Association Between Comitant Strabismus and Refractive Error in Children Attending a Tertiary Eye Care Center

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Bishal Mani Tripathi[1], **Usha Bhusal**[1], **Jharana Rayamajhi**[1], **Suraj Pal**[1], **Rakshya Pangeni**[1], **Anjana Sapkota**[1]

[1]Department of Opthalmology, Lumbini Eye Institute & Research Centre, Siddharthanagar, Rupandehi, Nepal.

ABSTRACT

Background

Comitant strabismus is a common ocular disorder in childhood and is frequently associated with refractive errors, which may lead to amblyopia and long-term visual impairment if not detected early. While this association has been well documented in high-income countries, evidence from low- and middle-income settings such as Nepal remains limited.

Methods

A hospital-based cross-sectional study was conducted from September 2024 to September 2025 among children aged 4-16 years diagnosed with comitant strabismus at a tertiary eye care center. Ethical approval was obtained from the Institutional Review Committee, and written informed consent was obtained from parents or guardians before participation. Comprehensive ophthalmic evaluation was performed, including cycloplegic refraction using streak retinoscopy. Differences in spherical equivalent among strabismus types were analyzed using the Kruskal–Wallis test with Dwass-Steel-Critchlow-Fligner post hoc comparisons.

Results

A total of 243 children were included. Refractive error was present in 70% of cases. Esotropia showed the highest proportion of refractive error (83.7%), with hyperopia accounting for 63% of these cases. Exotropia was more frequently associated with myopia and emmetropia. A significant difference in spherical equivalent was observed among esotropia, exotropia, and hypertropia ($\chi^2 = 54.5$, df = 2, $p < 0.001$, $\varepsilon^2 = 0.225$). Post hoc analysis demonstrated significantly more hyperopic refractive status in esotropia compared to exotropia ($p < 0.001$).

Conclusions

Refractive error is highly prevalent among children with comitant strabismus, with hyperopia predominantly associated with esotropia, highlighting the importance of routine cycloplegic refraction in pediatric strabismus evaluation.

Keywords: Child; Hyperopia; Myopia; Refractive Errors; Strabismus; Vision Screening

Correspondence: Dr. Bishal Mani Tripathi, Department of Opthalmology, Lumbini Eye Institute & Research Centre, Siddharthanagar, Rupandehi, Nepal. Email: bishal0096@gmail.com, Phone: +977-9817531301 **Article received**: 2025-9-20. **Article accepted**: 2025-02-12. **Article published**: 2026-06-30.

INTRODUCTION

Strabismus is an oculomotor disorder characterized by manifest misalignment of one or both eyes. [1, 2] It primarily occurs in two categories: comitant and incomitant strabismus. Comitant strabismus is further subdivided into esotropia, exotropia, hypertropia and hypotropia. It frequently occurs in children and is considered as a major cause of visual impairment during childhood. [1, 3, 4] The global prevalence of strabismus in children ranges from 0.14% to 5.65% [4] and has been reported as 1.2 to 5%, 0.84% ,1.6% and 1.55% in China Hong Kong , Korea and India respectively. [2, 5] In Nepal, the burden has been reported to be 1.43 %. [6] Premature birth, low birth weight, refractive errors, smoking during pregnancy and other environmental factors [1, 4, 7] predispose to development of strabismus. Refractive error is a major risk factor and is commonly associated with amblyopia and abnormal ocular posture. [7–9] Different studies have revealed the positive association between comitant strabismus and refractive error.[7, 9] Another study by Robaei et. al. found that strabismus was significantly linked to hyperopia, astigmatism, anisometropia, and amblyopia (P<0.0001). [10] Similarly, Noori et al. also identified a strong link between refractive error and horizontal strabismus among children in Baghdad, Iraq. [11] Hyperopic infants are more likely to be present with accommodative esotropia. [2, 5, 12, 13] Despite the clinical relevance, there are few studies that explore the prevalence and pattern of refractive error among strabismic children. In developing countries like Nepal, poor parental awareness and delayed presentation increase the risk of visual complications. A study in Nepal demonstrated that only 29.4% of parents whose children had strabismus had good knowledge about strabismus. [14] Early screening and treatment are essential, particularly for children who are approaching school-age, given the high incidence of refractive errors and amblyopia. [15] However, studies exploring the association between refractive error and strabismus, especially from western Nepal, remain limited. This study aimed to assess this association among children aged 4-16 years.

