Content available at: https://www.ipinnovative.com/open-access-journals

Indian Journal of Clinical and Experimental Ophthalmology

Journal homepage: www.ijceo.org

Original Research Article

An examination of the underlying causes of asthenopia in school-going children: A cross-sectional study

Nirmal Maity[1]*, Ashima Goyal[2], Renu Thakur[3], Navneet Sharma[4]

[1]Dept. of Optometry, P C Sharma Eye Hospital, Ambala, Haryana, India
[2]Dept. of Ophthalmology, P C Sharma Eye Hospital, Ambala, Haryana, India
[3]Dept. of Optometry, Centre for Research Impact and Outcome, Chitkara University, Punjab, India
[4]Dept. of Optometry, Chandigarh Pharmacy College, Chandigarh Group of Colleges, Jhanjeri, Mohali, Punjab, India

Abstract

Background: School-going children frequently report eye strain and headaches while reading or performing any near work.
Aim: An investigation into the underlying elements that are responsible for asthenopia is the purpose of the present study.
Materials and Methods: A hospital-based cross-sectional study was designed with school-aged children, ranging in age from seven to sixteen years old, who presented with active asthenopia symptoms being the participants. Each and every child was subjected to a full eye examination, which included a detailed history of asthenopia symptoms and screen usage, fogging and cycloplegic refraction, binocular vision evaluation, and the CISS questionnaire.
Result: Total of 140 school children were examined with mean age of 13.2 ± 2.7 years. Average number of symptoms in asthenopia child was 2.41 ± 1.13. Headache was found more common (78.57%) followed by ocular pain (50.71%), occasional blurriness (43.57%) and watering (31.43%). 6.25% child was found emmetrope. Among these, mild to moderate hyperopic error was more common (SH- 29.97%, SHA- 12.4%, CHA- 9.14%). CMA was found in 16.18%, MA was in 11.4% of the children. Average screen time was found 2.63 ± 2.01 hours/day. Mean CISS score was 15.96 ± 7.6 with a maximum 33 and a minimum value was 2. Accommodative anomalies were most common (37.5%) followed by CI (17.65%) and Difficulty to relax accommodation in 16.18%. Uncorrected refractive error (13.97%) and over corrected Myopia (7.35%) also shows significant asthenopia symptoms.
Conclusion: This study shows that screen time, refractive errors, and binocular vision anomalies are associated with asthenopia in school-aged children. The data imply that mild to severe hyperopic errors and accommodative anomalies are critical to asthenopia development and CISS questionnaire is a useful screening tool for asthenopia symptom's detection of school going students.

Keywords: Asthenopia, Binocular vision, NSBVD, Refractive error, Screen time.

Received: 10-10-2024; **Accepted:** 21-03-2025; **Available Online**: 09-06-2025

1. Introduction

Asthenopia is a subjective complaint involving the ocular system. These complaints primarily describe a variety of non-specific symptoms such as headache, ocular pain, occasional blurring of vision, diplopia, ocular strain, fatigue around the eyes, lacrimation, difficulty opening the eyes properly, and light sensitivity, among others. Most often, these symptoms manifest during work hours, but they can also manifest remotely. Depending on the cause it can be refractive asthenopia, asthenopia due to binocular vision anomalies, photogenous asthenopia, muscular asthenopia or nervous asthenopia. Previous studies have shown that the prevalence of asthenopia varies across different countries. Vilela MAP et al shows a prevalence of around 19.7% among Indian schoolchildren in 2015.[1] Also, Hashemi H et al shows that asthenopia in Australian, Swedish, and Indian schoolchildren ranges from 12.6% to 32.2%.[2] S. Abdi et al. study found a prevalence of 23% among schoolchildren. Asthenopia is mostly a common symptom among computer users (64–90%).[3,4] In the post-COVID era, children's modern lifestyles, including schooling, tuition, homework, and mobile phone use, have led to a significant increase in screen use and near-activity. In paediatric OPD, many parents come with

