

Non-Strabismic Binocular Vision Dysfunction Among Contact Lens Wearers

Ankur Banik*, Pramod C. K., Vandana M., Ashwini K. V.

Department of Optometry, Sapthagiri Institute of Medical Sciences and Research Center, Bangalore, India

ABSTRACT

Purpose: To investigate the prevalence and types of non-strabismic binocular vision dysfunction (NSBVD) among contact lens wearers. **Methods:** Participants attended one clinical visit while wearing their habitual contact lenses. Participants were required to have a spherical myopia range between -0.50 D and -12.00 D with ≤ 0.75 D of astigmatism and at least six months of experience wearing single-vision contact lenses. A comprehensive binocular vision assessment was performed, including phoria measurements, amplitude of accommodation, near point of convergence, fusional reserves, and relative accommodation. **Results:** Sixty-four participants completed the trial, and 15 (23.1%) were diagnosed with NSBVDs. Convergence insufficiency was the most prevalent disorder (7.8%), followed by basic exophoria (3.1%), ill-sustained accommodation (3.1%), and accommodative excess (3.1%). Participants with NSBVDs exhibited significantly higher near exophoria ($-6.7 \pm 7.2\Delta$ vs. $-1.6 \pm 2.2\Delta$, $p = 0.03$), receded near point of convergence (9.3 ± 3.1 cm vs. 5.5 ± 2.1 cm, $p = 0.01$), and reduced accommodative facility (monocular: 8.6 ± 5.8 cycles/min vs. 16.4 ± 4.3 cycles/min, $p = 0.001$; binocular: 4.3 ± 6.7 cycles/min vs. 13.3 ± 3.7 cycles/min, $p < 0.001$). Reduced fusional reserves and accommodative lag were also observed among affected participants. **Conclusion:** NSBVD are common among contact lens wearers and may contribute to visual discomfort, impacting contact lens tolerance and overall visual performance. Routine binocular vision assessment in contact lens practice is recommended to optimize visual outcomes and reduce contact lens discontinuation due to undiagnosed binocular vision anomalies.

Keywords: Non-strabismic binocular vision dysfunction, contact lens, convergence insufficiency

INTRODUCTION

Binocular vision dysfunction (BVD) refers to a range of anomalies that disrupt the coordinated binocular function of both eyes, resulting in symptoms of eyestrain, headache, blur vision, and increased difficulties with near activities. These disorders are prevalent among the general population, about 20 to 30% of individuals experience some form of accommodative or binocular dysfunction [1]. The proportion of BVDs among young adults, across different refractive groups ranges from 13 to 40% [2] [3] [4] [5]. Contact lenses are widely used for refractive error correction, providing superior visual comfort and cosmetic appearance over conventional spectacles. However, the relationship between contact lens wear and BVD has gained clinical interest. A recent study reported that 25% of myopic, nonpresbyopic adult contact lens wearers had BVD, the most prevalent was exo-related vergence disorders, especially convergence insufficiency [6].

This proportion may be influenced by myopic contact lens wearers requiring greater accommodative and convergence demand at near compared when spectacles are worn [6]. Though controversial [7], many commercially available single-vision contact lenses are present with negative spherical aberration [8] [9] that showed reduced accommodative lag [10] [11] by increasing accommodation among myopes wearing contact lenses [12]. The coexistence of BVD among contact lens wearers can exacerbate visual discomfort. There may be overlap of symptoms such as dry eye sensation and visual fatigue, making the clinical presentation more complicated. Rueff et al., [13] reported a significant correlation between dry eye symptoms and BVD in contact lens wearers, suggesting that individuals experiencing contact lens discomfort might have underlying binocular vision anomaly that may lead to contact lens discontinuation in some proportion of wearers due to BVD [6]. This study aims to investigate the prevalence and types of

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



Non-strabismic binocular vision dysfunction (NSBVD) among contact lens wearers.

