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Pattern of Non-Strabismic Binocular Vision Dysfunctions among Undergraduate Engineering Students of Vivekananda Global University

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ABSTRACT

Background: - Our eyes work together binocularly when they are functioning normally. This allows our eyes to view a single image instead of two separate ones. Patients without strabismus who have non-strabismic binocular vision dysfunction (NSBVD) have a visual disorder in which one eye's line of sight is somewhat off-alignment with the other eye's line of sight. The eye muscles are under a lot of strain since they are always attempting to adjust the alignment in order to attain single focus vision [2]. Many people suffer from binocular vision abnormalities that go undetected. Ocular and binocular dysfunction that is not recognized can cause discomfort, which can hinder clinical training and academic achievement.

Method: -The cross sectional based study was conducted at Vivekananda Global University, Jaipur, among 190 undergraduates engineering student. CISS score was measured in all the cases. VA for distance, Stereopsis, cover test at far and near were performed. Near point of convergence (NPC), amplitude of accommodation, positive and negative fusional vergence in near and distance, monocular and binocular accommodation facility, positive and negative relative accommodation, monocular estimation method (MEM) and AC/A ratio were evaluated in all participants.

Results: -The mean age of the participants was 21.44 ±1.523 ranging from 18 to 26 years of which 75.78% (144) were male and 24.22% (46) were females. And according to the symptom score 62.10% (118) were found being symptomatic and 37.90% (42) were found to being asymptomatic. The percentage of NSBVD was 71.06% among undergraduate engineering students of VGU. Out of 135 participants, 48 of them had accommodative anomaly and 87 of them had vergence anomaly. The prevalence of vergence anomaly was greater than accommodative anomaly. The highest percentage of NSBVD was observed for CI (22.10%) followed by AE (17.89%), FVD (14.73%), AI (6.31%), CE (4.21%), DE (3.15%), Basic exophoria (1.57%) and Accommodative Infacility (1.05%).

Conclusion: - This study shows that among the engineering students in the chosen sample, accommodative and vergence disorders are highly prevalent. These early findings suggest that better knowledge, diagnosis, and treatment of binocular dysfunctions are required. If an accommodative or vergence issue is discovered, prompt and efficient therapy should be recommended. Student will be able to reach their maximum potential if NSBVD is identified and treated promptly.

Keywords: *Accommodative dysfunction, Vergence dysfunction, Binocular vision dysfunction*

1. INTRODUCTION

Our eyes work together binocularly when they are functioning normally. As a result, our eyes can see a single image instead of two different ones [1]. In people without strabismus, a visual ailment known as non-strabismic binocular vision dysfunction (NSBVD) occurs when one eye's line of sight is somewhat out of alignment with the other eye's line to sight. The eye muscles are under a lot of strain since they are always attempting to adjust the alignment in order to attain single

focus vision [2]. Many patients suffer due to the undiagnosed binocular vision disorders. Undiagnosed binocular and ocular dysfunction may present with discomfort which has negative effect in clinical training and academic performance [3].

With the development of computers, smartphones, and other visual aids in the twenty-first century, college and university students now use them not just to do their daily coursework but also for enjoyment and to interact with various social media platforms. College students' use of visual aids grew significantly as a result. A significant portion of college students experience various forms of accommodative and vergence dysfunction as a result of prolonged use of visual devices, in addition to other variables such inadequate lighting, glare, screen brightness, uncorrected refractive error, and incorrect workstation layout. Non-Strabismic Binocular Vision Dysfunction, or NSBVD, is the name given to this group of conditions [4, 5]. NSBVD is mainly categorized into two groups which are accommodative vergence and vergence dysfunction [6].Accommodative dysfunction includes accommodative insufficiency (AI),accommodative spasm, accommodative infacility (AIF), and ill-sustained accommodation (ISA),while vergence dysfunction/anomalies includes convergence insufficiency (CI), convergence excess (CE), divergence excess (DE), divergence insufficiency (DI),basic exophoria, basic esophoria, vertical phoria and fusional vergence dysfunction (FVD)[6]. According to **Daum**, accommodating dysfunction caused blurry pictures in the retina because it was difficult for the eye muscles to focus on things at varying distances [7]. However, because of the eyes' inability to precisely coordinate, vergence dysfunction was shown as a failure to fixate and sustain pictures on the retina [8]. The visual system may become less efficient as a result of the effort required for continuous near vision, which would impede near vision activities and cause visual complaints. Individuals who suffer from these visual abnormalities may exhibit a broad range of related symptoms. Blurred vision, eyestrain, difficulties focusing close and far away, fatigued eyes, burning sensation, headache, ocular pain, redness, diplopia, and asthenopia are common signs of NSBVD [9,10]. CISS (Convergence Insufficiency Symptom Survey) questionnaire is the most valid and reliable method of assessing the symptom related to NSBVD [11].

