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Effect of Quality of Sleep on Vergence & Accommodation in College Students

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[1,2]Dissertation submitted to the Rajiv Gandhi University of Health Sciences, Karnataka, Bangalore.
In Partial Fulfilment of the Requirements for the Degree of Bachelor of Science in Optometry

Under the Guidance of
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Mrs. A.P. NISHAD BEGUM

M. Optom Date:

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CERTIFICATION

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2020-2025

By

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LIST OF ABBREVIATIONS USED

- D - Diopter
- RAF Ruler - Royal Air Force Ruler
- Log MAR Chart - Logarithm Measure of Angle of Resolution Chart
- VA - Visual acuity
- AC/A RATIO – Accommodative Convergence to Accommodation ratio
- OD - Oculus Dexter
- OS - Oculus Sinister
- OU - Oculus Uterque
- H_0 - Null Hypothesis
- H_1 - Alternate hypothesis
- IPD – Interpupillary Distance
- PBCT - Prism Bar Cover Test
- PSQI – Pittsburgh Sleep Quality Index
- NPA - Near Point of Accommodation
- BE – Both Eye
- BI – Base In
- BO – Base out
- AF - Accommodative Facility
- PD – Prism Diopter
- NPC - Near Point of Convergence
- H_n – Heterophoria at near in prism Diopter
- H_d - Heterophoria at distance in prism Diopter
- VF - Vergence Facility
- cm - Centimeter
- Cpm - Cycle per minute
- SD – Standard Deviation
- P – Probability value
- n- Refractive index
- Min - minutes
- DO - Direct Ophthalmoscopy

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ABSTRACT

➢ ***Background:***

Both sleep & visual functions like accommodation & vergence are very important for students, especially those doing long hours of study or screen time. Many students complain of eye strain, headache or difficulty focusing & we wanted to explore whether sleep quality could be affecting their visual performance.

➢ ***Objective:***

To compare vergence and accommodation in students with good and poor sleep & identify the relationship between sleep quality among college students using questionnaire. To check the effect of sleep quality by measuring the NPA, AF, AC/A Ratio, NPC & VF values.

➢ ***Methodology:***

First, we took informed consent from the participant. Next, the participant asked to fill out a validated questionnaire which is based on PSQI. This help us to assess their sleep quality. Based on their scores, participant was divided into two groups: a. those with good sleep quality (PSQI score ≤5). b. those with poor sleep quality(PSQI score≥5). After that detailed history taking done and then visual acuity was taken. If VA is less, then refraction was done and then slit lamp examination was taken After that fundus examination was done. Then, we checked the NPA, AF, NPC,VF &AC/A RATIO). After collecting data, the result was done and after that we discussed and at last we did conclusion. Statistical Analysis was done by using Microsoft Excel and R-programming language of version- R 4.4.2.

➢ ***Results:***

The study involved 71 participants, the Six visual and sleep-related measures' mean values are shown in the bar chart along with matching error bars. The Near Point of Accommodation (NPA_OD), which indicates appropriate accommodative ability, is within the typical adult range of 9–10 cm. At roughly 12–13 cycles per minute, the Accommodative Facility (AF_OD) performs well. At about 6:1, the AC/A ratio is somewhat higher, indicating a possible convergence surplus or a greater accommodative- vergence connection. A little lower ability to converge is shown by the NPC break value, which is borderline (around 6–7 cm). Vergence facility (VF cpm), which indicates strong binocular flexibility, is normal at around 12 cycles per minute. The PSQI mean score of about 5 indicates that participants' sleep quality was borderline.

➢ ***Conclusion:***

In our research we are concluding that in college students having poor sleep quality demonstrates a reduced NPC with increasing AC/A Ratio. Sleep quality assessment during binocular vision examination in college students is recommended. Regulation of sleep is mandatory among college students & also in regular eye tests it is necessary to take detailed sleep quality history among college students.

Keywords: *Accommodation, Vergence, PSQI Questionnaire, Binocular Vision, Sleep Quality.*

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CHAPTER ONE
INTRODUCTION

➢ *Introduction*

Sleep is one of the basic physiological needs essential for the maintenance of human life, supporting physical health, emotional balance, and cognitive restoration.[9] It is an active biological process required for neurophysiological recovery, metabolic regulation, immune system functioning, hormonal balance and overall well being.[7] Despite its fundamental role, poor sleep quality has become a growing public health issue, particularly among university and college students.[4] University life often introduces increased academic pressure, demanding coursework, multiple responsibilities, social obligations and irregular daily schedule, all of which contribute to insufficient sleep and disturbed sleep patterns.[3] Studies report that nearly one-third of students do not meet the recommended sleep duration and over half experience poor overall sleep quality.[8] The prevalence of inadequate sleep is even higher in Asian student population, where academic and social stressors are pronounced.

Poor sleep has been strongly associated with adverse physical, emotional and cognitive outcomes. Students with inadequate or poor-quality sleep frequently experience daytime sleepiness, reduced energy, impaired concentration, memory difficulties and decreased academic performance. Psychological consequences such as higher stress levels, anxiety, depressive symptoms and dissatisfaction with daily functioning are commonly reported. Moreover, unrealistic expectations about sleep or excessive worry about sleep loss can further aggravate insomnia symptoms, creating a cycle of poor sleep and impaired functioning.[8]

Beyond general health effects, sleep deprivation can influence visual functions that are crucial for students academic tasks, particularly near work and digital device use. Evidence shows that reduced sleep can impair binocular vision mechanisms by affecting eye coordination and degrading convergence ability. While accommodative power may remain mostly stable within short periods of sleep loss, convergence functions, fusional vergence ranges and binocular stability are more vulnerable to fatigue and insufficient rest. Weakness in vergence control can result in eye strain, blurred vision, difficulty focusing on near tasks and occasionally diplopia. Since modern students spend significant hours on reading, writing and screen-based activities, these visual disturbances can interfere directly with learning efficiency and visual comfort.

Given that both poor sleep and binocular vision problems- especially vergence insufficiency- are highly prevalent among university students, understanding the relationship between sleep quality and visual functions such as accommodation and vergence is of increasing importance. Sleep health is a multidimensional concept encompassing sleep duration, quality, regularity, timing, efficiency and satisfaction and disturbances in any of these dimensions may influence visual performance.[1] However, there is limited research exploring how sleep quality specifically affects the accommodative and vergence systems in young adult student populations. Examining this relationship is essential not only to identify potential visual risks associated with poor sleep but also to guide interventions that could improve students academic performance, reduce fatigue and enhance overall quality of life.

Therefore, this study aims to explore the effect of sleep quality on accommodation and vergence in college students. By identifying whether poor sleep contributes to binocular vision instability or accommodative difficulties, the findings may provide valuable insight for clinicians, educators and students in promoting better sleep habits and maintaining optimal visual efficiency.

➢ *Accommodation*

The ability of eye to change its focus from distant to near objects and vice versa.[11] This process is achieved by the lens changing its shape.[11] Accommodation is the adjustment of the optics of the eye to keep an object in focus on retina as its distance varies from the eyes.[12]

- Pupillary response and accommodation are important physiological processes of the eye that affect vision.[13]
- Ocular accommodation is a blur reflex and results in focusing of images onto the retina.[13]
- Other visual functions such as contrast sensitivity, colour perception and visual acuity are influenced by pupil size and accommodation.[13]
- The accommodative state is largely controlled by parasympathetic innervation of the culinary muscles, although sympathetic innervation plays a complementary role in relaxing accommodation.[13]

