



ORIGINAL ARTICLE

Prevalence and clinical profile of non-strabismic binocular vision anomalies in the Nepalese population: A hospital-based study

Santosh Chhetri^a, Rupesh Poudel^a, Srijana Adhikari^b, Umesh Belbase^c, Mario Cantó-Cerdán^{d,e,*}, Manish Poudel^f, Suraj Thapa^a

^a Department of Optometry, Tilganga Institute of Ophthalmology, Kathmandu, Nepal

^b Department of Pediatric ophthalmology, Tilganga Institute of ophthalmology, Kathmandu, Nepal

^c Department of Optometry, Himalaya Eye Hospital, Pokhara, Nepal

^d Department of Optometry, Visum (Miranza), Alicante, Spain

^e Grupo de Investigación en Optometría (GIOptom), University of Alicante, Alicante, Spain

^f Department of Research and Biostatistics, Tilganga Institute of Ophthalmology, Kathmandu, Nepal

Received 13 February 2025; accepted 1 July 2025

Available online 8 August 2025

KEYWORDS

Binocular dysfunction;
Accommodative dysfunction;
Non strabismic binocular vision anomalies;
Binocular vision;
Headache

Abstract

Purpose: To identify the prevalence of non-strabismic binocular vision anomalies in a systematically randomized sample of symptomatic, non-presbyopic subjects from a tertiary hospital, using a broader range of diagnostics signs.

Subjects and methods: The study was designed as hospital-based, cross-sectional, and analytical and was conducted from March 2022 to April 2023. Systematic random sampling was employed to select the subjects. Symptomatic subjects aged between 18 and 35 years with best-corrected visual acuity of 6/6 in each eye and no change in refractive error during the subjective refraction were included in the study.

Results: Out of the 231 subjects examined, 91 (39.39%) were found to have non strabismic binocular vision anomalies. Of all the non strabismic binocular vision anomalies, 60 subjects (26%) had binocular dysfunctions, 22 (9.5%) had accommodative dysfunctions, and 9 (3.9%) had both accommodative and binocular dysfunctions. The most common dysfunction was convergence insufficiency (18.2%), followed by accommodative infacility (6.06%) and fusional vergence dysfunction (3.9%). The most prevalent symptom was headache (16.7%), followed by visual fatigue (14.1%).

* Corresponding author at: Visum Miranza Alicante, Cabañal 1, 03016 Alicante, Spain.

E-mail address: mario.canto@visum.com (M. Cantó-Cerdán).

Conclusion: Two-fifths of the symptomatic subjects have non strabismic binocular vision anomalies. It is essential to assess all accommodative and binocular parameters in order to arrive at a diagnosis of non strabismic binocular vision anomalies.

© 2025 The Authors. Published by Elsevier España, S.L.U. on behalf of Spanish General Council of Optometry. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

To maintain a clear vision when reading or doing near tasks, both accommodative and vergence systems must be adequate. Failure of these systems can cause accommodation and vergence dysfunctions.¹ These dysfunctions might impair a child's academic growth or a person's ability to perform well at work.² These dysfunctions are grouped together under the umbrella term "Non-Strabismic Binocular Vision Anomalies" (NSBVA).³ Some researchers have observed that people who spend long hours on near activities, such as using a computer or reading, often report experiencing visual related symptoms,^{4–7} although recent research has reported that the main cause of symptoms is visual dysfunction, not the number of hours of electronic device use.⁸

Occurrence of NSBVA in hospital-based populations is relatively common. However, there is still some variation in the prevalence values in the clinical population presented by different authors.^{1,3,9–27} Currently, there is only one study with prevalence data on NSBVA in Nepal, although the main objective of the research was not to show prevalence data, and the sample used was somewhat small.²⁸

It would be highly beneficial to conduct a study on the prevalence of NSBVA in a clinical population presenting with visual symptoms associated with visual dysfunctions, utilizing diagnostic criteria established in the scientific literature. Such a study could contribute to future epidemiological research and enhance knowledge regarding the management of NSBVA in Nepal.

Under this scenario, the aim of this study was to evaluate the prevalence of non-strabismic binocular vision anomalies in a systematically randomized sample of symptomatic, non-presbyopic subjects from a tertiary hospital, using a broader range of diagnostics signs. The secondary objective was to explore the range of symptoms and analyze the distribution of age, gender and refractive errors among subjects with non-strabismic binocular vision anomalies.