*Corresponding author: Nirmal Maity
Email: nirmal78720@gmail.com

https://doi.org/10.18231/j.ijceo.2025.059

asthenopic symptoms in their children, which impact their educational performance at school, in tuition, or at home. Only a small percentage of these children actively use screens. According to the Binocular vision anomalies normative data (BAND) study 31.5% of schoolchildren in urban areas and 29.6% in rural areas have Non-Strabismic Binocular vision disorder (NSBVD). So, beyond the use of screens, NSBVD has a huge impact on schoolchildren. Binocular vision evaluation primarily evaluates NSBVD, yet it often overlooks cases of asthenopia in schoolchildren. The Convergence Insufficiency Treatment Trial Group (CITTG) developed a Convergence Insufficiency Symptoms Survey (CISS) questionnaire to quantitatively evaluate the patients Convergence Insufficiency (CI). Also, uncorrected refractive error is a major link to asthenopia because it lowers visual efficiency and is a cause of binocular vision problems like Accommodative Insufficiency (AI), CI, and heterophoria. Children with eye strain are known to experience hypermetropic errors more frequently.[5,6] Astigmatism ranks as the second most common type of refractive error among children with asthenopia. In India, to manage these patients with asthenopia, the most commonly used options are screen time management, blue light filter protection, the 20-20-20 rule, and lubricating eye drops, which are effective in a few cases but not in many. Routine eye examinations to ensure refractive error and binocular vision anomalies, along with vision therapy, are more effective in treating asthenopia.[7-10] Therefore, the current study seeks to identify all potential factors that contribute to asthenopia in school-aged children. The main objectives of this study was to assess and evaluate the refractive errors along with binocular vision anomalies among the school going children with asthenopic symptoms and also to correlate the average screen time with the Convergence insufficiency symptoms survey questionnaire and other parameters.

2. Materials and Methods

This was an cross sectional study conducted at P C Sharma Eye Hospital, a tertiary eye care centre in Ambala City, Haryana, India, within a time period of January, 24 to April, 24. Ethical clearance was taken from Institutional ethics committee of Chitkara University approved the study (Approval No. – EC/NEW/INST/2024/531/269) to conduct at P C Sharma Eye Hospital. Random sampling method was used where expected proportion was taken 24.7%,[17] with 5% Confidential Interval (d). OPD patients, who complained of Asthenopia, aged in between 7-16 years and has visual acuity of 6/9 or better then 6/9 (0.02 in Log Mar), and were responsive to all required tests, were included in the study. Also, Parents were informed about the need to fill the CISS questionnaire, those who agreed and were able to dedicate extra time to answer it, were only included. Students undergoing any ocular or vision therapy, having alternate tropia (>10PD) or constant tropia, any neurologic or developmental disorder, other ocular pathologies like dry eyes, posterior and anterior segment anomalies were excluded from the study. Also, if the difference between dry acceptance and cycloplegic refraction values was more than 1.00 D were excluded from study. Informed consent was taken from the parents of all students. All required evaluation and test were conducted in paediatric OPD with calibrated instrument. Topcon KR 800 Autorefractor, Welch Allyn retinoscopy, 3-meter calibrated LED Log Mar visual acuity chart, Trial set were used for Visual acuity and refraction. A set of orthoptics tool including Royal Air Force (RAF) ruler, centimetre scale, Gullstrand stick with linear target, Monocular Estimation Method (MEM) card, accommodative flipper (AF) (±2.00D), vergence flipper (VF) (12 prism diopter base out with 3 Prism diopter base-in), horizontal prism bar and translucent occluder are used for Binocular Vision (BV) evaluation. For cycloplegic refraction, cyclopentolate 1% along with tropicamide 0.8% and phenylephrine 5% were used.

2.1. Examination procedure

Non-contact tonometry and auto refractometer were used as initial examination. Details history of screen uses and asthenopic symptoms like Ocular pain, diplopia, headache, occasional blurring of vision, lacrimation, ocular strain, light sensitivity and unable to keep eyes open, are noted. Followed by parents and child are asked to fill the questionnaire and also explained to parents about the questions. Comprehensive eye examination including retinoscopy, Borish delayed subjective acceptance, anterior segment and undilated posterior segment evaluation were undergone next. Binocular vision evaluation includes Worth four dot test (WFDT), Cover test, Prism bar cover test (PBCT), accommodation test (NPA, AA, NRA, PRA, AF), Vergence test (NPC, NFV, PFV, VF) were performed. As per these findings, Non - Strabismic Binocular Vision dysfunction (NSBVD) was diagnosed and child were sent to instil eye drops for cycloplegic refraction. After 45-50 min, cycloplegic refraction was performed, if the difference between cycloplegic refraction and dry acceptance was found >1.00D, they are asked to come for post - mediatric test (PMT), and excluded from study. As per the final refraction, refractive error diagnosis was made. CISS scoring was done. If the score found ≥16, they were identified as convergence Insufficiency. Detail methodology is represented in **Figure 1**. Statistical analysis of Refractive error, Binocular vision evaluation, screen time and CISS questionnaire score, by using SPSS version 27 software. Pearson's correlation (r) and Mann- Whitney U test was performed to correlate and compare the value. Descriptive statistics were used with 95% confidential interval for explanation of data.