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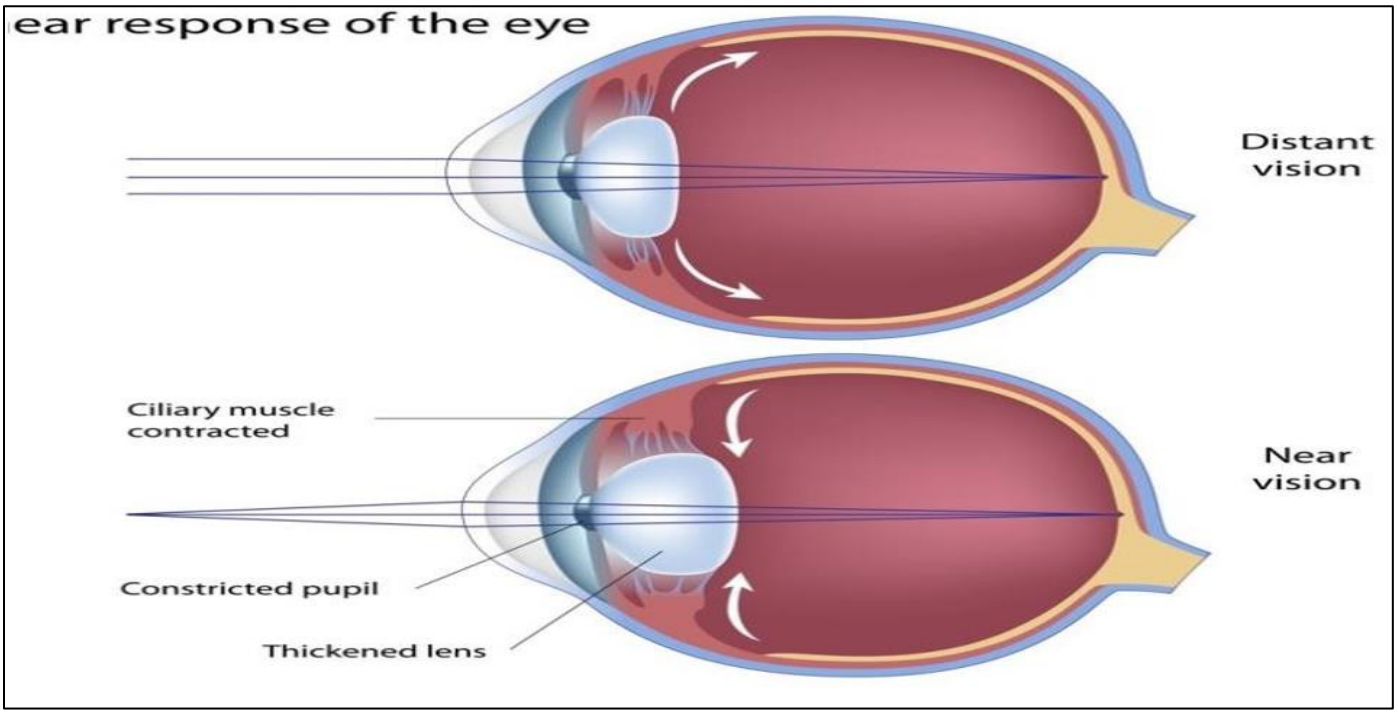

Fig 1 Effect of Accommodation on Divergent Rays Entering the Eye
(https://www.reviewofopthalomology.com/CMSImagesContent/2016/11/RP/069_rp1116_ttops.jpg)

➢ *Mechanism of Accommodation*

According to von Helmholtz's capsular theory the process of accommodation is achieved by a change in the shape of lens as below:[12]

When the eye is at rest (un-accommodated), the ciliary ring is large and keeps the zonules tense. Because of zonular tension the lens is kept compressed (flat) by the capsule.[12]

Contraction of the ciliary muscle causes the ciliary ring to shorten and thus releases zonular tension on the lens capsule.[12] This allows the elastic capsule to act unrestrained to deform the lens substance.[12] The lens then alters its shape to become more convex or conoidal (to be more precise).[12] The lens assumes conoidal shape due to configuration of the anterior lens capsule which is thinner at the centre and thicker at the periphery.[12]

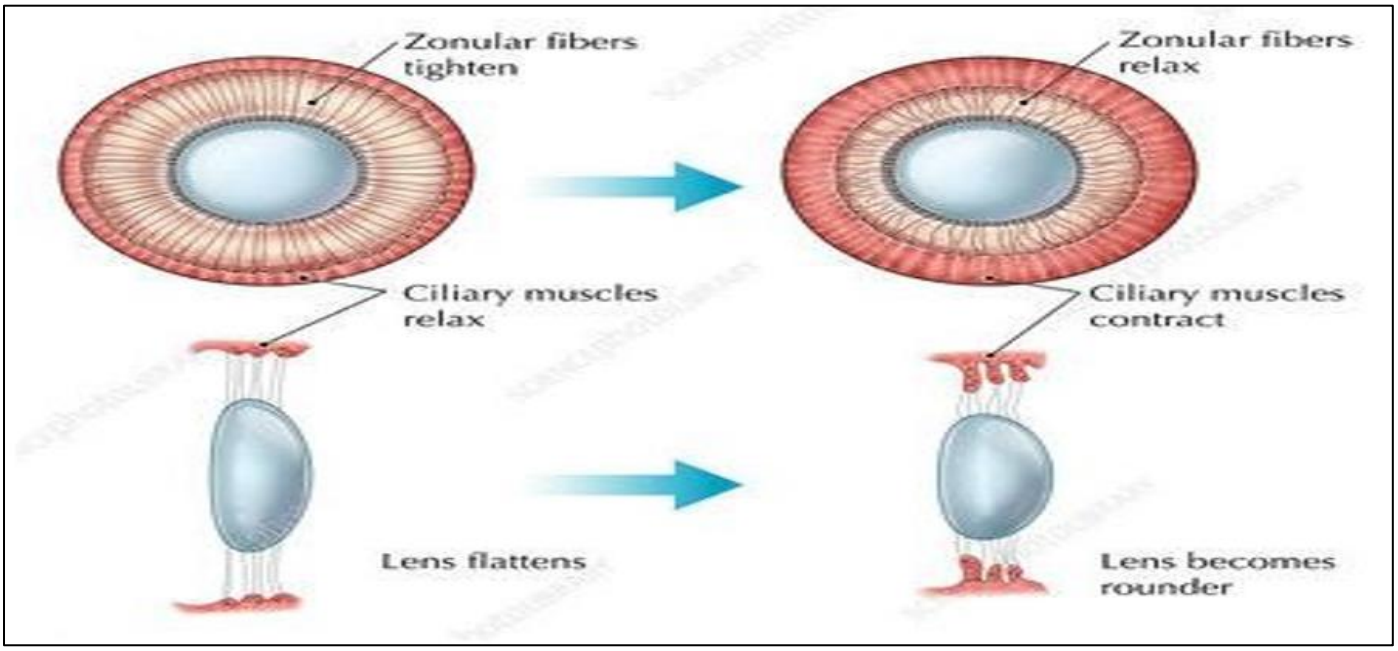

Fig 2 Changes in the Crystalline Lens During Accommodation
(https://media.sciencephoto.com/image/c0276462/800wm/C0276462Lens_Accommodation._Illustration.jg)

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➢ *Far Point and Near Point of the Eye*

The nearest point at which small objects can be seen clearly is called near point or punctum proximum and the distant point is called far point or punctum remotum.[12]

- *These Vary with the Static Refraction of the Eye as Shown Below:*

✓ In an emmetropic eye far point is infinity and near point varies with age.[12]
✓ In hypermetropic eye far point is virtual and lies behind the eye.[12]
✓ In myopic eye, it is real and lies in front of the eye.[12]

