Hypermetropia and Non-Strabismic Binocular Vision Anomalies: A Clinical Study

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ABSTRACT

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| **Aim***:* To assess the prevalence of non strabismic binocular vision anomalies among hypermetropic patients.  **Methodology:** Thisprospective, cross-sectional study was conducted among 145 hyperopic patients in the age group 18-30 years visiting tertiary eye hospital between Jan 2024 and July 2024. The comprehensive eye examination followed by binocular vision assessment was performed on all the recruited subjects. Diagnosis of non strabismic binocular vision anomalies was made on the basis of normative data and diagnostic criteria mentioned in the Scheiman and Wicks findings. Data was analyzed using SPSS 23.0.  **Results:** The prevalence ofnon strabismic binocular vision anomalies was 46.91% among hyperopic patients. Commonest form ofnon strabismic binocular vision anomalies was accommodative excess (30.88%) followed by convergence insufficiency (22.06%), accommodative excess with convergence insufficiency (19.11%), convergence excess (14.70%) and accommodative insufficiency (13.23%) respectively.  **Conclusion***:* Findings of the current study revealed that non strabismic binocular vision anomalies are highly associated with the hypermetropia. So, it is crucial to assess the status of accommodation and vergence while prescribing the correction for hypermetropia in order to provide the appropriate correction and ultimately improve visual functioning of eye. |

***Keywords:*** *Accommodation, Binocular Vision Anomalies, Hypermetropia, Vergence*

1. INTRODUCTION

When parallel light rays cannot be focused on the retina by the non-accommodating eyes, the condition is known as refractive error (RE).[1] According to the American Academy of Ophthalmology, hyperopia is defined as "a condition in which the eye is shorter than normal or has a cornea that is too flat, so light rays focus behind the retina instead of on it".[2]

Hyperopia is a prevalent refractive error which depends on the child's race/ethnicity and geographic location. The development of children's vision, their ability to execute different visual activities, and their academic achievement have all been negatively impacted by hyperopia, especially moderate to severe hyperopia.[3]

Perception of any single object as a single entity by the simultaneous use of two eyes is called as Binocular Single Vision. Non-strabismic binocular vision anomalies (NSBVA) refer to a group of visual disorders that affect the ability of the eyes to work together properly without involving a misalignment of visual axis (strabismus). Binocular vision anomalies possess a dynamic etiology and treatment which are triggered by refractive errors. The visual efficiency system (VES) is made up of three distinct systems: accommodative mechanisms, vergence mechanisms, and refractive errors.[4]

The visual system may not be able to carry out this type of activity effectively due to the emphasis on vision in today's society, which is associated with tasks requiring near vision. This can result in visual discomfort, fatigue, as well as impaired visual performance. Prolonged close work, is more frequent to report the symptoms and indicators of these challenges when engaging in activities like reading or operating gadgets.[5,6] Headache, blurred vision, trouble concentrating at various distances, and ocular pain; asthenopia is the umbrella term used to describe all of these symptoms.[7,8] According to the Vision in Preschoolers-Hyperopia in Preschoolers (VIP-HIP) study, the percentage of children with reduced visual functions (visual acuity, near stereoacuity, and/or accommodative response) increased from 17% in emmetropic children to 82% in children with uncorrected hyperopia of ≥4.0 D to ≤6.0 D.[9]

Individual with binocular vision anomalies (BVA) are more likely to experience learning problems, and after receiving vision therapy for BVA, academic behaviour, as measured by an academic behaviour survey is significantly improved.[8,10] It has been found that NSBVA affect about 80% of children with learning disabilities.[11,12] Also, they may have a detrimental effect on a child’s intellectual development because they reduce visual efficiency, cause pain, and hinder effective near work.[13]

It has been established that these dysfunctions can affect a reader's ability to read quickly, accurately, and efficiently. It is strongly advised to evaluate a child's binocular vision in youngsters with learning difficulties. The success of vision therapy in the treatment of binocular vision defects in student enrolled in regular stream education is well established.[14] If left undiagnosed, it will worsen the situation and can results to strabismus.[15] Timely diagnosis and treatments ensure adequate visual quality due to the rising prevalence of binocular vision anomalies and the increased demand for close work.[16] Previous studies focused on the pediatric population rather than young adults but nowadays it is an crucial part of ocular examination in young adult too. This study emphasizes on the Non-Strabismic Binocular Vision status among young adults due to their increased near work demand and exposure to digital screen.

