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FREQUENCY OF ANISOMETROPIC AMBLYOPIA AMONG CHILDREN: A CROSS-SECTIONAL STUDY

Original Research

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ABSTRACT

Background: Amblyopia is a leading cause of preventable visual impairment in children and remains a major contributor to unilateral visual loss worldwide. It commonly arises from anisometropia, strabismus, or visual stimulus deprivation, with anisometropia recognized as a frequent and often underdiagnosed cause. Delayed identification during the sensitive period of visual development may result in persistent visual deficits, emphasizing the importance of early detection and population-specific data.

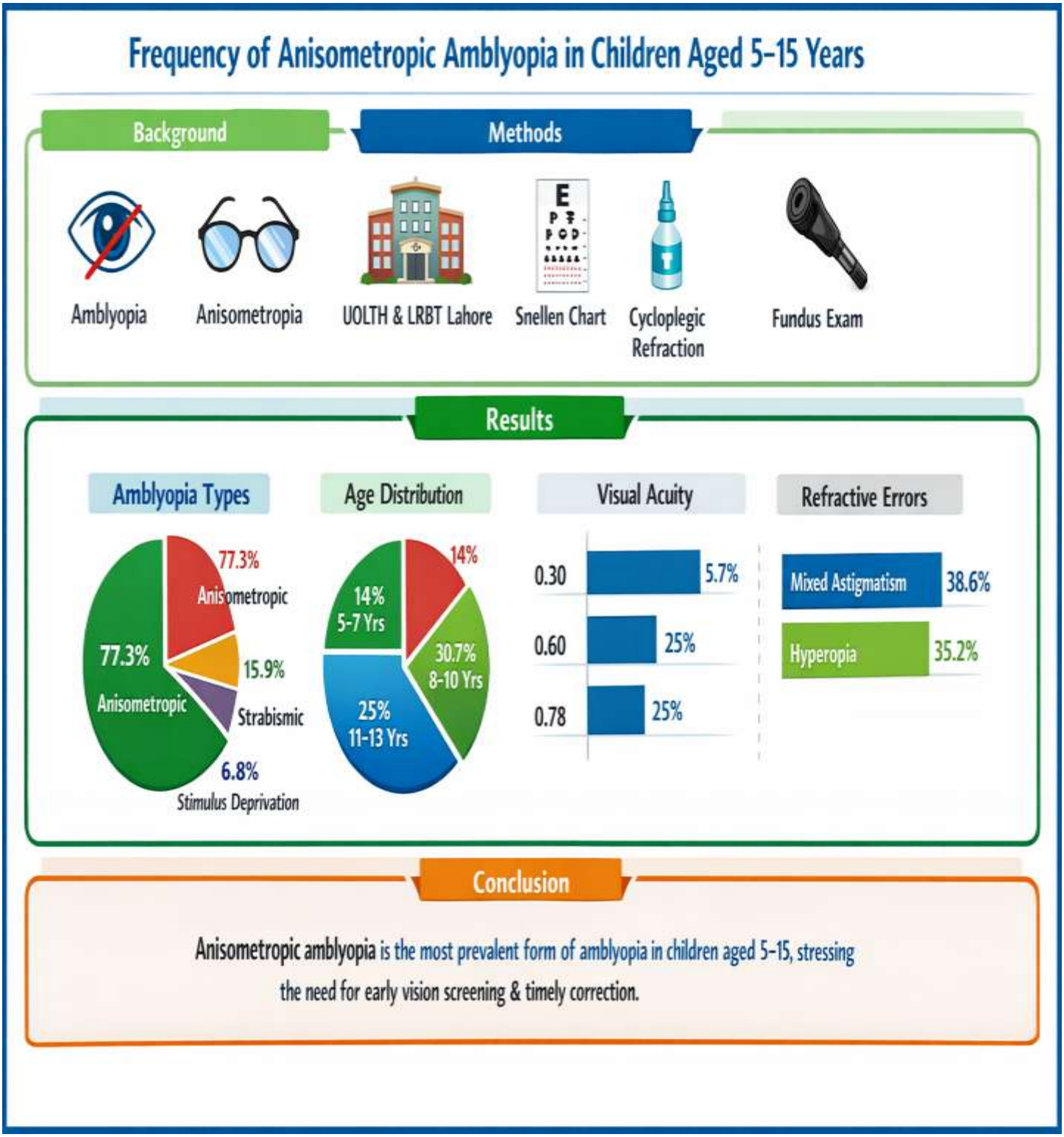
Objective: To determine the frequency of anisometropic amblyopia among children aged 5–15 years presenting to tertiary care ophthalmology clinics.

