

Research Article

Relationship between Status of Phoria with CISS and Refractive Error

Niyati Arun Keni*, Purushottam Naidu Menda and Swanandi Shriram Gawde

Department of Optometry, ITM Institute of Health Sciences, ITM Skills University, Navi Mumbai, Maharashtra, India

Abstract

Aim: To evaluate the relationship between phoria status, Convergence Insufficiency Symptom Survey (CISS) score, and refractive error.

Settings and design: Prospective, Institution-based cross-sectional study.

Methods and materials: Conducted at ITM Skills University, Navi Mumbai (September 2024–April 2026), involving 100 students. Data included refractive status, binocular vision assessment, and CISS responses. Non-parametric tests were applied due to non-normal data distribution.

Results: Mean age was 19.34 ± 1.22 years. Emmetropia (59%) was most common, followed by myopia (39%) and hyperopia (2%). Orthophoria predominated at distance and near. Mean CISS score was 12.85 ± 9.83 with Median = 10 and IQR = 12 (Q1 = 6, Q3 = 18). MSE showed a significant positive correlation with CISS score ($\rho = 0.296, p = 0.003$). Spearman's correlation showed a weak negative association between distance phoria score and mean spherical equivalent ($\rho = -0.202, p = 0.044$), whereas categorical analyses using Chi-square showed no significant association between distance phoria and refractive-status group ($\chi^2 = 8.72, df = 4, p = 0.069$).

Conclusion: Refractive error, phoria status, and symptoms showed weak associations, highlighting the importance of comprehensive binocular vision assessment.

More Information

***Corresponding author:** Niyati Arun Keni, Department of Optometry, ITM Institute of Health Sciences, ITM Skills University, Navi Mumbai, Maharashtra, India, Email: niyatiken7@gmail.com

ID <https://orcid.org/0009-0007-0306-5298>

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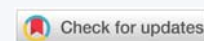
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Keywords: Phoria; Refractive error; CISS; Mean spherical equivalent



Introduction

Binocular vision enables both eyes to work together, producing clear, comfortable, and single vision. Efficient binocular coordination depends on balanced ocular alignment and proper interaction between the accommodative and vergence systems. Disruption of this coordination can lead to binocular vision anomalies that affect visual performance and daily function [1].

Heterophoria — a latent deviation of ocular alignment that becomes manifest when fusion is disrupted — is among the most commonly encountered binocular anomalies [1]. In many individuals it remains compensated and asymptomatic; however, when fusional reserves are inadequate, it can produce symptoms such as asthenopia, headache, blurred vision, intermittent diplopia, and difficulty sustaining near work [3].

Rising use of digital devices and prolonged near work

have increased visual demands on students and young adults. Sustained near tasks raise accommodative and vergence load, which can contribute to visual discomfort and reduced efficiency during academic activity [4].

The Convergence Insufficiency Symptom Survey (CISS) is a validated tool for quantifying subjective symptoms of binocular and accommodative dysfunction, capturing complaints such as eye strain, headache, difficulty concentrating, blurred vision, and near-work discomfort. Higher scores reflect greater symptom burden and can help identify individuals who warrant further binocular vision evaluation [5].

Because accommodation and vergence are neurally linked, refractive status may also shape binocular function. Variation in refractive error can alter accommodative demand and, in turn, ocular alignment and symptom expression. Hyperopes may exert greater accommodative effort during near tasks, while myopes may show different vergence responses owing to differing focusing demands [6].

While refractive error, phoria, and binocular symptoms have each been studied individually, fewer studies have examined their combined interaction. Clarifying these relationships could support earlier identification of symptomatic individuals and more comprehensive clinical assessment. This study therefore aimed to evaluate the association between phoria status, refractive error, and CISS scores among university students.