METHODS

1. Recruitment and Enrollment

Participants were recruited from our institute outpatient department of optometry. The study was reviewed and approved by the Institutional Ethical and Scientific Committee and followed the tenets of the Declaration of Helsinki. Informed consent was obtained from each participant after the nature, possible consequences, and procedures of the study were explained to them. Eligible participants aged between 18 and 30 years and had between -0.50 D to -12.00 D of spherical myopia with ≤ 0.75 D of astigmatism. Participants were also required to be wearing single-vision contact lenses with a minimum of 6 months wearing experience, with prescription of at least 15 days old. Participants had a best-corrected acuity of at least 0.10 logMAR (6/7.5) in each eye at 4 m. The exclusion criteria were any systemic or ocular conditions that may adversely affect contact lens wear, no ocular surgery including extraocular muscles, not strabismic and not pregnant.

2. Baseline Examinations

Total 64 participants were enrolled and all participants attended one clinic visit wearing their habitual contact lenses. During the baseline visit, participants were verbally questioned regarding their medical history including general and ocular health, family ocular history, history of their lenses (type, replacement frequency, care solution), wearing times (average days per week, average hours per week, average comfortable wearing time per day), date of last eye examination, allergies, medication, occupation, driving, visual display unit use, smoking, and hobbies. This was followed by measuring the logMAR monocular visual acuity with habitual lenses recorded at 4 m (I Chart HD Smart, Appasamy Associates, India) and 30 cm (MNREAD Acuity Chart Card; Precision Vision, Woodstock, IL). Binocular vision was fully assessed while the habitual contact lenses were being worn. Measurements of heterophoria (phoria), amplitude of accommodation, near point of convergence, fusional reserves, and relative accommodation were repeated three times

and the average value taken as the final measure. Phorias were measured by the modified Thorington technique. BC/1209F and BC/1209N Muscle Imbalance Cards (Bernell Corporation, Mishawaka, IN) were used at 3 meters and 40 cm, respectively. Phorias were expressed as negative for exophoria and positive for esophoria. Phorias at 3 meters that fell beyond the scope of the phoria card were redetermined through a trial frame with the required prism correction (base-in in the case of exophoria and base-out in the case of esophoria) in order to make the red line from the Maddox rod coincide within the range of the card. A cover/uncover procedure was used to reduce prism adaptation, and the final phoria measurement was found by adding the prism power to the remeasured phoria. The accommodative convergence/accommodation (AC/A) ratio was computed using the formula given by Scheiman and Wick [14]. Amplitude of accommodation was measured monocularly using the “push-up” technique with a Royal Air Force Ruler (Unitech Vision, India) while viewing the 0.20 logMAR (6/9.5) line. The participants were asked to keep the clarity of the letters as they were gradually moved closure. The outcome was documented as the dioptric distance at which sustained blur occurred. Near point of convergence was measured using a vertical row of 0.30 logMAR (6/12) letters taped to a pen torch. Participants were instructed to keep the row of letters as a single image. The pen torch was gradually moved closure until the participants reported diplopia, one eye drifted outward, or convergence ceased. Its result was noted as the distance in centimeters, from the center of the brow to the point where any such events occurred. Monocular and binocular accommodative facility was evaluated by a ± 2.00 D flipper (Bernell Corporation, Mishawaka, IN) with participants perceiving the 0.20 logMAR (6/9.5) line on a Saladin Near Point Balance Card Version 1.0 (Bernell Corporation) at a reading distance of 40 cm. For the purpose of testing monocular accommodative facility, participants' left eye was covered and instructed to make the letters clear as quickly as possible subsequent to each flip. For binocular accommodative facility, the cover was removed and instructed to make to make the letters clear and single as rapidly as possible following each flip. One cycle consisted of clearing both plus and minus lenses. The test was performed for one minute, with results measured in