2. material and methods

This prospective, cross-sectional study was conducted to assess the non strabismic binocular vision anomalies in hyperopic patients at tertiary eye hospital of west Uttar Pradesh in the year 2024. Ethical clearance was obtained by the Institutional Review Committee and the study was conducted in accordance to the Declaration of Helsinki regarding human research. Total 145 patients of 18-30 years of age were enrolled after obtaining the informed written consent. Inclusion criteria were hyperopic subject with best corrected visual acuity 0.0 or 6/6 or 20/20 and N6 at distance and near. Subject with any other ocular and systemic condition, refractive and ocular surgery were excluded from the study. Recruited patients underwent comprehensive eye examinations including history, visual acuity (Unaided/Aided at near and distance), refraction and torchlight examination.

Distant visual acuity was measured using the logMAR chart from the distance of 4 meters and near visual acuity was measured using the reduced Snellen chart at 40cm. Objective refraction was performed using the retinoscope followed by cycloplegic refraction. Broad H test was used to check the ocular motility. Cover test was performed at near and distance to check the presence and type of phoria. The amount of phoria was measured with the help of Prism bar cover test. Suppression was assessed with the help of worth four dot test. Gross stereopsis was assessed with the help of TNO. Then tests for accommodation and vergence assessment were carried out.

Vergence assessment includes NPC, VF, NFV and PFV. The Near Point Of Convergence (NPC) was assessed using the Royal Air Force Ruler (RAF). Negative Fusional Vergence (NFV) and Positive Fusional Vergence (PFV) at near and distance were measured with the help of horizontal prism bar with Base In (BI) and Base Out (BO) orientation. Vergence Facility (VF) was assessed using the 3BI/12BO prism flipper. Accommodation assessment included Near Point of Accommodation (NPA) assessed using the Royal Air Force (RAF) ruler. Negative Relative Accommodation (NRA) and Positive Relative Accommodation (PRA) was assessed using plus lens and minus lenses in increasing order respectively. Accommodative Facility (AF) with the help of +-2.00D accommodative flipper. Monocular Estimation method (MEM) using retinoscope to rule out the lead and lag of accommodation. AC/A ratio were calculated using heterophoria method. Diagnostic criteria for accommodative and vergence anomalies as well as normative data was according to the Scheiman and Wick.[17] Details of participants and their identities were kept confidential.

Statistical analysis: Data was recorded in MS Excel and was analyzed through SPSS version 23.0 (IBM, Armonk, New York, USA). Descriptive statistics including frequency, percentage, average and standard deviation were recorded.

3. results and discussion

The study comprised of total 145 patients diagnosed with hypermetropia. Of total 145 participants, number of male participants was 69(48%) and female was 76(52%) as shown in Figure 1. The age of recruited participants was 18-30 years. The mean age of study participants was 22.22±2.39year. The mean hyperopia of 2.14±1.17D spherical equivalent was found among recruited participants.

Assessment of sensory status included worth four dot test for suppression and stereopsis. Most of the patient had normal fusion, only one patient showed suppression with WFDT test. The mean stereopsis of the participants was 31.634±9.159 seconds of arc. Similarly, motor evaluation was performed which included ocular motility and cover test. Assessment of ocular motility in the nine position of gaze showed that none of the patient showed under/over action of EOM as well as restricted eye movement.

Out of 145 hyperopic patients, 68(46.91%) had diagnosed with Non-Strabismic Binocular Vision Anomalies. Table 1 showed the majority of hyperopic patients had Accommodative Excess (AE) found in 21(30.88%) participants followed by Convergence Insufficiency (CI) in 15(22.06%), Accommodative Excess (AE) With Convergence Insufficiency (CI) in 13(19.11%), Convergence Excess (CE) in 10(14.70%) and Accommodative Insufficiency (AI) in 9(13.23%) respectively.