Subjects and methods

The study was designed as hospital-based, cross-sectional, and analytical and was conducted at the Tilganga Institute of Ophthalmology, Kathmandu. This site was chosen for its accessibility and the presence of relevant units. Systematic random sampling was employed in selecting the subjects, considering symptomatic patients who reported symptoms in the anamnesis. Over the course of one year, from March 2022 to April 2023, 231 symptomatic subjects aged between 18 and 35 years were assessed who visited the comprehensive and/or orthoptic department and met the inclusion criteria. Symptomatic subjects aged between 18 and 35 years with best-corrected visual acuity of 6/6 in each eye

and change in refractive error during the subjective refraction were accepted for participation. The upper age limit of 35 years was established to exclude pre-presbyopic and presbyopic subjects from the study (considering presbyopia when the patient needed addition), as their inclusion could bias the diagnosis of a NSBVA.²⁹ Exclusion criteria encompassed various ocular and systemic pathologies, ocular surgeries, taking medication, neurological disorders, wearing contact lenses, anisometropia (more than 2.00 diopters), strabismus, or amblyopia.

This research was reviewed and approved by the Institutional Review Committee of Tilganga Institute of Ophthalmology (Reference number 10/2022), Kathmandu, and adhere to the principle of the Declaration of Helsinki. Written consent was obtained from all participants prior to enrolling them in the study. Participant's dignity and autonomy were preserved.

Initial history and complete ophthalmic evaluation including refraction (dry and cycloplegic), anterior and posterior segment examination was carried out in comprehensive department followed by complete binocular vision assessment in the orthoptics department. Binocular vision examination along with case history was carried out in the orthoptic department which included the following tests and procedures:

1. A case history, with special emphasis on symptomatology. Data was collected based on symptoms reported by the subjects. Instead of a questionnaire, we used symptom categories from García-Muñoz et al.² Scoping review, which detailed symptoms linked to NSBVA. Patients were presented with a list of 34 symptom categories and asked if they experienced any vision-related symptoms.
2. Accommodative and binocular tests: The ocular deviation was assessed using a prism bar cover test at both near and distance. Step positive and negative fusional vergence (PFV and NFV) was measured with a horizontal prism bar at near and distance, with NFV measured before PFV. The Near Point of Convergence (NPC) was measured using a Royal Air Force (RAF) rule in primary gaze. The amplitude of accommodation was measured monocularly and binocularly with the RAF rule. Positive and negative relative accommodation (PRA and NRA) were measured using a phoropter (NRA was measured before PRA). The lag of accommodation was assessed by dynamic retinoscopy with the Monocular Estimated Method (MEM). Monocular and binocular accommodative facility was evaluated using an accommodative flipper ± 2.00 diopters (D). The AC/A (Accommodative Convergence/Accommodation) ratio was measured using the gradient method.

NSBVA were diagnosed using the criteria established by Lara et al.¹⁹ For a diagnosis of dysfunctions, a subject needed to exhibit the fundamental signs along with at least

two additional complementary signs specific to the dysfunction. Those who did not meet these criteria were classified as “normal”.

Statistical analysis was performed using SPSS software (version 20.0). Mean and standard deviation were used to describe the central tendency and dispersion of the study parameters respectively. All of the study parameters showed a normal distribution during the normality test using Kolmogorov-Smirnov test ($p > 0.05$). A comparison of values between the subjects was carried out using the unpaired t -test. The results were considered significant at p -value < 0.05 at a 5 % level of significance.

Results

The study included 231 subjects (149 female), with an average age ($\pm$ Standard Deviation, SD) of 23.41 ± 4.92 years (from 18 to 35 years old). The mean ($\pm$ SD) spherical equivalent of refractive error was -0.238 ± 0.75 D, with values ranging from +2.00 D to -4.00 D Emmetropia (56.7 %) was the most prevalent refractive error, followed by myopia at 35.5 percent and hyperopia at 7.8 percent subjects.

Out of the 231 subjects examined, 91 subjects (39.39 %) were found to have a NSBVA. This included 66 females, 54 emmetropes, and 29 myopes. The age, gender, and refractive error distributions for these dysfunctions are shown in Table 1. Of all the NSBVA subjects, 60 (26.00 %) had binocular dysfunctions, 22 (9.50 %) had accommodative dysfunctions, and 9 (3.90 %) had both accommodative and binocular dysfunctions. The most common dysfunction was convergence insufficiency (18.20 %), followed by accommodative infacility (6.06 %) and fusional vergence dysfunction (3.90 %). Among 140 subjects who did not have NSBVA, 66 % had at least one affected accommodative or binocular parameter. Table 2 shows the prevalence of NSBVA.