According to a research conducted by **Richman and Laudon** on New England College of Optometry optometry students, 42% of the subjects exhibited binocular dysfunction (BD), and 25% of those with BD reported having asthenopia [12]. Two and a half percent of the population had accommodating dysfunctions, eight percent had binocular dysfunctions, and two and a half percent of university students had both. The most common dysfunctions among the accommodative and binocular disorders were convergence excess and accommodation excess (both with a prevalence of 2.29%) and convergence insufficiency (3.43%). In 2016, Garcia et al. conducted a cross-sectional study using a randomized sample of 175 college students between the ages of 18 and 35 [13]. Refractive dysfunction was present in 45.14% of cases, while accommodation and binocular dysfunction were present in 13.5% of cases overall. In order to examine the refractive and non-strabismic binocular vision status of 105 optometry students, Darko-Takyi et al. carried out a cross-sectional study using a thorough optometric examination [14].

The prevalence of non-strabismic binocular vision disorders was 34.3%, while the prevalence of refractive error was 59.0%. Convergence insufficiency/excess and divergence insufficiency/excess are the two most common diseases of the binocular vision system. According to these research, non-strabismic binocular dysfunction was significantly more common in college students. Because these abnormalities will add stress to any activity requiring eye coordination, whether at close range or at a distance, early detection of NSBVD is crucial. It could become strabismic without the right care, which would lead to suppression and a loss of stereopsis [15]. This will have a detrimental effect on daily activities. A person will be able to function to the best of their abilities if NSBVD is promptly identified and treated. These results imply that clinicians should be more cognizant of visual abnormalities that might be present among college students. So, through this study we aim to determine the prevalence of non-strabismic binocular vision dysfunction among the undergraduate engineering students of Vivekananda Global University and also create awareness among clinicians about visual anomalies that may be found in the university engineering student population.

2. AIM AND OBJECTIVES

2.1 General objective:

To find out the pattern of non-strabismic binocular vision dysfunction among the undergraduate engineering students of Vivekananda Global University.

2.2 Specific objectives:

- To study the demography of non- strabismic binocular vision dysfunction.
- To assess the symptom score of vision related problems among engineering students
- To measure the negative fusional vergence, positive fusional vergence
- To measure the near point of convergence
- To assess the accommodative functions such as near point of accommodation, accommodative facility, negative relative accommodation and positive relative accommodation)

- To determine the pattern of different NSBVD
- To correlate the symptom score with vergence dysfunction
- To correlate the symptom score with accommodative dysfunction
- To assess relationships of non-strabismic binocular vision dysfunctions with symptom score

3. METHOD AND MATERIAL

3.1 Study Design

The research design was analytical and cross-sectional.

3.2 Place of Study

This study was carried out at Optometry lab of Vivekananda Global University. The units involved were:

- Refraction unit
- Orthoptics unit

3.3 Study Duration

Six months

3.4 Study Population

The study population were Undergraduate Engineering Students of Vivekananda Global University.

3.5 Sampling Technique

Nonprobability and random

3.6 Sample size: 190

$$N = \frac{Z^2 .p. (1- p)}{d^2}$$

Where:

- n = required sample size
- Z = Z-score (based on confidence level, e.g., 1.96 for 95%)
- p= estimated proportion (prevalence from previous studies or pilot)
- d = margin of error (precision, e.g., 0.05 for ±5%)

For this research,

Z= 1.96 p=14% d=0.05 = 186

$$N = \frac{1.96^2 . 0.14. (1- 0.14)}{0.05^2}$$

3.7 Instrumentation

Required eye examinations were carried to each patient after taking their informed consent.

3.7.1 Demographic data

A demographic data consisted of name, age and sex were included.