**Table 1. Accommodative and vergence dysfunction in hyperopic patients**

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| --- | --- | --- |
| **Accommodative/Vergence anomalies** | **Frequency**  **(N)** | **Percentage (%)** |
| **Accommodative Insufficiency** | 9 | 13.23 |
| **Accommodative Excess** | 21 | 30.88 |
| **Convergence Excess** | 10 | 14.70 |
| **Convergence Insufficiency** | 15 | 22.06 |
| **Convergence Insufficiency with Accommodative Excess** | 13 | 19.11 |

The findings of accommodation testing in various forms of Non-Strabismic Binocular Vision Anomalies were depicted in Table 2. Assessment of Accommodation included amplitude of accommodation (monocularly and binocularly), Negative Relative Accommodation, Positive Relative Accommodation, Accommodative Facility (monocularly and binocularly), Monocular Estimation Method and AC/A ratio using gradient method.

**Table 2. Findings of Accommodative testing in various forms of NSBVA**

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| --- | --- | --- | --- | --- | --- |
| **TESTS** | **MEAN VALUE** | | | | |
| **CI** | **AI** | **CI & AE** | **CE** | **AE** |
| **AA** |  |  |  |  |  |
| **OD**  **OS**  **OU** | 11.72±3.35  11.90±2.91  11.41±3.14 | 6.4±2.468  6.52±2.009  7.05±2.012 | 10.18±2.139  10.35±1.999  9.63±1.970 | 10.47±2.736  10.79±1.722  10.19±2.217 | 9.47±2.081  9.62±2.179  8.9±2.066 |
| **NRA** | 2.13±0.75 | 2.46±0.52 | 1.86±0.528 | 2.90±1.946 | 1.57±0.709 |
| **PRA** | -2.84±0.62 | -1.45±0.950 | -2.93±0.450 | -2.143±0.868 | -2.87±0.590 |
| **AF** |  |  |  |  |  |
| **OD**  **OS**  **OU** | 7.14±3.152  7.0161±3.086  5.58±2.762 | 3.72±2.93  3.7±2.817  3.75±2.964 | 5.31±1.447  5.22±1.301  4.58±2.244 | 7.55±2.609  7.238±2.333  4.76±3.369 | 5.48±2.520  5.39±2.461  3.39±1.830 |
| **MEM** |  |  |  |  |  |
| **OD**  **OS** | 0.32±0.318  0.314±0.34 | 0.91±0.240  0.95±2.45 | 0.11±0.636  0.17±0.619 | 0.62±0.251  0.60±0.273 | 0.32±0.393  0.33±0.372 |
| **AC/A ratio** | 1.77±0.705:1 | 3.05±0.739 | 3.185±1.020 | 4.36±1.081 | 3.08±1.145 |

The findings of Vergence testing in various forms of Non-Strabismic Binocular Vision Anomalies were depicted in Table 3. Assessment of vergence included Near Point of Convergence (break/recovery), Negative Fusional Vergence at near and distance (break/recovery), Positive Fusional Vergence at near and distance (break/recovery) and Vergence Facility.