cycles per minute. The result was measured to the half cycle, and if neither plus nor minus could be cleared; it was recorded as 0 cycle per minute. Smooth fusional vergence (positive and negative fusional reserves) was assessed at 6 meters and 40 cm with a prism bar. At each distance, the target was positioned one line above the participant's binocular visual acuity with habitual contact lenses. The participant was asked to report when the letters become blurred or when diplopia was experienced. Prism power was increased gradually with the investigator frequently asking if the letters were still clear and if there was only a single line of letters visible. The blur, break, and recovery points were measured at the times when first blurring of the letters by prism power was experienced, diplopia appeared, and when single vision again occurred on the reduction of prism. When blur was not reported and diplopia was reported, it was recorded as "break before blur." Positive and negative relative accommodation was recorded at 40 cm with a trial frame with the same target employed for fusional vergence at 40 cm. The participants were instructed to keep the designated line clear and single while power was increased binocularly in 0.25 D steps. The final point was when the participant reported sustained blur. Monocular accommodative lag (right eye) was measured using "Monocular Estimation Method" (MEM) technique using a retinoscope attached with MEM card. The participant was instructed to fix binocularly at the MEM card in the plane of the retinoscope positioned at the near reading distance. The investigator observed the retinoscopic reflex and introduced spherical lenses in front of the participant's eye until the first neutral reflex was observed. An Appasamy slit-lamp biomicroscope, AIA-11 (Appasamy Associates, India), was used to assess the contact lens surface and lens fitting. Contact lenses were removed, and keratometric readings were measured using an IOL Master 500 (Carl Zeiss Meditech, Jena, Germany). Three readings were recorded for each eye with a Sound Noise Ratio (SNR) ≥ 100 and the result was the mean of these three measurements and a balanced subjective refraction for each eye was performed. Slit-lamp biomicroscope was used to assess the anterior ocular

surface at least 10 minutes after lens removal. The original Cornea and Contact Lens Research Unit grading scale [15] was used to grade bulbar, limbal, and palpebral hyperemia, corneal and conjunctival staining, and palpebral roughness in each eye on a 0 - 4 scale in 0.5 steps. The ocular surface was assessed for the presence or absence of lid-parallel conjunctival folds and meibomian gland dysfunction. Corneal and conjunctival staining was assessed using Fluorescein Sodium ophthalmic strips (Fluostrips; 1mg fluorescein sodium). Fluorescein was used to assess corneal staining and lid wiper epitheliopathy both graded as present or absent and to measure tear breakup time (TBUT). Following this all participants were grouped according to their binocular vision status (binocular vision dysfunction or non-binocular vision dysfunction). Each measurement of binocular vision was assessed relative to a cutoff score. This criterion was used for distance [16] and near [17] phoria, near point of convergence [18], accommodative facility [19], fusional reserves [20], relative accommodation [20], and accommodative lag [21]. Cutoff values for the calculated accommodative convergence/accommodation (AC/A) ratio were taken from published literature, [14] and the amplitude of accommodation was 2 D below Hofstetter's equation for minimum age [22]. Sheard's criterion [14] was also used as a cutoff for fusional reserves. The diagnostic criteria for each of the binocular vision dysfunction were determined from a literature review [2] [3] [4] [5] [6] [14] [23] [24] and are shown in Table 1.

3. Statistical Analyses

The data were entered into a Microsoft Excel spreadsheet and analyzed using SPSS version 20.0 (IBM, Somers, NY, USA) statistical software and significance was set at 5%. Measures of central tendencies including means, standard deviations, and range were calculated. To compare measurements between non-binocular vision disorder and binocular vision disorder group, a repeated measure analysis of variance (ANOVA) was conducted.

