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Original Research Article

Study of prevalence of non-strabismic binocular vision anomalies in a tertiary centre: An important but often forgotten cause of ophthalmic headache

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ABSTRACT

Aim: To study the presence of non strabismic binocular vision anomalies in young patients presenting with headache.

Materials and Methods: A prospective, non-interventional study of 110 patients was conducted for a period of one year in our tertiary eye care institute after obtaining informed consent and taking into consideration the inclusion and exclusion criteria. Patients presenting with asthenopic symptoms were subjected to thorough ophthalmic examination. After excluding refractive errors, patients were further subjected to detailed orthoptic evaluation (including accommodation and convergence assessment). Other non-ocular causes of headache were ruled out by appropriate referrals.

Results: Out of 110 patients, 33% were found to have accommodative insufficiency, 14% were having convergence insufficiency and 4% showed both accommodative and convergence insufficiency. 49% patients showed no extraocular muscle imbalance and were referred to relevant specialities for further evaluation.

Conclusion: It is important to perform a thorough evaluation of patients presenting with headache for the presence of non strabismic binocular vision anomalies after ruling out other ophthalmic causes.

1. Introduction

Non strabismic binocular vision anomalies [NSBVA] are a major problem in children and young adults in this era of gadgets. NSBVA is second most common ophthalmic condition reported worldwide next to refractive errors. It occurs when accommodation and vergence mechanisms of the eye are not synchronous and overwhelmed. NSBVA is broadly categorised as accommodative and vergence dysfunctions.[1,2] Various classifications were proposed by Donders initially and later by Duane's, Scheiman, and Wick's modification of Duane's classification. It includes 4 categories of NSBVA which include Binocular anomalies, vertical anomalies, Accommodative anomalies, and oculomotor anomalies. The accommodative anomalies include Insufficiency of accommodation, Ill-sustained accommodation, Inertia of accommodation or accommodative infacility and Excessive accommodation.[3] The presence of NSBVA affects the performance of near activities, stereopsis, and academic performance of school children.[4]

If not treated timely, it can decompensate to strabismus.Patients commonly present with headache, blurring of vision for distance or near, double vision and asthenopia.[5,6] NSBVA is one of the major causes of

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headache of ocular origin. Other ocular causes of headache include uncorrected or change in refractive errors, keratitis, uveitis, and angle closure glaucoma. Non ocular causes of headache can be secondary to neurological or other systemic conditions and sinusitis.

Due to prolonged near requirements in children and young adults, NSBVA needs to be promptly diagnosed and suitably managed lest it can affect the scholastic performance. Hence the study was taken up to screen the patients presenting with headache for the presence of NSBVA.

2. Materials and Methods

A prospective, non-interventional, hospital-based study of 110 patients aged between 9-45 years was conducted over a period of 1 year in our tertiary eye care institute after obtaining prior informed consent from patients to participate in the study and approval from institutional ethics committee. Patients with pre-existing refractive errors, amblyopia, squint, anterior and posterior segment disorders, accommodative spasm [neurological/stress related], head injury, intellectual disability, and other multiple systemic disabilities were excluded from the study. Patients presenting with asthenopic symptoms like headache, eye strain, double vision and watering of eyes in the outpatient department were referred to Strabismus clinic for refraction and orthoptic assessment (including accommodation and convergence assessment). Patients were first assessed for visual acuity and refraction [cycloplegic refraction wherever required- homatropine hydrobromide 2% eye drops for children less than 12 years; diluted homatropine hydrobromide eye drops for infants; atropine sulphate 1% eye ointment for children not achieving adequate cycloplegia with homatropine eye drops]. Those found to have refractive error were prescribed spectacles and advised follow up. Those without refractive errors were included in the study and subjected to further orthoptic assessment to detect the presence of NSBVA. Parameters assessed in orthoptic assessment included Bagolini striated glass test for Binocular single vision and Stereopsis test with TNO [The Netherlands Organisation] book and red and green glasses, Cover uncover tests for distance and near to detect presence of phoria, Near point of Accommodation [NPA], Near point of Convergence [NPC] and Accommodative Amplitude with RAF [Royal Airforce] ruler, accommodative facility test and Fusional vergence amplitudes with Prism bar for distance and near fixation.