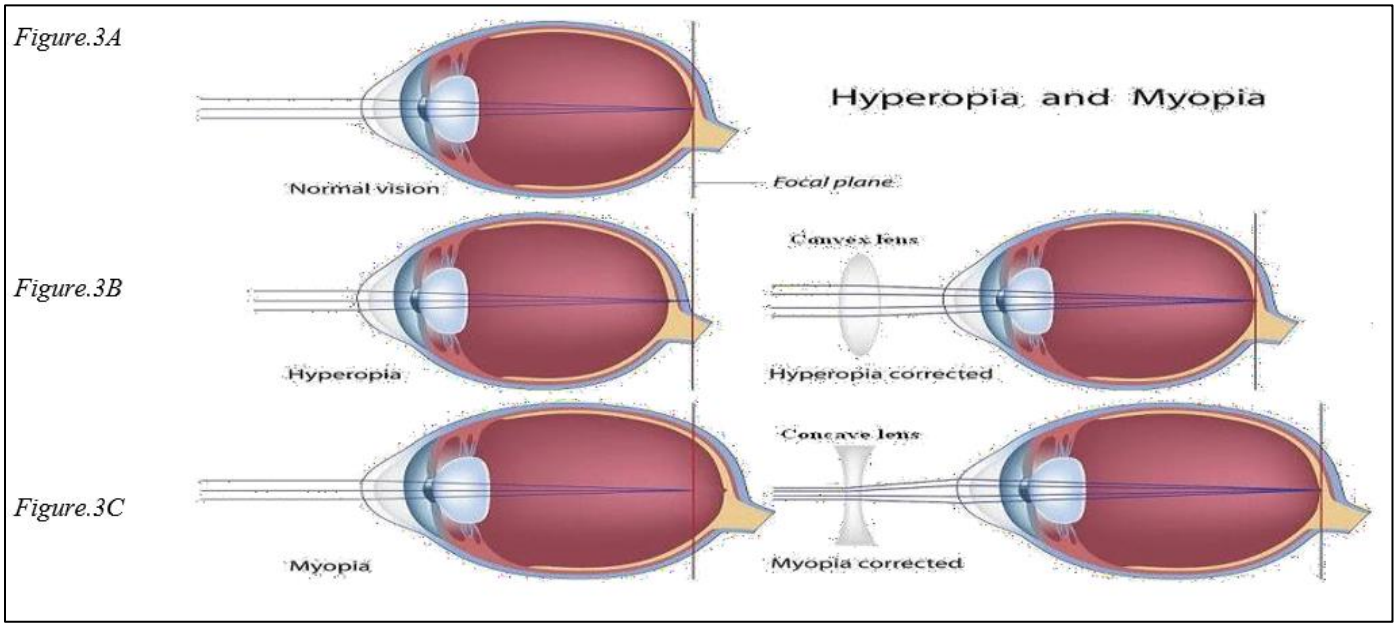

Fig 3 Far Point in Emmetropic Eye (A); Hypermetropic Eye (B); Myopic Eye (C)
Courtesy (https://images.app.goo.gl/KETxYKR5MNE7ZRTt7)

➢ *Range and Amplitude of Accommodation*

- *Range of Accommodation*

The distance between the near point and the far point is called the range of accommodation.[12]

- *Amplitude of Accommodation*

The difference between the dioptric power needed to focus at near point (P) and far point (R) is called amplitude of accommodation (A). Thus A = P–R[12]

Amplitude of accommodation and thus the near point of vision (punctum proximum) vary with age.[12]

Table 1 Estimate of Amplitude of Accommodation and Near Point at Different Ages

(in years)	Amplitude of Accommodation	Near point (in cm)
10	14 D	7
20	10 D	10
30	7 D	14
40	4 D	25
50	2 D	50
60	1 D	100

➢ *Theory of Accommodation*

- *Helmholtz Theory of Accommodation:*

Schematic representation of the Helmholtz theory of accommodation, in which contraction of the ciliary muscle during accommodation leads to relaxation of the zonular fibers.[14] The reduced zonular tension allows the elastic capsule of the lens to contract, causing an increase in the anterior and posterior lens curvature.[15]

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- *Schachar Theory of Accommodation:*

Schematic depiction of the Schacher theory, which proposes that only the equatorial zonules are under tension during accommodation and that the anterior and posterior zonular fibers serve solely as passive support structures for the lens. [15]

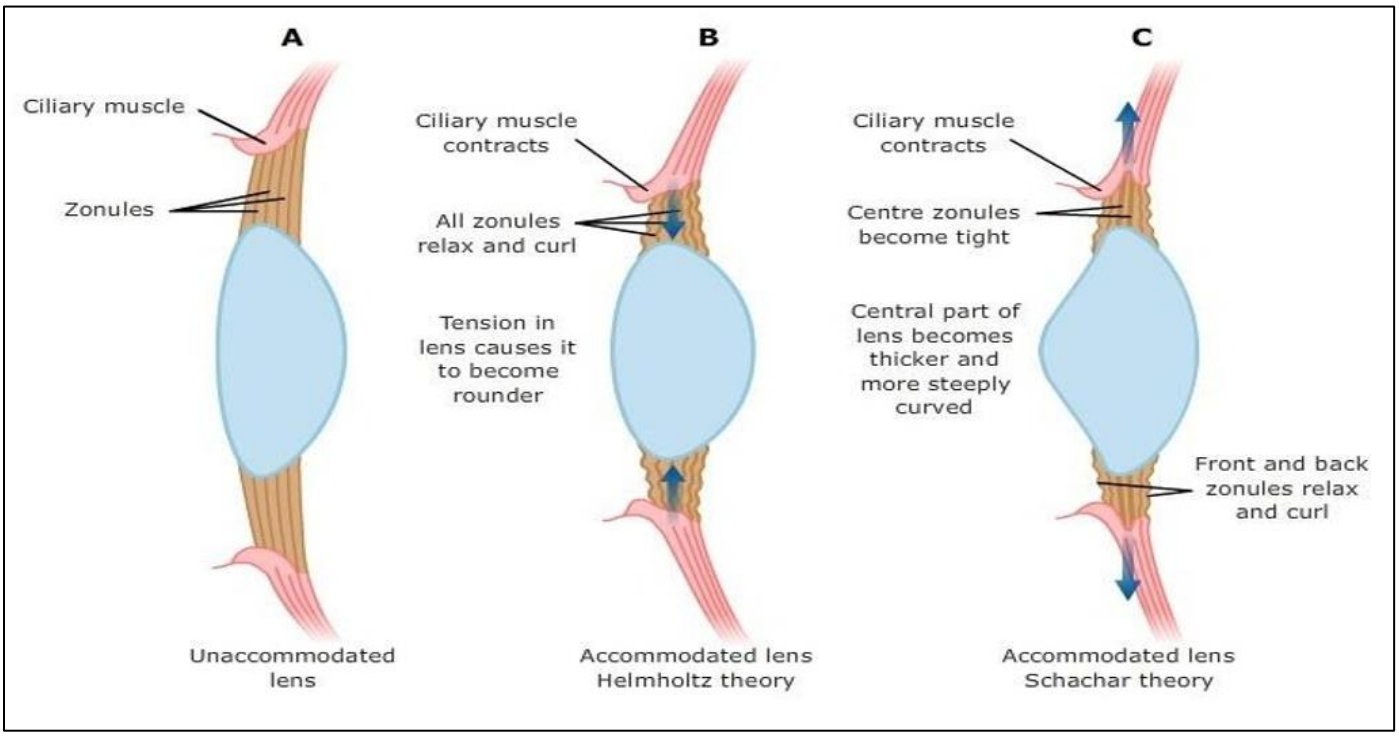

Fig 4 Theory of Accommodation
(http://images.app.goo.gl/zeHIyuX8af7zurJn6)

➢ *Vergence*

Vergence refers to the simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision. It is a type of disconjugate eye movement, meaning each eye moves in a different direction—unlike conjugate movements (e.g., looking left or right) where both eyes move in the same direction.[16]

The vergence angle is the angle formed between the lines of sight of the two eyes as they converge (or diverge) to focus on an object.[16] This angle changes depending on the distance of the object being viewed:

- Near object → larger vergence angle (convergence)
- Far object → smaller vergence angle (divergence)

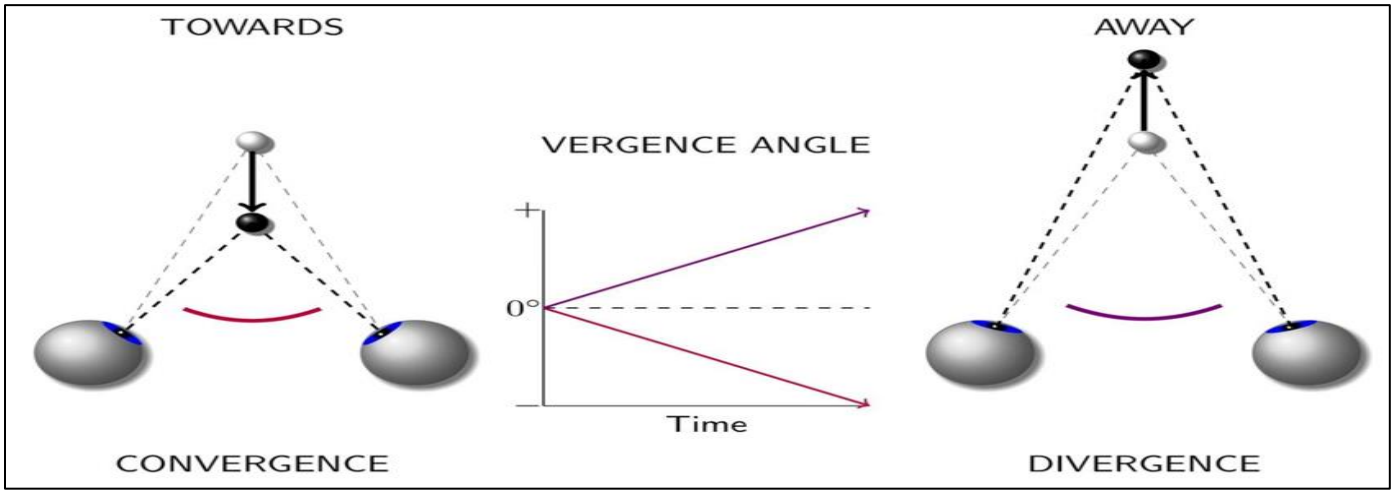

Fig 5 Vergence Angle
(https://www.nature.com/articles/s41598-019-53902-y)

