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RESEARCH ARTICLE

PROFILE OF BINOCULAR VISION & ACCOMMODATION DYSFUNCTION IN MYOPIC CHILDREN AT A TERTIARY EYE HOSPITAL IN NORTH INDIA

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ABSTRACT

Purpose: To evaluate the profile and frequency of binocular vision & Accommodation dysfunction among myopic children attending the myopia clinic at a tertiary care eye hospital in North India. **Methods:** A cross-sectional, prospective study was conducted at the Myopia and Binocular Vision Therapy (BVT) Clinic of Dr. Shroff's Charity Eye Hospital, New Delhi, from October 2023 to March 2024. A total of 543 children aged 6–18 years with myopia (spherical equivalent ≥ –0.50 D) were included. Binocular vision evaluation was performed using standard protocols including cover tests, NPC, NPA, fusional vergence amplitudes, accommodative facility, and MEM retinoscopy. BVDs were classified based on Scheiman and Wick criteria. Data were analyzed using SPSS v29, and statistical significance was set at $p < 0.05$. **Results:** Overall, 52.2% of children had at least one Binocular Vision Disorder. Convergence insufficiency (18.5%) and intermittent exotropia (16.3%) were the most common. Normal binocular function decreased significantly with increasing myopia severity (70.3% in mild vs. 29.7% in high myopia; $p < 0.001$). Poor convergence showed a moderate negative correlation with higher myopia ($r = –0.32$, $p = 0.03$). Accommodative insufficiency was rare and observed only in high myopia (2.7%). **Conclusion:** Binocular vision dysfunctions are highly prevalent among Indian children with moderate to high myopia, with convergence insufficiency and intermittent exotropia being the most significant. These findings underscore the importance of routine binocular vision screening and early intervention in pediatric myopia clinics.

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INTRODUCTION

The global surge in myopia among children has become an urgent public health concern, especially in urban and semi-urban regions of Asia. India, in particular, has seen a rising prevalence of pediatric myopia, which not only poses a threat to clear distance vision but also implicates critical aspects of functional vision—namely binocular vision (BV) and accommodative function. These systems, responsible for coordinated eye alignment and focusing ability, play a vital role in tasks like reading, writing, and screen-based activities. Dysfunction in either can lead to symptoms such as eyestrain, headaches, blurred vision, and decreased academic performance, yet these anomalies often remain underdiagnosed in clinical practice. In myopic children, non-strabismic binocular vision anomaliessuch as convergence insufficiency, convergence excess, fusional vergence dysfunction, and accommodative excessare frequently reported, especially in tertiary eye care settings[1]. For instance, a recent study by Sah et al. (2023)[2] at a vision therapy clinic in India observed that over 74% of children presenting with visual symptoms had accommodative dysfunctions, with accommodative excess being the most common[2]. Another compelling study by Sharma et al. (2022)[3] highlighted the increased incidence of accommodative excess during the COVID-19 pandemic lockdowns among Indian schoolchildren, linking it to prolonged near work and increased screen time[3,4]. These findings support the hypothesis that environmental and behavioral shifts, such as academic digitization and reduced outdoor exposure, exacerbate functional visual stress in children[4]. Importantly, the interrelationship between refractive errors and BV/accommodation is clinically significant. Research by Hussaindeen (2016)[4] on normative binocular

parameters among Indian school children revealed that myopic children often show reduced amplitudes of accommodation and poor vergence facility[4]. Similarly, Arvind et al. (2025)[5] reported variations in accommodative and vergence responses in Indian optometry students following prolonged near work, highlighting how sustained accommodation in myopes may destabilize binocular fusion[4,5]. In tertiary care hospitals, where pediatric eye services are consolidated, comprehensive binocular vision evaluations remain underutilized despite clear evidence that accommodative and BV dysfunctions can coexist with refractive anomalies. Saxena et al. (2020)[6] emphasized this in a national consensus statement on pediatric refraction, urging early screening and management of vergence and accommodation disorders to prevent amblyopia and academic delays[6,7]. Yet, there remains a research gap: limited region-specific data from North Indian tertiary eye hospitals assessing the profile, type, and co-existence of BV and accommodation anomalies among myopic children. This gap hinders the development of targeted vision therapy protocols and preventive public health measures.