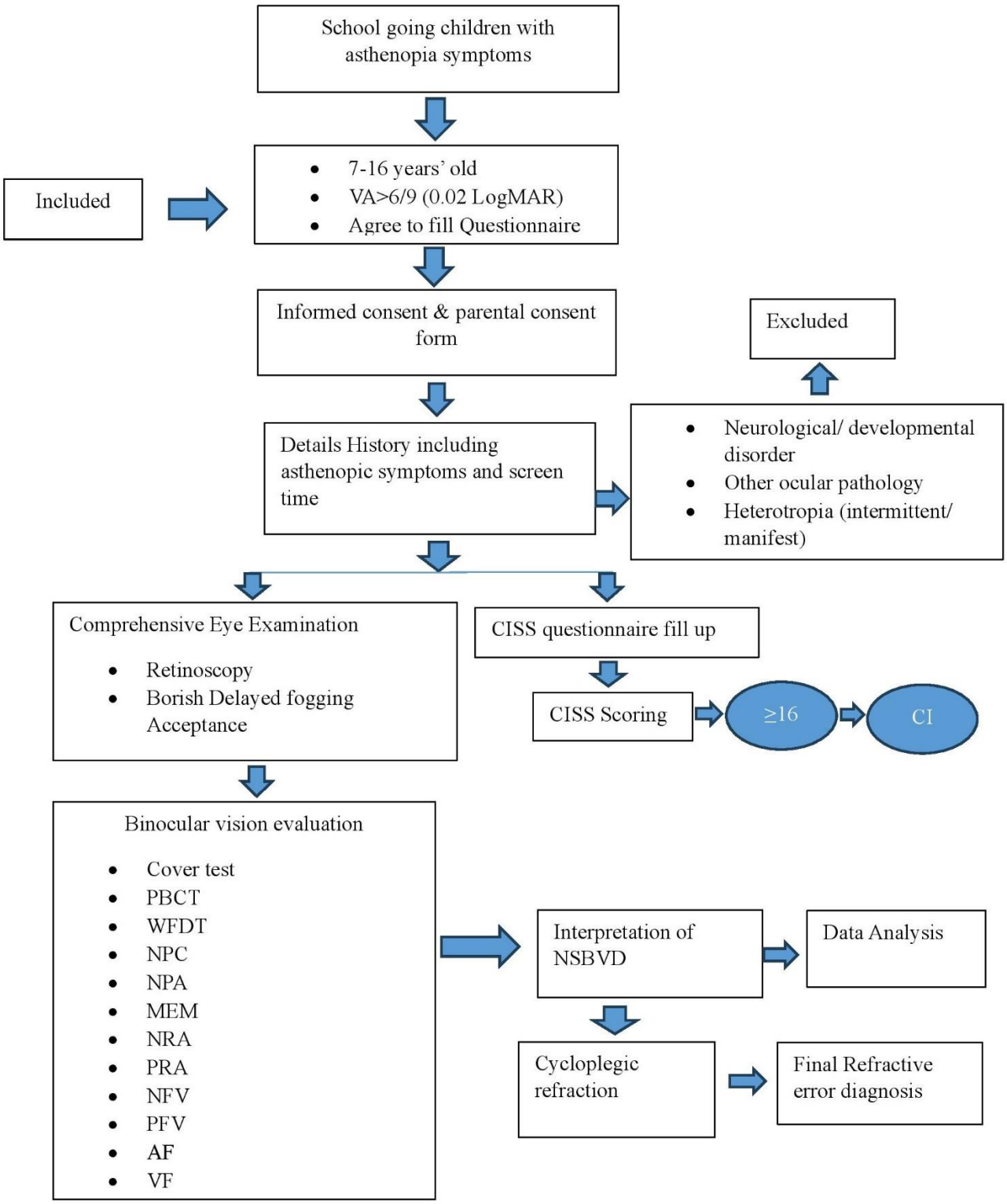

Figure 1: Illustrate stepwise methodology, all the test conducted for school going students, came with complain of asthenopia

3. Results

A total of 140 participants with active asthenopic symptoms are evaluated with mean age of 13.2 ± 2.7 years. 70% (n=98) were female and 30% (n=42) were male. No such difference in the number of symptoms between males and females (Z= 1.84, p = 0.065, not significant at p<0.05). Mean number of symptoms per child with asthenopia was 2.41 ± 1.13. Only one symptom was found in 23.53% (n= 32) of subject, at least two symptoms were in 31.62% (n= 43), at least three symptoms in 30.15% (n =41) and more than three symptoms were found in rest 14.07% of subject. Headache was more common (78.75%, n= 110) followed by Ocular Pain (50.71%, n=71), Occasional blurriness (43.57%, n= 61), watering (31.43%, n=44), Ocular strain (21.43%, n=2), light sensitivity (9.23%, n =13), unable to open eyes (3.57%, n= 5) and diplopia (1.43%, n=2). Visual acuity was good or normal