3.7.2 Standardized questionnaire

Students' asthenopic symptoms were evaluated using the Convergence Insufficiency Symptom Survey (CISS).The questionnaire consists of 15 items about how eyes feel when reading and doing close work which has to be selected as never, infrequently, sometimes, fairly often, always. Then the total score is calculated. If the score of CISS is less than 21 then considered asymptomatic and if the score of CISS is more than 21 then considered symptomatic.

3.7.3 Assessment tools for eye examination

Assessment for eye examination will include the examination and assessment procedures used in detecting vision related problems. Snellen's VA chart is used to assess visual acuity; Heine Retinoscope was used to detect lag of accommodation and lead of accommodation. Cover paddle and prism bar to detect deviation of eye and measure fusional vergences (positive fusional vergence and negative fusional vergence), Royal Air Force (RAF) rule to measure amplitude of accommodation and near point of convergence. Lens flippers (±2.00D) used to measure accommodative facility. Titmus fly test to assess stereopsis. Trial frame and lens to measurement of AC/A ratio by gradient method and finally Phoropter of Topcon IS600 is used to measure positive relative accommodation (PRA) and negative relative accommodation (NRA). A standardized questionnaire, the Convergence Insufficiency Symptom Survey (CISS)

developed by the Convergence Insufficiency Treatment Trial (CITT) investigator group was used to differentiate symptomatic and asymptomatic patients. The questionnaire was distributed to each participant and asked to tick the answers that best suits to them in each question.

3.8 Data collection Procedure

All participants underwent following assessments and tests.

Convergence Insufficiency Symptom Survey (CISS) Questionaire

This questionnaire was distributed to each participant before eye examination and asked to circle frequency choices of each items on the questionnaire according to how their eyes feel when reading or doing close work.

3.8.1 Visual Acuity

Visual acuity of each eye was assessed with or without glasses using Snellen's VA chart at 6 m distance. If VA of participants was more then 6/12 then it was not included in this study because the asthenopic symptom may be associated with uncorrected refractive error.

3.8.2 Stereopsis

The stereopsis was assessed with the Timus fly test by asking each participant to wear a polarized goggle and to identify a disparate image from each group of images in each plate until they couldn't identify the disparate image. The finding was noted in seconds of arc.

3.8.3 Cover test

A cover test was used to measure ocular alignment at a distance of 40 cm and six meters. Orthophoria was defined as no movement on the cover test. When the outward latent deviation was greater than four prism diopters at a distance and six prism diopters at a close distance, exophoria was deemed significant. When the inward deviation was greater than two prism diopters at a distance and four prism diopters at a close distance, esophoria was deemed serious.

3.8.4 Fusional vergence

Using horizontal prism bars in front of the subject's one eye, fusional vergence was assessed binocularly at 40 cm and 6 m distances. The prism's power was steadily increased until the

subject saw the initial blur, break, and recovery. Base out prism was used to measure positive fusional vergence, and base in prism in one eye was used to measure negative fusional vergence. Morgan's normal was considered for near (17/21/11) and distance (9/19/10) for positive fusional vergence and similarly near (13/21/13) and distance (7/4) for negative fusional vergence.

3.8.5 Amplitude of Accommodation

By using the Royal Air Force (RAF) rule with no target letter, the amplitude of accommodation was assessed binocularly. After that, the print was shifted in the direction of the subject until the letters 19 became unreadable. Using Hofsetter's

formula, the normal value of the amplitude of accommodation was determined. If the measured amplitude of accommodation was two diopters lesser than the age-matched amplitude of accommodation, it was deemed abnormal.

3.8.6 Lag of Accommodation

In order to determine the lag of accommodation, dynamic retinoscopy was performed at a distance of 35–40 cm with an accommodating goal of N8 at the retinoscopic plane under normal room illumination. A normal accommodation lag of + 0.75 D was applied.

3.8.7 Near point of convergence

The single dot target on the Royal Air Force (RAF) rule was moved along the scale towards the eye in order to measure the near point of convergence at primary gaze. Less than 10 cm of convergence was regarded as normal, 11–15 cm as decreased, and more than 15 cm as defective.

3.8.8 Accommodative facility

The accommodating facility was measured at 40 cm using a letter size comparable to N8 and a ±2.0 D flipper lens, both monocularly and binocularly. Each participant was asked to hold a flipper in one hand and reading material in another hand, bring the flipper closer to the eye and start reading the material. As soon as flipper was placed in front of eyes letters would become blur and unreadable. As soon as the letters became legible, they have to flip the lens to opposite side and they should repeat the procedure continuously for a minute. A flip from positive lens to negative lens and again back to positive lens while viewing the target letters was considered a complete cycle. Binocularly, the diagnostic threshold was set at 10 cycles per minute. A score below this was deemed abnormal.