MATERIALS AND METHODS

This prospective, cross-sectional study was conducted at the Myopia and Binocular Vision Therapy (BVT) Clinic at a tertiary eye care center, over a six-month period from October 2023 to March 2024. The study aimed to assess the profile of binocular vision and accommodative dysfunctions in children diagnosed with myopia. A total of 543 children aged 6 to 18 years were enrolled based on specific inclusion and exclusion criteria. Children included in the study had a spherical equivalent refractive error of –0.50 diopters (D) or more in at least one eye, best-corrected visual acuity of 6/9 or better in each eye, and comprehensive records including biometric measurements using the IOL Master (IOL Master 500 or 700, Carl Zeiss Meditec AG, Jen, Germany), binocular vision assessment results, and environmental exposure data. Children were excluded if they had manifest strabismus, amblyopia, significant ocular pathology, neurodevelopmental disorders, a history of intraocular surgery or trauma, or were uncooperative for clinical procedures. Additionally, those undergoing interventions that could affect binocular function or myopia progression during the study period were excluded. All participants underwent cycloplegic refraction after instillation of 1% cyclopentolate to determine their spherical equivalent (SE), which was used to classify the severity of myopia. Since statistical comparison showed no significant difference in SE between the right and left eyes ($p = 0.4510$), only data from the right eye were included in subsequent analyses. Binocular vision function was assessed by trained optometrists following standardized clinical protocols. The tests included distance and near cover tests, prism bar cover test, near point of convergence (NPC), near point of accommodation (NPA), and fusional vergence amplitudes (both positive and negative) evaluated using Sheard's criterion. Additionally, accommodative function was assessed through ±2.00 diopter flipper accommodative facility testing, monocular estimate method (MEM) retinoscopy for accommodative response, and AC/A ratio calculations using the gradient or calculated method.

Binocular vision dysfunctions were classified using the Scheiman and Wick criteria into categories including convergence insufficiency, accommodative insufficiency, accommodative infacility, fusional vergence dysfunction, and basic exophoria or esophoria based on test outcomes. Data were entered and analyzed using IBM SPSS Statistics version 29.0.2.0. Descriptive statistics summarized the frequency and distribution of different dysfunctions. Associations between types of binocular vision dysfunction and myopia severity were examined using Chi-square and ANOVA tests, while Pearson's correlation was employed to analyze relationships between axial length, spherical equivalent, and binocular vision parameters. A p-value less than 0.05 was considered statistically significant for all tests. The monocular data of Myopia Spherical Equivalent for the two eyes in Table 1, showed no statistically significant differences ($p = 0.4510$) with 95% confidence interval. Therefore, only data from the right eye were used for the statistical analysis. (Table:1)

RESULTS

A total of 543 myopic children aged between 6 and 18 years were included in the final analysis. The mean age of participants was 12.5 years (±3.61), reflecting a balanced representation across middle childhood and adolescence. The gender distribution was nearly equal, with 270 (49.8%) males and 273 (50.2%) females, indicating no gender-based enrollment bias. Regarding refractive status, based on the spherical equivalent (SE) classification, 210 children (40.2%) were diagnosed with mild myopia (SE between –0.50 D and –3.00 D), 111 children (20.6%) had moderate myopia (SE between –3.00 D and –6.00 D), and 222 children (40.2%) presented with high myopia (SE greater than –6.00 D) (Table:2). These findings demonstrate a bimodal distribution, with the highest proportions occurring in both mild and high myopia categories, suggesting that children presenting to a tertiary care center may represent both early and advanced stages of myopia progression. The balanced demographic profile supports the generalizability of findings across school-age and adolescent populations in similar clinical settings.

