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# Correlation of Clinical Profile with Frontal Lobe Functions in Children with ADHD-A Correlational Study

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## Abstract

**Background:** ADHD is characterized by developmentally inappropriate, persistent problem in attention and /or excessive motor restlessness and /or impulsivity that significant interfere with functioning. Population surveys suggest that ADHD occurs in most cultures in about 5% of children and about 2.5% of adults. The neuropsychological theories of attention-deficit hyperactivity disorder (ADHD) suggests that its symptoms arise from a primary deficit in executive functions.

**Aim:** To study the correlation between the clinical profile of children with ADHD with frontal lobe functions in children of ADHD. Methodology: A total of 33 ADHD children of age group 5 to 12 years attending OPD were included in the study after qualifying the inclusion and exclusion criteria for the study. DSM-5 criteria were used to make diagnosis of ADHD and severity was assessed using Conner's Rating Scale-Revised (CRS-R) Parent short version and assessed for frontal lobe functions using FAB battery, EXIT-25 Battery and NIMHANS battery for children.

**Results:** Around 3/4th participants in the study showed frontal lobe dysfunction which were comparable with severity of ADHD.

**Conclusion:** ADHD is a neuro-developmental disorder with impaired executive functions in a large number of patients.

## Background

Attention deficit hyperactivity disorder (ADHD) is a disorder of childhood and adolescence characterized by a pattern of extreme pervasive, persistent and debilitating inattention, over-activity and impulsivity [1]. The essential feature of ADHD is persistent pattern of hyperactivity-impulsivity and inattention that interferes with functioning or development of the child [2]. ADHD occurs in most cultures in about 5% of children and about 2.5% of adults [2]. A meta-regression analysis estimates for worldwide ADHD/HKD prevalence in a range of 5.9% to 7.1% in children and adolescents, and 1.2-7.3% (3.4%) in adults [3-6]. ADHD is more prevalent in male with estimated male: female ratio of 2:1 to 9:1 [6].

ADHD has been conceptualized as a disorder affecting frontal circuitry due to associated deficits in executive cognitive functioning. Structural imaging studies have documented diffuse abnormalities in children and adults with ADHD. A large study by Castellanos and colleagues [7] reported smaller total cerebrum, cerebellum, and the four cerebral lobes that did not change over time. A structural magnetic resonance imaging (MRI) study [8] in adults with and without ADHD also revealed a smaller anterior cingulate cortex (ACC) and dorsolateral prefrontal cortex (DLPFC). The DLPFC controls working memory that involves the ability to

retain information while processing new information.

Shaw and colleagues [9] reported a delay in cortical thickness among ADHD patients. The pattern of brain development, from sensorimotor to associative areas, was similar in children with and without ADHD. Using the same measure of cortical thickness data in adults, Makris and associates [9] have shown that cortical thickness is not normalized and that the areas of the brain that are affected in children with ADHD remain affected in adulthood. In this study the DLPFC, parietal areas, and ACC had thinner measures of cortical thickness in adults with ADHD than in adults without ADHD.

In 2008, Cherkasova and Hechtman published a study about ADHD children demonstrating that children with ADHD show less activity in their frontal lobes than non-ADHD children while resting or engaging in an activity. On assessment for tasks involving concentration, memory, decision-making and problem solving, there was decrease function seen in the study cases [7]. Even the neuro-imaging done in the cases showed smaller size of the prefrontal cortex of individuals with ADHD. Brennan and Arnsten contributes the aetiology to the fronto-striatal circuitry in the frontal lobe that is associated with the inhibition of certain behaviours. This is also supported by Cherkasova and Hechtman by suggesting this circuit to be a problem function in ADHD [8].

Augusto Pasini in 2009 conducted a study with intake of 50 patients with ADHD and 44 controls. All subjects were boys who were assessed by a clinical-psychopathological and neuropsychological battery to study the five main domains of EFs and attention. The results depicted a selective impairment on executive functions and attention tasks in the studied ADHD boys [9]. The author further discussed the involvement of partially independent neural circuits suggestive to cause control inhibition and divided attention in ADHD population.

Similar study was conducted by Vloet TD in 2010 [9], to use neuro-psychological testing to indicate that ADHD constitute a cognitively distinct subtype and showed cognitive dysfunctions associated with it. The author also concluded with usefulness of neuropsychological testing for identification of disorder-specific neuropsychological dysfunction which could be further helpful to understand the pathophysiology in ADHD and related disorders and could also be adjuvant for treatment considerations [9].