METHODS

Study Design

This quantitative, cross-sectional analytical study was conducted to determine the association between concomitant strabismus and refractive error in children.

Study Area

The study was conducted in the Pediatric and Strabismus Department of a tertiary eye care hospital from September 2024 to September 2025.

Study Population

Children aged 4-16 years diagnosed with concomitant strabismus attending the study setting were included.**Sample Size**

The sample size was calculated using Cochran's formula based on a prevalence of 78.66% refractive error among strabismic patients reported by Singh et al.[7]

Sampling Technique

Consecutive sampling was applied to recruit eligible participants during the study period.

Data Collection Tools and Techniques

Comprehensive ophthalmic examination was performed. Refractive error was measured using cycloplegic retinoscopy and classified by spherical equivalent (SE) as emmetropia (−0.50 D to < +0.50 D), myopia (< −0.50 D), hyperopia (> +0.50 D), and astigmatism (>1.00 D).[7] Visual acuity was assessed using Log MAR charts at 6 meters.

Variables/Measurements

Independent variables included refractive error type and spherical equivalent. The dependent variable was type of concomitant strabismus. SE was analyzed for both eyes, and due to strong correlation (Spearman's $\rho = 0.915$, $p < 0.001$), only right-eye data were used for further analysis.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 26 and Jamovi version 2.6.44. Descriptive statistics were expressed as median and interquartile range (IQR) for continuous variables and frequency and percentage for categorical variables. Normality was tested using the Kolmogorov–Smirnov test. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact

test when >20% of expected cell counts were <5. Differences in SE among strabismus types were analyzed using the Kruskal-Wallis H test followed by Dwass-Steel-Critchlow-Fligner post hoc comparisons. Effect size was reported using epsilon-squared (ε^2). The relationship between SE and horizontal deviation was assessed using Spearman's rank correlation.

Ethical Consideration

Ethical approval was obtained from the Institutional Review Committee of Lumbini Eye Institute & Research Centre (Ref. No.: 53/024/025). The study followed the Declaration of Helsinki. Written informed consent was obtained from parents or legal guardians, and assent was taken from older children when appropriate. Confidentiality and anonymity were strictly maintained, and all data were anonymised prior to analysis.

RESULTS

The ages of participants ranged from 4 to 16 years, with a median of 7 years and an interquartile range (IQR) of 6 years. The age distribution showed a mild positive skew, indicating a higher proportion of younger children in the study population (Table 1).

Table 1. Demographic characteristics of respondents (n=243).

Characteristics	Frequency n (%)
Sex	
Male	132 (54.30)
Female	111 (45.70)
Religion	
Hindu	179 (73.70)
Muslim	63 (25.90)
Christian	1 (0.40)
Nationality	
Nepalese	94 (38.70)
Indian	149 (61.30)

Chi-square analysis demonstrated a statistically significant association between type of deviation and refractive error presence ($\chi^2 = 15.4$, df = 2, $p < 0.001$), which was corroborated by the likelihood ratio test (17.0, df = 2, $p < 0.001$) and Fisher's exact test ($p < 0.001$), appropriate for the small sample size of hypertropia cases. The strength of the association, as measured by Cramer's V, was 0.252, indicating a moderate effect. These results indicated that esotropia is more frequently associated with refractive errors compared to exotropia and hypertropia (Table 2).

Table 2. Association between comitant strabismus and refractive error (n=243).