Bagolini striated glass test is a minimally dissociative test for retinal correspondence and thereby binocular single vision. It consists of striated plain glasses in the frame oriented at 45 and 135 degrees. Patient is told to fixate the penlight and report the pattern of line images seen. Normal retinal correspondence is present if cross pattern across the central spotlight is reported with no deviation detected on cover tests.

Stereopsis was checked with patient wearing red and green glasses at 35cm distance. The book was held vertically in front of patient's eyes and patient was instructed to identify the orientation of missing pie in the book binocularly. The stereopsis was quantified based on the number of plates correctly recognised by the patient. Normal range of stereopsis is 30-40 seconds of arc.

Cover- uncover test was done to detect the presence of phoria [latent strabismus]. It was done with Spielman occluder and accommodative targets at 33cm and 6m fixation distance. One eye was covered for 3 to 4 seconds and uncovered. Any recovery movement was noted in that eye. It was similarly done for the other eye and findings recorded for both distance and near fixation.

NPA was measured with RAF ruler. The cheek rests of the ruler were placed on patient's cheeks and held at slightly depressed reading position. The carrier housing the various condensed reading optotypes is slowly moved close to the patient's eyes from one end of the ruler and the point noted when the patient reports first blur. It was done binocularly and monocularly and result recorded in centimetres. The reciprocal of blur point was taken as a measure of accommodative amplitude in dioptres. The normal values of NPA vary with age.

NPC was measured with RAF ruler. The patient was told to fixate a line target with central dot on the carrier. It was progressively brought close to patient's eyes and point noted when he perceived the line double. NPC was recorded in centimetres. The test was repeated 2-3 times for any variations in the response. The normal NPC was taken as less than or equal to 10cm.

Accommodative amplitude was calculated by the Hoffstetter's formula 15-(0.25x patient's age in years) or by taking inverse of Near point of accommodation, which is expressed in meters. Normal range was taken to between 12-18 dioptres.

The Fusional vergence amplitudes were measured using prism bar and accommodative targets for near[33cm] and distance[6m] fixation distance. To assess the Positive Fusional vergence [PFV] amplitudes, base out prism of the prism bar was placed in front of one eye and an accommodative target shown. Slowly, the prism strength was increased till the point the patient perceived doubling [break point]. This was recorded in prism dioptres as the strongest convergent power of prisms through which patient could maintain binocular single vision for distance and near as fusional convergence amplitudes. The normal PFV range for near is 35-40PD and for distance 15PD.

The facility of Accomodation measures the ability of swiftness of accommodative response to visual blur and was measured using +/-2D flipper lens. The plus side of flipper lens relaxes accommodation and minus side stimulates accommodation. It is tested at 35cm distance monocularly

with best corrected visual acuity in place in well illuminated room. Patient holds the reading material in non-dominant hand and flipper lens in dominant hand. The patient was instructed to read the words through the flipper lens by swiftly flipping the plus and minus sides [by ensuring clarity of words before each flip]. The number of flips done in one minute was recorded as cycles per minute. Two consecutive flips constitute one cycle. The normal value of accommodative facility monocularly is 10 cycles per minute and binocularly 8-12cpm.

To measure the Fusional divergence amplitudes [NFV], prism bar was placed base in and recorded as above for both near and distance fixation. The normal NFV for near is 15PD and for distance is 5-7 PD.

Ocular motility examined included ductions [monocular eye movements], versions [binocular eye movements] and vergence[convergence].

After detailed orthoptic assessment, if NSBVA was ruled out, the patients were referred to appropriate speciality departments for further evaluation of headache.

The data obtained was plotted on Excel spread sheet and analysed using descriptive statistics.

3. Results

A total of 110 patients presenting with headache were screened for presence of NSBVA. The mean age of these subjects was 23.80 ± 5.1 years (range 6 to 45 years). In our study, 72 (65.5%) of them were females and 38 (34.5%) were males. 79 [71.8%] patients had headache, 11[10%] eyestrain and 20[18.2%] patients had intermittent blurring of vision as presenting complaints.

