)	Percentage (%)	χ^2 value	p-value
Male	72	72.0	19.36	<0.001*
Female	28	28.0		
Total	100	100.0		



Graph 1: Gender Distribution of Study Participants

2. Baseline Severity of Attention Deficits
Moderate attention deficits were observed in the majority of participants (52%), followed by severe deficits in 30% of children. The findings were statistically highly significant (p<0.001), indicating substantial baseline attentional impairment among participants (Table 2).

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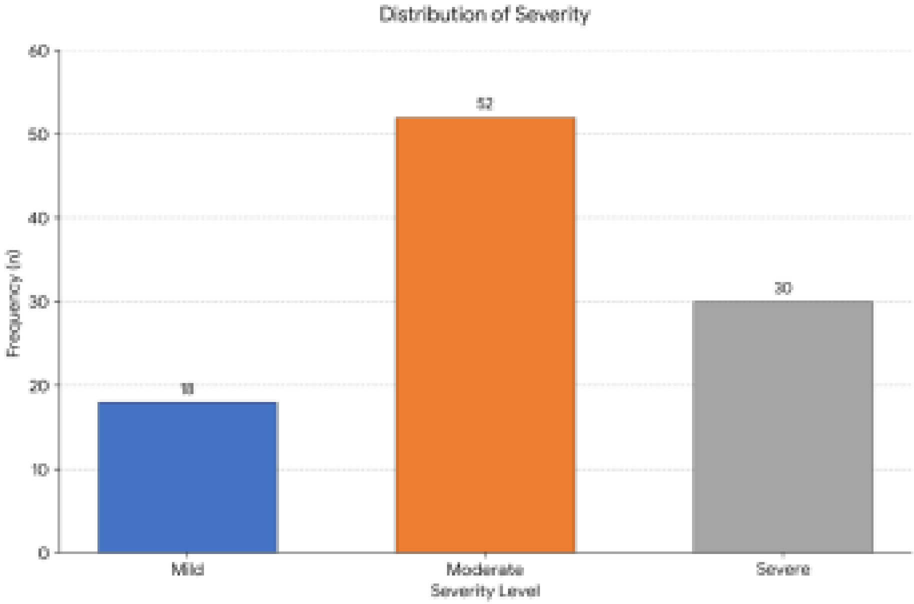
Table 2: Baseline Severity of Attention Deficits

Severity	Frequency (n)	Percentage (%)	χ^2 value	p-value
Mild	18	18.0	22.28	<0.001*
Moderate	52	52.0		
Severe	30	30.0		
Total	100	100.0		



Graph 2: Baseline Severity of Attention Deficits

3. Comparison of Pre- and Post-Intervention Attention Scores

Significant improvement was observed in all attention domains following cognitive retraining, with selective attention showing the highest mean improvement. The differences between pre and post-intervention scores were statistically highly significant (p<0.001) (Table 3).

Table 3: Comparison of Pre- and Post-Intervention Attention Scores

Attention Assessment	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	t value	p-value
Sustained Attention Score	48.62 ± 8.14	67.45 ± 7.52	18.83	18.64	<0.001*
Selective Attention Score	44.91 ± 7.36	63.88 ± 6.91	18.97	19.12	<0.001*
Divided Attention Score	39.72 ± 6.84	57.14 ± 6.32	17.42	17.55	<0.001*