3.8.9 Relative accommodation

PRA measures how much accommodation can be stimulated while still allowing for clear, single-lens vision when utilizing negative lenses. With plus lenses, NRA is a measurement of the greatest capacity to relax accommodation while preserving sharp, single-blind vision.

3.8.10 AC/A Ratio

It was evaluated by measuring the AC/A ratio using the gradiant approach.

3.9 Selection Criteria

3.9.1. Inclusion criteria:

Best corrected VA ≥6/9

Undergraduate engineering students of VGU

Age: 18-26 years

3.9.2. Exclusion Criteria:

Presence of any ocular disease that results in decreased vision

Presence of Nystagmus

Existence of Amblyopia

Existence of Anisometropia

3.10. Data Analysis Procedure

Data was entered into the Statistical Package for Social Science (SPSS) version 21 for analysis after being verified, examined, and arranged for accuracy and completeness.

Negative and positive fusional vergence, amplitude of accommodation, monocular and binocular accommodation facility, negative and positive relative accommodation, mean values of the CISS score, and near point of convergence.

Correlation of vergence status with CISS score through Spearman's Correlation test and Pearson's Correlation test for CISS and Near point of Convergence. Correlation of accommodative status with CISS score was done through Spearman correlation test. The relationship of NSBVD with CISS score was done along with the relationship of CISS score with vergence disorder and accommodative disorder.

4. RESULT

4.1 Subject Demographics

4.1.1 Demographic classification according to age and gender

The mean age of the participants was 21.44 ±1.523 ranging from 18 to 25 years of which 75.78% (144) were male and 24.22% (46) were females.

	Number of Participants	Minimum	Maximum	Mean	Standard Deviation
Age	190	18	25	21.44	1.523

Table 1: Mean age of participants

4.1.2 Demographic classification according to faculty of VGU

Out of 190 undergraduate engineering students of Vivekananda Global University involved in the study, 64.20% (122) were Computer Science students, 17.90% (34) were Mechanical Engineering students, 12.10% (23) were Civil Engineering students and 5.80% (11) were Electrical Engineering students.

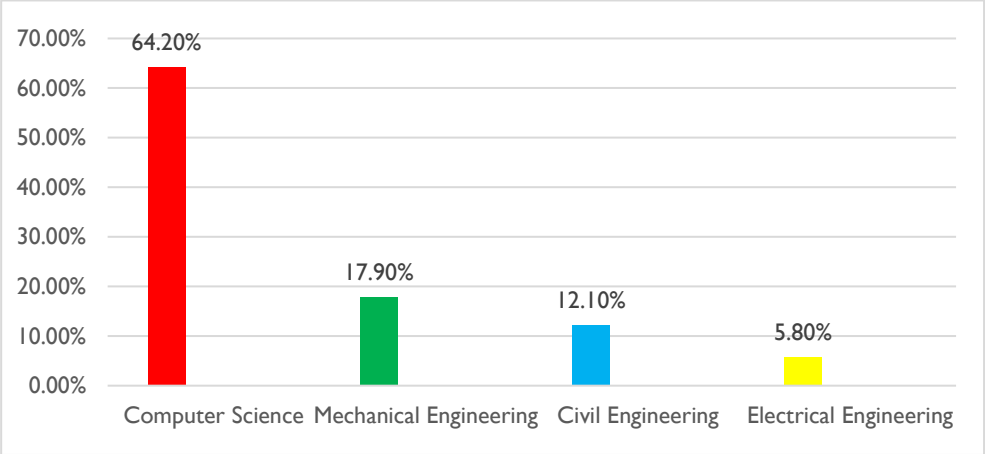

Figure 1: Demographic classification according to program of VGU

4.2 Frequency of CISS score

The mean convergence insufficiency symptom score (CISS) of 190 participants was 17.86 ± 6.86 with minimum value of CISS as 2 and maximum value of CISS as 42.