97.3% of patients recorded only gross stereopsis [less than 240 seconds of arc] and 2.7% had better than 120 seconds of arc on testing with TNO book and red and green glasses. 50% [55 patients] had exophoria for near fixation on Cover- uncover tests. 94.6% of patients had NPC farther than 10cm and 5.4% had NPC less than 10cm on measuring with RAF ruler. Mean NPC was 10.94 ± 2.807. The mean NPA was 12.55 cm with a standard deviation of 3.10. The mean accommodative amplitude was 8.5D±2.38. The PFC for near[33cm] was 25.6D ±8.7D. The PFV for distance[6m] was 26.85±6.3D. The NFV for near was 13.67D±2.3D. The NFV for distance was 14.55D±3.9D. 62 patients [68.2%] had less than or equal to 6 cycles per minute of monocular accommodative facility with flipper test. 9 [8%] had more 6 cycles per minute of accommodative facility. (Table 1).

Out of 110 subjects, 36(32.7%) were found to have accommodative insufficiency [AI], 14(12.7%) had convergence insufficiency [CI], 4(3.6%) diagnosed with components of both AI and CI. 56 (51%) subjects were found to be normal without any non-strabismic binocular vision anomalies. Prevalence of AI was found to be 32.7% in this study population. It was found to be higher in females i.e., 23.64% compared to males which was 10%.

Table 1: Various orthoptic parameters studied in our study

Parameter studied	Mean ±SD
Age	23.8 ± 5.1 years
Near point of Convergence	10.94 ± 2.807
Near point of Accommodation	12.55 ± 3.10
Positive fusional vergence [near]	25.6D ±8.7D
Positive fusional vergence [distance]	26.85±6.3D.
Negative fusional vergence [near]	13.67D±2.3D
Negative fusional vergence [distance]	14.55D±3.9D.
Accommodative Amplitude	8.5±2.3D

Table 2: Frequency distribution of types of NSBVA in our study

Our study	Number [N]-110	Frequency [%]
Accomodative insufficiency	36	32.7
Convergence insufficiency	14	12.7
Both	4	3.6
No NSBVA #	56	51

#NSBVA- Non strabismic binocular vision anomalies

Table 3: Comparison of prevalence of NSBVA with other studies

Study	NSBVA [%] $	Total number [N]
Our study	49	110
Magdelene et al [7]	67.35	115
Rao et al [8]	78	182

$NSBVA- Non- strabismic binocular vision anomalies

4. Discussion

Accommodative and binocular dysfunctions cause difficulties in activities requiring close vision. Convergence Insufficiency is a common binocular vision condition with a prevalence of approximately 2 to 8% in which there is an inadequacy of convergence mechanism for near work. The exact impact of these anomalies on quality of life is not known. Several studies have found some association between vergence disorders and attention deficit hyperactivity disorder and there is also some indication that convergence insufficiency can be related to reading problems. Symptoms associated with accommodative & convergence insufficiency often include blurred vision, eyestrain, headache, diplopia, frequent loss of focus, difficulty concentrating on near work, and/or avoidance of near work. Parents of children with symptomatic NSBVA report a significantly higher number of academic performance related symptoms (such as difficulty completing assignments, careless mistakes,

Table 4: Comparison of sub-groups of NSBVA among different studies

S. No.	Study	Age group	Accomodative dysfunctions [%]	Vergence dysfunctions [%]	Sample size[n]
1.	Our study	9-45 years	32.7	12.7	110
2.	Magdelene et al [7]	10-40 years	28	72	131
3.	Rao et al [8]	8-49 years	35	18	182
4.	Paniccia et al [9]	5-20 years	39	12.6	593
5.	Garcia et al [10]	13-35 years	18.8	8.7	328
6.	Manish Dahal et al [11]	18-30 years	21.42	28.57	150

avoidance of near work, inattentiveness, and worry about school performance), as compared to parents of children with normal binocular vision. [1]

The CIRS [Convergence insufficiency and Reading study] group criteria were followed for diagnosis of Convergence insufficiency [PFV at near less than 35PD and receded NPC more than 10cm]. [12] The diagnostic criteria for Accommodative insufficiency included Reduced Amplitude of Accommodation at least 2D below Hoffstetter's calculation and less than or equal to 6cpm monocular accommodative facility with 2D flippers. [13]

In our study, the mean age of these subjects was 23.80 ± 5.1 years (range 9 to 36 years). In the study by Magdelene et al, the age group ranged from 10- 40 years. In a study by Hoseini- Yazdi et al, the mean age of the patients was 21.3 ± 3.5 years. [14] Our study shows that NSBVA is rampant in older children and young adults similar to above mentioned studies thus warranting a thorough orthoptic evaluation.