among most. 40% among these subjects were presented with a history of using spectacle. Rest 60% never used spectacle. Mean presented visual acuity was 0.02 Log Mar. Refractive error was most commonly found among asthenopic subject except 6.25%, who were emmetrope. Simple Hyperopic (SH) error was commonly found refractive error (29.97%), although Astigmatism (including hyperopic and myopic) was most prevalent among refractive error (CMA= 16.18%, SHA= 12.4%, CHA= 9.14%, MA= 11.4%, SMA =7.66%). Simple Myopia (SM) was found in 6.57% of subject (**Table 1**).

Over corrected myopia (7.35%) and anisometropia (2.2%) also found as a significant factor in these subjects. Noticeably 37.14% of children with no screen time or minimum screen time (≤1.0 hour) were also presented with asthenopic symptoms along with refractive error and Binocular vision anomalies. Mean screen time was 2.63 ± 2.01 hours/day. A weak positive correlation found in between screen time and asthenopic symptoms (r= 0.1835, p=0.032, significant at p<0.05) (**Table 2**). However, a significant number of subjects were also found with high number of symptoms with low screen uses (**Figure 2**).

Table 1: Percentages of refractive error among asthenopic school going students.

Refractive error	**No of Eyes (n) (N= 280)**	**Percentage (%)**
Simple Hyperopia (SH)	84	29.93
Compound Hyperopic Astigmatism (CHA)	25	9.12
Simple Myopia (SM)	18	6.57
Simple Myopic Astigmatism (SMA)	21	7.66
Simple Hyperopic astigmatism (SHA)	35	12.41
Compound Myopic Astigmatism (CMA)	46	16.18
Mixed Astigmatism (MA)	33	11.4

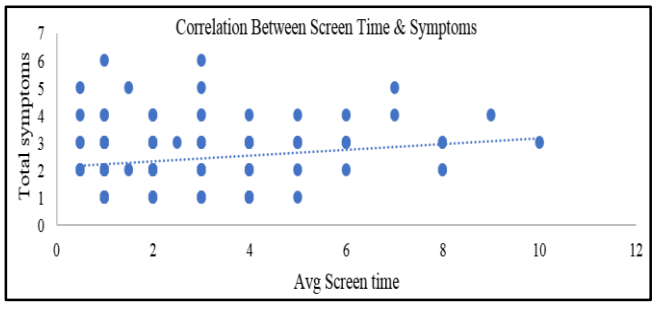

Figure 2: Illustrate *c*orrelation between average screen time and total no of symptoms

CISS questionnaire scoring shows a mean value of 15.96 ± 7.6 with maximum value of 33 and minimum value of 2. According to questionnaire around 43.57% subject shows CI. Correlation between CISS score and Screen time shows a negative correlation at p<0.05 (r= 0.1431, p= 0.965) (**Table 3**). Although strong positive correlation was found between CISS score and number of symptoms (r= 0.443948, p=<0.00001, significant at p<0.05) (**Figure 3**, **Table 2**).

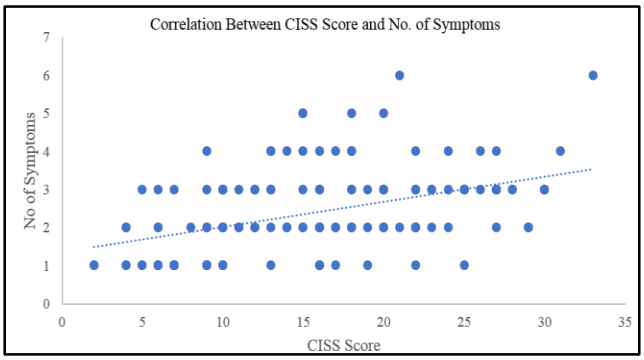

Figure 3*:* Illustrate *c*orrelation between No of symptoms and CISS Score

Table 2: Correlation of no of symptoms with age, CISS score and screen time at p<0.05.

	No of Symptoms	
	r	p
Age	0.22023	<0.00001
CISS Score	0.44395	<0.00001
Screen Time	0.1835	0.032484

r = Pearson's Correlation Coefficient, CISS- Convergence Insufficiency Symptoms Survey,

Table 3: Correlation between screen time and CISS score and near exophoria at p<0.05.