TABLE 1. Summary of diagnostic criteria for each binocular vision dysfunction

Binocular vision dysfunction	Diagnostic criteria	Specific binocular vision measurement cutoff
Basic exo	Exo at distance and near with $\leq 5 \Delta$ between distance and near Low distance PFR (at least one $\leq 5/11/6$) Low near PFR (at least one $\leq 12/15/4$ or fails Sheard's criterion) Must have at least one of the following: Normal calculated AC/A Receded NPC Low plus BAF Low NRA Low lag	$3 < AC/A < 6 \Delta/D$ $\geq 6 \text{ cm}$ ≤ 3 Cycles/min/difficulty with +2.00 D $\leq +1.25 \text{ D}$ $< +0.25 \text{ D}$
Convergence insufficiency	Exo at near and $\geq 5 \Delta$ exo at near compared with distance Receded NPC $\geq 6 \text{ cm}$ Low near PFR (at least one $\leq 12/15/4$ or fails Sheard's criterion) Must have at least one of the following: Low calculated AC/A ratio Low plus BAF Low NRA Low lag	$\leq 3 \Delta/D$ ≤ 3 Cycles/min/difficulty with +2.00 D $\leq +1.25 \text{ D}$ $< 0.25 \text{ D}$
Accommodative insufficiency	Reduced AA: $AA < ((\text{age} - 15/4) - 2) \text{ D}$ Low MAF: $\leq 6 \text{ cycles/min}$ / difficulty with -2.00 D Must have at least one of the following: Low minus BAF Low near PFR Low PRA High lag	≤ 3 Cycles/min/difficulty with -2.00 D At least one $\leq 12/15/4$ $\geq -1.25 \text{ D}$ $> 1.00 \text{ D}$
Ill-sustained accommodation	Low MAF: $\leq 6 \text{ cycles/min}$ / difficulty with -2.00 D Must have at least one of the following: Low minus BAF Low near PFR Low PRA High lag	≤ 3 Cycles/min/difficulty with -2.00 D At least one $\leq 12/15/4$ $\geq -1.25 \text{ D}$ $> +1.00 \text{ D}$
Accommodative excess	Low MAF: $\leq 6 \text{ cycles/min}$ / difficulty with $+2.00 \text{ D}$ Must have at least one of the following: Low plus BAF Low near NFR Low NRA Low lag	$\leq 3 \text{ Cycle/min/difficulty}$ with +2.00 D At least one $\leq 9/17/8$ $\geq -1.25 \text{ D}$ $< 0.25 \text{ D}$
Basic eso	Eso at distance and near with $\leq 5 \Delta$ between distance and near Low distance NFR (at least one $\leq 4/2$) Low near NFR (at least one $\leq 9/17/8$) Must have at least one of the following: Normal calculated AC/A ratio Low minus BAF Low PRA High lag	$3 < AC/A < 6 \Delta/D$ ≤ 3 Cycles/min/difficulty with -2.00 D $\geq -1.25 \text{ D}$ $> +1.00 \text{ D}$
Convergence excess	Eso at near and $\geq 3 \Delta$ eso at near compared with distance Low near NFR (at least one $\leq 9/17/8$) Must have at least one of the following: High calculated AC/A ratio Low plus BAF Low PRA High lag	$\geq 7 \Delta/D$ $\leq 3 \text{ Cycles/min}$ (difficulty with -2.00 D) $\geq -1.25 \text{ D}$ $> +1.00 \text{ D}$

AA = amplitude of accommodation; AC/A = accommodative convergence to accommodation ratio; BAF = binocular accommodative facility; MAF = monocular accommodative facility; NFR = negative fusional reserve; NPC = near point of convergence; NRA = negative relative accommodation; PFR = positive fusional reserve; PRA = positive relative accommodation.

RESULTS

1. Demographic Data

Sixty-four participants were enrolled in this study, 15 (23.1%) were diagnosed with a binocular vision dysfunction. Convergence Insufficiency 5 (7.8%),

were more common. The specific binocular vision dysfunctions are summarized in Table 2. The majority of participants were female 35 (54.6%). The average age of all the participants was 24.8 ± 2.6 years ranging from 18 to 27 years of age. The mean subjective spherical refraction was about -5.50 D. (Table 3)

TABLE 2. Specific type of binocular vision dysfunction and prevalence

Binocular vision dysfunction	n	VD (%)		AD (%)	VD + AD (%)	BVD (%)
		Exo related	Eso related			
Convergence insufficiency	5	7.8	—	—	—	—
Basic exophoria	2	3.1	—	—	—	—
Basic esophoria	1	—	1.5	—	—	—
Convergence excess	1	—	1.5	—	—	—
Ill-sustained accommodation	2	—	—	3.1	—	—
Accommodative insufficiency	1	—	—	1.5	—	—
Accommodative excess	1	—	—	1.5	—	—
Pseudoconvergence insufficiency	1	—	—	—	1.5	—
Convergence excess + accommodative excess	1	—	—	—	1.5	—
Totals	15	10.9	3.0	6.1	3.0	23.1
Percentages are relative to the total cohort (n = 64). AD = accommodative disorder; BVD = binocular vision disorder; Eso = esophoria; Exo = exophoria; VD = vergence disorder.						

