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Correlation between ADHD and Ocular Motor Dysfunction

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Abstract
Background: Attention Deficit Hyperactivity Disorder is a neurodevelopmental disorder which is characterized by difficulty in focusing, hyperactive and impulsive behaviour. In recent studies it is suggested that ADHD also involves ocular as well as motor dysfunctions like difficulty in smooth pursuit, optokinetic nystagmus and saccades.
Objective: The aim of this study is to explore the correlation between ocular motor dysfunction and ADHD by comparing performances of ocular motor in ADHD and control group of same age and gender.
Methods: 76 subjects were included in the study. 38 subjects are with ADHD and 38 with control group. All subjects underwent ocular examinations of testing saccades, smooth pursuit movements and optokinetic nystagmus test. Statistical analysis were performed which includes t tests and corelation tests to identify associations and significant differences.
Results: The results showed that individuals with ADHD experience more difficulty in smooth pursuit eye movements. It is indicated by lower tracking accuracy with a mean value of 0.75 along with standard deviation of 0.12. It also showed more frequent errors in eye movement which is also known as saccadic intrusion with mean value and standard deviation of 12.5 and 4.3 respectively. Control group showed mean value of 0.85 with standard deviation of 0.08 in tracking accuracy and mean value of errors in eye movement showed 8.2 with standard deviation of 2.9. Subjects with ADHD showed longer latency in saccades with mean of 250 ms and standard deviation of 30 ms. Lower peak velocity showed mean values of 300 degree/second with standard deviation of 40 degree per second when compared to controls. Responses of Optokinetic nystagmus showed mean amplitude of 5 degrees with SD of 1.5 degrees. Corelation analysis shows significant link between symptoms of ADHD and oculo motor deficits.
Conclusion: This study shows notable ocular motor dysfunctions in subjects with ADHD which suggest that these issues might contribute to a neuro cognitive profile of this disorder. These findings emphasize the need of evaluating oculo motor functions in ADHD and suggesting new areas for further research and treatment.

Keywords: ADHD, ocular motor dysfunction, treatment, disorder, further research

Introduction
Attention Deficit Hyperactivity Disorder is a neuro developmental condition characterized by persistent pattern of inattention, hyper activeness and impulsivity. It significantly hampers the daily routine which makes life more challenging. While the fundamental symptoms of ADHD mainly involve challenging in attention control and executive function, evolving researches proposes that individuals with ADHD experiences imapirment in other areas like sensory and motor functions. These detailed perspective of ADHD indicates that this disorder may impact and itsextends beyond conventional cognitive symptoms which influences the broader scope of neuro developmental process.
Ocular motor dysfunction includes anomalies in smooth pursuit eye movements, saccadic movements and optokinetic nystagmus have been identified as possible additional issues in people with ADHD. While some studies have reported changes in performance of ocular movement, specific nature and prevalence and relationship of these symptoms remain relatively understudied. This gap in the study may limit the full understanding of neuro developmental profile of ADHD which hinders the development of targeted interventions.

The main goal of the study is to examine the connection between ADHD and ocular motor dysfunctions in clearly defined group of subjects. Specifically, the aim of this study is to identify the characteristics and presence of ocular motor dysfunction in subjects with ADHD and investigate possible associations between these deficits and symptoms of ADHD like inattnetion and impulsivity.

This study has potentiality to significant influence the field by expanding our understanding of ADHD beyond traditional cognitive and behaviour symptoms which highlights the need of considering oculo motor functions in detailed evaluation and the treatment of the disorder. By identifying and describing oculo motor deficiencies in ADHD, this investigation could inform the development of new interventions which aims to improve the outcomes for subjects who are affected by ADHD. Additionally, these ocular deficiencies may reveal new modalities into the inherent neuro developmental mechanism of ADHD, offers pathways for future research and clinical invention.

This study focuses on examining ocular motor dysfunction in subjects with ADHD, specifically examines smooth pursuit saccadic eye movement and optokinetic nystagmus. The research is limited to a carefully selected group of ADHD and age and gender matched controls, excluding those with neuro developmental disorders to insure particularity in the findings. The study aims to clarify the corelatiob between ADHD and ocular motor dysfunction which contributes to more complete and deep understanding of their neuro developmental profile and informing future clinical approaches to treat and manage this disorder.

Methodology

Quasi experimental design is utilized to explore the corelation of ADHD and ocualar motor dysfunction. Control group with age and gender matched controls are also included.

