

# ATTENTION AND EXECUTIVE FUNCTIONS OF CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

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## ABSTRACT

Attention Deficit Hyperactivity Disorder (ADHD) is a highly prevalent neurobehavioral disorder that may be associated with impairment in attention and executive functions. Very few Indian studies have focused on neuropsychological functions in children with ADHD. We evaluated attention and executive functions such as psychomotor speed, response inhibition and set-shifting in 6-12 year old children with ADHD in comparison with age, gender and education matched healthy controls. The participants included 16 children, out of which eight had ADHD and eight were healthy comparators. They were assessed with Vanderbilt ADHD Diagnostic Rating Scale, Trail Making Test A and B (TMT A and B), Stroop Color Word Interference Test (SCWIT) and Wisconsin Card Sorting Test (WCST). The ADHD group was found to have significant deficits in the TMT A ( $p=0.04$ ) and TMT B ( $p=0.03$ ); and in color ( $p=0.01$ ), word ( $p=0.008$ ) and color word ( $p=0.03$ ) subscores of SCWIT. No significant differences were observed in SCWIT interference score or WCST scores. The study shows that ADHD is associated with impairments in attention, psychomotor speed, color naming and word reading but not with impairments in response inhibition or set shifting. Studies with larger sample size are needed for a better understanding of neuropsychological deficits in ADHD.

Keywords: Attention deficit hyperactivity disorder, executive functions, response inhibition, set shifting

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## INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is characterized by inattention and/or hyperactivity-impulsivity, persisting for at least six months, to a degree that is inconsistent with developmental level, and that negatively impacts social and academic/occupational activities. ADHD is highly prevalent and point prevalence estimates of ADHD cluster around 5–10%.<sup>1</sup> A prevalence of 1.6% was observed among children in a well conducted multicentre community-based Indian study.<sup>2</sup> Though a few Indian studies have focussed on clinical profile and comorbidities in ADHD, there is still a dearth of Indian data on the neuropsychological basis of the disorder.<sup>3,4</sup>

Neuropsychological tests are carried out to assess the extent of impairment of brain functions such as attention, memory and executive functions. Studies had pointed out that executive function deficits may be the core pathology leading to attention deficit and hyperactivity symptoms.<sup>5,6</sup> But a few studies have elicited no significant differences in this domain between ADHD patients and controls.<sup>7,8</sup>

The inconsistency among studies could be attributed to methodological limitations like inclusion of children with comorbid autism spectrum disorders, obsessive compulsive disorders (OCD), oppositional defiant disorder (ODD) or conduct disorder (CD) — which themselves are associated with executive dysfunctions.<sup>9,10</sup> So it would be ideal if a study is conducted in an ADHD sample free of comorbid disorders. Hence we aimed to compare the neuropsychological profile of children who suffer from ADHD and no other comorbidities to that of a healthy comparative group, using well validated attention and executive function tasks.

## METHODS

The sample included eight right-handed children (assessed using Edinburgh Handedness Inventory<sup>11</sup>) with diagnosis of ADHD (assessed by Diagnostic Interview Schedule for Children for DSM-IV<sup>12</sup>, parent version and Vanderbilt ADHD

Diagnostic Parent Rating Scale<sup>13</sup>). All consecutive children with ADHD, satisfying the inclusion and exclusion criteria, attending the outpatient facility of the Departments of Psychiatry and Neurology of a tertiary care medical college hospital between July 2014 and August 2014 were included.

The control group was eight healthy children individually matched with cases for gender, age, intelligence and education. They were selected from relatives of patients attending the Paediatrics department of the same hospital.

The children were included based on the following criteria: age of 6–12 years, drug naive status and right handedness. Children satisfying a diagnosis of autism spectrum disorders, Tourette syndrome, OCD, ODD, CD, mood disorders, psychotic disorder, substance use disorder or mental retardation (Binet Kamat test score below 70) were excluded. Children with history of epilepsy, or head injury resulting in loss of consciousness, and children having diagnosable or self-reported visual/auditory impairment were also excluded. Written informed consent was obtained from parents. The study was approved by Institutional Ethics Committee.

The second author assessed both the groups with the Diagnostic Interview Schedule for Children for DSM-IV, parent version, Vanderbilt ADHD Diagnostic Parent Rating Scale, and The Edinburgh Handedness Inventory. The following tests were administered to both the groups:

- Test for attention: Trail Making Test - A (first author)
- Test for psychomotor speed: Trail Making Test- B (first author)
- Tests for executive functions: Stroop Colour Word Interference Test for response inhibition and cognitive flexibility (first author); Wisconsin Card Sorting Test (WCST) for attentional set shifting (fourth author).

Out of the 15 consecutive ADHD children screened for the study, two children each were excluded due to comorbid ODD, mental retardation and failure to

complete neuropsychological tests. One child's parents did not consent to participate in the study.

Comparisons across the groups were performed by using the Mann Whitney U test for continuous data and Chi-square test for categorical variables.

## RESULTS

All the study subjects were boys (n=16). There was no significant difference between the two groups in terms of age, years of education or IQ score. The low Vanderbilt scores of the control group validated our clinical impression that they did not have ADHD (Mann Whitney U= 0.00, p<0.001) (Table 1).