TABLE 3. Demographics of the study population (n = 64)

Age (y), mean \pm SD (range)	24.8 \pm 2.6 (18 to 27)
Sex (%)	
Female	54.6
Male	45.4
Contact lens material (%)	
Silicone hydrogel	56
Hydrogel	44
Contact lens replacement (%)	
Daily	21
Monthly	79
Lens care solution (%)	
Multipurpose	95
Hydrogen Peroxide	05
Subjective Spherical refraction (D), mean \pm SD (range)	
Right Eye	-5.3 \pm 2.7 (-11 to -1.5)
Left Eye	-5.6 \pm 2.8 (-11.5 to -1.5)
Average keratometry (D), mean \pm SD (range)	
Right Eye	44.2 \pm 1.4 (40.5 to 46.7)
Left Eye	44.3 \pm 1.4 (41.0 to 46.5)
Contact lens wear (d/wk), mean \pm SD (range)	5.6 \pm 1.8 (2 to 7)
Contact lens wear (h/d), mean \pm SD (range)	11.8 \pm 3.4 (6 to 19)
Comfortable contact lens wear (h/d), mean \pm SD (range)	7.2 \pm 3.5 (1 to 14)
D = diopters; d/wk= days/week; h/d = hours/day; SD = standard deviation.	

2. Binocular Vision Measurements

vision status. No other binocular vision measurements showed a significant difference ($P > .08$).

Table 4 presents the significant differences in binocular vision measurements based on binocular

Table 4: Mean \pm SD for binocular vision measurements showing a significant difference ($P < .05$) within binocular vision status

Measurement	Non-binocular vision dysfunction (n = 49)	Binocular vision dysfunction (n = 15)	P
Phoria (Δ) 40 cm	-1.6 ± 2.2	-6.7 ± 7.2	0.03
Near point of convergence (cm)	5.5 ± 2.1	9.3 ± 3.1	0.01
Accommodative facility at 40 cm (cycles/min)			
Monocular	16.4 ± 4.3	8.6 ± 5.8	.001
Binocular	13.3 ± 3.7	4.3 ± 6.7	<.001
Positive fusional reserves at 6m (Δ)			
Blur	13.3 ± 4.2	5.6 ± 2.2	<.001
Break	22.1 ± 5.7	14.9 ± 6.9	.01
Recovery	9.87 ± 4.9	5.2 ± 3.1	.01
Negative fusional reserves at 40 cm (Δ)			
Blur	14.7 ± 3.7	12.5 ± 5.5	0.4
Positive fusional reserves at 40 cm (Δ)			
Blur	25.6 ± 6.6	14.9 ± 7.7	0.001
Break	29.3 ± 6.9	18.2 ± 8.7	<.001
Recovery	14.4 ± 4.3	13.0 ± 6.9	.007
Relative accommodation at 40 cm (D)			
Negative	2.3 ± 1.1	2.0 ± 1.6	0.04
Positive	-2.1 ± 1.3	-1.9 ± 0.4	0.01
Phoria: minus = exophoria, plus = esophoria. AC/A = accommodative convergence/ accommodation ratio; D = diopters; SD = standard deviation; (Δ) = prism diopters.			

DISCUSSION

Of the 64 myopic, nonpresbyopic, adult, single-vision contact lens wearers, 15 (23%) were diagnosed with a Non-strabismic binocular vision dysfunction (NSBVD). The condition most frequently diagnosed was convergence Insufficiency (7.8%), followed by basic exophoria (3.1%), and ill-sustained accommodation (3.1%). These findings are consistent with Tilia et al., [6] who found 25% binocular vision disorders in myopic, nonpresbyopic adults who wore contact lenses, where exo-related vergence disorders, especially convergence insufficiency (9.2%), dominated. The frequency and nature of binocular vision disorder are comparable with studies using similar criteria on nonpresbyopic adult cohort's [2] [3] [4] [5]. The exception is the study of Rueff et al., [13] reported a much greater proportion of BVD (48% vs. 23%) and also stated pseudoconvergence insufficiency (31%) as the most common binocular vision dysfunction. The rates of prevalence between studies can be explained by variation in study