	Screen Time	
	r	**p**
CISS Score	0.143125	0.096517
Near exophoria	0.069771	0.419394

Exophoric deviation was found in 19.85% of subject for distance and 61.02% of subject for near. Mean exophoria for distance was 0.6 ± 1.4 PD and for near it was 2.9 ± 3.2 PD. Only one subject was found with esophoria for near who was diagnosed accommodative excess. Although it has no significant correlation with screen time (**Table 3**). Where WFDT shows no suppression or diplopia. Mean Binocular vision evaluation parameters are showed in **Table 4** and compared with normative data for children as per BAND study of 2017.[26] Which shows slightly reduced amplitude of Accommodation (AA), distance and near negative fusional vergence (NFV), Accommodative facility (AF) and Vergence facility (VF).

Table 4: Binocular vision anomalies data of present study and binocular vision anomalies normative data (BAND) study27

Evaluation test		BV data (Mean) Present Study	BAND study data
NPC (cm)		5.86 ± 3.33	3 ± 3
NPA (cm)	OD	7.34 ± 4.01	13 ± 3 (7-10 Y)
	OS	7.38 ± 4.02	11 ± 2 (11-17Y)
	OU	6.74 ± 2.52	13 ± 3 (7-10 Y)
MEM (D)	OD	+0.57 ± 0.4	+0.4 ± 0.2
	OS	+0.6 ± 0.4	+0.4 ± 0.2
NRA (D)		+2.46 ± 0.53	
PRA (D)		-2.99 ± 0.85	
NFV (PD) (Distance)	Blur	4.0 ± 3.0	
	Break	6.44 ± 3.1	8 ± 2
	Recovery	4.39 ± 3.0	6 ± 2
NFV (PD) (Near)	Blur	9 ± 3.5	
	Break	15.3 ± 4.4	15 ± 4
	Recovery	12.9 ± 3.7	11 ± 4
PFV (PD) (Distance)	Blur	12.71 ± 3.5	
	Break	17.75 ± 7.1	17 ± 8
	Recovery	14.86 ± 6.2	12 ± 7
PFV (PD) (Near)	Blur	19.92 ± 5.5	
	Break	28.19 ± 9.5	26 ± 10
	Recovery	23.42 ± 8.5	21 ± 10
VF (CPM)		12.64 ± 2.57	14 ± 4
AF (CPM)	OD	8.94 ± 3.04	11 ± 4 (7-12 Y)
	OS	8.99 ± 2.91	14 ± 5 (13-17 Y)
	OU	9.02 ±3.02	10 ± 4 (7-12Y)

Table 5: Findings of binocular vision anomalies on asthenopic children

BV anomalies	Percentage (%)	No of child (n) N=140
Accommodative anomalies	37.5	52
CI	17.65	24
AI with CI	2.94	4
IXT	5.15	7
Over corrected Myopia	7.35	10
Reduce NFV	8.09	11
FVD	1.47	2
AI	6.62	9
Diff to relax Acc/ Acc excess	16.18	22
Near Eso	0.74	2
WNL	19.84	29

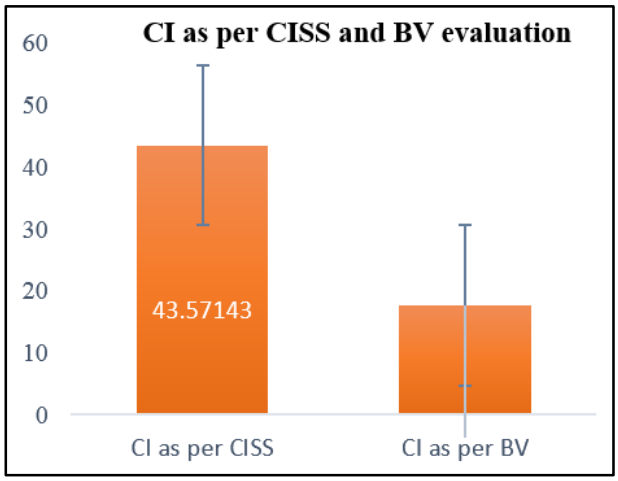

Figure 4: Illustrate convergence insufficiency (CI) found in CISS scoring and binocular vision evaluation.

Although it was difficult to comment on NSBVD as diagnosis factors are not directing to any one anomaly (**Table 5**). Overall accommodative anomalies were found in most of the subjects (37.5%, n= 51) where NPA, NRA, PRA and monocular AF were not in normal range or not correlating with one another. Around 16.18% (n= 22) subject was found

only difficulty to clear plus lens in AF without other characteristics of Accommodative excess, those are categorized as 'difficulty to relax Accommodation'. CI was found in 17.65% (n=24) which was less as compared to CI found in CISS questionnaire (**Table 4**). AI was diagnosed in 6.62% (n= 9) of subject. Reduced NFV (8.08%, n= 11) was also found as one of the significant factors which affecting asthenopia (**Table 5**).