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➢ *Types of Vergence:*

- Convergence: Inward movement of both eyes toward the nose (e.g., when focusing on a nearby object).[16]
- Divergence: Outward movement of both eyes (e.g., when shifting focus to a distant object).[16]
- Vertical Vergence: One eye moves up while the other moves down (less common, often due to muscle imbalances).[16]
- Cyclovergence: Rotational movements of the eyes (helps maintain image stability on the retina).[16]

➢ *Importance of Vergence:*

- Maintains binocular vision and depth perception (stereopsis).[16]
- Crucial for tasks requiring accurate focus on near objects, such as reading or using digital devices.[16]
- Dysfunction in vergence can lead to eye strain, double vision, or conditions like convergence insufficiency.[16]

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CHAPTER TWO
REVIEW OF LITERATURE

➢ *Review of Literature*

- Kuhn et al. (2024) conducted a cross- sectional online survey among 1,566 Canadian university students to examine how academic discipline, sleep hygiene, insomnia, and sleep attitudes relate to sleep quality. The study found that sleep quality and sleep duration varied significantly across academic disciplines, with students in Humanities and Social Sciences demonstrating better sleep hygiene and fewer dysfunctional sleep attitudes, while Health and STEM students reported poorer sleep hygiene and worse overall sleep quality. The results also showed that sleep hygiene practices and dysfunctional sleep attitudes were strong predictors of both sleep quality and sleep duration. The study concluded that academic discipline plays an important role in influencing students' sleep patterns, and improving sleep habits may help students—especially those in demanding Health and STEM fields— manage stress and achieve better sleep outcomes.

- Woi et al. (2024) conducted a cross-sectional study on 64 university students to compare vergence mechanisms between those with good and poor sleep quality. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), and various vergence measures—including near point of convergence, fusional vergence ranges, and convergence ability—were evaluated. The study found that students with poor sleep quality showed significantly reduced convergence ability and smaller fusional vergence ranges compared to students with good sleep quality. These findings suggest that inadequate sleep may negatively affect the visual system's ability to maintain comfortable binocular vision. The authors concluded that poor sleep quality can impair vergence mechanisms in university students, potentially reducing visual comfort and affecting academic performance.

- Maciel et al. (2022) carried out a cross-sectional study involving 996 university students to identify factors associated with sleep quality. Sleep quality was measured using the Mini Sleep Questionnaire, and data were analyzed using Poisson regression to determine significant predictors. The study found that 23.1% of students experienced poor sleep quality, and several factors were strongly linked to this problem, including psychological distress, food insecurity, discrimination, low social support, and being female. These findings highlight that sleep quality among university students is influenced not only by personal habits but also by broader social and emotional stressors. The researchers concluded that improving mental health resources, reducing stress, and enhancing social and economic support systems may play an important role in improving students' overall sleep quality.

- Lukowski et al. (2021) in this study examined conducted a quantitative cross- sectional study involving 167 university students to examine how temperament, sleep hygiene, and insomnia are related. Using standardized questionnaires such as the ATQ for temperament, SHI for sleep hygiene, PSQI for sleep quality, and ISI for insomnia severity, the researchers analyzed the data through correlation, mediation, and moderation methods. The study showed that students with certain temperament traits—particularly high negative affect or low effortful control—tended to have poorer sleep hygiene, which in turn contributed to poor sleep quality and increased insomnia symptoms. These findings suggest that individual personality traits can influence sleep behaviors and mental well-being. The study concluded that enhancing sleep hygiene and improving emotional regulation may help students achieve better sleep and reduce insomnia severity.

- Nielson et al. in (2021) in this study surveyed 247 college students using a cross- sectional design to explore how the value students place on sleep relates to their actual sleep health and daytime functioning. Using standardized tools such as the PSQI for sleep quality, the ESS for daytime sleepiness, and additional measures for fatigue, emotional functioning, depression, and anxiety, the researchers found a strong connection between high sleep valuation and better sleep outcomes. Students who valued sleep more tended to have better sleep quality, fewer sleep disturbances, and lower levels of daytime sleepiness. They also reported significantly reduced symptoms of depression and anxiety, whereas those with poor sleep quality experienced more psychological distress and emotional problems. The study concluded that recognizing sleep as an important priority can positively influence both mental and physical well-being by promoting healthier sleep behaviors and improved daytime functioning.

- Yildirim et al. (2020) conducted a descriptive cross-sectional study with 512 university students to assess sleep quality and the factors influencing it. The results showed that many students had poor sleep quality, with worse scores seen in those who shared rooms, woke up feeling tired, or used cigarettes and alcohol. The study concluded that unhealthy daily habits, lifestyle behavior and poor sleep environments strongly affect how well students sleep, highlighting the need for healthier routines to improve sleep quality.

- Jin et al. (2018) examined dysfunctional sleep beliefs in 1,333 Chinese college students and found that those with poor sleep quality held more negative and incorrect beliefs about sleep. These beliefs were more common among female and non-medical students, who also tended to exercise less, relax less, and use sleep medication more often. The study suggests that correcting false sleep beliefs through awareness and education can help improve sleep quality and encourage healthier sleep habits.

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- Tong J. et al. (2016) conducted an experimental investigation involving 87 participants with normal vision to determine how sleep deprivation affects binocular coordination. The subjects were kept awake for 26 hours under supervision, and their binocular coordination was measured at three different time points using a visual tracking task that required horizontal eye movements. Eye-tracking metrics such as gaze–target synchronization and the standard deviation of gaze position were analyzed to assess changes in stability. The findings showed that prolonged sleep deprivation caused a significant decline in binocular coordination, with participants displaying more unstable and less accurate eye movements, especially during horizontal tracking tasks. The researchers concluded that lack of sleep negatively impacts visual performance and emphasized the importance of ensuring adequate sleep for individuals working in fields that require precise and stable visual coordination.

- Lund et al. (2012) was a cross-sectional survey conducted with 1,125 first-year university students to understand their sleep quality and its impact. Using the Pittsburgh Sleep Quality Index and questions about academics, stress, mental health, and lifestyle, the researchers found that more than 60% of students had poor sleep quality. These students also showed lower GPA, higher stress levels, more depressive symptoms, and greater alcohol use. The study concluded that poor sleep is very common among college students and is strongly linked to both poorer academic performance and worse mental well-being.

- Behnke A. (2001) tested 11 college students to see how sleep deprivation affects their eyes. After staying awake for 24 hours, students showed a worse near point of convergence, meaning their eyes had trouble working together at close distances. Accommodation changed very little. The study concluded that lack of sleep affects vergence more than accommodation, and good sleep is important for healthy binocular vision.

➢ *Need of Study*

- Relation between vergence and accommodation among college students to check their sleep quality.

➢ *Hypothesis*

- *Null Hypothesis(H0):*
  There was no significant changes in accommodative and vergence parameters while checking sleep quality.

➢ *Alternate Hypothesis(H1):*
  There was a significant change in accommodative and vergence parameters while checking sleep quality.

➢ *Aim & Objectives*

- *AIM:*
  To study the effect of sleep quality on vergence and accommodation in SIAHS students.

- *Objectives:*

✓ To compare vergence and accommodation in students with good and poor sleep.
✓ To identify relationship between sleep quality and eye strain.
✓ To identify the relationship between sleep quality among college students using questionnaire.
✓ To check the effect of sleep quality by measuring the NPA, AF & AC/A Ratio values.
✓ To check the effect of sleep quality by measuring the NPC & VF.