	Number of Participants	Minimum	Maximum	Mean	Standard Deviation
CISS	190	2	42	17.86	6.86

Table 2: Distribution of CISS score

CISS	Frequency	Percentage
Symptomatic	118	62.10
Asymptomatic	42	37.90

Table 3: Distribution of symptoms

4.3 Distribution of vergence function

The mean value for the near point of convergence was 6.24 ± 2.110 cm, with a minimum value of 5 cm and a high value of 25 cm. Out of 190 persons, the near point of convergence value was found to be lower in 7.89% (15), whereas 92.11% (175) was the typical value for the majority of other participants.

The BO and BI prisms were used to measure the positive and negative fusional vergence first at a distance and subsequently at close range. The mean negative fusional vergence was 13.20 ± 4.086 prism diopters BI at close range and 8.40 ± 3.24 at

far range. The mean positive fusional vergence was 14.60 ± 6.28 prism diopters BI at close range and 27.40 ± 9.24 at far range.

	Number of Participants	Minimum	Maximum	Mean	Standard Deviation
NPC	190	2	40	17.40	6.86

Table 4: Distribution of near point of convergence

NPC	Frequency	Percent
Normal	175	92.11
Reduced	15	7.89

Table 5: Condition of near point of convergence

Break Value	Minimum	Maximum	Mean	Standard deviation	Total
DBI Break	4	18	8.40	3.24	190
DBO Break	6	35	14.60	6.28	190
NBI Break	8	30	13.20	4.086	190
NBO Break	10	45	27.40	9.24	190

Table 6: Condition of vergence function

4.4 Descriptive statistics of accommodation

The mean amplitude of accommodation of participants was found to be 12.10 ± 2.10 Diopters, with minimum AA 4D and maximum AA as 18D. The mean monocular accommodative facility was found to be 12.48 ± 5.0314cpm. The mean value of negative relative accommodation and positive relative accommodation was +2.14 ± 0.542D and 3.082 ± 1.22D respectively.

The percentage of NSBVD was 71.06% among undergraduate engineering students of VGU. Out of 135 participants, 48 of them had accommodative anomaly and 87 of them had vergence anomaly. The highest percentage of NSBVD was observed for CI (22.10%) followed by AE (17.89%), FVD (14.73%), AI (6.31%), CE (4.21%), DE (3.15%), Basic Exophoria (1.57%) and Accommodative Infacility (1.05%).

	Total	Minimum	Maximum	Mean	Standard deviation
AA	190	4	18	12.10	2.10
MAF	190	2	20	12.48	4.98
BAF	190	3	18	12.76	4.082
NRA	190	0.75	3.25	2.14	0.542
PRA	190	-0.50	-6.00	3.082	1.22

Table 7: Status of Accommodation

Diagnosis	Frequency	Percentage
Normal	55	**28.94**
Convergence Insufficiency (CI)	42	22.10
Accommodative Excess (AE)	34	17.89
Fusional Vergence Dysfunction	28	14.73

(FVD)		
Accommodative Insufficiency (AI)	12	6.31
Convergence Excess (CE)	8	4.21
Divergence Excess (DE)	6	3.15
Basic Exophoria	3	1.57
Accommodative Infacility	2	**1.05**