	Refractive Error	
Type of Strabismus	**Absent (%)**	**Present (%)**
Exotropia	58 (39.20)	90 (60.80)
Esotropia	15 (16.30)	77 (83.70)
Hypertropia	0	3 (100)

The distribution of refractive error types varied significantly across strabismic deviations ($\chi^2 = 59.6$, df = 6, $p < 0.001$; likelihood-ratio $\chi^2 = 61.3$, df = 6, $p < 0.001$; Fisher's Exact test $p < 0.001$). Among the 243 participants, emmetropia and myopia were more commonly observed in exotropic cases (39.2% and 25.0%, respectively), whereas hypermetropia predominated in esotropic participants (63.0%). Hypertropia was infrequent (n = 3), with most cases showing myopia (66.7%) or astigmatism (33.3%). The strength of association, as measured by Cramer's V, was 0.350, indicating a moderate-to-strong relationship between strabismus type and refractive error pattern. These findings demonstrated a significant variation in the type of refractive error according to strabismic deviation, with hypermetropia closely linked to esotropia and myopia/emmetropia to exotropia (Table 3).

Table 3. Distribution of refractive error across different types of comitant strabismus (n=243).

Type of Refractive Error		
Myopia (%)	**Hypermetropia (%)**	**Astigmatism (%)**
Exotropia		
37 (25.00)	27 (18.20)	26 (17.60)
Esotropia		
6 (6.50)	58 (63.00)	13 (14.10)
Hypertropia		
2 (66.70)	0	1 (33.30)

A Kruskal-Wallis H test was performed to assess differences in right-eye spherical equivalent (SE) among the three types of comitant strabismus. The test revealed a statistically significant difference in SE across the groups (χ^2 (2) = 54.5, $p < 0.001$), with an effect size of $\varepsilon^2 = 0.225$, indicating a strong

association between the type of strabismus and the degree of refractive error. Post-hoc pairwise comparisons using the Dwass-Steel-Critchlow-Fligner (DSCF) test showed that the SE differed significantly between exotropia and esotropia (W=10.372, $p < 0.001$). However, no significant differences were found between exotropia and hypertropia (W=−0.727, $p = 0.865$) or between esotropia and hypertropia (W=−2.547, $p = 0.169$). These findings suggested that children with esotropia exhibited significantly different refractive error profiles compared with those with exotropia (Table 4).

Table 4. Differences in Spherical Equivalent across different type of strabismus (n=243).

Kruskal-Wallis				
	χ^2	Df	P	ε^2
Spherical Equivalent	54.5	2	<.001	0.225

Figure. 1 showed the spherical equivalent (SE) among strabismic participants ranged from −18.00 D to +12.00 D, with a median of +0.13 D (IQR: 1.38 D). The angle of deviation (HBT) ranged from 0 to 45 prism dioptres, with a median of 15 PD (IQR: 10 PD). A Spearman's rank-order correlation was performed to assess the relationship between the spherical equivalent and angle of deviation, as both variables were continuous and not normally distributed. The analysis revealed a weak but statistically significant positive correlation between SE and HBT ($\rho = 0.167$, $p = 0.009$), indicating that higher spherical equivalent values were slightly associated with higher HBT measurements. A linear trend was observed, with an R^2 value of 0.0117 and the regression equation was $y = 0.3396x + 15.755$, suggesting a minimal positive change in HBT with increasing SPEQ. (Figure. 1).

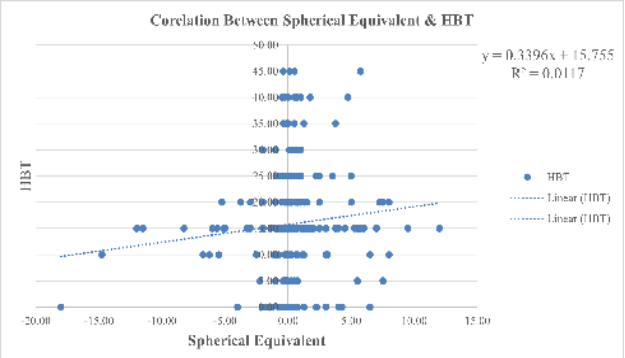

Figure 1. Corelation between Spherical Equivalent (SE) and Angle of Deviation (HBT)

The majority exhibited alternate deviation (n = 138, 56.79%), followed by constant deviation (n = 81, 33.3%) and intermittent deviation (n = 24, 9.88%). These findings indicate that alternate deviation was the predominant pattern of ocular misalignment among the study population (Figure. 2).