4. Discussion

Most of the pediatric population nowadays are suffering from asthenopic symptoms due to the increased screen time and less outdoor activity. Presentation of these symptoms may vary across different age group of children. As we have seen in our data, among 140 children, females (70%) were more prone to asthenopia than males (30%). Majority of children were found with two (31.62%) to three (30.15%) symptoms of asthenopia. Hashemi et al reported a prevalence of having two, three and four symptoms among 24.9%, 14.4% and 9.1% of child and males being more prone to asthenopia (62.8%). Refractive error was found as one of the major contributing factors in asthenopic symptoms like headache[7] followed by ocular pain, occasional blurring of vision, watering and ocular strain. Although tearing and ocular pain was found as commonest in the study by V. Gupta et al.[11] However, in our study, simple hyperopic error was most common (29.93%), followed by compound myopic astigmatism (16.18%), Simple hyperopic astigmatism (12.41%), mixed astigmatism (11.4%) and only 6.25% child was emmetropic. Majority of children having asthenopic symptoms found with near exophoria (61.02%) more than distance exophoria (19.85%). Around 60.9% near horizontal phoria and 71.6% mild hyperopic error was found in Manual AP Vilela's[17-20] study of 'Asthenopia in Schoolchildren'. Uncorrected hyperopic error and near exophoria leads to worsening of near visual acuity, stereopsis and accommodative response which can impact to accommodative convergence interaction during near work and cause asthenopic symptoms.[8-12] This study shows accommodative anomalies as most common binocular vision anomalies among asthenopic schoolchild. Most of them were felt difficulty to clear with plus lens in accommodative facility. Convergence insufficiency was found as second major binocular vision anomalies. Although Normal BV parameters found in 19.84% of child. J R Hussaindeen et al found a prevalence of NSBVD among urban children was 31.5%, where convergence insufficiency was most common.[5] Whereas D Rao found lack of clear information regarding prevalence of NSBVD specially among asthenopic child.[14] Mean screen time was 2.63 hours/day which was less than previous several studies.[11-22] Whereas no specific outdoor activity was also noted among these children. More near centric activity may one of the major reasons towards poor BV parameters among children. Padavettan C et al showed a significant reduction of BV parameter value after continue 30 min of near work. Clinical CI found less in number compared to CI found with CISS questionnaire that means CISS questionnaire give high false positive and poor sensitivity rate. CISS questionnaire can't be used as screening tool for university student. In children, because of false positivity, it's still a question.[31-34]

5. Conclusion

The study on asthenopia in schoolchildren concluded that the refractive errors primarily caused headaches and ocular pain. Incorrect binocular vision and screen time also contribute to asthenopia. Comprehensive eye exams and vision treatment are crucial for controlling and preventing these symptoms. Tertiary eye care hospitals should use the CISS questionnaire to measure the effects of symptoms in children with active asthenopia and perform detailed ocular investigations on students with asthenopic symptoms.

6. Research Gap

A very few studies which is hospital and clinics based has been done to find out various possible factors that affects various asthenopic symptoms among school going children in especially in northern India.

7. Limitations & Future Prospective

As proper prevalence of asthenopia in Haryana especially in Ambala region are not found in the previous studies, but to found an exact factors among all the population with asthenopic symptoms are limited to 140 subjects only. Screen time was noted as per the history of parents, no specific prove or surety related to this was not considered during data collection. Few subjects (specially aged <10 years) are not aware of the proper symptoms when filling convergence insufficiency symptom survey (CISS) questionnaire, so answer of few questions of questionnaire may vary in case of few subjects. Other few factors like psychological or environmental factors are not considered in our study which also can cause headache like symptoms. Although for children these factors are less affective but cannot neglect. A larger sample will assist understand all factors. Screen use history and CISS questionnaire score can vary due to poor child/parent responses. Psychological and environmental factors that may cause asthenopia are ignored. Although more research is needed to determine the optimal asthenopia treatment for schoolchildren.

Despite these limitations, the result of this study may help to spread an awareness to optometry and ophthalmology practitioner as well as parents, against, neglecting asthenopic symptoms, use of screen for children's time spending, less outdoor activity and most Importantly to add binocular vision evaluation and proper refractive error correction as a evaluation process for a child with asthenopia.

8. Ethical No.

EC/NEW/INST/2024/531/269.