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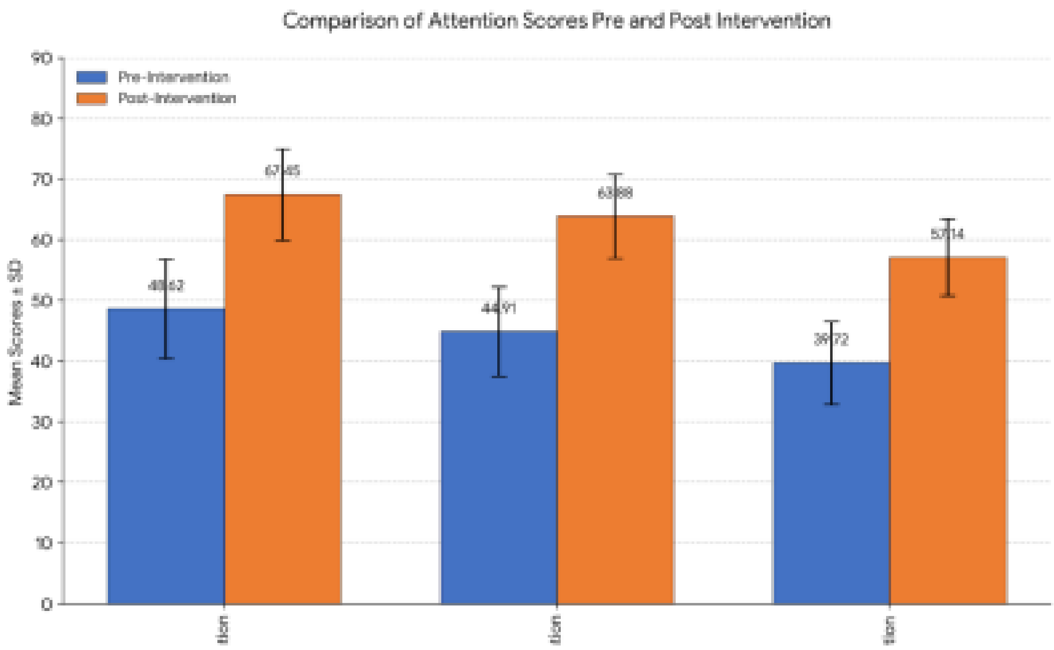


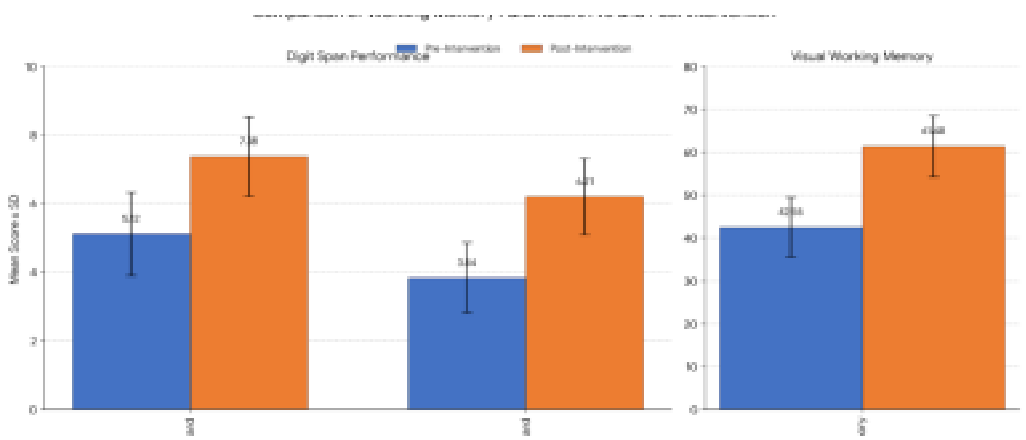
Graph 3: Comparison of Pre- and Post-Intervention Attention Scores

4. Comparison of Pre- and Post-Intervention Working Memory Scores

Working memory parameters improved significantly after cognitive retraining, with visual working memory demonstrating the greatest improvement. All differences were statistically highly significant (p<0.001) (Table 4).

Table 4: Comparison of Pre- and Post-Intervention Working Memory Scores

Working Memory Parameter	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	t value	p-value
Digit Span Forward	5.12 ± 1.21	7.38 ± 1.16	2.26	14.28	<0.001*
Digit Span Backward	3.84 ± 1.02	6.21 ± 1.11	2.37	17.66	<0.001*
Visual Working Memory	42.55 ± 6.94	61.48 ± 7.12	18.93	18.94	<0.001*