Table 8: Status of NSBVD

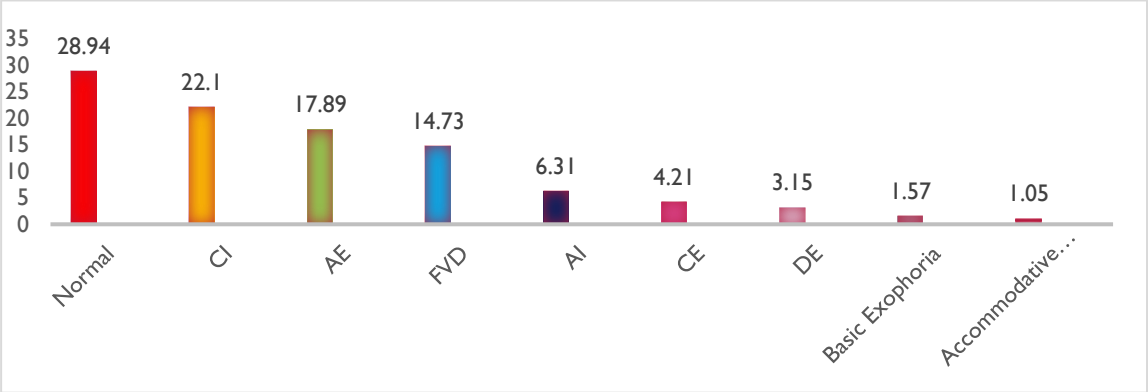

Figure 2: Bar graph distribution of NSBVD

4.5 Correlation of vergence status with CISS score

Through Spearman's correlation test negative fusional vergence distance (p=0.189, r=-0.84) and negative fusional vergence near (p=0.124, r=-101), positive fusional vergence distance (p=0.189, r=-0.82), and positive fusional vergence near (p=0.106, r=-104) showed insignificant correlation with CISS score. On Pearson's Correlation test for CISS and Near point of Convergence, significant level (p) was 0.006 and correlation coefficient (r) was 1.80.

Vergence	Correlation cofficient	P value
Positive Fusional Vergence distance	r=-0.82	p=0.189
Positive Fusional Vergenec near	r=-104	p=0.106
Negative Fusional Vergence near	r=-101	p=0.124
Negative Fusional Vergence distance	r=-0.84	p=0.189

Table 9: Correlation of vergence status with CISS score

4.6 Correlation of accommodative status with CISS score

Accommodation	**Correlation coefficient (r)**	**P value**
Amplitude of Accommodation (AA)	-0.172	0.008
Monocular Accommodative Facility (MAF)	-0.184	0.004
Binocular Accommodative Facility (BAF)	-0.202	0.002
Negative Relative Accommodation (NRA)	-0.072	0.268
Positive Relative Accommodation (PRA)	-0.10	0.864

Table 10: Correlation between accommodative factors

Through Spearman correlation test of CISS with amplitude of accommodation the correlation coefficient was found to be -0.172 with significance value of p=0.008, with monocular accommodation facility correlation coefficient was found to be -0.184 with significance value of p-0.004, and with BAF correlation coefficient was found to be -0.202 with significance value of p=0.002, and with NRA correlation coefficient was found to be -0.072 with significance value 0.268, and with PRA correlation coefficient was found to be -0.10 with significance value of p=0.864.

4.7 Relationship between NSBVD and CISS Score

4.7.1 Relationship between NSBVD and CISS Score

The mean CISS score for CI is 18.64 ± 7.248 with 4 as minimum value and 32 as maximum value. The mean CISS score for AE is 21.67 ± 6.824 with 4 as minimum value and 36 as maximum value. The mean CISS score for FVD was 18.24 ±7.627 with minimum value of 2 and maximum value of 34. The mean CISS score for Al was 21.14 ± 7.125 with minimum value as 8 and maximum value as 32. The mean CISS score of CE was 15.286 ± 7.652 with 4 as minimum CISS score and 30 as highest CISS score. The mean CISS score of basic exophoria was 18.86 ± 7.428 with 5 as minimum symptom score and 36 as maximum symptom score. The mean CISS score of DE was 20.14 ± 5.829 with 8 as minimum symptom score and 32 as maximum symptom score. The mean CISS score of accommodative infacility is 22.674± 11.069 that has 6 as minimum symptom score and 31 as maximum symptom score. The mean CISS score of normally diagnosed individual was 13.406 ±6.892 with minimum value of 2 and maximum value of 42.

NSBVD	CISS score (Mean ± SD	Minimum CISS score	Maximum CISS score
	21.35± 7.329	3	35
	17.42 ± 7.876	2	36

Table 11: Relationship between NSBVD and CISS Score

4.7.2 Relationship of vergence disorder and accommodative disorder with CISS Score

The mean CISS score of accommodative disorder is 21.35± 7.329 with minimum value of 3 and minimum value of 35. The mean CISS score of vergence disorder is 17.42 ± 7.876 with maximum value as 2 and maximum value as 36.

Out of 135 individuals diagnosed with NSBVD (vergence disorder and accommodative disorder), 21 of the accommodative disorder diagnosed cases were symptomatic and 32 of the vergence disorder cases were symptomatic whereas all others were asymptomatic.