Twenty different categories of visual symptoms were reported by the 231 subjects. All subjects reported one or more visual symptoms. The most prevalent symptom was headache (16.7 %), followed by visual fatigue (14.1 %). Table 3 shows these different categories of visual symptoms, along with the number of complaints reported by the subjects.

Tables 4, 5, and 6 show the number of subjects with each complementary sign of NSBVA. The most affected complementary clinical signs for accommodative infacility, convergence insufficiency, basic exophoria, and convergence excess were Binocular Accommodative Facility (BAF), Positive Fusional Vergence (PFV) at near, PFV at far and near, and Negative Fusional Vergence (NFV) at near, respectively.

There were significant differences in BAF ($p < 0.005$), MAF ($p = 0.02$), PFV break and recovery for near ($p < 0.005$),

NRA ($p < 0.005$), and PRA ($p < 0.005$) between subjects with and without NSBVA in this studied populations. However, for all other clinical findings, the differences between the two groups were not statistically significant ($p > 0.05$).

Discussion

This study was conducted to determine the prevalence of NSBVA in symptomatic subjects from tertiary eye hospital. Currently, only one study in Nepal has reported prevalence data on NSBVA.²⁸ However, its primary objective was not to determine prevalence, and it was based on a relatively small sample. Therefore, this study is the first to specifically assess the prevalence of NSBVA in a clinical population. According to the results of this study, the prevalence of NSBVA in the hospital-based population is important from a clinical point of view. Among 231 subjects examined, 92 (39.82 %) presented some kind of NSBVA. The most common NSBVA was convergence insufficiency (18.2 %).

The prevalence of NSBVA observed in this hospital-based population study is lower than that reported in other studies conducted in similar populations.^{12,22} Conversely, it is higher than the prevalence reported in studies involving clinical populations, where values ranged from 19.30 % to 32.00 %, ^{19,21,23} and even greater than those found in the general population, where prevalence ranged from 13.15 % to 31.50 %. These differences may be attributed to the characteristics of individuals attending the hospital, where the likelihood of presenting a visual problem is higher compared to clinical or general populations. Additionally, variations in prevalence values may be influenced by study design, inclusion criteria—which tend to be more restrictive in clinical studies than in general population studies—or differences in diagnostic criteria.

To accurately diagnose NSBVAs, a complete battery of binocular vision tests was carried out as well as standard clinical diagnostic signs to measure binocular and accommodative parameters. In the scientific literature, there are numerous diagnostic criteria for these dysfunctions.³⁰ NSBVA were diagnosed in this study using the criteria proposed by Lara et al.¹⁹ Different diagnostic criteria (in terms of the cut-off points of tests and number of criteria) used to classify anomalies, type of population studied,³⁰ study design and sampling method may be the main factors causing variations in the prevalence of dysfunctions in the various studies.³¹ Some studies reference the classification proposed by Scheiman and Wick,^{9,11,12,27} while others adopt the classification by Lara et al.,^{19,21,23} as applied in the present study. As highlighted in the systematic review by Cacho-Martínez et al.,³⁰ diagnostic accuracy studies indicate that evidence regarding accommodative conditions remains limited, with

Table 1 Age, gender, and refractive distribution among NSBVA subjects.

Age groups (Years)	Number of subjects (n)	Gender distribution n (%)		Distribution of refractive error n (%)		
		Male	Female	Emmetropia	Myopia	Hypermetropia
18–23	51	14 (27.45)	37 (72.54)	36 (70.58)	11 (21.56)	4 (7.84)
24–29	29	6 (20.68)	23 (79.31)	13 (44.82)	14 (48.27)	2 (6.89)
30–35	11	5 (45.45)	6 (54.54)	5 (45.45)	4 (36.36)	2 (18.18)

Table 2 Prevalence of Non Strabismic Binocular Vision Anomalies.