In our study, the prevalence of NSBVA [AI, CI and both] was 49% [54] and 51% [56] of patients had no NSBVA. In the study by Hussaindeen et al, the prevalence of non-strabismic anomalies of binocular vision in the urban and rural arms were found to be 31.5 and 29.6 per cent, respectively. [4] In the study by Magdelene et al, the prevalence of NSBVA was 67.35% (n = 87) with 22.45% (n = 28) without NSBVA. [7] In the study by Diwakar Rao, out of the 182 subjects who were screened, 142 were diagnosed with Non strabismic binocular vision disorder (Table 3). [8] According to the findings of our study, the mean NPC is 11.54, which is higher compared to the values reported by Ostadimoghaddam et al for the 20–29 years age range (10.24 cm). [14]

In our study, out of 110 subjects, 33(30%) were found to have accommodative insufficiency [AI], 14(12.7%) had convergence insufficiency [CI], 4(3.6%) diagnosed with components of both AI and CI. In the study by Rao et al, Convergence insufficiency was the most common NSBVA across all age groups. [8] In the study by Rouse et al, a high prevalence of Convergence insufficiency was noted in paediatric age group. In the study by Paniccia et al group, the conditions with the highest prevalence were AI (39%), CI (12.6%) like our study although it covered the age group of 5-20 years. [9]

In a study by Garcia et al, of the 69 patients in the sample, 31 had accommodative dysfunctions (13 with accommodative insufficiency and 18 with accommodative excess), 19 had binocular anomalies (13 with convergence excess and six with convergence insufficiency), and19 had combined accommodative and binocular disorders (10 with convergence excess combined with accommodative excess and nine with convergence insufficiency combined with accommodative excess). [10] In a study by Manish Dahal et al, Of the 150 students with NSBVD, 45 students (21.42%) presented with accommodative dysfunctions, 60 students (28.57%) presented with vergence dysfunctions, 24 students (11.42%) had combined accommodative and vergence dysfunctions. [11] In a study by Montes'- Mico,' of the 1679 subjects aged between 18-38 years, 56.2% presented symptoms of binocular dysfunctions, 61.4% with accommodation disorders and 38.6% vergence disorders. Accommodation insufficiency was most prevalent among those with symptoms (11.4%) (Table 4). [15]

There seems to be a wide variation in prevalence of CI and AI in various studies conducted. This was probably due to wide variations in the normative data and cut off diagnostic criteria applied. Most of the studies on NSBVA have been conducted in children rather than adults. The data obtained from paediatric and adult studies cannot be compared since children cannot be relied upon for subjective responses in contrast to the adults. Hence the prevalence of different NSBVA reported in the two studies are different.

It is important to highlight the greater intensity of symptoms in children with these conditions, especially those with an accommodative insufficiency. Other authors have also reported this relationship, noting that accommodative changes are more symptomatic than changes in convergence. In addition, studies that have investigated the relationship between the intensity of near-work and visual complaints, found an association between the cumulative amount of near work, decreased accommodative facility and increased asthenopia.

Since our study was mainly intended to screen the presence of NSBVA in patients with headache, the treatment and follow up of patients diagnosed with NSBVA has not been included. Further studies can be undertaken in the future including a larger sample size over a longer duration.

5. Conclusion

This study highlights the importance of keeping in mind the entity of NSBVA in patients presenting to ophthalmologists with headache. All patients with headache should be screened for presence of NSBVA after ruling out common ocular causes of headache so that prompt intervention can be initiated to address them and thereby improve the academic performance, reading ability and better quality of life in children and young adults. Further studies with larger sample size will enhance the reliability of the results.

6. Source of Funding

None.

7. Conflict of Interest

None.

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