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CHAPTER THREE
MATERIALS & METHODOLOGY

➢ *Materials And Methodology*

- *Research Design*

✓ Study site: Shridevi Institute of Allied Health Sciences, Tumkur.
✓ Source of data: Students of Shridevi Institute of Allied Health Sciences, Tumkur.
✓ Study design: Cross-sectional study Sampling method: Convenience study Sample size: 71 Samples
✓ Study duration: March 2025 to September 2025

- *Sample Calculation Formula:*

$$\textbf{Sample Size (n)} = \frac{Z^2 * p * q}{E^2} = 71 \text{ Participants}$$

Where

p = Expected prevalence rate of Poor sleep quality

q = 1-p

Z = Standard normal variate at 90% is 1.645 E = Margin of errorMATERIALS USED

➢ *Materials Used*

Fig 6 Trial Set & Trial Frame (Self Image)

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Fig 7 Royal Air Force (Self Image)

Fig 8 Accommodative Flipper(±1.50D) (Self Image)

Fig 9 Vergence Flipper (3BI & 12BO (Self Image)

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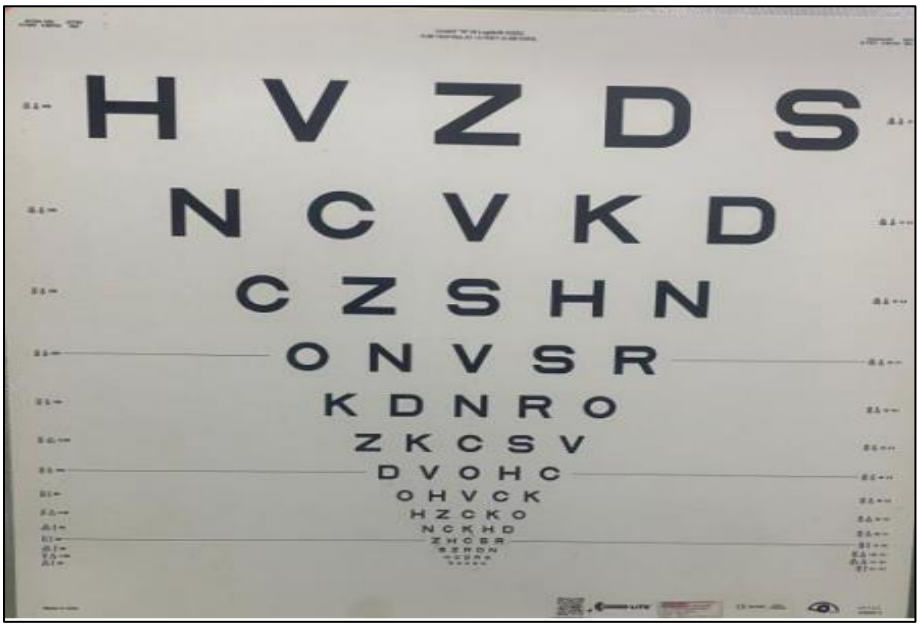

Fig 10 Logmar Chart (Self Image)

Fig 11 Prism Bar (Self Image)

Fig 12 Retinoscope & Ophthalmoscope (Self Image)

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Fig 13 Pentorch (Self Image)

Fig 14 Occluder & Linear Target (Self Image)

1 today	2 shall	3 clean	4 after	5 brown
6 under	7 found	8 never	9 again	10 thank
11 white	12 sleep	13 green	14 which	15 three
16 every	17 force	18 seven	19 teach	20 start
21 could	22 their	23 black	24 where	25 carry
26 about	27 ruler	28 comet	29 bring	30 world
31 robin	32 stand	33 watch	34 hotel	35 round
36 night	37 drink	38 north	39 short	40 place

Fig 15 Word Rock Card (Self Image)

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Fig 16 Stopwatch (Self Image)

QUESTIONNAIRE (Validated on- 17/06/25)

TITLE: EFFECT OF QUALITY OF SLEEP ON VERGENCE AND ACCOMMODATION IN COLLGE STUDENTS

Participant Name:

Age/Gender:

Pittsburgh Sleep Quality Index (PSQI) (CC By-NC- ND 4.0)

Items:

1. What time have you usually gone to bed at night?
2. How long has it usually taken you to fall asleep each night?
3. What time have you usually gotten up in the morning?
4. How many hours of actual sleep did you get at night?
5. How often have you had trouble sleeping because you:
   a. Cannot get to sleep within 30 minutes
   b. Wake up in the middle of the night or early morning
   c. Have to get up to use the bathroom
   d. Cannot breath comfortably
   e. Cough or snore loudly
   f. Feel too cold
   g. Feel too hot
   h. Have bad dreams
   i. Have pain
   j. Other reason(s), please describe
6. How often have you taken medicine to help you sleep (prescribed or "over the counter")?
7. How often have you had trouble staying awake while driving, eating meals or engaging in social activity?
8. How much of a problem has it been for you to keep up enough enthusiasm to get things done?
9. How would you rate your sleep quality overall?
10. Do you have a bed partner or roommate?

Answers: Wai et al (Int J Ophthalmol)

Yours sincerely,

Sajana Kannan

Rita Chaudhury Thora

Guided By:

Mrs. A.P. Nishad Begum

Fig 17 PSQI Questionnaire (Self Image)

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➢ *Inclusion Criteria:*

- Age between 19 to 27 years.
- All participants must have 0.0 Log unit (6/6) vision with or without subjective correction.
- Refractive error within +6.00D to -6.00D sphere and ≤ 1.50D cylinder.
- No significant binocular vision anomalies (only heterophoria allowed).
- Consent to participate in the study.

➢ *Exclusion Criteria:*

- History of ocular diseases.
- History of systemic diseases.
- Neurological or psychiatric disorders.
- Binocular vision anomalies other than heterophoria.
- Taking medication affecting sleep or poor general health.