Dysfunctions	Number of Subjects		CI95 %	
	n	%	Lower	Upper
Convergence Insufficiency	42	18.20	13.21	23.16
Accommodative Infacility	14	6.06	2.98	9.14
Fusional Vergence Dysfunction	9	3.90	1.40	6.39
Accommodative Insufficiency	6	2.60	0.55	4.65
Basic Exophoria	5	2.16	0.29	4.04
Accommodative Excess	2	0.86	0.00	2.06
Convergence Excess	4	1.73	0.05	3.41
Accommodative Insufficiency with Convergence Insufficiency	5	2.16	0.29	4.04
Fusional Vergence Dysfunction with Accommodative Excess	3	1.30	0.00	2.76
Convergence Insufficiency with Accommodative Insufficiency	1	0.43	0.00	1.28
Normal (without NSBVA)	140	60.60	54.30	66.91
Total	231	100		

NSBA: Non Strabismic Binocular Vision Anomalies.

CI 95 %: Coefficient Interval at 95 %.

considerable variability in the diagnosis of binocular dysfunctions.

Similar to this study, the prevalence will be higher in the hospital based population than in the general population because hospital based populations are more likely to complain of visual problems than the general population.^{2,18,19,21} In this hospital based study, we evaluated the prevalence of NSBVA among symptomatic non

presbyope age group. Hokoda studied the prevalence of general binocular dysfunction in asthenopia non-presbyopes in an urban clinical population and found that 21 percent of subjects had NSBVA.³² As diagnosis was made based on one or two clinical signs, it is difficult to compare their results to those obtained in our study. Similarly, Lara and colleagues found 59 (22.3 %) subjects with NSBVA among 265 consecutive symptomatic Spanish clinical populations of aged between 10 and 35 years.¹⁹ The diagnostic criteria used in this study were similar to our study but there is a much variation in the prevalence of NSBVA compare to our study, which may be related to the age of the subjects and inclusion of refractive dysfunction.

The study included individuals aged 18 to 35 years, with a higher proportion of females than males. Non-strabismic binocular vision anomalies were found to be more prevalent among females and those aged 18 to 23 years. This age group is often involved in prolonged near-visual tasks, such as studying and screen use, which may contribute to the higher prevalence of dysfunctions. Furthermore, females are generally less active outdoors compared to males, which could account for their larger number, both in the study and among those with binocular vision dysfunctions.

In addition, it was obtained that binocular dysfunctions were more prevalent than accommodative dysfunctions, as in previous research.^{18,19,21,22} In our study, 61 subjects (26.40 %) were diagnosed with a binocular dysfunction. This prevalence is more than that reported by Ovenseri-Ogbomo and Eguegu¹⁸ (12.7 %), Hoseini-Yazdi et al.²¹ (12.1 %), Magdalene et al.²² and Lara et al.¹⁹ (12.9 %).

The prevalence of convergence insufficiency (18.2 %) is more than the results found by Franco et al.³³ although they used von Graefe method to assess the deviation. According to Cantó-Cerdán et al.,³⁴ the von Graefe technique gives higher exophoric mean values than the cover test. Similar to our result, Magdalene et al.²² also reported convergence insufficiency (32 %) to be the most common NSBVA. Magdalene et al. also used the cover test method to assess horizontal phoria but their diagnostic criteria differed from ours which may cause greater prevalence than ours.

Table 3 Symptoms categories encountered in all subjects of the Sample.

Symptoms	Number of complaints of subjects	
	n	%
Asthenopia	21	7.9
Avoid near tasks	11	4.2
Blurred vision	12	4.6
Difficulty focusing from one distance to another	7	2.7
Diplopia	2	0.7
Eye Turned noticed	2	0.7
Feel sleepy	16	6.1
Headache	44	16.7
Lack of concentration	16	6.1
Loss of place when reading	12	4.6
Ocular pain	6	2.3
Excessive Sensitivity to light	14	5.3
Reading problems	10	3.8
Sore eye	4	1.5
Visual discomfort	17	6.5
Visual fatigue	37	14.1
Words appear to move or jump at near vision	14	4.6
Change reading distance	3	1.1
Tearing	10	3.8
Dry Eye	7	2.7
Total	265	100

Table 4 Number of subjects with complementary sign among accommodative dysfunctions.

Accommodative dysfunction/ Orthoptic parameter	Number of subjects with complementary sign	
	n	%
Accommodative insufficiency (n = 6)		
MAF < 6 cpm with −2.00D lenses	6	100
BAF < 3 cpm with −2.00D lenses	4	66.67
MEM > 0.75D	5	83.33
PRA < −1.25D	3	50
Accommodative excess (n = 1)		
BAF < 6 cpm with +2.00D lenses	0	
MEM < 0.25D	1	100
NRA < 1.50D	1	100
Accommodative Infacility (n = 14)		
BAF < 3 cpm with ± 2.00D lenses	11	78.57
PRA < 1.25D	8	57.14
NRA < 1.50D	9	64.28

MAF: Monocular Accommodative Facility, BAF: Binocular Accommodative Facility, MEM: Monocular Estimated Method, PRA: Positive Relative Accommodation, NRA: Negative Relative Accommodation.