**Table 3. Findings of Vergence testing in various forms of NSBVA**

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| --- | --- | --- | --- | --- | --- |
| **TESTS** | **MEAN VALUE** | | | | |
| **CI** | **AI** | **CI & AE** | **CE** | **AE** |
| **NPC** |  |  |  |  |  |
| **BREAK**  **RECOVERY** | 5.59±2.167  7.27±2.62 | 4.95±2.312  8.45±2.819 | 4.70±1.940  6.4±2.006 | 7.143±1.909  9.857±2.336 | 8.07±2.921  10.29±3.547 |
| **NFV (distance)** |  |  |  |  |  |
| **BREAK**  **RECOVERY** | 9.48±1.965  7.06±1.702 | 9.63±1.869  6.94±1.986 | 9.33±1.633  6.96±1.875 | 9.33±1.782  7.14±1.807 | 9.87±2.676  7.73±2.508 |
| **NFV (near)** |  |  |  |  |  |
| **BREAK**  **RECOVERY** | 14.42±3.998  12.51±4.157 | 15.21±3.019  12.63±2.599 | 16.18±3.031  13.85±2.71 | 15.04±4.180  13.14±4.132 | 14.82±3.284  12.75±3.234 |
| **PFV (distance)** |  |  |  |  |  |
| **BREAK**  **RECOVERY** | 12.19±5.183  9.81±4.659 | 12.68±3.495  10.31±3.179 | 12.37±3.927  10.22±3.269 | 16.48±3.567  11.28±2.914 | 9.87±2.676  7.13±2.379 |
| **PFV (near)** |  |  |  |  |  |
| **BREAK**  **RECOVERY** | 16.19±7.105  14.6±6.87 | 16.5±3.804  13.11±3.107 | 16.92±4.705  13.78±4.357 | 21.43±5.559  16.76±5.371 | 22.13±7.455  18.51±5.883 |
| **Vergence facility** | 6.97±4.122 | 10.42±3.195 | 8.65±4.286 | 10.64±2.996 | 11.35±3.858 |

Current study was conducted to assess the association between non strabismic binocular vision anomalies and hypermetropia among college students as hypermetropia can exacerbate non- strabismic binocular vision anomalies due the increased accommodative demand, altered binocular vision dynamics and difficulty with near tasks. Students utilized most of their time on study materials mainly included books, articles or digital screen result in increasing demand of near work. If near work is performed for a prolonged period of time, their accommodation and vergence mechanisms may be subjected to additional strain, which may lead to the development of Non- strabismic binocular vision anomalies. Most of the study related to non-strabismic binocular vision anomalies was conducted on pediatric population only but there is a high requirement of assessing the accommodation and vergence status of adult population also, especially those who had refractive error as the modality of treatment required for uncorrected refractive error with non-strabismic binocular vision anomalies may differ rather than uncorrected refractive error or non-strabismic binocular vision anomalies only. Appropriate correction for refractive error is must if refractive error left unaddressed it impose significant burden on individual and society.[18, 19]

Current study included 47% male which was lesser than 53% female participants. The prevalence of NSBVA was 46.91% in the current study. Similarly, Wajuihian SO et al (2022) had recruited 37% male and 62% female participants in their study and they found hyperopia among 30% participants. Also 22% hyperopic participants were most symptomatic due to non strabismic binocular vision anomalies.[20] Study conducted by Cai J et al (2024) showed that 36.71% had eyestrain due to binocular vision anomalies and 08 students reported visual fatigue in the presence of normal binocular visual function may be due to improper correction of Ametropia. Also they reported that the age and refractive status were not associated with non strabismic binocular vision anomalies.[21] Saif Hassan Alrasheed et al (2023) concluded that refractive error significantly varied with binocular vision disorders.[22] We found that the 31.03% hyperopic participants had accommodative excess participants followed by convergence insufficiency, accommodative excess with convergence insufficiency, convergence excess and accommodative insufficiency. The study conducted by Hussaindeen JR et al (2015) found the convergence insufficiency as most common non strabismic binocular vision anomalies followed by accommodative Infacility.[23] Sandra Franco (2021) found that the 32% showed binocular vision or accommodative disorders accompanied by refractive error or not. Accommodative insufficiency was the most common disorder followed by convergence insufficiency.[24] About 44.68% of students with non-strabismic binocular vision anomalies had refractive error in the study conducted by Tiwari et al. The result of the previous study implied that non strabismic binocular vision anomalies are highly associated with refractive error. Binocular vision anomalies possess a dynamic etiology and treatment which are triggered by refractive errors.[25]

4. Conclusion

Most commonly excessive near work and digital screen usage may contribute to the development of non strabismic binocular vision anomalies. It is crucial for individual with not only hypermetropia but also myopia and astigmatism to undergone comprehensive binocular vision assessment to detect and address any underlying non strabismic binocular vision anomalies. So that appropriate treatment plan such as vision therapy or corrective lenses can be utilized to help alleviate symptoms and improve binocular vision function ultimately supports the visual and academic well-being of students.

Ethical approval

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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