An Indian study was conducted in 2004 by Preeti Sinha, Rajesh Sagar and Manju Mehta at All India Institute of Medical Sciences, Delhi; to assess executive functions in medication naïve children with attention deficit/hyperactivity (ADHD). In this a group matched (age and gender) children with ADHD (N=30) and healthy children (N=30) in the age range of 6-14 years were compared on measures of executive functions (response inhibition, working memory, cognitive flexibility, fluency and planning). The results were suggestive of: - ADHD children had significant deficits in response inhibition, working memory, cognitive flexibility and design fluency; concluding that deficits in executive functions may be a central feature of ADHD [10].

## Aim

To study the correlation between the clinical profile of children with ADHD with frontal lobe functions in children of ADHD.

## Methodology

- The children with ADHD presenting to Child and Adolescent Psychiatry OPD a tertiary care neuropsychiatry institute (IHBAS) were approached after diagnosis was confirmed using DSM-5 criteria.
- After applying inclusion and exclusion criteria participants were selected. Briefing was done regarding study and written informed consent from parents and assent from children were taken.
- A total of 35 children with ADHD were identified, out of which 1 was excluded due to seizure disorder and one was excluded as caregiver refused to continue the study.
- Thus, after exclusion of 2 subjects, a total of 33 children diagnosed with ADHD were recruited for study (Figure 1).

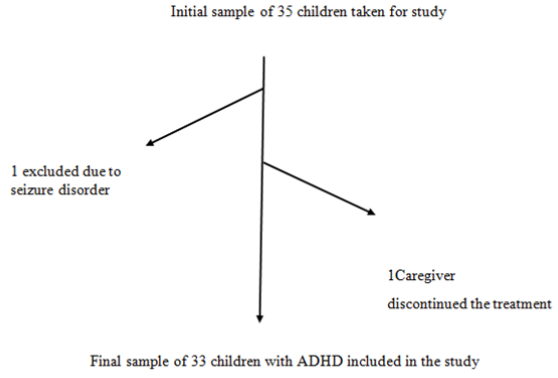



**Figure 1:** Recruitment of the sample for the study .

## Results and Discussion

The present study was carried out at the Institute of Human Behaviour and Allied Sciences (IHBAS), a tertiary neuropsychiatry hospital and an academic institute in Delhi. It was a cross-sectional study wherein children were taken from Child and Adolescent Psychiatric OPD over a period

of nine months. DSM-5 criteria were applied to objectively validate the diagnosis and assessment of the clients taken for the study. A period sample of 100 children was initially taken and after application of inclusion and exclusion criteria, 33 children were included in the study. Children who had other comorbidities like epilepsy and other psychiatric illness that could confound the process of assessment and results were excluded from the study [11,12].

The Conner's scores range is from 0 to 81. In the present study this score range was arbitrarily divided into groups as: - 0 to 20= equivocal, 21 to 41= mild, 42 to 62= moderate and 63 to 81= severe level of ADHD for descriptive and correlation analysis. The study cases were assessed for frontal lobe functions using both International as well as Indian tools i.e. FAB, EXIT-25 and NIMHANS Neuropsychological battery for Children (primarily the behavioural function). While FAB and EXIT-25 were developed and used majorly in the Western studies; NIMHANS Neuropsychological battery for Children is an Indian battery developed and studied on Indian population.

## Sample Characteristics

The results were analyzed from the data collected from 33 children with ADHD who fulfilled the study criteria. The mean age of the children was 8.61 years (SD=2.16) (Table 1).

| AGE GROUP | NO. OF CHILDREN |
|---|---|
| (n=33) | n (%) |
| 1) 5 to < 8 years | 10 (30.30) |
| 2) 8 to < 10 years | 13 (39.40) |
| 3) 10 to 12 years | 10 (30.30) |

**Table 1:** Age group distribution of the study population.

On distribution of the data based on age group division 10 (30.30%) children lied in age group of 5 to < 8 years, 13 (39.40%) in 8 to < 10 years and remaining 10 (30.30%) in age group of 10 to 12 years.

In the study most of the children were male (78.8%), having a male: female ratio of 3.71 which is similar to the estimated sex ratio for ADHD in worldwide study [1].