9. List of Abbreviations

BV: Binocular Vision; OPD: Out Patient Department; BAND: Binocular Vision Anomalies Normative Data; NSBVD: Non Strabismic Binocular Vision Disorder; CI: Convergence Insufficiency; AI: Accommodative Insufficiency; AE: Accommodative Excess; CE: Convergence Excess; FVD: Fusional Vergence Dysfunction; CISS: Convergence Insufficiency Symptoms Survey; CITTG: Convergence Insufficiency Treatment Trial Group; NPC: Near Point of Convergence; NPA: Near Point of Accommodation; NFV: Negative Fusional Vergence; PFV: Positive Fusional vergence; DES: Digital Eye strain; RAF: Royle Air Force; PD: Prism Diopter; BO= Base Out, BI: Base In; MEM: Monocular Estimation Method; NRA: Negative Relative Accommodation; PRA: Positive Relative Accommodation; RE: Right Eye, LE: Left eye; SH: Simple Hyperopia; CHA: Compound Hyperopic Astigmatism; CMA: Compound Myopic astigmatism; MA: Mixed Astigmatism; SM: Simple Myopia; SHA: Simple Hyperopic Astigmatism; SMA: Simple Myopic Astigmatism; AF: Accommodative Facility; VF: Vergence Facility; CPM: Cycles Per Minute; Eso: Esophoria; Exo: Exophoria; IXT: Intermittent Exotropia.

10. Source of Funding

No Funding.

11. Conflict of Interest

There is no conflict of interest.

12. Acknowledgement

All Authors are acknowledged to P C Sharma Eye Hospital, Ambala, Haryana for allowing to conduct this study.

References

1. Vilela MAP, Pellanda LC, Fassa AG, Castagno VD. Prevalence of asthenopia in children: A systematic review with meta-analysis. *J Pediatr (Rio J)*. 2015;91(4):320–5.
2. Hashemi H, Khabazkhoob M, Forouzesh S, Nabovati P, Yekta AA, Ostadimoghaddam H. The prevalence of asthenopia and its Determinants among schoolchildren. *J Compr Pediatr*. 2017;8(1):e43208.
3. Abdi S, Rydberg A. Asthenopia in schoolchildren, orthoptic and ophthalmological findings and treatment. *Doc Ophthalmol*. 2005;111(2):65–72.
4. Mohan A, Sen P, Shah C, Jain E, Jain S. Prevalence and risk factor assessment of digital eye strain among children using online e-learning during the COVID-19 pandemic: Digital eye strain among kids (DESK study-1). *Indian J Ophthalmol*. 2021;69(1):140–4.
5. Hussaindeen JR, Rakshit A, Singh NK, George R, Swaminathan M, Kapur S, et al. Prevalence of non-strabismic anomalies of binocular vision in Tamil Nadu: report 2 of BAND study. *Clin Exp Optom*. 2017;100(6):642–8.
6. Scheiman M, Mitchell GL, Cotter S, Kulp M, Rouse M, Hertle R, et al. The convergence insufficiency treatment trial: Design, methods, and baseline data. *Ophthalmic Epidemiol*. 2008;15(1):24–36.
7. Wajuihian SO. Frequency of asthenopia and its association with refractive errors. *Afri Vis Eye Health*. 2015;74(1):e293.
8. Jenny JM, Robaei D, Kifley A, Wang JJ, Rose KA, Mitchell P. Prevalence of Hyperopia and Associations with Eye Findings in 6- and 12-Year-Olds. *Ophthalmology*. 2008;115(4)678–85.
9. Abuallut I, Qumayi EA, Mohana AJ, Almalki NM, Ghilan ME, Dallak FH, et al. Prevalence of Asthenopia and Its Relationship with Electronic Screen Usage During the COVID-19 Pandemic in Jazan, Saudi Arabia: A Cross-Sectional Study. *Clin Ophthalmol*. 2022;16:3165–74.
10. Ichhpujani P, Singh RB, Foulsham W, Thakur S, Lamba AS. Visual implications of digital device usage in school children: A cross-sectional study. *BMC Ophthalmol*. 2019;19(1):76.
11. Gupta V, Bhatti A. Prevalence of Eye Disorders in Children Presenting In Outpatient Department with Asthenopia. *Int J Med Biomed Stud*. 2019;3(5):227–31.
12. Mavi S, Chan VF, Virgili G, Biagini I, Congdon N, Piyasena P, et al. The Impact of Hyperopia on Academic Performance Among Children: A Systematic Review. *Asia Pac J Ophthalmol (Phila)*. 2022;11(1):36-51.
13. Thakur M, Panicker T, Satgunam PN. Refractive error changes and associated asthenopia observed after COVID-19 infection: Case reports from two continents. *Indian J Ophthalmol*. 2023;71(6):2592–4.
14. Rao D. Prevalence of Non Strabismic Binocular Vision Disorders in Patients with Asthenopia. *J Multidiscip Res Healthcare*. 2014;1(1):33–41.
15. Convergence Insufficiency symptom survey (CISS). https://www.sankaranethralaya.org/pdf/patient-care/Convergence-Insufficiency-Symptom-Survey.
16. Simon C, Paul S. Prevalence and determinants of digital eye strain among school children during the COVID-19 pandemic. *Int J Community Med Public Health*. 2021;9(1):7.
17. Vilela MAP, Castagno VD, Meucci RD, Fassa AG. Asthenopia in schoolchildren. *Clin Ophthalmol*. 2015;9:1595–603.
18. Hashemi H, Saatchi M, Yekta A, Ali B, Ostadimoghaddam H, Nabovati P, et al. High prevalence of asthenopia among a population of university students. *J Ophthalmic Vis Res*. 2019;14(4):474–82.
19. Wajuihian SO. Characteristics of astigmatism in Black South African high school children. *Afr Health Sci*. 2017;17(4):1160–71.
20. Sheppard AL, Wolffsohn JS. Digital eye strain: Prevalence, measurement and amelioration. *BMJ Open Ophthalmol*. 2018;3:e000146.
21. Li L, Zhang J, Chen M, Li X, Chu Q, Jiang R, et al. Contribution of Total Screen/Online-Course Time to Asthenopia in Children During COVID-19 Pandemic via Influencing Psychological Stress. *Front Public Health*. 2021 Dec 1:9:736617.
22. Junghans BM, Azizoglu S, Crewther SG. Unexpectedly high prevalence of asthenopia in Australian school children identified by the CISS survey tool. *BMC Ophthalmol*. 2020;20(1):408.
23. Xu Y, Deng G, Wang W, Xiong S, Xu X. Correlation between handheld digital device use and asthenopia in Chinese college students: a Shanghai study. *Acta Ophthalmologica*. 2019;97(3):e442–7.
24. Griffin JR, Grisham JD. BOOK REVIEWS Binocular Anomalies: Diagnosis and Vision Therapy, 4th Ed [Internet]. 2005. Available from: http://journals.lww.com/optvissci
25. Nguyen E, Inger H, Jordan C, Rogers D. Ocular Causes for Headache. Vol. 40, Seminars in Pediatric Neurology. W.B. Saunders; 2021.
26. Hussaindeen JR. Binocular Vision Anomalies and Normative Data (BAND) in Tamilnadu-Study Design and Methods [Internet]. 2015. Available from: https://www.researchgate.net/publication/296679349
27. Abdi S, Lennerstrand G, Pansell T, Rydberg A. Orthoptic findings and asthenopia in a population of Swedish schoolchildren aged 6 to 16 years. *Strabismus*. 2008;16(2):47–55.
28. Nunes AF, Monteiro PML, Ferreira FBP, Nunes AS. Convergence insufficiency and accommodative insufficiency in children. *BMC Ophthalmol*. 2019 Feb 21;19(1):58.
29. Chandra P, Akon M, Non-Strabismic Binocular Vision Abnormalities. *J Ophthalmol Vis Sci*. 2016;1(1):1006.