Graph 4: Comparison of Pre- and Post-Intervention Working Memory Scores

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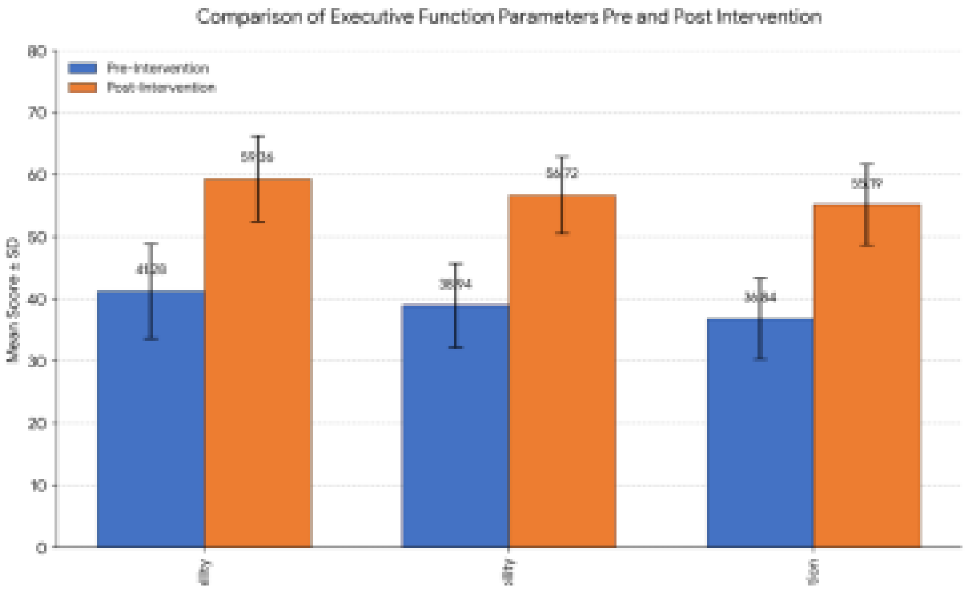
5. Comparison of Pre- and Post-Intervention Executive Function Scores

Executive functioning improved significantly following cognitive retraining, with response inhibition demonstrating the highest mean improvement. The improvements across all executive domains were statistically highly significant (p<0.001) (Table 5).

Table 5: Comparison of Pre- and Post-Intervention Executive Function Scores

Executive Function Parameter	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	t value	p-value
Planning Ability Score	41.28 ± 7.62	59.36 ± 6.88	18.08	16.91	<0.001*
Cognitive Flexibility Score	38.94 ± 6.74	56.72 ± 6.21	17.78	17.42	<0.001*
Response Inhibition Score	36.84 ± 6.48	55.19 ± 6.57	18.35	18.16	<0.001*



Graph 5: Comparison of Pre- and Post-Intervention Executive Function Scores

6. Comparison of Pre- and Post-Intervention Processing Speed Scores

Cognitive retraining significantly improved processing speed and response efficiency across all measured parameters. Reaction response scores demonstrated the highest improvement and all findings were statistically significant (p<0.001) (Table 6).

Table 6: Comparison of Pre- and Post-Intervention Processing Speed Scores

Processing Speed Parameter	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	t value	p-value
Timed Symbol Matching	46.11 ± 7.35	64.75 ± 6.81	18.64	18.03	<0.001*
Visual Scanning Speed	43.82 ± 6.94	62.14 ± 6.58	18.32	17.66	<0.001*

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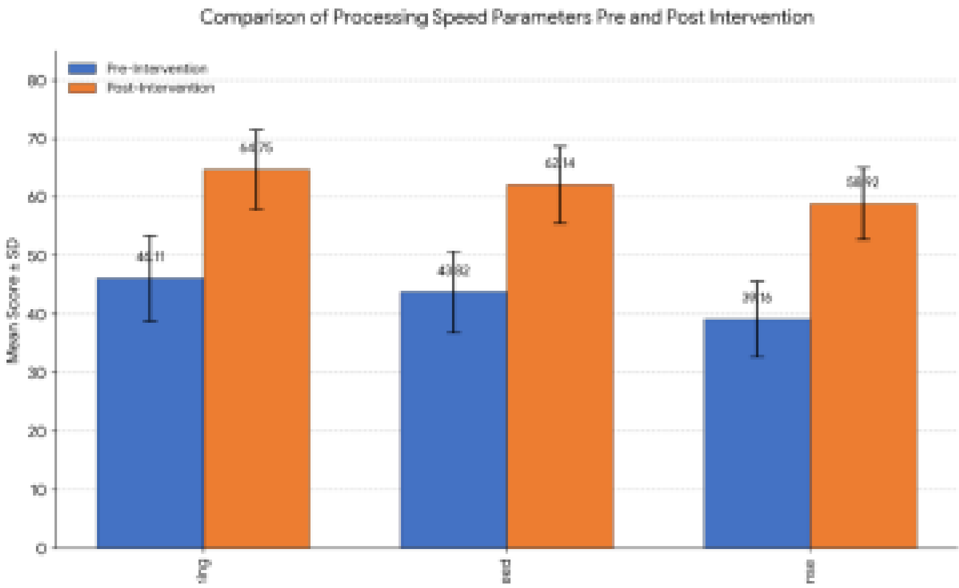
Reaction Response Score	39.16 ± 6.42	58.92 ± 6.14	19.76	19.82	<0.001*