## Severity of ADHD

Conner's scores ranged from 43 to 67 with mean being 54.52 (SD=6.00) in the study (Table 2 & Figure 2).

| LEVEL OF SEVERITY (n-33) | NO. OF CHILDREN n (%) |
|---|---|
| 1. MODERATE (42-62) * | 30 (90.9) |
| 2. SEVERE (63-81) * | 3 (9.10) |

**Table 2**: Severity of ADHD on Conner's Rating Scale Revised (Parent short version).

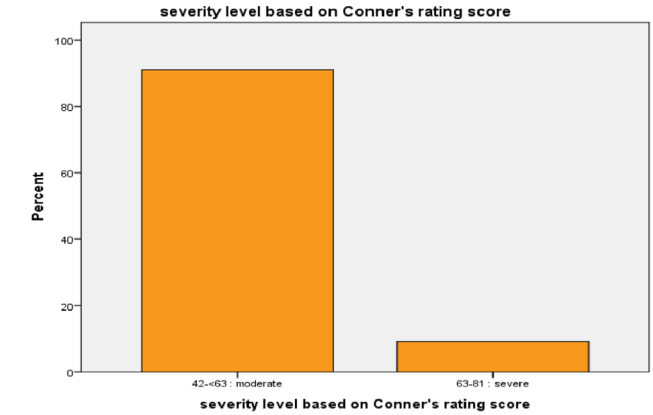



**Figure 2:** Severity level distribution in children with ADHD.

The distribution of equivocal (0-20), mild (21-41), moderate (42-62) and severe (63-81). Most of the cases of ADHD-30 out of 33 lied in the moderate range (90.9%) and 3 cases were in the severe level of severity (9.1%).

## Frontal Lobe Functions

The cut-off taken to assess dysfunction was: - < 12 for FAB (11), 15 for EXIT-25 battery (12) and NIMHANS Neuropsychological Battery for Children was quantified as 1 for presence of poor performance as dysfunction (Table 3).

| VARIABLES | MEAN VALUES | | DYSFUNCTION n (%) | |
|---|---|---|---|---|
| | MEAN | S.D. | ABSENT | PRESENT |
| FAB* (n=33) | 9.96 | 4.66 | 13 (39.40) | 20 (60.60) |
| EXIT-25** (n=33) | 19.67 | 9.19 | 13 (39.40) | 20 (60.60) |
| NIMHANS BATTERY*** (n=33) | 10.24 | 5.85 | 13 (39.40) | 20 (60.60) |

*Frontal Assessment Battery: FAB
**Executive Interview-25 (EXIT-25) test: EXIT-25
***NIMHANS Neuropsychological Battery for Children: NIMHANS battery.
**Table 3:** Frontal lobe functions assessment in children with ADHD.

The frontal lobe testing done by FAB test lied in the range of 3 to 17, having a mean value of 9.96 (S.D.-4.66). Among the 33 cases of study population there were 20 (60.60%) cases which showed dysfunction by FAB test and remaining 13 (39.40%) showed no dysfunction in the testing (Figure 3). When subjected to Executive Interview-25 (EXIT-25) test a range of 7 to 36 and mean of 19.67 (S.D.-9.19) was seen. In this, 20 (60.60%) cases had Dysfunction while 13 (39.4%) had normal testing results (Figure 4). On assessment by NIMHANS Neuropsychological Battery for Children, scores ranged from 3 to 22 having a mean value of 10.24 (S.D.-5.85). Assessment by this battery showed a normal test results in 13 (39.4%) cases and 20 (60.60%) cases had dysfunction present (Figure 5).