Methods

One hundred students aged 17–30 years who met the eligibility criteria and consented to participate were recruited by non-probability consecutive sampling. Participants with ocular or systemic pathology affecting binocular vision or accommodation and those unwilling to participate were excluded. Refractive status was determined from objective retinoscopy followed by subjective refraction. The spherical equivalent (SE) was calculated as sphere + $\frac{1}{2}$ cylinder. Participants with an SE from -0.50 D to $+0.50$ D were classified as emmetropic, those with an SE < -0.50 D as myopic, and those with an SE $> +0.50$ D as hypermetropic. Classification was therefore based on the refractive status measured during the study examination rather than solely on previous spectacle or refractive-error history.

This prospective, institution-based cross-sectional study was conducted at a university-based optometry center over 24 months (September 2024–April 2026). The study was approved by the Institutional Ethics Committee of ITM IHS College of Nursing, Navi Mumbai, India (Approval No. ITMIHSCON/260325/3197, dated 26th March 2025). Written informed consent was obtained from the participant.

Sample-size calculation

An a priori sample-size calculation was performed before participant recruitment. The required sample size was estimated using the single-proportion formula:

$$n = Z^2 p(1-p) / d^2$$

where $Z = 1.96$ for a 95% confidence level, $p = 0.531$ (The anticipated proportion ($p = 0.531$) was based on previous(11), and $d = 0.05$. The calculated minimum sample size was 382 participants. Due to the available eligible student population and recruitment constraints during the study period, 100 participants were ultimately included in the analysis. The discrepancy between the calculated and achieved sample size is acknowledged as a limitation of the study and may have reduced the precision and statistical power of subgroup analyses.

Procedure

Students meeting the eligibility criteria were invited to participate. Refractive status was subsequently determined by objective retinoscopy followed by subjective refraction

and classified according to the spherical equivalent criteria described above.

Distance and near visual acuity were assessed using a standard LogMAR chart. Objective refraction (retinoscopy) was followed by subjective refraction to determine final correction and best corrected visual acuity (BCVA); mean spherical equivalent was recorded for analysis.

Binocular vision assessment included phoria measurement using the Maddox rod test at distance (6 m) and near (40 cm) with best correction in place. Horizontal and vertical phorias were recorded in prism diopters and classified by direction of deviation, with prism neutralization used to quantify deviation where required.

Symptoms of binocular vision dysfunction were evaluated using the CISS questionnaire, administered in a standardized setting and scored according to established guidelines.

Data were recorded using standardized forms and Google Forms. Instrument calibration, consistent testing conditions, and examiner training were maintained throughout to ensure reliability and minimize inter-observer variation.

Statistical analysis

Data were recorded in Microsoft Excel. Continuous variables (age, MSE, distance phoria score, near phoria score) were summarized descriptively; categorical variables (refractive error category, distance phoria type, near phoria type, total CISS category) were presented as frequencies and percentages.

Analysis was performed in Jamovi. Although continuous variables were non-normally distributed, mean $\pm$ SD was retained as a supplementary descriptive measure for comparability and to describe the central tendency and dispersion of the overall sample; median and IQR were used as the primary descriptive measures for group comparisons.

Chi-square tests were used to examine the association between categorical refractive status and phoria status. Observed and expected cell frequencies were examined to assess the appropriateness of the Chi-square analysis. Because the hypermetropic subgroup comprised only two participants, several expected cell frequencies were less than 5. Therefore, the Pearson Chi-square results were interpreted cautiously and considered exploratory, particularly with respect to the hypermetropic subgroup.

Spearman's rank correlation was performed in the overall sample to assess the relationships between the continuous distance phoria score and mean spherical equivalent (MSE), the continuous near phoria score and MSE, distance phoria score and near phoria score, and MSE and total CISS score. The correlation analyses used the continuous measured values rather than the categorical refractive-error or phoria groups.

Results

The cohort comprised 100 participants (mean age 19.34 ± 1.22 years; range 17–23), representative of a young student population.