Methods: A descriptive cross-sectional study was conducted from October 2023 to January 2024 in the Ophthalmology outpatient departments of the University of Lahore Teaching Hospital and LRBT Hospital, Lahore, Pakistan. A total of 88 children aged 5–15 years were enrolled using a convenience sampling technique. Visual acuity was assessed monocularly using a Snellen chart at 6 meters. Children with visual acuity ≤6/12 in either eye or an interocular difference of ≥2 Snellen lines underwent cycloplegic refraction using 1% cyclopentolate. Bruckner reflex assessment and fundus examination were performed with a direct ophthalmoscope to confirm the diagnosis and exclude organic pathology. Data were recorded on a structured proforma and analyzed descriptively.

Results: Among the 88 participants, 49 were females (55.7%) and 39 were males (44.3%). Anisometropic amblyopia was identified in 68 children (77.3%), followed by strabismic amblyopia in 14 (15.9%) and stimulus deprivation amblyopia in 6 (6.8%). The highest proportion of amblyopia cases was observed in the 8–10-year age group (30.7%). Visual acuity values were distributed as follows: 0.30 in 5 children (5.7%), 0.48 in 21 (23.9%), 0.60 in 22 (25.0%), 0.78 in 22 (25.0%), and 1.00 or less in 18 children (20.5%). Mixed astigmatism (38.6%) and hyperopia (35.2%) were the most frequently associated refractive errors. Moderate and severe amblyopia were each observed in 41 children (46.6%).

Conclusion: Anisometropic amblyopia was the most prevalent form of amblyopia among children aged 5–15 years, particularly in the 8–10-year age group, highlighting the need for early vision screening and timely refractive correction to prevent long-term visual impairment.

Keywords: Amblyopia, Anisometropia, Child; Refractive Errors, Visual Acuity. Vision Screening, Visual Impairment.



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INTRODUCTION

Amblyopia, commonly referred to as "lazy eye," represents a reduction in best-corrected visual acuity that arises from abnormal visual development during infancy and early childhood, a period when the visual system is highly plastic and dependent on adequate sensory stimulation (1). Among its various etiologies, anisometropia—defined as an interocular difference in refractive error of one diopter or more—has been consistently recognized as a major and potentially preventable cause (2). When this refractive imbalance leads to unequal retinal image clarity between the two eyes, anisometropic amblyopia develops, a condition that may result from myopia, hyperopia, astigmatism, or combinations thereof (3). Globally, amblyopia affects approximately 1–5% of the population, with substantial variation across age groups, geographic regions, and ethnicities (4). The World Health Organization estimates that among visually impaired children under 15 years of age, a large proportion suffer from uncorrected refractive errors and amblyopia, underscoring the magnitude of this public health issue (5). Astigmatism has been identified as the most frequent refractive contributor to ametropic and anisometropic amblyopia, with hyperopic astigmatism emerging as a particularly amblyogenic combination in pediatric populations (6). The neural basis of amblyopia is well established, with pathological changes primarily involving the primary visual cortex and lateral geniculate nucleus. Seminal experimental work by Hubel and Wiesel demonstrated neuronal loss in the primary visual cortex following early visual deprivation, providing a biological explanation for the persistent visual deficits observed in amblyopia (7). In anisometropic amblyopia, additional mechanisms such as anisokonia—unequal retinal image size between the eyes—further complicate visual development, particularly in cases of high myopic anisometropia exceeding four diopters, a subgroup that has often been excluded from clinical studies and remains inadequately understood (8). Epidemiological data indicate wide-ranging prevalence estimates for amblyopia, from 1–6% in children to 1.43–5.64% in adults, reflecting differences in diagnostic criteria, age at assessment, and population characteristics (9). While most refractive errors are isometropic, meaning both eyes are similarly affected, a significant subset of individuals develop anisometropia, predisposing them to amblyopia if left uncorrected during the critical period of visual maturation (10).