➢ *Methodology*

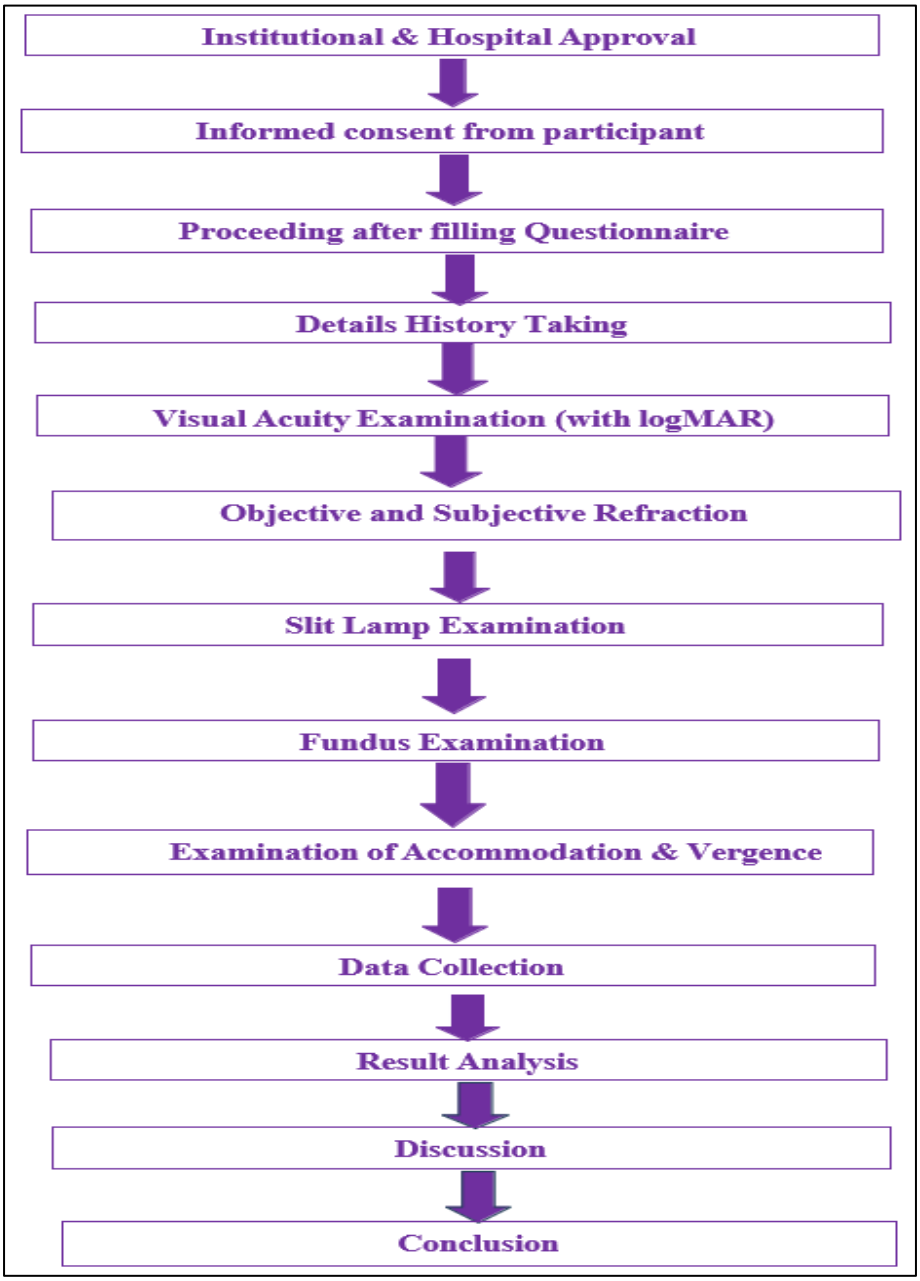

Fig 18 Flow Chart of "Effect of Quality of Sleep on Vergence and Accommodation in College students"

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Subjects were selected from Shridevi Institute of Allied Health Science of Tumkur from March 2025 to September 2025. The purpose of the study was explained and informed, consent was taken from them.

All the participants had to undergo a comprehensive ocular examination. Eyes that fulfilled the inclusion criteria were selected for further assessment and 71 subjects were selected for this study. Visual Acuity, Subjective Refraction, Objective Refraction, Slit Lamp Examination, Fundus Examination, Accommodation Parameters (Near Point of Accommodation, Accommodative Facility, AC/A ratio) & Vergence Parameters (Near Point of Convergence, Vergence Facility). The detailed procedure performed in the study is explained below.

➢ *History Taking:*

History taking is a step to evaluate subjects eye health by recording their Demographic History such as Name, Age, Gender, Address, Contact Info proceeded by Chief Complaints, Ocular History, Systemic History, Medical History, Family History, Social History were documented.[17]

➢ *Visual Acuity:*

- *Distant Visual Acuity:*

A log MAR chart (Logarithm of the Minimum Angle of Resolution) was used to evaluate Distant Visual Acuity from distance of 4 meter.[18] The subject was asked to sit comfortably and read with each eye separately. Then the Visual Acuity was recorded (Aided & Unaided).[19]

✓ *The Formula Used in Calculating the Score is:*

- Log MAR VA = 0.1 + Log MAR value of the best line read – 0.02 X (number of optotypes read)
- Log MAR VA = Log MAR value of the best line read + 0.02 X (number of optotypes missed) [19]

- *Near Visual Acuity:*

Near visual acuity was tested with the help of Roman test type at 40cm. (11) The subject was asked to read the chart kept at 35 - 40cm with the good illumination. (11) Each eye was tested separately and recorded.[11]

Fig 19 Near Visual Acuity Test (Self Image)

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➢ *Refraction:*

- *Objective & Subjective Refraction:*

The subject is made to sit at the distance of 1m from the examiner & instructed to focus on a distance target 6/60.[14] Now the examiner, through retinoscope observe the red reflex in the subject eye.[14] If the reflex moves 'with the movement' a plus lens is needed and if it moves 'against the movement' a minus lens is needed to Neutralise.[18] This procedure is repeated for both the vertical & horizontal meridian to measure the astigmatism. Same procedure is repeated to other eye. [14,18] Then we subtract the Working Distance from the neutralising lens by which we get value of subjective refraction. [14,18]

➢ *Slit Lamp Examination:*

The slit- lamp was used as comprehensive eye exam to visualize the Anterior Segment of the eye.[22] The participant was made to seat comfortably in front of the slit-lamp with the chin placed at the chin rest & forehead against head rest to keep it steady. Diffused illumination was used to examine the Lid Margin, Conjunctiva, Iris pattern. Pupil regularity was observed by changing the intensity of illumination. [12] Cornea, Anterior Chamber depth and Crystalline Lens was observed using optical section.[12,22]

➢ *Fundus Examination:*

Fundus examination was performed using Direct Ophthalmoscope (DO). Subject was informed about the procedure.[12,18] The subject is asked to sit comfortably and asked to look at distant point.[12] Slowly the DO is moved closer to subjects eye from 15 inches to 1 or 2 inches, particularly the Retina, Optic Disc, Macula & Blood Vessels are observed and recorded monocularly.[12,18]

➢ *Accommodation:*

- *Near Point of Accommodation:*

The subject was explained about the procedure & asked to sit comfortably in well light area & asked to wear corrected lenses (if any), it was performed binocularly.[13] The Royal Air Force Ruler (RAF) was positioned horizontally & aligned with subject visual axis starting from a distance of 50cm with target of N8 line, now slowly begin to move the target closer to the subjects eye.[18] Instruct them to inform as soon as the target becomes blurry/difficult to read. Record the measurement in centimetre from the target becomes blurry.[18]

- *Accommodative Facility:*

It was performed using Accommodative Flipper ±1.50 D and Word Rock Card from the distance of 40 cm. Ensure the subject is seated comfortably with proper lighting condition. Explain the test to the subject & instruct to focus on Word Rock Card.[12]Start with +1.50 D lens, ask the subject to read as the word become clear and now flip the flipper to -1.50 D lens. Perform the procedure for a set period, usually of 1 minute.[18] Count the number of cycles (one flip of +1.50 D & one flip of -1.50D is considered as One Cycle) the subject completes in 1 minute.[12,18]

Fig 20 NPA Test (Self Image)

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Fig 21 AF Test (Self Image)

- *AC/A Ratio:*

The AC/A ratio (Accommodative Convergence to Accommodation ratio) describes how much the eyes converge for every 1 diopter of accommodation. Normally, it ranges from 3:1 to 6:1. A high AC/A ratio means the eyes converge too much for the amount of accommodation, commonly seen in convergence excess or near esotropia,while a low AC/A ratio means the eyes do not converse enough, often seen in convergence insufficiency or near exophoria. [12] The heterophoria method is calculated by using formula: AC/A ratio= IPD + NFD (Hn-Hd).

➢ *Vergence:*

- *Near Point of Convergence:*

The Royal Air Force (RAF) rule was placed on the bridge of the participants's nose, they were asked to fixate on the dot stimulus on the carrier. The participants were asked to inform the examiner when the target become double. It was then pulled back until it was single and the distance from the ruler recorded. This test was undertaken BE only.[20]

Fig 22 AC/A Ratio Method (Self Image)

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Fig 23 NPC Test (Self-Test)

- *Vergence Facility:*

Vergence facility aims to represent the capacity of the fusional vergence system to react quickly and percisely to changing vergence demands over time. It is defined by the number of cycles per minute (cpm) that a stimulus can be fused through alternative BI & BO prisms. VF was calculated while reading N6 test at a distance of 40cm usin the prism flippers (12 Prism Dioptre (PD) BO and 3 Prism Dioptre (PD) BI).[21]

Fig 24 VF Test (Self Image)

➢ *PSQI Questionnaire*

Sleep quality was measured using the validated Malay version of Pittsburgh Sleep Quality Index (PSQI- M) questionnaire. It was used to measure self-reported sleep quality and sleep disturbance that occurred in the past month. It consistes of 19 individual items that can be divided into seven score components which are sleep quality, sleep latency, sleep duration, sleep efficiency, sleep

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disturbance, sleep medication, and daily dysfunction. The total score from each component gives a global score ranging from 0 to 21. Lower global PSQI- M score indicates good sleep quality while high PSQI- M indicates poor sleep quality. Subjects with a global score greater than 5 are categorized as poor sleepers, while those with a score less than or equal to 5 are categorized as good sleepers.