Refractive status: emmetropia 59%, myopia 39%, hyperopia 2%. Mean $\pm$ SD spherical equivalent was -0.77 ± 1.31 D (range -7.25 to $+1.50$ D), reflecting an overall mild myopic tendency in the sample.

Phoria distribution: Distance - orthophoria 40%, esophoria 32%, exophoria 28%. Near - orthophoria 50%, exophoria 33%, esophoria 17%. Orthophoria was the most common classification at both distances.

The mean distance phoria score was -0.13 ± 4.10 PD. The mean near phoria score was -1.35 ± 3.71 PD, suggesting a divergent (exophoric) shift at near relative to distance.

The mean total CISS score was 12.85 ± 9.83 , indicating low-to-moderate near-work symptom burden.

Shapiro–Wilk testing showed significant departures from normality ($p < 0.001$) for MSE, distance phoria score, near phoria score, and total CISS score, supporting use of non-parametric analysis throughout.

Spearman's correlations — overall sample.			
Comparison	Rho	p - value	Interpretation
Distance phoria score vs. Mean Spherical Equivalent (MSE)	-0.202	0.044	Weak, significant
Near phoria score vs. Mean Spherical Equivalent (MSE)	-0.107	0.289	Not significant
Distance phoria score vs. Near phoria score	0.203	0.043	Weak, significant
Mean Spherical Equivalent (MSE) vs. total CISS score	0.296	0.003	Weak-to-moderate, significant

Spearman's correlations — within refractive subgroups (distance vs. near phoria)

- Myopia ($n = 39$): $\rho = 0.364$, $p = 0.023$ — significant; higher distance phoria scores associated with higher near phoria scores. No significant correlation between CISS score and either phoria measure in this subgroup ($p > 0.05$).
- Emmetropia ($n = 59$): $\rho = 0.284$, $p = 0.029$ — significant, weak positive association between distance and near phoria.
- Hyperopia ($n = 2$): Correlation coefficients were at the mathematical extreme ($\rho = \pm 1$) with $p = 1$; given the sample size ($n = 2$), these results are not interpretable and should be disregarded.

A significant positive correlation was found between MSE and total CISS score ($\rho = 0.296$, $p = 0.003$), indicating that

more hyperopic refractive status was weakly-to-moderately associated with higher symptom scores (Tables 1,2).

$$\chi^2 = 8.72, df = 4, p = 0.069$$

$$\chi^2 = 6.33, df = 4, p = 0.176$$

Neither association reached statistical significance

Several expected cell frequencies were <5 because of the very small hypermetropic subgroup ($n = 2$) (Tables 3,4).

CISS scores did not differ significantly across distance phoria groups (Kruskal–Wallis $\chi^2 = 1.78$, $df = 2$, $p = 0.410$, $\epsilon^2 = 0.018$). The median CISS score was 10.5 (IQR: 7–18.25) in the orthophoria group, 11 (IQR: 6–18) in the exophoria group, and 8.5 (IQR: 4–14.5) in the esophoria group. Similarly, no statistically significant difference was observed across near phoria groups (Kruskal–Wallis $\chi^2 = 2.02$, $df = 2$, $p = 0.365$, $\epsilon^2 = 0.0204$). Median CISS scores were 9 (IQR: 5.25–15.75), 12 (IQR: 7–23), and 11 (IQR: 6–17) in the orthophoria, exophoria, and esophoria groups, respectively. Bonferroni-adjusted post-hoc comparisons revealed no statistically significant pairwise differences between the phoria groups.

Table 1: Distribution of distance phoria categories across refractive-status groups (Chi-square)

Distance phoria	Emmetropia n (%)	Myopia n (%)	Hypermetropia n (%)	Total
Orthophoria	29 (72.5%)	11 (27.5%)	0 (0%)	40
Exophoria	14 (50.0%)	14 (50.0%)	0 (0%)	28
Esophoria	16 (50.0%)	14 (43.8%)	2 (6.3%)	32
Total	59 (59.0%)	39 (39.0%)	2 (2.0%)	100

Table 2: Distribution of near phoria categories across refractive-status groups (Chi-square).

