Original Article

Accommodation and Convergence in Dyslexia Individuals with and without Refractive Errors

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ABSTRACT

Aim: To investigate the state of convergence and accommodation in individuals with dyslexia with and without refractive errors.

Study Design: Observational Study

Duration and Settings of the Study: Mayo Hospital Lahore from March 2024 to November 2024.

Methods: The study received approval from the Ethical Review Board. Individuals with dyslexia were recruited between March and November 2024 using a purposive (non-probability) sampling technique. A total of 30 participants, comprising 15 individuals with refractive error and 15 without refractive error, were included. Exclusion criteria included current use of medications affecting vision, inability to complete the examination after three attempts, and ocular disorders unrelated to dyslexia. Written informed consent was obtained from all participants. Near point of convergence was measured using an RAF ruler, and accommodative lag/lead was assessed through dynamic retinoscopy. Data were analyzed in SPSS version 27.0 using the Mann–Whitney U test, with $p < 0.05$ considered statistically significant.

Results: The study included 30 individuals with dyslexia, with a mean age of 15.77 + 4.52 years with 19 (63.3%) males. Among the fifteen participants with refractive error, 11(73.3%) had hyperopia. Findings showed that participants with refractive errors exhibited significantly greater accommodative lag (Mean Rank = 17.17, U = 28.00, p = .005) and a more distant near point of convergence (Mean Rank = 21.90, U = 16.50, p < .001) compared with those without refractive errors.

Conclusion: Refractive errors may contribute to binocular vision difficulties in individuals with dyslexia, particularly affecting near focus and convergence.

Keywords: Accommodation; Convergence; Dyslexia; Refractive Error

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INTRODUCTION

Dyslexia is defined as a learning disability that primarily affects the development of accurate and fluent word recognition and spelling skills.[1] It is a complex, multifaceted, and lifelong condition rather than a disease and occurs across the full spectrum of intellectual abilities. Its characteristic features include difficulties in phonological awareness, verbal memory, and verbal processing speed.[2] Dyslexia is the most prevalent and extensively researched learning disability, accounting for approximately 80% of individuals classified as learning disabled. It presents with considerable variability in symptoms.[3]

Neurobiological investigations have demonstrated structural and functional differences in the brains of individuals with dyslexia compared with non dyslexic individuals.[4] These differences are most prominent in the temporoparietal and occipitotemporal regions of the left cerebral hemisphere. Alterations in these areas distinct from classical language regions such as Wernicke's area suggest atypical neural connectivity that contributes to deficits in phonological awareness and word decoding skills.[5] Additionally, reduced activity within the magnocellular visual pathway, which

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processes motion and spatial information, has been reported in dyslexic individuals. This diminished activity may impair motion analysis, spatial localization of visual stimuli, and the spatial organization of letters, thereby complicating reading and spelling acquisition.[6]

The contribution of visual factors to dyslexia remains an area of ongoing debate. The International Dyslexia Association acknowledges that dyslexia is complex and that visual processing issues may coexist with, or exacerbate, reading difficulties.[7] Several studies have reported abnormalities in binocular vision and accommodative function among individuals with dyslexia. Difficulties in converging or diverging the eyes appropriately can lead to eye strain, headaches, blurred or double vision, and learning challenges. Accommodative dysfunction (difficulty maintaining clear focus at varying distances), may further contribute to discomfort during reading.[8]

Visual disturbances such as binocular and accommodative dysfunctions can significantly hinder reading performance and may intensify the challenges faced by individuals with dyslexia.[9] Consequently, assessing and correcting visual dysfunctions is an important component of supporting reading comfort and efficiency.[10] Binocular single vision, which depends on fusion and retinal correspondence, enables clear and comfortable vision using both eyes.[11]

Despite growing evidence, a critical knowledge gap remains regarding how refractive errors such as myopia, hyperopia, or astigmatism interact with accommodation and convergence in individuals with dyslexia. This gap underscores the need to investigate the coexistence of refractive errors and binocular vision dysfunctions.[12] Such findings may enhance understanding of fine and coarse visual processing in dyslexia, support early identification of visual contributors to reading difficulty. It informs that timely interventions that improve reading outcomes and overall well being.

METHODS

The study received approval from the Ethical Review Board of College of Ophthalmology & Allied Vision Sciences (Ref: COAVS/365/24). Data were collected in Mayo Hospital Lahore from individuals with dyslexia between March 2024 and November 2024. Sample size was determined using the formula $n = (\sigma^2 (Z_{1-\alpha} + Z_{1-\beta})^2) / (\mu_0 - \mu\partial)^2$, based on a significance level of 5%, test power of 90%, population standard deviation of 1.21, variance of 1.46, a test mean of 7.32, and an anticipated mean of 6.67.13 Purposive (non probability) sampling was used to recruit participants. The final sample consisted of 30 individuals with dyslexia, including 15 with refractive error and 15 without. Exclusion criteria included current use of medications affecting vision, inability to complete the examination after three attempts, and ocular disorders unrelated to dyslexia. Written informed consent was obtained from all participants prior to examination. Near point of convergence was measured using an RAF ruler, and accommodative lag/lead was assessed using dynamic retinoscopy.