Other recognized causes of amblyopia include visual deprivation from congenital cataract and early-onset strabismus, particularly infantile esotropia, highlighting the multifactorial nature of the condition (11). Clinically, amblyopia manifests as blurred vision due to impaired binocular interaction and cortical processing rather than an isolated ocular defect, and objective tools such as electrophysiological assessments may aid in its evaluation (12). Its impact extends beyond vision, as amblyopia is more prevalent in school-aged children and has been associated with reduced academic performance and quality of life (5). The risk of amblyopia increases markedly with specific thresholds of refractive asymmetry, including myopic anisometropia greater than 2 diopters, hyperopic anisometropia exceeding 1 diopter, and astigmatic anisometropia above 1.5 diopters (13,14). Treatment outcomes are influenced by several factors, notably older age at initiation of therapy, higher degrees of astigmatism in the amblyopic eye, poor compliance, and severely reduced baseline visual acuity (≤20/200), all of which are associated with higher rates of treatment failure (14). Despite advances in understanding, the precise interplay between anisometropia, age of onset, and amblyopia development remains unclear. This uncertainty is partly attributable to the difficulty of establishing temporal relationships, as anisometropia and amblyopia are often detected long after their initial onset (15). Population-based studies have nonetheless demonstrated anisometropia to be a leading risk factor for amblyopia, accounting for a substantial proportion of cases across diverse ethnic groups (11). Given that early detection is critical for successful intervention, photoscreening has emerged as a valuable, vision-independent method for identifying anisometropia and assessing its relationship with amblyopia severity across different ages (13). However, important gaps persist regarding how the magnitude of anisometropia relates to the depth of amblyopia, particularly in the absence of hypermetropia, and how optical and biometric factors such as axial length and corneal curvature contribute to this relationship (8). Moreover, evidence suggests that while lower degrees of hyperopic anisometropia and higher degrees of myopic or mixed anisometropia exert comparable amblyogenic effects, patients with hyperopic anisometropia often demonstrate greater visual improvement following optical correction and adjunctive therapies (10). In this context, the present study is designed to clarify the association between the degree of anisometropia and the severity of amblyopia, and to explore related optical determinants, with the objective of informing earlier detection strategies and optimizing individualized management of anisometropic amblyopia.

METHODS

A descriptive cross-sectional study was conducted between October 2023 and January 2024 at the University of Lahore Teaching Hospital and the Layton RahmatUllah Benevolent Trust, following formal permission from the respective departments. The study

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population comprised 88 participants aged 5 to 15 years, recruited through a convenience sampling technique. Participants of both genders diagnosed with anisometropic amblyopia were included, with anisometropia operationally defined as an interocular refractive error difference corresponding to more than two Snellen lines on visual acuity testing. Individuals with a refractive error difference of less than 0.5 diopters (approximately equivalent to two Snellen lines), those with manifest strabismus, a history of ocular surgery, or other ocular pathologies likely to affect visual acuity were excluded to minimize confounding factors. Data were collected using a self-designed structured questionnaire that recorded demographic information and relevant clinical details. Prior to examination, informed consent was obtained from parents or legal guardians, and assent was taken from children when appropriate, in accordance with ethical research practices. Visual acuity was assessed monocularly using a standard Snellen chart positioned at a distance of 6 meters. Anterior and posterior segment evaluations were performed, with fundus examination conducted using a direct ophthalmoscope to rule out underlying retinal or optic nerve pathology. Objective refractive status was determined through cycloplegic refraction using retinoscopy, after which best-corrected visual acuity was documented for each eye. Collected data were entered and analyzed using appropriate statistical software. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize demographic and clinical variables. Where applicable, associations between the degree of anisometropia and severity of amblyopia were explored using suitable inferential statistical tests, with statistical significance set at a conventional threshold. Ethical approval was obtained from the institutional ethical review committee prior to study initiation.

RESULTS

A total of 88 children aged between 5 and 15 years were included in the analysis. Of these, 49 were females (55.7%) and 39 were males (44.3%), demonstrating a slight female predominance in the study population. Age-wise distribution showed that the largest proportion of participants belonged to the 8–10-year age group (30.7%), followed by children aged 14–15 years (29.5%) and 11–13 years (25.0%). The youngest age group of 5–7 years accounted for the smallest proportion of cases (14.8%), indicating that amblyopia was more frequently identified in mid to late childhood within the sampled population. Regarding amblyopia subtype distribution, anisometropic amblyopia was the most frequently observed form, diagnosed in 68 children (77.3%). Strabismic amblyopia was present in 14 children (15.9%), while stimulus deprivation amblyopia was identified in 6 children (6.8%). These findings indicate that anisometropia constituted the dominant etiological factor among amblyopic children in this cohort. Assessment of visual acuity revealed a wide range of impairment levels. Visual acuity values of 0.60 and 0.78 were each observed in 22 children (25.0% each), while 21 children (23.9%) had a visual acuity of 0.48. Lower visual acuity of 0.30 was documented in 5 children (5.7%), whereas 18 children (20.5%) demonstrated visual acuity of 1.00 or less, reflecting that the majority of participants had moderate to marked visual impairment rather than mild reduction. Severity grading of amblyopia showed that moderate amblyopia (visual acuity range 0.4–0.6) was present in 41 children (46.6%), and an equal proportion of children (46.6%) exhibited severe amblyopia (>0.6). Mild amblyopia (0.1–0.3) was comparatively uncommon and was observed in only 6 children (6.8%). Analysis of refractive error patterns demonstrated that mixed astigmatism was the most prevalent refractive error, affecting 34 children (38.6%), followed by hyperopia in 31 children (35.2%). Myopia was observed in 18 children (20.5%), while isolated astigmatism was least common, present in 5 children (5.7%). The distribution pattern indicated a higher occurrence of anisometropic amblyopia among children with mixed astigmatism and hyperopic refractive errors.