Unlike Daum, accommodative infacility (6.1 %) was found to be the most common accommodative dysfunction, followed by accommodative insufficiency (2.6 %). Daum's reported higher accommodative insufficiency in their clinical populations.³⁵ He found that 96 subjects (80 %) showed accommodative insufficiency in his study of 114 subjects with accommodative dysfunctions. Daum's criteria for diagnosing accommodative insufficiency depended only on the measurement of accommodation amplitude. If other diagnostic signs are also taken into

account, the outcome may differ. Larger the number of diagnostic signs used to diagnose a NSBVA, the lower the prevalence of the anomaly.^[33] Scheiman et al.³⁶ studied 2023 subjects of ages up to 18 year using more diagnostic sign and observed that 19.7 % showed NSBVA. The population studied in that study was younger than ours and the prevalence of accommodative insufficiency was found to be just 2 %.

This study included only those subjects who did not require any changes in refractive correction. This approach

Table 5 Number of subjects with complementary sign among binocular dysfunctions.

Binocular dysfunction/ Orthoptic parameter	Number of patients with complementary sign	
	n	%
Convergence insufficiency (n = 42)		
PFV at near ≤ 11/14/3 Δ	32	76.19
NPC ≥ 6 cm	20	48.09
BAF < 3 cpm with ±2.00D lenses	23	54.76
MEM < 0.25D	8	19.04
NRA < 1.50D	16	38.09
Fusional vergence dysfunction (n = 9)		
BAF < 3 cpm with ±2.00D lenses	9	100
PRA < −1.25D	9	100
NRA < 1.50D	9	100
Basic exophoria (n = 6)		
PFV at far ≤ 4/10/5 Δ and at near ≤ 11/14/3 Δ	5	83.33
NPC ≥ 6 cm	4	66.67
BAF < 3 cpm with ±2.00D lenses	3	50
MEM < 0.25D	2	33.33
NRA < 1.50D	2	33.33
Convergence Excess (n = 4)		
NFV at near ≤ 8/16/7 Δ	4	100
BAF < 3 cpm with −2.00D lenses	2	50
MEM > 0.75D	1	25
PRA < −1.25D	2	50

PFV: Positive Fusional Vergence, NFV: Negative Fusional Vergence, NPC: Near Point convergence, MAF: Monocular Accommodative Facility, BAF: Binocular Accommodative Facility, MEM: Monocular Estimated Method, PRA: Positive Relative Accommodation, NRA: Negative Relative Accommodation.

Table 6 Number of subjects with complementary signs among accommodative and binocular dysfunctions.

Dysfunction/ Orthoptic parameter	Number of patients with complementary sign	
	n	%
Accommodative Insufficiency with Convergence Insufficiency (n = 5)		
MEM $\geq +0.75$ D	5	100
MAF < 6cpm	4	80
PRA < 1.25 D	5	100
PFV at near $\leq 11/14/3 \Delta$	4	80
NPC > 6 cm	4	80
BAF < 3 cpm	4	80
Fusional Vergence Dysfunction with Accommodative Excess (n = 3)		
BAF < 3 cpm with ± 2.00 D lenses	3	100
PRA < 1.25D and NRA < 1.50D	3	100
MEM < +0.25 D	3	100
MAF < 6cpm	2	66.67
Convergence Insufficiency with Accommodative Insufficiency (n = 1)		
BAF < 3 cpm	1	100
NRA < 1.50 D	1	100
NPC > 6 cm	1	100
PFV at near $\leq 11/14/3 \Delta$	1	100
MAF < 6 cpm	1	100
MEM $\geq +0.75$ D	1	100
PFV: Positive Fusional Vergence, NFV: Negative Fusional Vergence, NPC: Near Point convergence, MAF: Monocular Accommodative Facility, BAF: Binocular Accommodative Facility, MEM: Monocular Estimated Method, PRA: Positive Relative Accommodation, NRA: Negative Relative Accommodation.		

aligns with findings from most studies, which emphasize the importance of addressing refractive errors before diagnosing or managing NSBVA. García-Munoz et al.³⁷ observed that 13 of 23 participants with NSBVA also had uncorrected refractive problems. Similarly, in the study of Franco et al.³³ among 156 patients, 106 (68 %) were diagnosed with uncorrected refractive error. A special note should be made of the high prevalence rate of NSBVA found in this study when compared to previous studies, which may be related to the exclusion of change subjective refractive error.