- *Statistical Analysis*

The data assessment process will be performed by using Microsoft Excel and R- programming language of version- R 4.4.2. In the data assessment process, the demographic variables frequency, averages, percentages will be measured by descriptive statistics. The Shapiro- Wilks test and skewness were used to test for near and distance heterophorias. The PSQI global scores will be used to assess the sleep quality, sleep efficacy and total sleep time. The correlation co-efficient will be used to examine aspects of convergent and discriminant validity between sleep valuation, sleep quality and day time sleepiness if necessary. An independent sample t-test will be used for continuous and Chi- square test will be applied to categorical variables wherever necessary. A significance level of 0.05 ($p<0.05$) is considered for statistical significance.

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CHAPTER FOURE
RESULT

➢ *Result*

Table 2 Distribution of Participants by Age-Group and Gender

Age-group	Males	Females	Total
19-21	11 (42.30%)	18 (40%)	29 (40.85%)
21-23	4 (15.38%)	11 (24.44%)	15 (21.13%)
23-25	6 (23.08%)	11 (24.44%)	17 (23.94%)
25-27	5 (19.23%)	5 (11.11%)	10 (14.08%)
Total	26 (36.62%)	45 (63.38%)	71 (100%)

The table 2 shows that females represented the majority of the sample (63%), particularly at younger ages, and the largest subgroups are girls aged 19–21 (40%). Only the oldest age group (25–27) has an approximately equal proportion of males and females and smaller age groups have more females. Age and gender differences may affect both visual function and sleep measures, therefore these demographic variables are crucial for understanding study results.

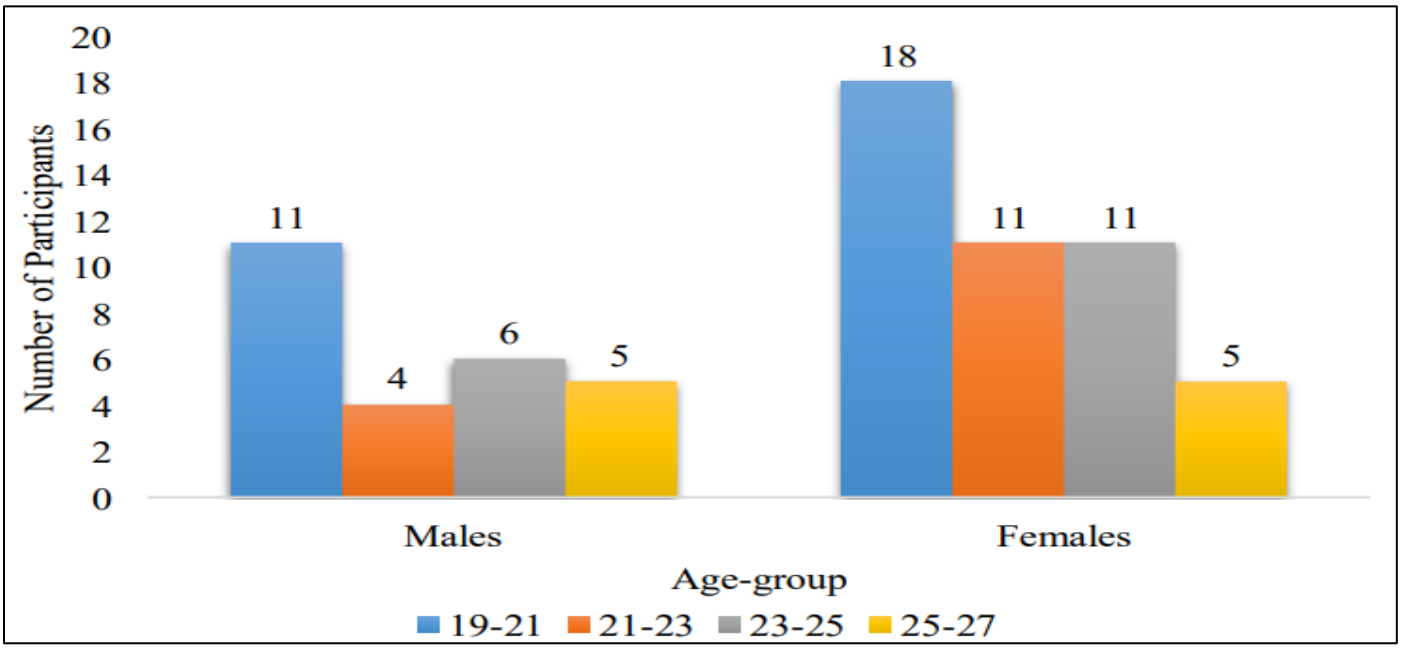

Fig 25 Distribution of Participants by Age-Group and Gender

- *Interpretation:*

According to the age-wise gender distribution, there are more female participants than male participants in the majority of age categories. The age range of 19 to 21 had the largest representation, with 18 girls and 11 males, indicating that this is the most prevalent category in the sample. In the 21–23 and 23–25 age groups, the proportion of girls (11 in each group) is more than double that of males (4 and 6, respectively). On the other hand, the 25–27 age group is the only balanced age group in the sample, with five participants from each gender. Overall, the distribution indicates that young individuals between the ages of 19 and 25 make up the bulk of participants, with females having a notably greater participation percentage.

Table 3 Clinical Summary of Accommodative and Vergence Parameters with Normative Value

Parameter	Sub group	Mean	SD	Normative Value
NPA	OD	9.52	1.73	10-15
	OS	9.28	1.64	10-15
	OU	8.33	1.68	10-15
AF	OD	12.57	2.92	9-12
	OS	13.07	2.75	9-12
	OU	13.49	2.61	9-12
AC/A ratio	RATIO	0.26	0.02	6:1
NPC	BREAK	6.68	1.84	5-10
	RECOVERY	8.90	1.94	7-12
VF	VF	12.33	1.77	9-12

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- *Interpretation:*

The measured mean values of important accommodative and vergence function parameters are compared with their corresponding normative (expected) ranges in the table. This helps in assessing whether visual efficiency is within normal limits or whether disturbance might exist. Stronger accommodating ability (closer focus) is indicated by lower NPA levels. The majority of accommodative and vergence criteria, the results show typically good visual efficiency. Strong accommodating capacity is indicated by Near Point of Accommodation (NPA) values for OD, OS, and OU that are marginally better than the anticipated range. All subgroups have above-average Accommodative Facility (AF) ratings, which show high flexibility in switching between near and distance targets. With Near Point of Convergence (NPC) break and recovery values falling within the typical physiological range, vergence skills also seem to be sufficient. Vergence Facility (VF) demonstrates good binocular synchronization and performs somewhat above average. The AC/A ratio, however, is much below the normative range, suggesting a diminished accommodating convergence response. This could indicate an increased risk for poor convergence in spite of generally good visual function. Except for a noticeably lower AC/A ratio, individuals generally show effective accommodation and vergence performance.

Table 4 Correlation Coefficients with PSQI

Measures	Correlation with PSQI
NPA_OD	-0.18
AF_OD	-0.04
AC/A Ratio	0.07
NPC Break	-0.16
VF cpm	0.15

- *Interpretation:*

A weak negative link is indicated by a correlation of -0.18 with PSQI. This implies that sleep quality may somewhat deteriorate (higher PSQI = poorer sleep) while accommodation ability slightly deteriorates (greater NPA signals worse accommodation). However, this association is weak and probably not clinically relevant. There is essentially no significant linear association between accommodative facility and sleep quality, as seen by the very small negative correlation (-0.04) with PSQI changes in this ratio do not consistently reflect variation with sleep quality; the weak positive correlation (0.07) indicates no significant link. Again, the effect is modest, but the negative association (-0.16) with PSQI indicates a slight tendency that weaker convergence ability can be associated with poorer sleep. A modest but positive connection (0.15) suggests that improved vergence capacity may be linked to higher- quality sleep. These connections between PSQI-measured sleep quality and vision-related metrics are not statistically significant or meaningful in this data set. These accommodative and vergence indices show that vision function is essentially unaffected by sleep quality.

Table 5 Distribution of Participants by Gender

Gender	Samples
Males	26 (37%)
Females	45 (63%)

- *Interpretation:*

The gender distribution of all 71 study participants is shown in the table. Of the sample as a whole, 45 participants (63.4%) were female and 26 participants (36.6%) were male. This suggests that a greater percentage of the study sample consisted of women than men. The gender disparity raises the possibility that female responses had a greater impact on the study's conclusions, which should be taken into account when extrapolating the findings to a larger population.