30. Jenny JM, Robaei D, Rochtchina E, Mitchell P. Prevalence of Eye Disorders in Young Children With Eyestrain Complaints. *Am J Ophthalmol*. 2006;142(3):495–7.
31. Padavettan C, Nishanth S, Vidhyalakshmi S, Madhivanan N, Madhivanan N. Changes in vergence and accommodation parameters after smartphone use in healthy adults. *Indian J Ophthalmol*. 2021;69(6):1487–90.
32. Pang Y, Teitelbaum B, Krall J. Factors associated with base-in prism treatment outcomes for convergence insufficiency in symptomatic presbyopes. *Clin Exp Optom*. 2012;95(2):192–7.
33. Rouse MW, Borsting EJ, Lynn Mitchell G, Scheiman M, Cotter SA, Cooper J, et al. Validity and reliability of the revised convergence insufficiency symptom survey in adults. Ophthalmic Physiol Opt. 2004;24(5):384–90.
34. Horwood AM, Toor S, Riddell PM, Horwood A. Screening for convergence insufficiency using the CISS is not indicated in young adults. *Br J Ophthalmol*. 2014;98(5):679–83.
35. Lin N, Zhu Y, Wu X, Yang M, Lu F, Deng R. Prevalence and determinants of asthenopia among ophthalmologists in China: a national cross-sectional survey. *Front Public Health*. 2023;11:1290811.

Cite this article: Maity N, Goyal A, Thakur R, Sharma N. An examination of the underlying causes of asthenopia in school-going children: A cross-sectional study. *Indian J Clin Exp Ophthalmol*. 2025;11(2):336–343.