Table 1: Descriptive Statistics of Visual Acuity

Visual Acuity	Frequency	Percent
0.30	5	5.7%
0.48	21	23.9%
0.60	22	25.0%
0.78	22	25.0%
1.00 or less	18	20.5%
Total	**88**	**100%**

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Table 2: Descriptive statistics of severity of amblyopia

Severity	Frequency	Percent%
0.1-0.3(mild)	6	6.8%
0.4-0.6(moderate)	41	46.6%
>0.6(severe)	41	46.6%
Total	**88**	**100.0%**

Table 3: Descriptive statistics of types of Refractive Errors

Refractive Errors	Frequency	Percent%
Myopia	18	20.5%
Hyperopia	31	35.2%
Astigmatism	5	5.7%
Mixed Astigmatism	34	38.6%
Total	**88**	**100%**

Table 4: Descriptive statistics of Amblyopia

Amblyopia	Frequency	Percent%
Anisometropic amblyopia	68	77.3%
Strabismic amblyopia	14	15.9%
Stimulus deprivation amblyopia	6	6.8%
Total	**88**	**100%**

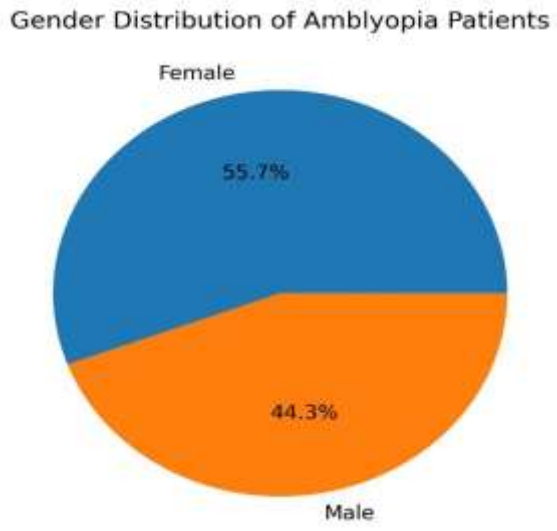

Figure 1 Gender Distribution of Amblyopia Patients

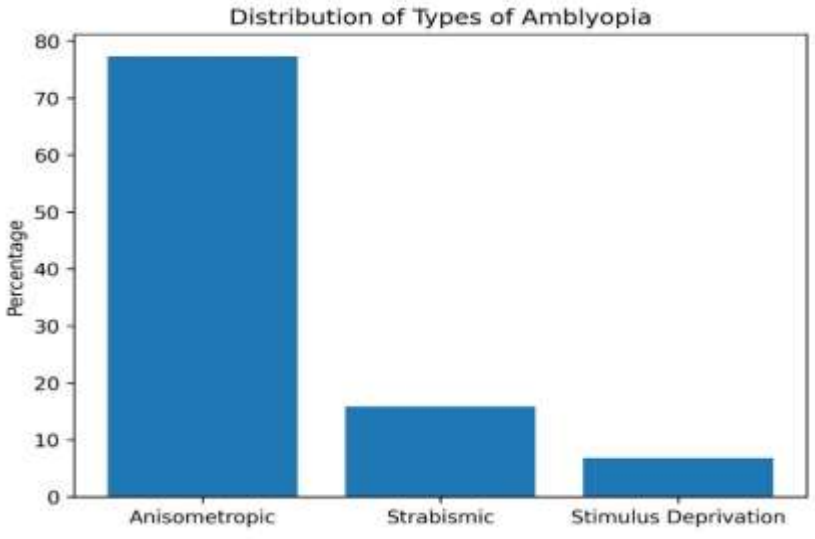

Figure 2 Distribution Type of Amblyopia

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DISCUSSION

The present study, conducted in tertiary ophthalmology settings in Lahore, Pakistan, demonstrated that anisometropic amblyopia constituted the predominant subtype of amblyopia among children aged 5–15 years, accounting for more than three-quarters of all diagnosed cases. This finding reinforces the understanding that anisometropia remains a leading amblyogenic factor in pediatric populations, particularly when refractive asymmetry is not identified and corrected during the critical period of visual development. The higher concentration of cases in the 8–10-year age group suggests that amblyopia is often detected after early childhood, potentially reflecting delayed screening practices or limited access to routine pediatric eye examinations. This age-related pattern is clinically important, as treatment responsiveness is known to decline with increasing age, emphasizing the need for earlier detection strategies. The predominance of mixed astigmatism and hypermetropia among affected children aligns with existing evidence indicating that these refractive profiles carry a higher amblyogenic potential than isolated myopia or simple astigmatism (15,16). The high proportion of moderate and severe amblyopia observed in this cohort further suggests that many children presented with established visual deficits rather than early or mild disease, which may reflect delayed referral, poor awareness, or socioeconomic barriers to eye care. The observed female predominance contrasts with several population-based reports that have shown a higher frequency among males, although sex-related differences in amblyopia prevalence remain inconsistent across regions and are likely influenced by cultural, behavioral, and sampling factors rather than true biological variation (17,18).

When compared with previously published regional and international studies, the frequency of anisometropic amblyopia in the present work appeared higher, although the overall pattern of anisometropia being the most common cause of amblyopia was consistent across diverse populations (19). Differences in reported prevalence rates across studies may be attributed to variations in sample size, age ranges, diagnostic criteria, screening methods, and study settings. Larger population-based investigations with broader age coverage have reported lower absolute proportions of amblyopia but have similarly identified anisometropia as the dominant etiology. Methodological