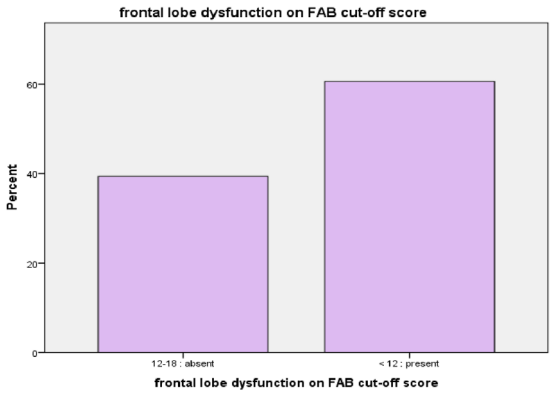



**Figure 3:** Frontal lobe function assessment by FAB test in children with ADHD.

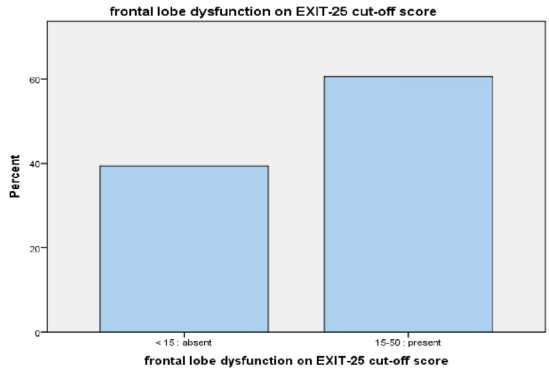



**Figure 4:** Frontal lobe function assessment by EXIT-25 battery in children with ADHD.

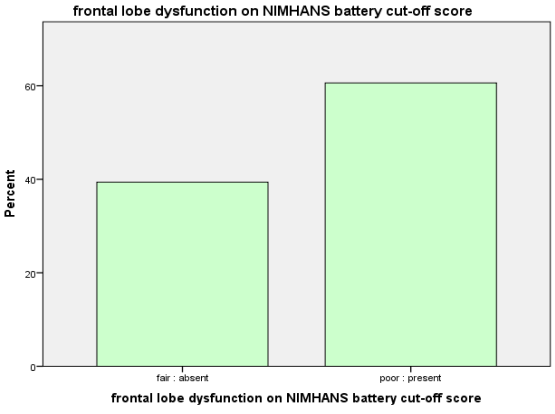



**Figure 5:** Frontal lobe function assessment by NIMHANS Neuropsychological Battery for Children in children with ADHD.

## Correlation of Clinical Profile of Children with Adhd with the Frontal Lobe Function

The overall clinical profile based on clinical severity was correlated with Frontal lobe functions by using Pearson Correlation statistics (Table 4).

| VARIABLES (n = 33) | CORRELATION COFFICIENT ® | p-value# |
|---|---|---|
| FAB *AND SEVERITY OF ADHD | -0.18 | 0.16 |
| EXIT-25** AND SEVERITY OF ADHD | 0.27 | 0.13 |
| NIMHANS BATTERY*** AND SEVERITY OF ADHD | -0.22 | 0.21 |

*Frontal Assessment Battery: FAB
**Executive Interview-25 (EXIT-25) test: EXIT-25
***NIMHANS Neuropsychological Battery for Children: NIMHANS battery
# Level of significance is <0.05

**Table 4:** Correlation of clinical severity with frontal lobe function in the cases of ADHD children.

The severity of ADHD was correlated with FAB and found to have weak correlation (r=0.18) and of low significance value (p-value=0.16). Similar results were found with EXIT-25(r=0.27 and p-value=0.13), NIMHANS Neuropsychological Battery for Children (primarily the behavioural function) (r=0.22 and p-value=0.21) and theta: beta ratio (r=0.30 and p-value=0.09). The Conners score is negatively correlated with FAB and NIMHANS Neuropsychological Battery for Children which indicate that they are inversely related; which evident from pattern of scoring in them (Table 5).

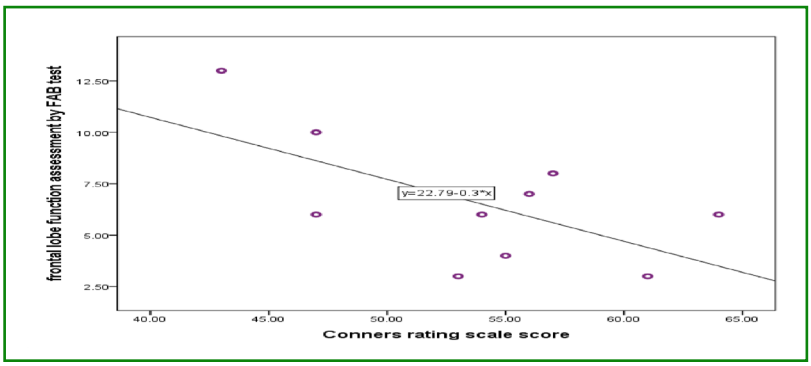
| VARIABLES ( n = 10 ) | SEVERITY OF ADHD | |
|---|---|---|
| | CORRELATION COFFICIENT ® | p-value# |
| FAB* AND SEVERITY OF ADHD | -0.63 | 0.05 |
| EXIT-25** AND SEVERITY OF ADHD | 0.71 | 0.02 |
| NIMHANS BATTERY*** AND SEVERITY OF ADHD | -0.64 | 0.04 |

*Frontal Assessment Battery: FAB
**Executive Interview-25 (EXIT-25) test: EXIT-25
***NIMHANS Neuropsychological Battery for Children: NIMHANS battery # level of significance is <0.05

**Table 5:** Correlation of clinical severity with frontal lobe function in age group of 5 to < 8years cases of in ADHD children.