population, diagnostic criteria, and method of assessment. No participant of the current study was diagnosed as having divergence insufficiency, which is at variance with Ma et al., [4] who reported that the percentage with this issue increased with the extent of myopia. The present study concurs with other study findings, reporting no divergence insufficiency [3] [4] [5] [6]. The present study also identified notable differences in binocular measurements between both NSBVD and non-NSBVD participants. In particular, those with NSBVD presented increased near exophoria ($-6.7 \pm 7.2\Delta$ vs. $-1.6 \pm 2.2\Delta$, $p = 0.03$), a receded near point of convergence (9.3 ± 3.1 cm vs. 5.5 ± 2.1 cm, $p = 0.01$), and reduced monocular (8.6 ± 5.8 cycles/min vs. 16.4 ± 4.3 cycles/min, $p = 0.001$) and binocular (4.3 ± 6.7 cycles/min vs. 13.3 ± 3.7 cycles/min, $p < 0.001$) accommodative facility. Chen et al., [25] also demonstrated that single-vision contact lenses did increase accommodative lag and influenced negative relative accommodation, suggesting that contact lens wear can alter accommodative and vergence functions. Tilia et al.,

[6] also established that individuals with binocular vision dysfunctions had a higher score on the Ocular Surface Disease Index, reflecting higher contact lens dissatisfaction, regardless of contact lens discomfort. These findings indicate that contact lens wear can aggravate pre-existing binocular vision disorders or lead to their development. This research has some limitations, such as a relatively small number of participants and a narrow age range of participants, which can restrict the generalizability of the results. Moreover, the cross-sectional nature of the study does not allow for the establishment of causal links between contact lens wear and the occurrence of NSBVD. Nevertheless, the prevalence of binocular vision dysfunction is comparable to other research that employed similar diagnostic criteria on cohort of nonpresbyopic adult [2] [3] [4] [5] [6]. Thus, these restrictions had no influence on the overall findings of this current study.

CONCLUSIONS

Non-strabismic binocular vision dysfunction is common among contact lens wearers and may have a strong effect on visual comfort and satisfaction. These results emphasize the importance of complete binocular vision assessments in contact lens practice. Through the detection and control of NSBVD, clinicians can enhance visual outcomes and avoid contact lens dropout because of visual discomfort.

Conflict of interest:

There are no conflicts of interest.

REFERENCE

- Shongmu T. L, & Akhtar Z. Prevalence of non-strabismic binocular vision anomalies (NSBVA) among university students of North India. *Indian Journal of Clinical and Experimental Ophthalmology* 2024, 281–287. <https://doi.org/10.18231/j.ijceo.2024.050>.
- Cacho-Martinez P, Canto-Cerdan M, CarbonellBonete S, et al. Characterization of Visual Symptomatology Associated with Refractive, Accommodative, and Binocular Anomalies. *J Ophthalmol* 2015; 2015:895803. <https://doi.org/10.1155/2015/895803>.
- Garcia-Munoz A, Carbonell-Bonete S, Canto-Cerdan M, et al. Accommodative and Binocular Dysfunctions: Prevalence in a Randomised Sample of University Students. *Clin Exp Optom* 2016; 99:313–21. <https://doi.org/10.1111/cxo.12376>.
- Ma MM, Yeo ACH, Scheiman M, et al. Vergence and Accommodative Dysfunctions in Emmetropic and Myopic Chinese Young Adults. *J Ophthalmol* 2019; 2019:5904903. <https://doi.org/10.1155/2019/5904903>.
- Porcar E, Martinez-Palomera A. Prevalence of General Binocular Dysfunctions in a Population of University Students. *Optom Vis Sci* 1997; 74:111–3. <https://doi.org/10.1097/00006324-199702000-00023>.
- Tilia D, Bakaraju R. C, Asper L. J, & Papas, E. B. Associations between binocular vision disorders and contact lens dissatisfaction. *Optometry and Vision Science* 2021; 1160–1168. <https://doi.org/10.1097/oxp.0000000000001780>.
- Altoaimi BH, Almutairi MS, Kollbaum P, et al. Accommodative Behavior of Eyes Wearing Aspheric Single Vision Contact Lenses. *Optom Vis Sci* 2017; 94:971–80. <https://doi.org/10.1097/oxp.0000000000001121>.
- Papas E, Dahms A, Carnt N, et al. Power Profiles and Short-term Visual Performance of Soft Contact Lenses. *Optom Vis Sci* 2009; 86:318–23. <https://doi.org/10.1097/oxp.0b013e318198959e>.
- Wagner S, Conrad F, Bakaraju RC, et al. Power Profiles of Single Vision and Multifocal Soft Contact Lenses. *Cont Lens Anterior Eye* 2015; 38:2–14. <https://doi.org/10.1016/j.clae.2014.07.008>.
- Altoaimi BH, Almutairi MS, Kollbaum P, et al. Accommodative Behavior of Eyes Wearing Aspheric Single Vision Contact Lenses. *Optom Vis Sci* 2017; 94:971–80. <https://doi.org/10.1097/oxp.0000000000001121>.
- Gambra E, Sawides L, Dorronsoro C, et al. Accommodative Lag and Fluctuations when Optical Aberrations Are Manipulated. *J Vis* 2009; 9:4.1–15. <https://doi.org/10.1167/9.6.4>.
- Atchison DA, Varnas SR. Accommodation Stimulus and Response Determinations with Autorefractors. *Ophthalmic Physiol Opt* 2017; 37:96–104. <https://doi.org/10.1111/opo.12340>.