differences, such as the use of autorefractors, infrared retinoscopy, stereopsis testing, or cover–uncover tests in other studies, may also account for variability in detection rates when compared with studies relying primarily on Snellen visual acuity assessment and cycloplegic refraction (20,21). The strengths of this study included a clearly defined pediatric age range, standardized assessment of visual acuity and refractive error under cycloplegia, and inclusion of fundus reflex evaluation to exclude organic causes of reduced vision. However, several limitations should be acknowledged. The use of convenience sampling and a relatively small sample size limited the generalizability of the findings. The cross-sectional design precluded assessment of causal relationships or treatment outcomes. In addition, the absence of detailed inferential analysis examining the relationship between the magnitude of anisometropia and amblyopia severity, as well as the lack of biometric parameters such as axial length and corneal curvature, restricted deeper exploration of underlying mechanisms. Future research would benefit from larger, multicenter, population-based designs incorporating standardized screening protocols, objective refractive and biometric measurements, and longitudinal follow-up to evaluate treatment response (22). Integrating school-based vision screening programs and advanced diagnostic tools may help identify anisometropic amblyopia at earlier stages, potentially reducing the burden of moderate to severe visual impairment observed in older children. Overall, the findings underscore anisometropic amblyopia as a significant and potentially preventable cause of childhood visual impairment, highlighting the critical need for early detection and timely intervention within pediatric eye care services.

CONCLUSION

This study concludes that anisometropic amblyopia represents the dominant form of amblyopia in school-aged children and is closely linked with uncorrected refractive errors, particularly mixed astigmatism and hyperopia, which contribute to clinically meaningful visual impairment. The findings highlight that many children remain undiagnosed until increasing educational and visual demands reveal functional deficits, underscoring a critical gap in early eye care. By addressing the study objective, the results reinforce the importance of early identification of refractive asymmetry and prompt optical correction to support normal visual development. From a practical perspective, strengthening routine pediatric vision screening and integrating comprehensive eye examinations into early childhood and school health programs can play a decisive role in reducing preventable visual impairment. Overall, the study adds valuable regional evidence emphasizing that timely detection and intervention remain the cornerstone for improving long-term visual outcomes and quality of life in children at risk of amblyopia.

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AUTHOR CONTRIBUTIONS

Author	Contribution
Sadia Muneer	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Hamza	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Rehana Kausar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muzamil Fatima	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Usama Elahi*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Shah Fahad	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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