Diagnosis	CISS Score (Mean+ SD)	Minimum	Maximum
CI	18.64 ± 7.248	4	32
AE	21.67 ± 6.824	4	36
FVD	18.24 ± 7.627	2	34
AI	21.14 ± 7.125	8	32
CE	15.286 ± 7.652	4	30
Basic Exophoria	18.86 ± 7.428	5	36
DE	20.14 ± 5.829	8	32
Accommodative Infacility	22.674 ± 11.069	6	31
Normal	13.406 ± 6.892	2	42

Table 12: Relationship of accommodative and vergence disorder with CISS score

5. DISCUSSION

This study, which was carried out at Vivekananda Global University (VGU), Jaipur, was cross-sectional and analytical. It was conducted on 190 individuals in the VGU Optometry Lab. This study set out to determine the prevalence of non-strabismic binocular vision impairment among Vivekananda Global University (VGU) undergraduate engineering students.

The mean convergence insufficiency symptom score (CISS) of 190 participants was 17.86 ± 6.86 with minimum value of CISS as 2 and maximum value of CISS as 42. And according to the symptom score 62.10% (118) were found being symptomatic which is higher than 47.5% reported by **Ponsonby et al** [20]. This scenario might have influenced the respondents to choose a certain symptom because they were shown a list of symptoms. As a result, symptoms might have been overestimated or students might have experienced symptoms as a result of working too much.

The mean value for the near point of convergence was 6.24 ±2.110 cm, with a minimum value of 5 cm and a high value of 25 cm. According to **Schieman and Wick** the mean value of convergence is 2.54±4 cm which is low than our value because it was assessed in children [21]. The NPC was 8.42 ± 2.94 cm in the Iranian population done by **Hassan Hashemi et al.** In a study done by Momeni-Moghaddam Hamedet al the mean NPC measured using accommodative target of 20/30 size was found to be 9.5 ± 4.5 cm in all subjects [22]. The difference of our study with these research papers might be due to the use of non-accommodative target in present study. And of 180 participants the near point of convergence value was found to be reduced in 7.89% (15), and 92.11% (175) had their values normal. And reduced our mean value might be less than other population since the percentage of students with reduced NPC is low.

The BO and BI prisms were used to measure the positive and negative fusional vergence first at a distance and subsequently at close range. The average negative fusional vergence at distant and close is 7±3 prism diopters and 13±6 prism diopters, respectively, according to Schieman and Wick [21]. Based on the current investigation, the mean negative fusional vergence outcome was 13.20±4.086 prism diopters Base In and 8.40±3.269 prism diopters at distant

[21]. According to **Schieman and Wick**, the average positive fusional vergence is 11±7 prism diopters at close range and 19±9 prism diopters at far range. In a study done by **David A. Gosset al** the mean NEV for near was 21.4±9.4 and PFV was 28.9±11.00 prism diopters [23]. In a study the mean NFV for distance and near in asymptomatic individuals was found to be 12.96±1.54 prism diopters and 14.5±1.98 prism diopters and PFV value was found to be 14.76±1.95 prism diopters and 15.84±1.74 prism diopters respectively [24]. The difference might be because our study has incorporated both symptomatic and asymptomatic individuals in the study.

Since the amplitude of accommodation had been reported to decrease with age [25, 26, 27]. Hofstetter's formula (18.5 -1/3 age), which is based on Duane's calculations [28], is a more widely used approach. The mean amplitude of accommodation of participants was found to be 12.10±2.10 Diopters, with minimum AA 4D and maximum AA as 18D. Using Hofstetter's equations expected mean AA was 11.90D which was similar to present research [8]. According to a study by Neethu G. Abraham et al., using the minus lens approach, the mean amplitude of accommodation was 9.09±1.47 D.

The accommodative response's dynamics and endurance are assessed by the accommodating facility. Through several studies the mean monocular accommodation facility is found to be 11±5cpm and mean binocular accommodation facility is 10 ± 5cpm [29] and 8.84±4.47cpm and 11.13 ± 5.58cpm were the BAF and MAF values in a study done by **Abbas Ali Yekta et al** [26] and in our study the mean monocular accommodative facility was 12.48±4.980cpm and binocular accommodation facility was 12.76± 4.082cpm. It was discovered that binocular accommodating facility was superior to monocular accommodating facility. The majority of accommodative and binocular tests are subjective, and disparities in assessment methods may have led to measurement inconsistencies.

The vergence system is indirectly measured by the relative accommodation tests; PRA measures NFV and NRA measures PFV [30]. In our study the mean value of negative relative accommodation and positive relative accommodation was +2.140±0.542D and -3.082±1.22D respectively. According to study done in Iran the mean PRA was -3.001±0.72D and NRA was +2.10±0.29D which was similar to our mean values. The mean PRA and NRA for Scheiman and Wick were -2.37±1.00D and +2.00±0.50D, respectively.