Near phoria	Emmetropia n (%)	Myopia n (%)	Hypermetropia n (%)	Total
Orthophoria	33 (66.0%)	16 (32.0%)	1 (2.0%)	50
Exophoria	20 (60.6%)	13 (39.4%)	0 (0%)	33
Esophoria	6 (35.3%)	10 (58.8%)	1 (5.9%)	17
Total	59 (59.0%)	39 (39.0%)	2 (2.0%)	100

Table 3: CISS scores across Distance phoria type (Kruskal–Wallis).

Distance phoria	N	CISS, Median (IQR)	Kruskal–Wallis χ^2	df	p-value	ϵ^2
Orthophoria	40	10.5 (7–18.25)				
Exophoria	28	11 (6–18)	1.78	2	0.410	0.0180
Esophoria	32	8.5 (4–14.5)				
Overall	100	10 (6–18)				

Table 4: CISS scores across Near phoria type (Kruskal–Wallis).

Near phoria	N	CISS, Median (IQR)	Kruskal–Wallis χ^2	df	p-value	ϵ^2
Orthophoria	50	9 (5.25–15.75)				
Exophoria	33	12 (7–23)	2.02	2	0.365	0.0204
Esophoria	17	11 (6–17)				
Overall	100	10 (6–18)				

Discussion

This study evaluated the relationship between phoria status, refractive error, and CISS scores among university students. Most participants were emmetropic, followed by myopic individuals, while hyperopia was minimally represented. Orthophoria was the most common finding at both distance and near fixation [1]. A significant positive association was observed between MSE and CISS score, indicating that participants with a more hyperopic refractive profile reported greater visual symptoms, possibly due to increased accommodative demand during prolonged near work [2,5]. However, the association remained weak, suggesting that refractive status alone does not fully explain symptom burden.

The difference between the Spearman correlation and Chi-square findings is attributable to the different forms of the variables and statistical questions addressed by the two analyses. Spearman's rank correlation evaluated the relationship between the continuous distance phoria score and mean spherical equivalent (MSE), whereas the Chi-square analysis evaluated the association between categorized phoria status (orthophoria, esophoria, and exophoria) and categorized refractive status (emmetropia, myopia, and hypermetropia). Categorization of continuous measurements may result in loss of quantitative information and reduced statistical power. In addition, the very small hypermetropic subgroup resulted in low expected cell frequencies in the contingency tables. Therefore, the weak significant Spearman correlation and the non-significant Chi-square result should not be interpreted as contradictory findings, as the two analyses assessed different representations of the data.

Distance phoria showed a weak association with refractive error, whereas near phoria showed no significant relationship. CISS scores did not differ significantly across phoria categories, indicating that symptom severity cannot be predicted solely by phoria type. Visual discomfort may depend on additional factors such as accommodative function, fusional vergence reserves, and individual visual demands [1,5]. The relatively low mean CISS score may reflect effective binocular compensation in young adults. Limitations include the restricted student population, small hyperopic sample, and exclusion of other binocular vision parameters. Overall, these findings support combining objective binocular vision assessment with subjective symptom evaluation for comprehensive clinical assessment.

Conclusion

Refractive error, phoria status, and CISS scores showed only weak associations in this cohort. Mean spherical equivalent was significantly related to symptom severity, while phoria status was not. These findings underscore that binocular vision symptoms are multifactorial, supporting the need for comprehensive binocular vision assessment in individuals presenting with near-work-related visual discomfort.

Limitation

The hyperopic subgroup consisted of only two participants, substantially limiting the precision, statistical power, and interpretability of subgroup-specific analyses. Therefore, findings involving the hyperopic subgroup were interpreted cautiously and were not considered sufficient to support independent conclusions regarding hyperopia.

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