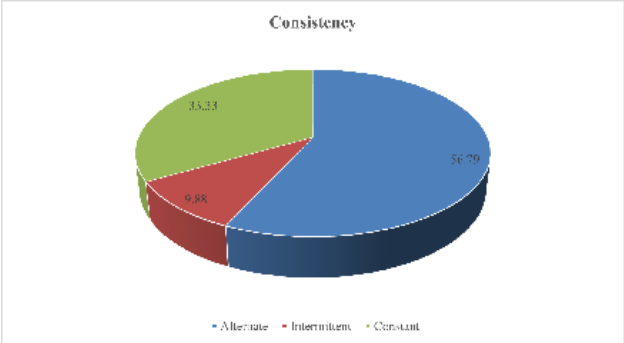

Figure 2. Consistency of Strabismus (n=243).

DISCUSSION

Strabismus is a prevalent ocular disorder in children, characterized by misalignment of one or both eyes, and is broadly classified into comitant and incomitant types, with comitant forms including esotropia, exotropia, hypertropia, and hypotropia.[1,2] It represents a significant cause of visual impairment during childhood, with global prevalence ranging from 0.14% to 5.65% and regional reports of 1.2% to 5% in China, 0.84% in Hong Kong, 1.6% in Korea, 1.55% in India, and 1.43% in Nepal. [2, 4–6, 16, 17] Multiple factors, including prematurity, low birth weight, and refractive errors, contribute to its development [1,4,7] with hyperopia particularly implicated in accommodative esotropia. [2, 5, 7, 12, 13] This methodology is consistent with previous hospital-based and population-based studies [2,5,7,13,16], allowing direct comparison of strabismus-refractive error associations using standardized clinical measures. Additionally, the use of cycloplegic refraction ensures accurate measurement of latent hyperopia, which is particularly important in pediatric populations where accommodation can mask refractive errors.

This study found that 70% of children with comitant strabismus had a refractive error, which aligns with the findings of Singh, who reported 78.66% among

Indian pediatric patients. [7] Similar trends have been observed in China, Korea, and Hong Kong, suggesting that a high proportion of strabismic children present with refractive abnormalities.[2,5,16] This reinforces the role of refractive error as a major contributing factor in strabismus, particularly in regions with similar demographic and clinical characteristics. These findings emphasize the need for routine early screening for refractive errors in children, especially those presenting with ocular misalignment, to prevent amblyopia and optimize visual development.

Esotropia demonstrated the strongest association with refractive error at 83.7%, with hyperopia present in 63% of cases. These findings are consistent with studies on Chinese preschool children and longitudinal research on accommodative esotropia, which link hyperopia to increased accommodative convergence and resultant esodeviation.[2, 5, 12, 13] The strong predominance of hyperopia in esotropic children underscores the clinical importance of early cycloplegic assessment to detect high hyperopic states before deviation becomes manifest or amblyopia develops. Corrective interventions, including prescription of appropriate hyperopic spectacles, can significantly reduce the need for surgical intervention and improve binocular visual outcomes.

Exotropia was most commonly associated with myopia and emmetropia, with 25% showing myopia and 18.2% hypermetropia. This pattern reflects findings from Korea and Ethiopia, where horizontal exodeviations are more frequently linked with lower or negative spherical equivalents. [4, 16] The contrast between esotropia and exotropia in spherical equivalent, confirmed by Kruskal-Wallis and post-hoc analyses, highlights that refractive status strongly influences the type of deviation, supporting the notion that corrective strategies must consider the refractive profile. These differences suggest that individualized management plans based on refractive error type may optimize alignment outcomes and reduce progression of strabismus.