All qualitative and quantitative variables were recorded and analyzed in SPSS version 27.0. The Mann–Whitney U test was applied, and a p value < 0.05 was considered statistically significant.

RESULTS

A total of 30 individuals with dyslexia participated in the study. Participant ages ranged from 10 to 28 years (Mean = 15.77, SD ± 4.52), indicating that the sample consisted predominantly of adolescents. Most participants were male (n = 19, 63.3%), while 11 (36.7%) were female.

Refractive error information was available for 15 participants (50%). Among those with complete data, hyperopia was the most common refractive error, present in 11 participants (73.3%), followed by myopia in 3 participants (20%) and astigmatism in 1 participant (6.7%). The remaining 15 participants had no recorded refractive error data, representing a notable limitation in the dataset.

Mann–Whitney U analyses revealed significant differences in binocular vision measures between participants with and without refractive errors. Individuals with refractive errors demonstrated a significantly greater accommodative lag (Mean Rank = 17.17, U = 28.00, p = .005) and a more distant near point of convergence (NPC) (Mean Rank = 21.90, U = 16.50, p < .001) compared with those without refractive errors.

Table 1 shows that eyes with refractive errors demonstrated a significantly greater accommodative lag (Mean Rank = 17.17) compared with eyes without refractive errors (Mean Rank = 9.15). This indicates that individuals with dyslexia who also have refractive errors exhibit reduced ability to accommodate to near targets, resulting in a tendency for their eyes to focus behind the intended point. No statistically significant difference was found in accommodative lead between participants with and without refractive errors. However, this comparison was limited by very small subgroup sizes (three participants with refractive error and two without), which likely reduced the sensitivity of the analysis.

In contrast, a significant difference was observed in near point of convergence (NPC). Participants with refractive errors had markedly higher NPC values (Mean Rank = 21.90) than those without refractive errors (Mean Rank = 9.10), indicating poorer convergence ability. This suggests that dyslexic individuals with refractive errors have reduced capacity to converge their eyes effectively and may only achieve clear vision at farther distances.

Table 2 indicates that the Mann–Whitney U test confirmed a significant difference between the groups in accommodative lag (U = 28.000, p = 0.005). Individuals with refractive

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errors demonstrated a longer accommodative lag, reflecting reduced ability to focus accurately on near targets. In contrast, no statistically significant difference was observed in accommodative lead ($U = 0.000$, $p = 0.068$). This finding should be interpreted cautiously, as the comparison involved very small subgroup sizes (three participants with refractive errors and two without), which likely limited the test's sensitivity. A highly significant difference was found in near point of convergence (NPC), with the refractive error group showing markedly more remote NPC values ($U = 16.500$, $p < 0.001$). This indicates poorer convergence ability among individuals with refractive errors, suggesting that they may struggle to maintain clear binocular vision at near distances.

DISCUSSION

The purpose of this study was to examine the relationship between refractive errors and binocular vision function in individuals with dyslexia. The findings demonstrated that participants with refractive errors exhibited significantly greater accommodative lag and a more distant near point of convergence (NPC) compared with those without refractive errors.[14] These results suggest that refractive errors may impair the ability to focus and converge on near targets skills essential for efficient reading.

The Mann–Whitney U analyses further supported these observations, showing a significantly higher accommodative lag (Mean Rank = 17.17, $U = 28.000$, $p = .005$) and more remote NPC (Mean Rank = 21.90, $U = 16.500$, $p < .001$) in the refractive error group. No significant difference was found in accommodative lead, likely due to the very small subgroup sizes available for this comparison. Collectively, these findings indicate that refractive errors may contribute to binocular vision difficulties in dyslexic individuals.

These results align with previous research reporting a higher prevalence of binocular vision disorders among students with dyslexia.[15] Prior studies have documented increased accommodative and vergence insufficiencies in this population, highlighting the potential impact of these visual dysfunctions on reading performance. The present study adds to this body of evidence by demonstrating that refractive errors may further exacerbate binocular vision deficits.[10]

These findings underscore the importance of comprehensive visual screening in individuals with dyslexia. Assessment should extend beyond refractive status to include detailed evaluation of binocular vision function, as early identification and management of these abnormalities may support improved reading comfort and academic performance.