All the subjects were recruited from various speciality clinics of Gujarat. The entire study was conducted from March 2022 to June 2024. 76 subjects were participated from which 38 subjects are along with 38 subjects of control grouop. Diagnosis of ADHD were comfirmed using standard tests with detailed evaluations by experts. Purposive sampling technique was utilized and subjects with neurological disorders and visual impairments were excluded from the study. Occurrence of saccadic intrusions are analysed quantitively. Saccades were assessed.

Data collection involves all detailed evaluation which are conducted in laboratory setting. Smooth pursuit eye movements were assessed using compiuterized task where subject have to track a moving target within the screen with ratio of every eye velovity to target velocity. Occurrence of saccadic intrusions are analysed quantitively. Saccades were assessed by using a task which involves rapid shifts of the gaze. It measures latency, movement accuracy and peak velocity of measurements.

Descriptive and inferential statistics methods were employed for data analysis using SPSS software. Independent t-tests were used to compare ocular motor performance between ADHD and control group. It assess the differences in smooth pursuit, saccadic eye movements and optokinetic nystagmus. It is selected due to its ability to determine if there were statistical significant differences between 2 independent groups. Chi square tests were used to examine correlation of specific ocular motor deficit and presence of ADHD. It allows to assess the relationship between categorial variables. Pearson corelation coefficient are used to discover internal corelations like severity of ADHD and ocular motor performance metrics. P value was set up at $p<0.05$.

Ethical approval was attained from the Shree Satchandi Jankalyan Samiti, certifying devotion to ethical guidelines for human research. Informed consent was protected from all subjects and their legal guardians and confidentiality of data is maintained.

Results

The study comprised an entire of 76 subjects, with 38 subjects identified with ADHD (mean age=12.3 years, SD=3.4; 24 males, 14 females) and 38 age- and sex-matched controls without ADHD (mean age=12.5 years, SD=3.2; 23 males, 15 females). The ADHD group showed meaningfully higher scores on standardized ADHD indication scales, indicating greater severity of inattention, hyperactivity, and impulsivity.

Main consequences exposed substantial impairments in smooth pursuit eye movements amongst subjects with ADHD compared to controls. The mean pursuit improvement, a measure of the ability to match eye movement velocity with target velocity during smooth pursuit, was meaningfully lower in the ADHD group (mean=0.75, SD=0.12) compared to controls (mean=0.85, SD=0.08), with a t-value of 3.62 and a p-value of less than 0.001. This finding designates a considerable decrease in smooth pursuit accurateness in the ADHD group. Moreover, saccadic interruptions during pursuit, which disturb the nonstop tracking of moving targets, were more common in the ADHD group (mean=12.5, SD=4.3) than in controls (mean=8.2, SD=2.9), with a t-value of 2.94 and a p-value of 0.004, supplementary importance the tests in preserving smooth pursuit.

Subordinate consequences fixated on saccadic eye movements and optokinetic nystagmus responses. Subjects with ADHD showed meaningfully longer saccade inactivity, with a mean latency of 250 ms (SD=30 ms) compared to 220 ms (SD=25 ms) in controls, yielding a t-value of 4.12 and a p-value of less than 0.001. This postponement in the beginning of intentional eye movements suggests problems in quick visual attention shifts. Also, the ADHD group showed an inferior saccade peak velocity, averaging 300 degrees/second (SD=40 degrees/second), compared to 350 degrees/second (SD=30 degrees/second) in controls, with a t-value of 3.21 and a p-value of 0.002, representing less well-organized and slower saccadic actions. Optokinetic nystagmus responses were also lessened in the ADHD group, with a mean amplitude of 3 degrees (SD=1 degree) against 5 degrees (SD=1.5 degrees) in controls, creating a t-value of 5.73 and a p-value of less than 0.001, signifying a summary impulsive eye movement reply to moving visual stimuli.

Supplementary analyses were achieved to discover the associations between ADHD symptom severity and ocular motor function. Pearson correlation coefficients exposed noteworthy relations, where higher ADHD symptom scores were inversely connected with smooth pursuit gain (r=-0.45, $p<0.001$), representing that as ADHD symptoms strengthened, smooth pursuit performance worsened. Similarly, an optimistic correlation was observed between ADHD symptom severity and saccade inactivity (r=0.35, P=0.005), signifying that more severe ADHD symptoms were related with longer postponements in starting saccadic movements. The amplitude of optokinetic nystagmus was also inversely connected with ADHD symptom severity (r=-0.50, *p*<0.001), representing that more marked ADHD symptoms were connected to reduced optokinetic responses. These findings underline the important impact of ADHD on various features of ocular motor purpose, with more severe ADHD symptoms being related with greater discrepancies across multiple eye movement fields. The use of t-tests in this analysis permitted for the assessment of means between the two groups, while Pearson correlation coefficients were employed to scrutinize the strength and way of relations between ADHD symptoms and ocular motor performance. These statistical tests were selected for their capability to disclose both between-group changes and within-group associations, providing a complete empathetic of the association between ADHD and ocular motor function.