Hypertropia was rare in our sample and largely associated with myopia, consistent with global trends showing vertical deviations are less frequent than horizontal strabismus. [10] The weak but significant positive correlation between spherical equivalent and angle of deviation ($\rho = 0.167$, $p = 0.009$) suggests that higher hyperopic values may slightly increase the deviation magnitude, echoing observations in Chinese preschool cohorts. [2] Although the correlation is modest, it highlights that even subtle refractive differences can influence strabismus severity, reinforcing the need for comprehensive refractive assessment in all pediatric strabismus cases.

Alternate deviation was the predominant pattern (56.79%), followed by constant and intermittent deviations, aligning with South Asian studies where alternate fixation is common in pediatric strabismus. [6, 17] This finding indicates adaptive ocular control mechanisms in children that may mitigate amblyogenic risk. Recognition of alternate fixation patterns is important for treatment planning, as children with such deviations may have better binocular potential and different responses to therapy compared with those with constant deviations. [18]

Conclusion

This study demonstrated a strong association between refractive error and comitant strabismus among children attending a tertiary eye care center. Esotropia showed the highest burden of refractive error, particularly hyperopia, while exotropia was more frequently linked with myopia and emmetropia. Vertical deviations were uncommon and showed no clear pattern. A small but significant correlation was noted between spherical equivalent and the magnitude of deviation, suggesting that refractive status may influence strabismic presentation. These findings highlight the importance of routine cycloplegic refraction in all strabismic children and underscore the need for early detection to prevent amblyopia and long-term visual consequences. Larger, multicenter studies are recommended to further validate these associations and support the development of screening strategies for pediatric populations in Nepal.

Limitations

This study is limited by its cross-sectional design

and single-center setting, which may affect generalizability. The small number of hypertropia cases restricted detailed analysis, and longitudinal changes or genetic and environmental factors were not assessed.

Conclusions

This study demonstrated a strong association between refractive error and comitant strabismus among children attending a tertiary eye care center. Esotropia showed the highest burden of refractive error, particularly hyperopia, while exotropia was more frequently linked with myopia and emmetropia. Vertical deviations were uncommon and showed no clear pattern. A small but significant correlation was noted between spherical equivalent and the magnitude of deviation, suggesting that refractive status may influence strabismic presentation. These findings highlight the importance of routine cycloplegic refraction in all strabismic children and underscore the need for early detection to prevent amblyopia and long-term visual consequences. Larger, multicenter studies are recommended to further validate these associations and support the development of screening strategies for pediatric populations in Nepal.

Recommendations

Future studies incorporating multicenter cohorts and genetic profiling may provide a more comprehensive understanding of strabismus etiology and progression. Future research should include multicenter or population-based studies, explore long-term refractive and strabismus outcomes, and examine preventive strategies, genetic contributions, and environmental influences to strengthen understanding and guide pediatric eye care in Nepal. Furthermore, integration of school-based screening programs and parent education on early detection could improve timely intervention and reduce the burden of visual impairment in children.

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Conflicts of Interest: The authors declare that there is no any conflict of interest.

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Ethical and Publication Integrity: The study adhered to the principles of the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Committee of Lumbini Eye Institute & Research Centre (Ref. No.: 53/024/025). Written informed consent was obtained from all participants or their guardians prior to data collection. The manuscript is original, has not been submitted elsewhere, and is not under consideration in any other journal. The authors declare that there is no plagiarism, data fabrication, or duplicate publication. All authors confirm adherence to ethical publishing standards and accept responsibility for the integrity of the work.

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. Due to institutional policies and participant confidentiality considerations, raw data are not publicly available.

Authors' Contributions

Conceptualization: Bishal Mani Tripathi.
Methodology: Bishal Mani Tripathi.
Data curation: Jharana Rayamajhi, Usha Bhusal, Suraj Pal.
Investigation: Jharana Rayamajhi, Usha Bhusal.
Formal analysis: Bishal Mani Tripathi, Usha Bhusal.
Supervision: Bishal Mani Tripathi, Anjana Sapkota.
Writing-original draft: Bishal Mani Tripathi.
Writing-review and editing: Bishal Mani Tripathi, Anjana Sapkota, Jharana Rayamajhi, Usha Bhusal.

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