The findings of this study align with and extend existing literature on the visual characteristics of individuals with dyslexia. Mukhtar et al reported an increased prevalence of accommodative dysfunction and reduced distance positive fusional vergence recovery in children with dyslexia. This is consistent with the present study's observation of a larger accommodative lag and more distant near point of convergence (NPC) in dyslexic participants with refractive errors, both of which indicate deficits in accommodation

Table 1: Comparison of Accommodation and Convergence Measures between Groups (Using Mann–Whitney U Test)

Outcome Measure	Group	N	Mean Rank	P value	Exact Sig. (2 tailed)
Lag of Accommodation	With refractive error	12	17.17	0.005	0.005
	Without refractive error	13	9.15		
	Total		25		
Lead of Accommodation	With refractive error	3	2.00	0.068	0.2
	Without refractive error	2	4.50		
	Total		5		
Near Point of Convergence (NPC)	With refractive error	15	21.90	0.001	0.001
	Without refractive error	15	9.10		
	Total		30		

N=frequency

Table 2: Comparative Analysis of Accommodation and Convergence

Outcome Measure	Mann–Whitney U	Wilcoxon W	Z	P value	Exact Sig. (2 tailed)
Lag of Accommodation	28.000	119.000	−2.801	0.005	0.005
Lead of Accommodation	0.000	6.000	−1.826	0.068	0.200
Near Point of Convergence (NPC)	16.500	136.500	−4.006	0.001	0.001

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and convergence.[16]

Similarly, Shahudin et al emphasized the importance of evaluating visual acuity and refractive errors in dyslexic children, reinforcing the relevance of refractive status in this population.[17] Charlotte Gibert et al demonstrated that visual training can improve visual perceptual skills in dyslexic children, further supporting the role of visual factors in dyslexia and suggesting that targeted visual interventions may be beneficial.[18]

The review by Vidyasagar, focused on visual attention and neural oscillations in dyslexia, highlighting the broader relationship between visual processing and reading.[19] The identification of binocular vision problems in dyslexic individuals with refractive errors in the present study contributes to this understanding by linking refractive status with functional visual performance. Likewise, research by Vikesdal reported that children and adults with dyslexia report more optometric symptoms than controls, supporting the relevance of examining visual and binocular factors in this population.[20]

Raghuram et al found frequent accommodative and oculomotor tracking deficits in dyslexic children, and the current study builds on this by demonstrating that refractive errors may further increase accommodative lag.[21] Feizabadi et al reported reduced monocular and binocular near point accommodation in dyslexic children, consistent with the accommodative dysfunction observed here.[13] The present study also found a statistically significant difference in accommodative lag ($p = 0.005$) between groups, complementing findings from Wajuihian S and Nadioo K work identified significant associations between dyslexia and binocular accommodative facility at near ($p = 0.027$).[22]

Overall, the results are largely consistent with previous research and extend current knowledge by clarifying the contribution of refractive errors to accommodation and convergence deficits in dyslexia.[23] This highlights the importance of comprehensive visual assessment—including refractive status and binocular vision evaluation in individuals with dyslexia.

The implications of these findings are clinically meaningful. Addressing refractive errors in dyslexic individuals may reduce visual discomfort and improve accommodative and vergence function, potentially enhancing reading speed, accuracy, and academic performance. These results also underscore the need for interprofessional collaboration between educators, ophthalmologists, and optometrists to ensure that dyslexic individuals receive appropriate visual assessment and management.

However, several limitations should be acknowledged. The sample size was relatively small, and refractive error data were incomplete for half of the participants, which may have constrained the strength of the findings. Additionally, the study did not account for the type or degree of refractive error and lacked a healthy control group. Future research should include larger samples, detailed refractive classifications, and broader binocular vision assessments to better understand the visual mechanisms underlying dyslexia.

Despite these limitations, this study contributes valuable insight into the relationship between refractive errors, binocular vision, and dyslexia.[14] The findings suggest that refractive errors may be associated with binocular vision problems in dyslexic individuals, emphasizing the need for comprehensive vision care. Further research should explore the effectiveness of visual therapies and interventions targeting accommodation and convergence in dyslexic individuals with refractive errors, as well as their impact on reading performance.

CONCLUSION

Refractive errors in dyslexic individuals are associated with reduced accommodative and convergence efficiency, underscoring the need for comprehensive ophthalmic evaluation and timely correction to support comfortable near work and reading performance.

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Conflict of Interest

The author(s) declare no conflicts of interest.

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AI Declaration

No artificial intelligence tools were used in the preparation of this manuscript.

Patient Consent:

Informed consent was obtained from all patients involved in this study.

Ethical Approval

Ethical approval for this study was granted by Ethical Review Board of College of Ophthalmology & Allied Vision Sciences (Ref: COAVS/365/24).

Authors' Contribution Statement

AS: Made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data, AND Drafted the work or revised it critically for important intellectual content; AND Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MAA: Made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data, AND Drafted the work or revised it critically for important intellectual content. MS: Made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data, AND Drafted the work or revised it critically for important intellectual content; AND Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. AR: Made a substantial contribution to the concept or design of the work; or acquisition, analysis or interpretation of data. MM: Drafted the work or revised it critically for important intellectual content; AND give a final approval of the version to be published.