13. Rueff EM, King-Smith PE, Bailey MD. Can Binocular Vision Disorders Contribute to Contact Lens Discomfort? *Optom Vis Sci* 2015; 92: e214–21.
<https://doi.org/10.1097/OPX.0000000000000671>.
14. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2014.
15. Schiffman RM, Christianson MD, Jacobsen G, et al. Reliability and Validity of the Ocular Surface Disease Index. *Arch Ophthalmol* 2000; 118:615–21. <https://doi.org/10.1001/archophth.118.5.615>.
16. Cebrian JL, Antona B, Barrio A, et al. Repeatability of the Modified Thorington Card Used to Measure Far Heterophoria. *Optom Vis Sci* 2014; 91:786–92. <https://doi.org/10.1097/OPX.0000000000000297>.
17. Wong EP, Fricke TR, Dinardo C. Interexaminer Repeatability of a New, Modified Prentice Card Compared with Established Phoria Tests. *Optom Vis Sci* 2002; 79:370–5. <https://doi.org/10.1097/00006324-200206000-00010>.
18. Scheiman M, Gallaway M, Frantz KA, et al. Nearpoint of Convergence: Test Procedure, Target Selection, and Normative Data. *Optom Vis Sci* 2003; 80: 214–25. <https://doi.org/10.1097/00006324-200303000-00011>.
19. Zellers J, Alpert T, Rouse M. A Review of the Literature and a Normative Study of Accommodative Facility. *J Am Optom Assoc* 1984; 55:31–7.
20. Morgan MWJ. Analysis of Clinical Data. *Optom Vis Sci* 1944; 21:477–91. <https://doi.org/10.1097/00006324-194412000-00001>.
21. Nguyen AT, Wayne JL, Ravikumar A, et al. Accommodative Accuracy by Retinoscopy versus Autorefraction Spherical Equivalent or Horizontal Meridian Power. *Clin Exp Optom* 2018; 101:778–85. <https://doi.org/10.1111/cxo.12678>.
22. Hofstetter H. A Useful Age-amplitude Formula. *Optom World* 1950; 38:42–5. <https://doi.org/10.1097/00006324-194704000-00030>.
23. Lara F, Cacho P, Garcia A, et al. General Binocular Disorders: Prevalence in a Clinic Population. *Ophthalmic Physiol Opt* 2001; 21:70–4. <https://doi.org/10.1046/j.1475-1313.2001.00540.x>.
24. Rouse MW, Borsting E, Hyman L, et al. Frequency of Convergence Insufficiency among Fifth and Sixth Graders. The Convergence Insufficiency and Reading Study (CIRS) Group. *Optom Vis Sci* 1999; 76:643–9. <https://doi.org/10.1097/00006324-199909000-00022>.
25. Chen ST, Tung HC, Chen YT. et al. The influence of contact lenses with different optical designs on the binocular vision and visual behavior of young adults. *Sci Rep* 2022, 6573. <https://doi.org/10.1038/s41598-022-10580-7>.

HOW TO CITE: Ankur Banik*, Pramod C. K., Vandana M., Ashwini K. V., Non-Strabismic Binocular Vision Dysfunction Among Contact Lens Wearers, *Int. J. Sci. R. Tech.*, 2025, 2 (7), 302-309. <https://doi.org/10.5281/zenodo.15921034>