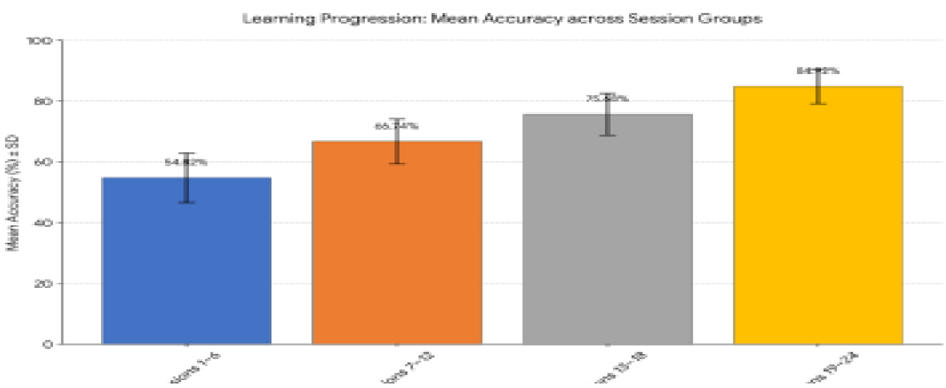


Graph 6: Comparison of Pre- and Post-Intervention Processing Speed Scores

7. Session-wise Improvement in Accuracy Scores
Progressive improvement in task accuracy was observed across intervention sessions, increasing from 54.82% during sessions 1–6 to 84.92% during sessions 19–24. The improvement was statistically highly significant (p<0.001) (Table 7).

Table 7: Session-wise Improvement in Accuracy Scores

Session Group	Mean Accuracy (%) ± SD	F-value	p-value
Sessions 1–6	54.82 ± 8.16	62.84	<0.001*
Sessions 7–12	66.74 ± 7.42		
Sessions 13–18	75.68 ± 6.88		
Sessions 19–24	84.92 ± 5.72		



Graph 7: Session-wise Improvement in Accuracy Scores

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8. Comparison of Neurocognitive Domains Showing Maximum Improvement

Processing speed and attention demonstrated the greatest responsiveness to cognitive retraining compared to executive functioning and working memory. The differences in improvement across neurocognitive domains were statistically significant (p<0.001) (Table 8).