The analysis of refractive error and ocular biometric parameters among the myopic children (aged 6–18 years) revealed distinct trends across myopia severity categories, as detailed in Table 3. The mean spherical equivalent (SE) progressively decreased with increasing myopia severity: $–1.98 \pm 0.76$ D in the mild group, $–4.43 \pm 0.90$ D in the moderate group, and $–6.80 \pm 2.63$ D in the high myopia group. Correspondingly, axial length showed a strong positive correlation with myopia severity, increasing from 24.15 ± 0.97 mm in mild myopia to 25.69 ± 1.32 mm in high myopia, consistent with axial elongation as a key biomarker of myopic progression. Anterior chamber depth (ACD) remained relatively stable across groups, with minor variations (3.77 ± 0.27 mm in mild, 3.80 ± 0.24 mm in moderate, and 3.75 ± 0.24 mm in high myopia), suggesting limited anterior segment remodeling in early-onset myopia.

Lens thickness also remained similar among all three groups, with values ranging from 3.32 ± 0.71 mm in mild to 3.36 ± 0.17 mm in high myopia. Interestingly, central corneal thickness (CCT) was lowest in the moderate myopia group (508.17 ± 21.85 µm), compared to both mild (536.79 ± 37.44 µm) and high myopia groups (534.42 ± 34.65 µm), though no statistically significant trend was observed across severity levels. Pupil size showed mild fluctuation, being largest in the mild group (7.08 ± 1.58 mm),

followed by high myopia (6.87 ± 2.19 mm), and smallest in moderate myopia (6.54 ± 1.18 mm). These biometric findings collectively reinforce the critical association between axial length and myopia progression, while other ocular parameters remained largely constant across severity levels. All myopic children evaluated at the Myopia and Binocular Vision Therapy Clinic, binocular vision dysfunction (BVD)or accommodative anomalies were identified in 52.2%of the participants (n = 313), highlighting a substantial burden of functional visual issues in this pediatric population. The

Table 1. Monocular Spherical Equivalent data

Group	Right Eye	Left Eye	P
Mean	-5.43342	-5.03533	0.4510
SD	3.71820	3.42449	
SEM	0.38765	0.35703	
Number	543	543	

Table 2. Baseline demographic data of Myopic children included in analysis

Parameters		Number (%)	Mean
Age (Years)		543	12.5 ±3.61
Gender		Male: 270 (49.8% Female: 273 (50.2%)	
Distribution of Myopia (SE)	Mild (–0.50 D to –3.00 D)	210 (40.2%)	
	Moderate (–3.00 D to –6.00 D)	111 (20.6%)	
	High (> –6.00 D)	222 (40.2%)	

overall incidence of normal binocular function declined significantly with increasing severity of myopia, present in 70.3% of children with mild myopia, 55.6% with moderate myopia, and only 29.7% among those with high myopia, indicating a strong inverse relationship between refractive severity and functional binocular stability. Notably**,** intermittent exotropia (XT) showed a marked rise in prevalence with increasing myopia severity, occurring in 5.4% of mild, 22.2% of moderate, and 24.3% of high myopes. Similarly, convergence insufficiency (CI) was significantly more prevalent in high myopes (24.3%) compared to those with moderate (11.1%) and mild myopia (2.7%), suggesting that receded near point of convergence and poor positive fusional vergence are more frequently associated with higher axial elongation**.** Esophoria was absent in mild myopia but observed in 5.6% of moderate and 5.4% of severe myopes. Basic exophoria, was found 13.5% in mild myopes, 5.6 % in moderate and 10.8% in severe myopes which was not statistically significant. showing in Table 4. Accommodation-related anomalies were less common but still clinically relevant. Accommodative insufficiencyand accommodative infacility were each observed in 2.7% of high myopes, and in 0–2.7% of other groups, with overall incidence rates of 1.1% and 2.2%, respectively(Table:4). These conditions, although infrequent, pose significant challenges in near-vision tasks such as reading and screen use, particularly in school-aged children.