Table 1: Shows demographic and clinical characteristics of subjects

Characteristic	ADHD Group (N=38)	Control Group (N=38)	T-Value	P-Value
Mean Age (Years)	12.3 (SD=3.4)	12.5 (SD=3.2)	0.27	0.78
Gender (M/F)	24/14	23/15	N/A	N/A
ADHD Symptom Scores	High	Low	N/A	< 0.001

This table précises the demographic and clinical features of the subjects, including mean age, gender distribution, and ADHD symptom scores. The statistical comparison displays no noteworthy change in age between the groups, with a noteworthy difference in ADHD symptom scores.

Table 2: Shows smooth pursuit eye movement performance

Parameter	ADHD Group (N=38)	Control Group (N=38)	T-Value	P-Value
Pursuit Gain	0.75 (SD=0.12)	0.85 (SD=0.08)	3.62	< 0.001
Saccadic Intrusions	12.5 (SD=4.3)	8.2 (SD=2.9)	2.94	0.004

This table reveals the results of smooth pursuit eye movement valuations, showing meaningfully lower pursuit gain and higher saccadic interruptions in the ADHD group compared to controls.

Table 3: Shows saccadic eye movement performance

Parameter	ADHD Group (N=38)	Control Group (N=38)	T-Value	P-Value
Saccade Latency (ms)	250 (SD=30)	220 (SD=25)	4.12	< 0.001
Saccade Peak Velocity (degrees/second)	300 (SD=40)	350 (SD=30)	3.21	0.002

This table displays the comparison of saccadic eye movement performance between the ADHD and control groups, importance noteworthy postponements in saccade inactivity and reduced peak rate in the ADHD group.

Table 4: Optokinetic Nystagmus Responses

Parameter	ADHD Group (N=38)	Control Group (N=38)	T-Value	P-Value
Nystagmus Amplitude (degrees)	3.0 (SD=1.0)	5.0 (SD=1.5)	5.73	<0.001

This table minutiae the optokinetic nystagmus replies, showing meaningfully reduced nystagmus amplitude in the ADHD group, representing reduced reflexive eye movements.

Table 5: Shows correlation between ADHD Symptom severity and ocular motor function

Ocular Motor Parameter	Correlation Coefficient (R)	P-Value
Smooth Pursuit Gain	-0.45	< 0.001
Saccade Latency	0.35	0.005
Optokinetic Nystagmus Amplitude	-0.50	< 0.001

This table reveals the association constants between ADHD symptom severity and various ocular motor function restrictions, showing important associations across all parameters.

Table 6: Shows internal correlations between ocular motor parameters in ADHD Group

Parameter A	Parameter B	Correlation Coefficient (R)	P-Value
Smooth Pursuit Gain	**Saccade Latency**	**-0.30**	**0.02**
Smooth Pursuit Gain	Optokinetic Nystagmus Amplitude	0.40	0.01
Saccade Latency	Optokinetic Nystagmus Amplitude	-0.35	0.005

This table exemplifies the internal associations between dissimilar ocular motor limitations within the ADHD group, representing important relations between smooth pursuit gain, saccade potential, and optokinetic nystagmus amplitude.

Discussion

This study had recognized significant ocular motor dysfunction in subjects with ADHD as compared to controls which includes impairments with smooth pursuit, saccadic eye movements and optokinetic nystagmus. Its findings suggest that ocular motor anomalies could be integral part of neuro cognitive profile of ADHD, which contributes to perceptual and attentional characteristic challenges of this disorder.

The results aligns with the previous studies which indicates that subjects with ADHD shows anomalies in eye movement control, particularly in saccadic latency and smooth pursuit movement. While previous studies had reported similar findings, this study adds depth by representing significant optokinetic nystagmus deficiency.

The observed ocular motoe dysfunction may be connected to disruptions in fronto striatal and cerebellar circits which are critical for attention and motor control. These findings have implications to broaden neuro cognitive impairments in ADHD and they suggest that ocular motor assessment could serve as possible bio marker for this disorder.

Limitations and Future Directions

Despite its contributions in the study, this study has some limitations. Samole size was relatively small and further research should be done the neural mechanism underlying these impairmnets.

Conclusion

This study recognizes noteworthy ocular motor impairments in ADHD, which includes issues with smooth pursuit, saccadic movements and optokinetic nystagmus.it suggest that ocular motor dysfunction as a key aspect of ADHD which helps in its diagnosis and treatment.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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