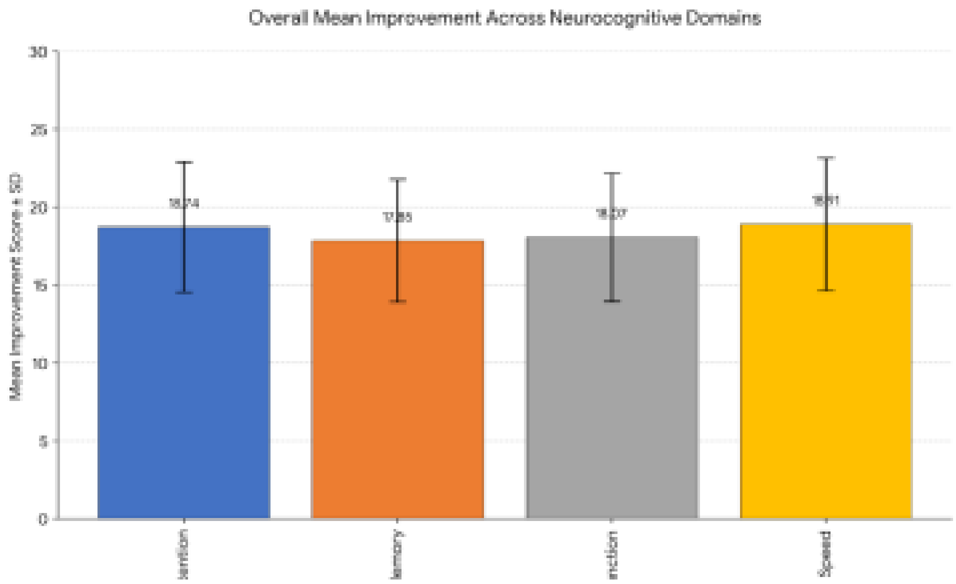

Table 8: Comparison of Neurocognitive Domains Showing Maximum Improvement

Neurocognitive Domain	Mean Improvement Score ± SD	F-value	p-value
Attention	18.74 ± 4.18	8.96	<0.001*
Working Memory	17.85 ± 3.94		
Executive Function	18.07 ± 4.12		
Processing Speed	18.91 ± 4.26		

Graph 8: Comparison of Neurocognitive Domains Showing Maximum Improvement

9. Overall Pre- and Post-Intervention Neurocognitive Functioning Scores

Overall neurocognitive functioning improved significantly following structured cognitive retraining intervention. The total cognitive score increased from 42.84 ± 6.92 before intervention to 61.72 ± 6.38 after intervention (p<0.001) (Table 9).

Table 9: Overall Pre- and Post-Intervention Neurocognitive Functioning Scores

Overall Neurocognitive Score	Pre-Intervention Mean ± SD	Post-Intervention Mean ± SD	Mean Difference	t value	p-value
Total Cognitive Score	42.84 ± 6.92	61.72 ± 6.38	18.88	21.36	<0.001*

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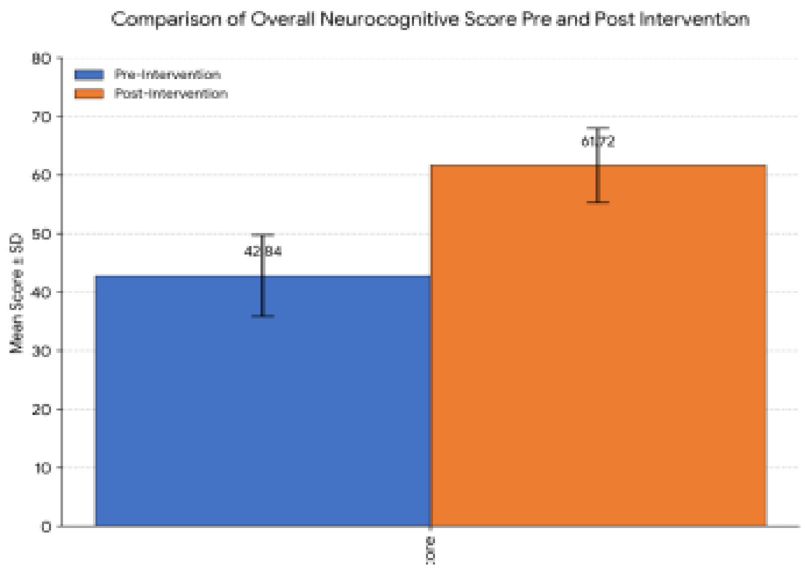


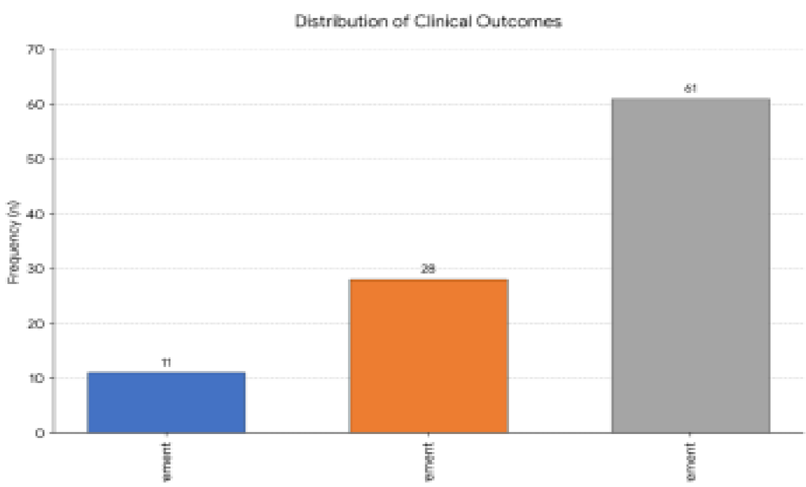
Graph 9: Overall Pre- and Post-Intervention Neurocognitive Functioning Scores