Binocular vision dysfunctions (BVDs) were found to be significantly more prevalent in children with moderate to high myopia compared to those with mild myopia **(**p = 0.001**),** indicating a strong association between increasing refractive error and functional visual anomalies. Specifically, phoria and intermittent tropia were observed at significantly higher rates among children with moderate to severe myopia **(**p < 0.01**),** suggesting that ocular alignment instability intensifies with axial elongation. A moderate negative correlation was observed between the severity of myopia and convergence ability (r = –0.32, p = 0.03), indicating that higher myopic refractive error is associated with poorer convergence function**,** a key feature of convergence insufficiency. In contrast, accommodative insufficiency was absent in children with mild and moderate myopia and was observed at only a minimal rate in those with high myopia, suggesting a weaker association between accommodative function and refractive severity in this cohort.

DISCUSSION

This study provides a comprehensive analysis of binocular vision and accommodation dysfunctions (BVDs) in a large cohort of 543 myopic children, aged 6 to 18 years, attending a tertiary eye hospital in North India. The findings reinforce a growing body of evidence suggesting that binocular vision anomalies, particularly convergence insufficiency and intermittent exotropia, are highly prevalent among children with moderate to high degrees of myopia. More than half (52.2%) of the myopic children in this study presented with at least one form of BVD, a rate comparable to the prevalence observed in other Indian studies. For example, Hussaindeen et al. (2017)[7] in the BAND study reported a 32.8% prevalence of non-strabismic binocular vision anomalies in South Indian schoolchildren aged 7–17 years, indicating that the burden may be even greater in referral-based populations like ours[7]. Our cohort's higher BVD prevalence may reflect the more severe myopia and referral bias inherent to tertiary centers. Importantly**,** binocular dysfunctions were significantly more common with increasing myopia severity**,** particularly convergence insufficiency (CI), intermittent exotropia (XT), and basic exophoria[8]. Children with severe myopia (> –6.00 D) exhibited normal binocular function in only 29.7% of cases, compared to 70.3% among those with mild myopiaa statistically significant inverse relationship (p < 0.001).

The association between poor convergence and increasing myopia (r = –0.32, p = 0.03) aligns with findings from Ali et al. (2021), who emphasized the role of axial elongation and reduced fusional reserves in vergence dysfunctions[9] Intermittent exotropia, observed in 24.3% of high myopes in this study, has been previously linked to unstable sensory fusion and reduced accommodative convergence, particularly in the presence of reduced positive fusional vergence (PFV) at near[8].

Studies by Srivastava et al. (2024)[10] and Maharjan et al. (2022)[11] have noted similar associations between refractive error and intermittent tropias, suggesting a biomechanical strain on binocular coordination as the axial length increases and convergence demands become unmanageable. Accommodation insufficiency**,** although relatively rare in this study (1.1% overall), was confined to children with high myopia and entirely absent in mild or moderate myopes. This low incidence is consistent with findings from Chakraborty et al. (2025), who also reported a low prevalence of accommodative insufficiency in children with normal AC/A ratios and stable near work habits (Cureus, 2025)[12]. The relatively well-preserved accommodation function may be due to the young age group and habitual use of near devices in Indian schoolchildren, which may paradoxically train