There were 10 children in the age group of 5 to < 8 years, among which 9 (90.00%) moderate level and 1 (10.00%) had severe level of ADHD. The severity of ADHD children in the age group of 5 to < 8 years was correlated with FAB and found to have strong negative correlation (r= - 0.63) and significance value (p-value=0.05) (Figure 6).

Similarly, results were found to be of moderate to strong positive correlation with EXIT-25 (r=0.71) and significant p-value=0.02 of the result. By NIMHANS Neuropsychological Battery for Children (r= - 0.64and p-value=0.04) moderate negative correlation with significant value was found and with theta: beta ratio (r=0.36 and p-value=0.30) weak correlation and significance was present (Table 6). The Conners score is negatively correlated with FAB and NIMHANS Neuropsychological Battery for Children which indicate that they are inversely related.



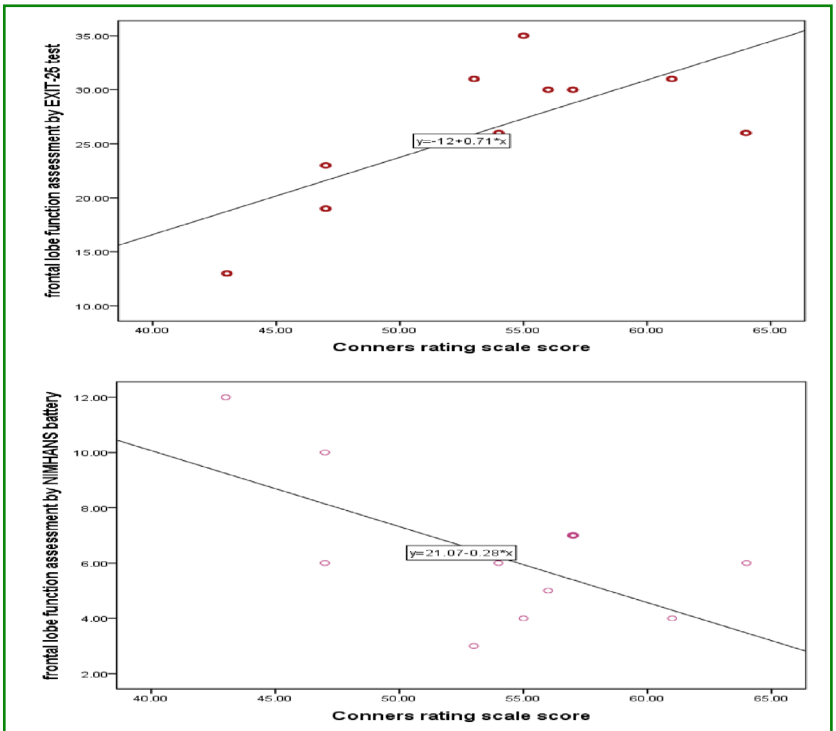



**Figure 6:** Neuropsychological Battery for Children.

| VARIABLES | SEVERITY OF ADHD | |
|---|---|---|
| | CORRELATION COFFICIENT ® | p-value# |
| FAB* AND SEVERITY OF ADHD | -0.23 | 0.45 |
| EXIT-25** AND SEVERITY OF ADHD | 0.26 | 0.39 |
| NIMHANS BATTERY*** AND SEVERITY OF ADHD | -0.55 | 0.05 |

*Frontal Assessment Battery: FAB

**Executive Interview-25 (EXIT-25) test: EXIT-25

***NIMHANS Neuropsychological Battery for Children: NIMHANS battery # level of significance is <0.05

**Table 6:** Correlation of clinical severity with frontal lobe function in age group of 8 to < 10 years cases of ADHD children.