10. Overall Clinical Outcome Following Cognitive Retraining

Marked overall clinical improvement was observed in the majority of participants (61%) following cognitive retraining intervention. The findings were statistically highly significant (p<0.001), indicating strong overall effectiveness of the intervention (Table 10).

Table 10: Overall Clinical Outcome Following Cognitive Retraining

Clinical Outcome	Frequency (n)	Percentage (%)	χ^2 value	p-value
Mild Improvement	11	11.0	56.72	<0.001*
Moderate Improvement	28	28.0		
Marked Improvement	61	61.0		
Total	100	100.0		



Graph 10: Overall Clinical Outcome Following Cognitive Retraining

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DISCUSSION

The present study evaluated the effects of cognitive retraining on neurocognitive functioning in children diagnosed with ADHD. The findings demonstrated significant improvement across multiple neurocognitive domains including attention, working memory, executive functioning processing speed, response consistency, and behavioral regulation following structured cognitive retraining intervention. The majority of participants in the present study were males (72%), which is consistent with previous literature reporting higher prevalence of ADHD among boys. Similar findings were reported by Biederman (2005), who observed greater male predominance in ADHD populations [11].

In the present study, significant improvement was observed in attention domains including sustained, selective, and divided attention following intervention. Selective attention demonstrated the highest improvement among attention parameters. These findings are consistent with the study conducted by Steiner et al. (2014), which reported improved attentional control and reduced distractibility following cognitive training interventions in children with ADHD [12]. Similarly, Johnstone et al. (2010) reported enhanced sustained attention and vigilance following structured neurocognitive retraining [13].

Working memory scores also improved significantly in the current study, particularly visual working memory and digit span performance. These findings support earlier research by Holmes et al. (2010) and van der Donk et al. (2015), who demonstrated significant enhancement in working memory capacity following cognitive retraining programs in children with ADHD [14, 15].

Executive functioning demonstrated statistically significant improvement after retraining, particularly in response inhibition and cognitive flexibility. Similar outcomes were reported by Dovis et al. (2015), who identified improvement in executive control and behavioral regulation following cognitive intervention programs [16]. Reduction in omission and commission errors in the present study additionally indicated improved inhibitory control and attentional regulation.

Processing speed showed the highest overall responsiveness to cognitive retraining in the current study. These findings are consistent with Pontifex et al. (2013), who observed improved neurocognitive efficiency and faster response performance following intervention in children with ADHD [17]. Progressive improvement in session-wise accuracy scores and reduction in therapist prompts also indicated enhanced engagement and learning adaptation across intervention sessions.

Overall neurocognitive functioning improved significantly after intervention, with 61% of participants demonstrating marked clinical improvement. The findings support the neuroplasticity-based framework proposed by Bryck and Fisher (2012), emphasizing that repeated cognitive stimulation can strengthen neural efficiency and cognitive control systems

[18]. Thus, the present study provides strong evidence that structured cognitive retraining is an effective non-pharmacological intervention for improving neurocognitive functioning in children with ADHD.

CONCLUSION

The present study demonstrated that cognitive retraining significantly improved neurocognitive functioning in children with ADHD across multiple domains including attention, working memory, executive functioning, processing speed, and response inhibition. Progressive improvement in session-wise accuracy and overall clinical outcomes further supported the effectiveness of structured cognitive intervention. The findings highlight cognitive retraining as a promising non-pharmacological and neuroplasticity-based therapeutic approach that can enhance cognitive performance, behavioral regulation, and adaptive functioning in children with ADHD, thereby improving their academic and psychosocial outcomes.

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