Out of the eight cases, 6 (75%) had the combined type of ADHD and 2 (25%) had the inattentive subtype. The mean age of ADHD onset was 4.89±1.05 years and the mean duration of ADHD was 3.78±1.20 years.

The study showed a decreased level of attention in ADHD children as evidenced by the significant difference in the Trail Making Test A scores between patients and comparative group (Mann Whitney U= 15.00, p=0.04). Significant difference was also noted in the Trail Making Test B scores (Mann Whitney U= 14.00, p=0.03) (Table 2).

The results of the Stroop test subdivisions showed significant differences between ADHD children and control group in the Stroop word score (Mann Whitney U=3.00, p=0.008), Stroop colour score (Mann Whitney U=11.50, p=0.01), Stroop colour-

word score (Mann Whitney U=6.00, p= 0.03) and predicted colour word score (Mann Whitney U=3.30, p=0.08). There was no significant difference in the interference score (Mann Whitney U=8.00, p=0.07) or attentional set shifting (assessed with WCST) (Table 2).

## DISCUSSION

This study examined attention and executive function after excluding patients with comorbidities to get a representative ADHD sample. The assessment was done on drug naïve children to overcome the confounding effect of attention enhancing drugs. The subjects included only right handed children, and the controls were individually matched with the cases for age, gender and education.

The study found that children with ADHD have attention deficits, but no executive dysfunction, compared to matched healthy controls. Executive dysfunction hypothesis of ADHD is still debated due to inconsistent and contradicting research findings. We did not observe impairments in response inhibition or set shifting in ADHD. Our finding is in accordance with the results of a recent metaanalysis of response inhibition on Stroop test and a few studies of set shifting in ADHD.<sup>14,15</sup> However, the finding is in contrast to a few other studies on executive functions of children with ADHD.<sup>6</sup> We found significant difference in the attention and psychomotor speed between ADHD and control children in trail making tests, which is in consistence with previous studies.<sup>16</sup>

**Table 1:** Distribution of sociodemographic and clinical variables

Variable	ADHD	Control	Mann Whitney U	p value
Age	8.67 ±2	8.50 ± 2	34.00	0.88
Years of education	3.11±1.69	2.71±1.70	34.50	0.88
Intelligence (BKT)	108.55±12.57	109.62±12.18	33.50	0.81
Vanderbilt score	38.11±8.00	6.00 ± 1.60	0	<0.01

**Table 2:** Neuropsychological test scores

Variable	ADHD	Control	Mann Whitney U	p value
<b>Trail making test (TMT) scores</b>				
TMT A	11.33	6.38	15.0	0.04
TMT B	11.11	6.34	14.0	0.03
<b>Stroop Colour Word Interference Test scores</b>				
Stroop color	11.72	5.94	11.5	0.01
Stroop word	10.00	4.43	3.0	0.008
Stroop color word	9.50	4.86	6.0	0.03
Predicted color word	10.00	4.43	3.0	0.08
Interference	9.17	5.14	8.0	0.07
<b>Wisconsin Card Sorting Test (WCST) scores</b>				
Total correct	8.61	9.44	32.5	0.74
% Errors	9.22	8.75	34.0	0.88
% Perseverative response	6.89	1.38	17.0	0.07
% Perseverative errors	7.94	10.19	26.5	0.37
% Non- perseverative errors	10.61	7.19	21.5	0.16
% Conceptual level response	9.44	8.5	32.0	0.74
Categories completed	9.22	8.75	34.0	0.88

In the Stroop test, individual scores for naming the colours, words, and colour word were found to be higher in children with ADHD. Stroop interference score is the most important parameter determining the cognitive flexibility and it is rarely assessed in ADHD studies.<sup>17</sup> In our sample, we could not find a significant group difference in the interference score. Similar results were elicited in a previous study also.<sup>17</sup> In our study, Stroop colour and word scores were significantly higher in ADHD children, denoting that more time was needed for ADHD children to name the colours and read the name of colour words. These deficits, without deficits in interference score, are more common in children having reading disorder comorbid with ADHD.<sup>18</sup> As we did not exclude children with reading disorder in our sample, such difference in Stroop colour and word score may be caused due to undiagnosed reading disorder too.

The WCST has differentiated children with ADHD from normal controls in a number of studies.<sup>10</sup> In our study, the percentage perseverative responses and percentage perseverative errors were not significantly different between ADHD patients and controls. Similar to our study, no differences have been observed in WCST scores with regard to percentage perseverative responses or percentage perseverative errors between ADHD children and controls in other studies.<sup>19</sup> But a study with large sample has shown significantly impaired cognitive flexibility in ADHD samples compared to healthy controls.<sup>17</sup>

Major limitations of our study are the low sample size, inclusion of only boys in both the groups, and limitations of using tests like TMT and WCST at a low age group. Hence larger studies devoid of such

methodologic limitations are needed to confirm these results.

To conclude, this study showed impaired attention, colour and words naming and psychomotor speed in ADHD, but other executive functions such as response inhibition and set shifting were found to be unimpaired. Studies with larger sample are needed to get more insights into neuropsychological dysfunction in ADHD.

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