A study conducted in South Africa found that the positive relative accommodation was -2.44 ± 0.71D while the negative relative accommodation was 2.17 ± 0.48DS. The dynamics of refraction have an impact on the relative accommodation tests [31, 32]. The NRA values below that would imply hyper-tonicity, overcorrection of plus, or undercorrection of minus at distance, while those over +2.25 DS would suggest undercorrection of plus or overcorrection of negative in distance refraction. It is usual for young, healthy individuals with high AA to have PRA levels greater than -2.75 DS. Non-strabismic binocular vision dysfunctions are becoming a more prevalent issue, thus it's critical to identify the population most at risk and to start managing and preventing them as soon as feasible. The prognosis for binocular impairment can be improved by prompt diagnosis.

Prolonged near work is typically linked to this disease [33, 34, 35, 36]. According to the current study, 71.06% of VGU undergraduate engineering students have NSBVD. The major problem was Convergence insufficiency with the percentage of 22.10% followed by accommodative excess which is (17.89%). Several research findings concurred that the prevalence of accommodating dysfunction was noticeably greater than that of vergence dysfunction. In a study on the population of optometry students, **Dahal M.** found that accommodative disorder was the most common NSBVD, followed by vergence and oculomotor disorder. However, our study's NSBVD prevalence stood out from that of other studies. Out of 135 participants, 48 of them had accommodative anomaly and 87 of them had vergence anomaly, which means the percentage

of vergence anomaly is much higher than that of accommodative disorder.

As demonstrated even by a study conducted in South Africa, the CISS score did not correlate with positive fusional vergence distance or positive fusional vergence near or negative fusional vergence distance and near as determined by Spearman's Correlation test [32]. According to these results, there may not have been any underlying vergence abnormalities in the participants' magnitude or intensity that could have triggered symptoms.

On Pearson's Correlation test for CISS and Near point of Convergence, significance level (P) was 0.006 and correlation coefficient (r) was 1.80. Using various cutoff points, several studies discovered substantial correlations between NPC and symptoms [22]. As per our present research CI was the most common NSBVD. The most important diagnostic sign of CI is NPC due to which it might have been significantly correlated in present study.

Through Spearman correlation test of CISS with amplitude of accommodation, monocular accommodation facility and binocular accommodation facility were found to be strongly significant whereas NRA and PRA were found to be insignificant in a study done by Hennessy et al [37]. The facility that provided accommodations showed the strongest associations with symptoms. While the AA and NRA were the only ones found to be substantially linked with symptoms by Sterner et al., the AF test is more dynamic, interactive, and requires the accommodative-vergence to adapt to frequent changes in the stimulus, potentially producing more realistic results [38, 39].

The current study, which indicates that accommodative disorder is more symptomatic than vergence disorder, is consistent with a previous study that found accommodative abnormalities to be more symptomatic than vergence anomalies [40]. Out of vergence anomaly, divergence excess is the most symptomatic one according to the present study. But CISS score is more symptomatic for the convergence insufficiency in most of the studies.

Out of accommodative anomaly, the accommodative infacility was the more symptomatic one in the present study. The AF test produce more realistic results since it is a dynamic, more interactive test that requires the accommodative-vergence to react to rapid changes in the input [38].

Limitation of the Study

- Undergraduate students of only one college was included in the study, multicentric study could be done in future.
- There was age limit in our study.
- Refractive error was not correlated to other parameters in our study.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Among undergraduate engineering students, this study found that NSBVD was highly prevalent (71.06%), with 62.10% of the individuals exhibiting symptoms. According to these findings, it's critical to perform a comprehensive eye and binocular vision assessment on engineering students in order to identify NSBVD and to assess their own visual health. Furthermore, optometric vision treatment and the skill of lens prescription can effectively address these dysfunctions [21, 26]. Consequently, prompt diagnosis and treatment will have a beneficial effect on their future and raise life productivity.

6.2 Recommendations

- The results of this study imply that in order to identify NSBVD, proper eye test and binocular vision examination is necessary.
- Students who receive timely diagnosis and appropriate treatment for NSBVD will be able to reach their maximum potential.

The need of awareness among undergraduate engineering students about NSBVD is necessary.

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