In this study, symptom categories from García-Muñoz et al.² were used. Headaches, followed by visual fatigue and asthenopia were the most commonly reported symptoms in our study, similar to the results that other authors have reported.^{2,9} Headache symptoms were more commonly observed in subjects diagnosed with convergence insufficiency. As expected, subjects diagnosed with accommodative excess experienced blurred vision more frequently. Similarly, blurred vision at near was significantly more common among those with accommodative insufficiency. It is essential to consider the presence of these dysfunctions (refractive, accommodative, and/or binocular) in a subject, as they may trigger the onset of this symptomatology. Therefore, it is necessary to address these dysfunctions to reduce the prevalence of visual symptoms.⁸

This study has several limitations as it was conducted in a hospital-based setting, the findings may not be directly applicable to the general population, given that patients seeking care at a tertiary eye hospital may have a higher prevalence of NSBVA. Future studies in a general population or a multicenter study should be carried out in order to

provide more accurate prevalence data. Additionally, we did not use standardized symptom questionnaires for assessing NSBVA, which may impact the consistency and comparability of our findings. In the scientific literature there is only one validated questionnaire to collect the symptoms associated with visual dysfunctions, the Symptom Questionnaire for Visual Dysfunctions,^{38,39} but it has not been validated in the language of the study subjects. In order to overcome this limitation, the examiner asked the patient about the symptomatology in the anamnesis and the symptoms reported by the subject were classified according to the symptom categories described in the scientific literature. Lastly, the relatively small sample size may have limited the reliability of our results, suggesting that future research should aim to include larger samples to improve the accuracy of the findings.

Conclusion

It is the first prevalence study of non-strabismic binocular vision anomalies in Nepalese populations. It is essential to assess all accommodative and binocular parameters in order to arrive at a diagnosis of non-strabismic binocular vision anomalies. Differences in diagnostic criteria, type of population studied, study design, and sampling methods may be the main reasons for variations in the prevalence of non-strabismic binocular vision anomalies. The current study showed two-fifth of the symptomatic subjects have non-strabismic binocular vision anomalies. Convergence insufficiency was the most common dysfunctions presented in the hospital-

based population, followed by accommodative infacility and fusional vergence dysfunction. Headaches, along with visual fatigue and asthenopia, were the most frequently reported symptoms in subjects with non-strabismic binocular vision anomalies. These dysfunctions can be successfully managed with vision therapy, prism prescription and optical correction if diagnosed early.

Sources of funding

Nil.

Source(s) of support

Nil.

Presentation at a meeting

Nil.

Declaration of competing interest

Nil

Acknowledgements

Nil.