There were 13 children in the age group of 8 to < 10 years, among which 12 (92.30%) had moderate level and 1 (7.70%) had severe level of ADHD. The severity of ADHD in the age group of 8 to < 10 years was correlated with FAB and found to have weak correlation (r= - 0.23) and of low significance value (p-value=0.45). Similar results were found with EXIT-25 (r=0.26 and p-value=0.39), though NIMHANS Neuropsychological Battery for Children had weak to moderate negative correlation and significance (r=0.55 and p-value=0.05) and theta: beta ratio (r=0.40 and p-value=0.18) had weak correlation coefficient values and low significance. The Conner's score is negatively correlated with FAB and NIMHANS Neuropsychological Battery for Children which indicate that they are inversely related (Table 7).

| VARIABLES | SEVERITY OF ADHD | |
|---|---|---|
| | CORRELATION COFFICIENT ® | p-value# |
| FAB* AND SEVERITY OF ADHD | 0.08 | 0.83 |
| EXIT-25** AND SEVERITY OF ADHD | 0.29 | 0.42 |
| NIMHANS BATTERY*** AND SEVERITY OF ADHD | 0.18 | 0.63 |

*Frontal Assessment Battery: FAB

**Executive Interview-25 (EXIT-25) test: EXIT-25

***NIMHANS Neuropsychological Battery for Children: NIMHANS battery # level of significance is <0.05

**Table 7:** Correlation of clinical severity with frontal lobe function in age group of 10 to 12 years cases of ADHD children.

There were 10 children in the age group of 10 to 12 years, among which 9 had moderate level and 1 (10.00%) had severe level of ADHD. The severity of ADHD of the age group of 10 to 12 years was correlated with FAB and found to have weak correlation (r=0.08) and of low significance value (p-value=0.83). Similar results were found with EXIT-25(r=0.29 and p-value=0.42), NIMHANS Neuropsychological Battery for Children (primarily the behavioural function) (r=0.18 and p-value=0.63) and theta: beta ratio (r=0.10 and p-value=0.78).

The study population when subjected to frontal lobe function assessment by FAB, EXIT-25 and NIMHANS Neuropsychological battery for children. The FAB test had a mean score of 9.96 (S.D.=4.66) suggestive of presence of dysfunction. The mean score on EXIT-25 battery test was 19.67 (S.D.=9.19) supporting the dysfunction. Even the mean score of NIMHANS Neuropsychological battery for children was 10.24 (S.D.=5.85) which indicated dysfunction in frontal lobe testing. Majority of the children in the sample, around 20 (60.6%) cases showed dysfunction by FAB, EXIT-25 and NIMHANS Neuropsychological battery for children. These findings are in support with the past available literature. The study conducted by Cherkasova and Hechtman (2009), Augusto Pasini in 2007 and Vloet, Timo D in 2010 reported about the problems of decreased concentration , inattention, decreased problem solving skills and decreased executive function [7,9]. An Indian study conducted in 2008 by Preeti Sinha, Rajesh Sagar and Manju Mehta at All India Institute of Medical Sciences, Delhi, also supports the present study findings suggesting that deficits in executive functions may be a central feature of ADHD [10]. The remaining 13 (39.40%) children performance had normal frontal lobe test functions.

The current study was further directed to study for the correlation of the clinical profile of the children with ADHD with the frontal lobe functions. The results based on age group distribution had shown moderate correlation of the clinical profile with the frontal lobe functions assessed by FAB, EXIT-25 and NIMHANS Neuropsychological battery for children in the age group of 5 to < 8 years.

## The Current Study Reveals the Presence of Frontal Lobe Dysfunction in The Children of ADHD

Here around 60.60 % of the total population had dysfunction when assessed by FAB test, EXIT-25 battery and NIMHANS Neuropsychological battery for children. This in a way was also indicated of validation of FAB test, EXIT-25 and NIMHANS Neuropsychological battery for children to assess the frontal lobe functions. The positive similar results also helpful to evaluate the sensitivity of Western tests/ battery with Indian battery.

The available research in this field does mention about the correlation of the clinical profile with the frontal lobe functions, however the current study attempted to do so.

## Conclusion

The present study was carried out cross-sectional in Child and Adolescent Psychiatry Outpatient Department, IHBAS, which is a tertiary neuropsychiatry hospital in Northern India. In the study group more than 3/4th children were male and the male: female ratio of 3.71:1 was seen. Majority of children had moderate severity of ADHD and around < 10% had severe level of severity of ADHD. The dysfunction for frontal lobe functions was present for 2/3rd of the total cases tested by Western and Indian tests. The study showed weak correlation for the clinical profile with frontal lobe functions on overall estimation. Though the results showed strong correlation for clinical severity and frontal lobe functions in age group of 5 to < 8 years; and moderate correlation for clinical severity with frontal lobe functions with limiting significance related to smaller sample size.

## Acknowledgement

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