Table 3. Correlation between Myopia and ocular Biometry

Parameters	Mild (–0.50 D to –3.00 D)	Moderate (–3.00 D to –6.00 D)	Severe (> –6.00 D)	P value
Myopia (Mean, SD)	-1.98 ± 0.76	-4.43± 0.90	-6.80 ± 2.63	(p < 0.001)
Axial Length (mm)	24.15± 00.97	24.82± 0.87	25.69 ± 1.32	(p < 0.001)
AC Depth(mm)	3.77 ± 0.27	3.80 ± 0.24	3.75± 0.24	*(p > 0.05)*
Lens Thickness(MM)	3.32 ± 0.71	3.32 ± 0.19	3.36 ± 0.17	*(p > 0.05)*
Central Corneal Thickness (µm)	536.79 ± 37.44	508.17 ± 21.85	534.42 ± 34.65	(p < 0.001)
Pupil Size(MM)	7.08 ± 1.58	6.54 ± 1.18	6.87 ± 2.19	(p < 0.001)
Parameters are given as mean ± SD				

Table 4. Correlation between myopia and Binocular vision & Accommodation functions (n = 543)

	Mild (–0.50 D to –3.00 D)	Moderate (–3.00 D to –6.00 D)	Severe (> –6.00 D)	P Value
Normal Binocular Functions	**70.3%**	**55.6%**	**29.7%**	*(p < 0.001)*
Exophoria (PD)	13.5%	5.6%	10.8%	*(p > 0.05)*
Esophoria (PD)	0%	5.6%	5.4%	***(p < 0.01)***
Intermittent XT	5.4%	22.2%	24.3%	***(p < 0.001)***
Convergence Insufficiency	2.7%	11.1%	24.3%	***(p < 0.001)***
Accommodation Insufficiency	0%	0%	2.7%	***(p < 0.05)***
Accommodation Infacility	2.7%	0%	2.7%	*(p > 0.05)*
Parameters are given as mean ± SD				
PD, prism diopter; *NFV*, negative fusional vergence; *PFV*, positive fusional vergence; *NPC*, near point of convergence				

accommodative systems even in progressing myopia[12]. Interestingly, accommodative infacility also demonstrated a non-significant trend (p = 0.205), indicating that dynamic accommodation (tested using ±2.00 D flippers) may not degrade in a linear manner with increasing myopia. This suggests a potential dissociation between accommodative amplitude and facility in pediatric populations and warrants further electrophysiological and longitudinal study. Environmental and behavioral factors such as increased digital screen use, reduced outdoor activity, and sustained near workhave been implicated in both myopia progression and binocular vision instability. The present findings underscore the multifactorial etiology of BVDs in Indian children, echoing results from Roshni Sengupta (2023)[13], who emphasized that prolonged near activity in undercorrected myopes contributes to vergence instability and digital eye strain. Taken together, this study highlights a clear pattern: as myopia severity increases, the likelihood of vergence anomalies rises, particularly convergence insufficiency andexotropia**,** while accommodative dysfunctions remain relatively rare but non-negligible in high myopes. This differentiation is clinically significant and supports the Scheiman & Wick model of classifying BVDs based on convergence, accommodation, and phoria components. Moreover, the use of standardized clinical protocols and objective measurements such as NPC, NPA, PFV, MEM retinoscopy, and flipper facility ensures reliability and reproducibility of the diagnostic process. This study provides a detailed profile of binocular vision and accommodative dysfunctions among myopic children attending a tertiary eye care hospital in North India. The findings reveal that more than half (52.2%) of the children exhibited at least one form of binocular vision or accommodative anomaly, with a significantly higher incidence observed in those with moderate to high myopia. Convergence insufficiency and intermittent exotropia emerged as the most prevalent dysfunctions, showing a strong association with increasing refractive error and axial length. In contrast, accommodative insufficiency was relatively rare, indicating that vergence mechanisms are more vulnerable to myopic progression than accommodation in this age group. The results emphasize the critical importance of integrating comprehensive binocular vision assessment into routine pediatric myopia care. Early identification and targeted management of binocular vision anomalies can not only alleviate symptoms such as visual fatigue and academic difficulties but also contribute to improved quality of life and functional vision outcomes. These findings also support the need for interdisciplinary collaboration between optometry and ophthalmology in designing preventive strategies and vision therapy interventions for children with progressive myopia and associated functional visual stress.

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