References

- Shin HS, Park SC, Park CM. Relationship between accommodative and vergence dysfunctions and academic achievement for primary school children. *Ophthalmic Physiol Opt.* 2009;29(6):615–624. <https://doi.org/10.1111/j.1475-1313.2009.00684.x>.
- García-Muñoz Á, Carbonell-Bonete S, Cacho-Martínez P. Symptomatology associated with accommodative and binocular vision anomalies. *J Optom.* 2014;7(4):178–192. <https://doi.org/10.1016/j.optom.2014.06.005>.
- Hussaindeen JR, Shah P, Ramani KK, Ramanujan L. Efficacy of vision therapy in children with learning disability and associated binocular vision anomalies. *J Optom.* 2018;11(1):40–48. <https://doi.org/10.1016/j.optom.2017.02.002>.
- Sheedy JE, Hayes J, Engle J. Is all Asthenopia the Same? *Optom Vis Sci.* 2003;80(11):732–739. <https://doi.org/10.1097/00006324-200311000-00008>.
- Watten RG. Reinvention of visual fatigue: accumulation of scientific knowledge or neglect of scientific history? *Ophthalmic Physiol Opt.* 1994;14(4):428–432. <https://doi.org/10.1111/j.1475-1313.1994.tb00137.x>.
- Evans BJW. The need for optometric investigation in suspected Meares-Irlen syndrome or visual stress. *Ophthalmic Physiol Opt.* 2005;25(4):363–370. <https://doi.org/10.1111/j.1475-1313.2005.00289.x>.
- Chris C, Chinatsu T, Borsting E, William HR. Visual discomfort and objective measures of static accommodation. *Optom Vis Sci.* 2009;86(7):883–889.
- Cacho-Martínez P, Cantó-Cerdán M, Lara-Lacárcel F, García-Muñoz Á. Assessing the role of visual dysfunctions in the association between visual symptomatology and the use of digital devices. *J Optom.* 2024;17(3). <https://doi.org/10.1016/j.optom.2023.100510>.
- Hussaindeen JR, Rakshit A, Singh NK, et al. Prevalence of non-strabismic anomalies of binocular vision in Tamil Nadu: report 2 of BAND study. *Clin Exp Optom.* 2017;100(6):642–648. <https://doi.org/10.1111/cxo.12496>.
- Nunes AF, Monteiro PML, Ferreira FBP, Nunes AS. Convergence insufficiency and accommodative insufficiency in children. *BMC Ophthalmol.* 2019;19(1):1–8. <https://doi.org/10.1186/s12886-019-1061-x>.
- Ma MML, Yeo ACH, Scheiman M, Chen X. Vergence and accommodative dysfunctions in emmetropic and Myopic Chinese young adults. *J Ophthalmol.* 2019;2019. <https://doi.org/10.1155/2019/5904903>.
- Atiya A, Hussaindeen JR, Kasturirangan S, Ramasubramanian S, Swathi K, Swaminathan M. Frequency of undetected binocular vision anomalies among ophthalmology trainees. *J Optom.* 2020;13(3):185–190. <https://doi.org/10.1016/j.optom.2020.01.003>.
- Davis AL, Harvey EM, Twelker JD, Miller JM, Leonard-Green T, Campus I. Convergence insufficiency, accommodative insufficiency, visual symptoms, and astigmatism in Tohono O'odham students. *J Ophthalmol.* 2016;2016. <https://doi.org/10.1155/2016/6963976>.
- Hashemi H, Nabovati P, Khabazkhoob M, et al. The prevalence of convergence insufficiency in Iran: a population-based study. *Clin Exp Optom.* 2017;100(6):704–709. <https://doi.org/10.1111/cxo.12522>.
- Hassan LI, Ibrahim SM, Abdu M, Mohamedsharif A. Prevalence of convergence insufficiency among secondary school students in Khartoum, Sudan. *Oman J Ophthalmol.* 2018;11(2):129–133. https://doi.org/10.4103/ojo.OJO_170_2017.
- Atowa UC, Wajuihian SO, Hansraj R. Vergence profile and prevalence of non-strabismic vergence anomalies among school children in Abia State, Nigeria. *Ophthalmic Epidemiol.* 2019;26(2):121–131. <https://doi.org/10.1080/09286586.2018.1532523>.
- Ma MML, Long W, She Z, et al. Convergence insufficiency in Chinese high school students. *Clin Exp Optom.* 2019;102(2):166–171. <https://doi.org/10.1111/cxo.12838>.
- Ovenseri-Ogbomo GO, Eguegu OP. Vergence findings and horizontal vergence dysfunction among first year university students in Benin City, Nigeria. *J Optom.* 2016;9(4):258–263. <https://doi.org/10.1016/j.optom.2016.01.004>.
- Lara F, Cacho P, García Á, Megías R. General binocular disorders: prevalence in a clinic population. *Ophthalmic Physiol Opt.* 2001;21(1):70–74. <https://doi.org/10.1046/j.1475-1313.2001.00540.x>.
- Scheiman M, Gallaway M, Coulter R, et al. Prevalence of vision and ocular disease conditions in a clinical pediatric population. *J Am Optom Assoc.* 1996;64(4):193–202. <https://europemc.org/article/med/8888829>.
- Hoseini-Yazdi SH, Yekta A, Nouri H, Heravian J, Ostadimoghaddam H, Khabazkhoob M. Frequency of convergence and accommodative disorders in a clinical population of Mashhad, Iran. *Strabismus.* 2015;23(1):22–29. <https://doi.org/10.3109/092737972.2014.1002622>.
- Magdalene D, Dutta P, Choudhury M, Deshmukh S, Gupta K. Clinical profile of nonstrabismic binocular vision anomalies in patients with asthenopia in North-East India. *TNOA J Ophthalmic Sci Res.* 2017;55(3):182. https://doi.org/10.4103/tjosr.tjosr_36_17.
- Franco S, Moreira A, Fernandes A, Baptista A. Accommodative and binocular vision dysfunctions in a Portuguese clinical

- population. *J Optom.* 2022;15(4):271–277. <https://doi.org/10.1016/j.optom.2021.10.002>.
24. García-muñoz Á, Carbonell-bonete S, Cantó-cerdán M., Cacho-martínez P. Accommodative and binocular dysfunctions: prevalence in a randomised sample of university students. Published online 2016;1–9. doi:10.1111/cxo.12376.
 25. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: systematic review and meta-analysis. *J Curr Ophthalmol.* 2018;30(1):3–22. <https://doi.org/10.1016/j.joco.2017.08.009>.
 26. Cacho-Martínez P, García-Muñoz Á, Ruiz-Cantero MT. Do we really know the prevalence of accommodative and nonstrabismic binocular dysfunctions? *J Optom.* 2010;3(4):185–197. [https://doi.org/10.1016/S1888-4296\(10\)70028-5](https://doi.org/10.1016/S1888-4296(10)70028-5).
 27. Wajuihian SO, Hansraj R. Vergence anomalies in a sample of high school students in South Africa. *J Optom.* 2016;9(4):246–257. <https://doi.org/10.1016/j.optom.2015.10.006>.
 28. Shrestha GS, Mohamed FN, Shaha DN. Visual problems among video display terminal (VDT) users in Nepal. *J Optom.* 2011;4(2):56–62. [https://doi.org/10.1016/S1888-4296\(11\)70042-5](https://doi.org/10.1016/S1888-4296(11)70042-5).
 29. Russell GE, Wick B. A prospective study of treatment of accommodative insufficiency. *Optom Vis Sci.* 1983;70(2):131–135.
 30. Cacho-Martínez P, García-Muñoz Á, Ruiz-Cantero MT. Is there any evidence for the validity of diagnostic criteria used for accommodative and nonstrabismic binocular dysfunctions? *J Optom.* 2014;7(1):2–21. <https://doi.org/10.1016/j.optom.2013.01.004>.
 31. Hashemi H, Nabovati P, Khabazkhoob M, et al. The prevalence of fusional vergence dysfunction in a population in Iran. *J Curr Ophthalmol.* 2021;33(2):112–117. https://doi.org/10.4103/JOCO.JOCO_61_20.
 32. Hokoda SC. General binocular dysfunctions in an urban optometry clinic. *J Am Optom Assoc.* 1985;56(7):560–562. <https://europepmc.org/article/med/4020010>.
 33. Franco S, Moreira A, Fernandes A, Baptista A. Accommodative and binocular vision dysfunctions in a Portuguese clinical population. *J Optom.* 2021;1–16. <https://doi.org/10.1016/j.optom.2021.10.002>. (November).
 34. Cantó-Cerdán M, Cacho-Martínez P, García-Muñoz Á. Measuring the heterophoria: agreement between two methods in non-presbyopic and presbyopic patients. *J Optom.* 2018;11(3):153–159. <https://doi.org/10.1016/j.optom.2017.10.002>.
 35. Daum KM. Accommodative dysfunction. *Doc Ophthalmol.* 1983;55(3):177–198. <https://doi.org/10.1007/BF00140808>.
 36. Scheiman M, Gallaway M, Coulter R, Reinstein F, Ciner E, C Herzberg MP. Prevalence of vision and ocular disease conditions in a clinical pediatric population. *J Am Optom Assoc.* 1996;67(4):193–202.
 37. García-Muñoz Á, Carbonell-Bonete S, Cantó-Cerdán M, Cacho-Martínez P. Accommodative and binocular dysfunctions: prevalence in a randomised sample of university students. *Clin Exp Optom.* 2016;99(4):313–321. <https://doi.org/10.1111/cxo.12376>.
 38. Cacho-Martínez P, Cantó-Cerdán M, Lara-Lacárcel F, García-Muñoz Á. Validation of the symptom questionnaire for visual dysfunctions (SQVD): a questionnaire to evaluate symptoms of any type of visual dysfunctions. *Transl Vis Sci Technol.* 2022;11(2):1–11. <https://doi.org/10.1167/tvst.11.2.7>.
 39. Cantó-Cerdán M, Cacho-Martínez P, Lara-Lacárcel F, García-Muñoz Á. Rasch analysis for development and reduction of symptom questionnaire for visual dysfunctions (SQVD). *Sci Rep.* 2021;11(1):1–10. <https://doi.org/10.1038/s41598-021-94166-9>.