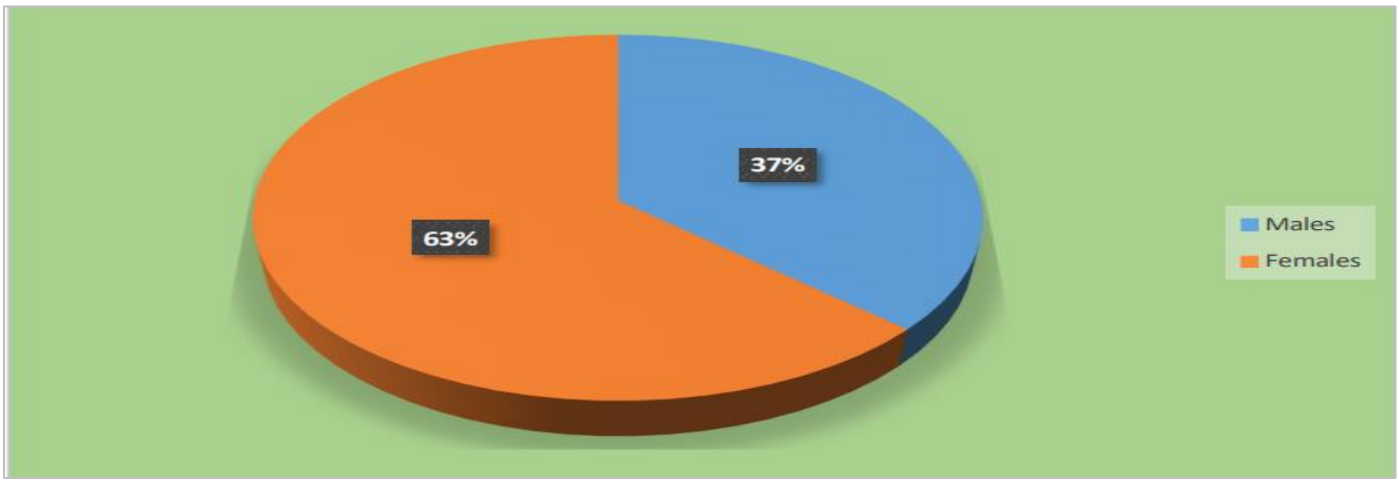

Fig 26 Distribution of Participants by Gender

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- *Interpretation:*

The distribution of genders of the 71 participants is displayed in the pie chart. Males make up 37% of the sample as a whole, while females make up the majority at 63%. This suggests that the survey included more female respondents than male respondents. There may be more ladies available to participate, as indicated by the larger percentage of females. Overall, the graph clearly shows that the majority of study participants were female.

Table 6 Statistical Analysis Table of Comparison

S.NO.	Comparison	Test Statistic	p-Value	Interpretation Result
1.	NPA (OD v/s OS)	Paired t-test	0.021	There is a significant difference between eyes
2.	AF (OU) v/s VF	Wilcoxon signed rank test	0.00002	The values are not equal and no difference is observed

- *Interpretation:*

A statistically significant difference (p = 0.021) was found when the Near Point of Accommodation (NPA) of the right eye (OD) and left eye (OS) was compared using a paired t-test. This suggests that the two eyes' capacities for accommodation differed, and the observed discrepancy is unlikely to be the result of chance. Depending on the size of the difference, the clinical relevance should be cautiously interpreted even though it is statistically significant. The Wilcoxon Signed Rank Test, on the other hand, produced a highly significant p-value (p = 0.00002) when comparing Accommodative Facility (AF) and Vergence Facility (VF). This outcome demonstrates that there is a significant disparity between the two functional visual talents and that AF and VF scores are not equivalent. Indicating different visual system demands for accommodation and vergence, the substantial difference implies that participants perform better in one metric than the other.

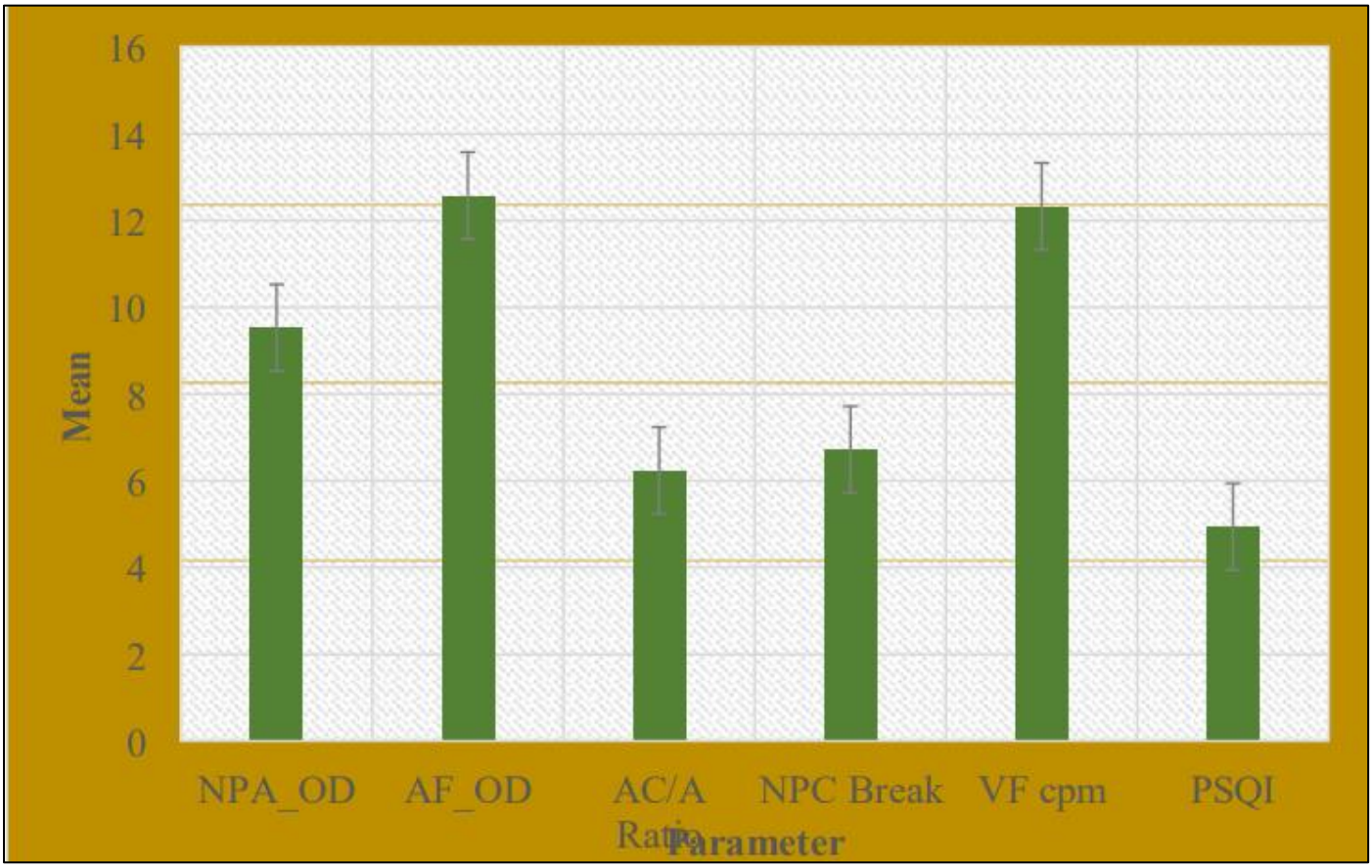

Fig 27 Mean and Standard Deviation of Vision and Sleep Quality Parameters

- *Interpretation:*

The Six visual and sleep-related measures' mean values are shown in the bar chart along with matching error bars. The Near Point of Accommodation (NPA_OD), which indicates appropriate accommodative ability, is within the typical adult range of 9–10 cm. At roughly 12–13 cycles per minute, the Accommodative Facility (AF_OD) performs well. At about 6:1, the AC/A ratio is somewhat higher, indicating a possible convergence surplus or a greater accommodative-vergence connection. A little lower ability to converge is shown by the NPC break value, which is borderline (around 6–7 cm). Vergence facility (VF cpm), which indicates strong binocular flexibility, is normal at around 12 cycles per minute. The PSQI mean score of about 5 indicates that participants' sleep quality was borderline. Only the AC/A ratio and NPC break show signs of minor binocular stress or near-vision fatigue tendencies; otherwise, the majority of values fall within normal or above-average limits.

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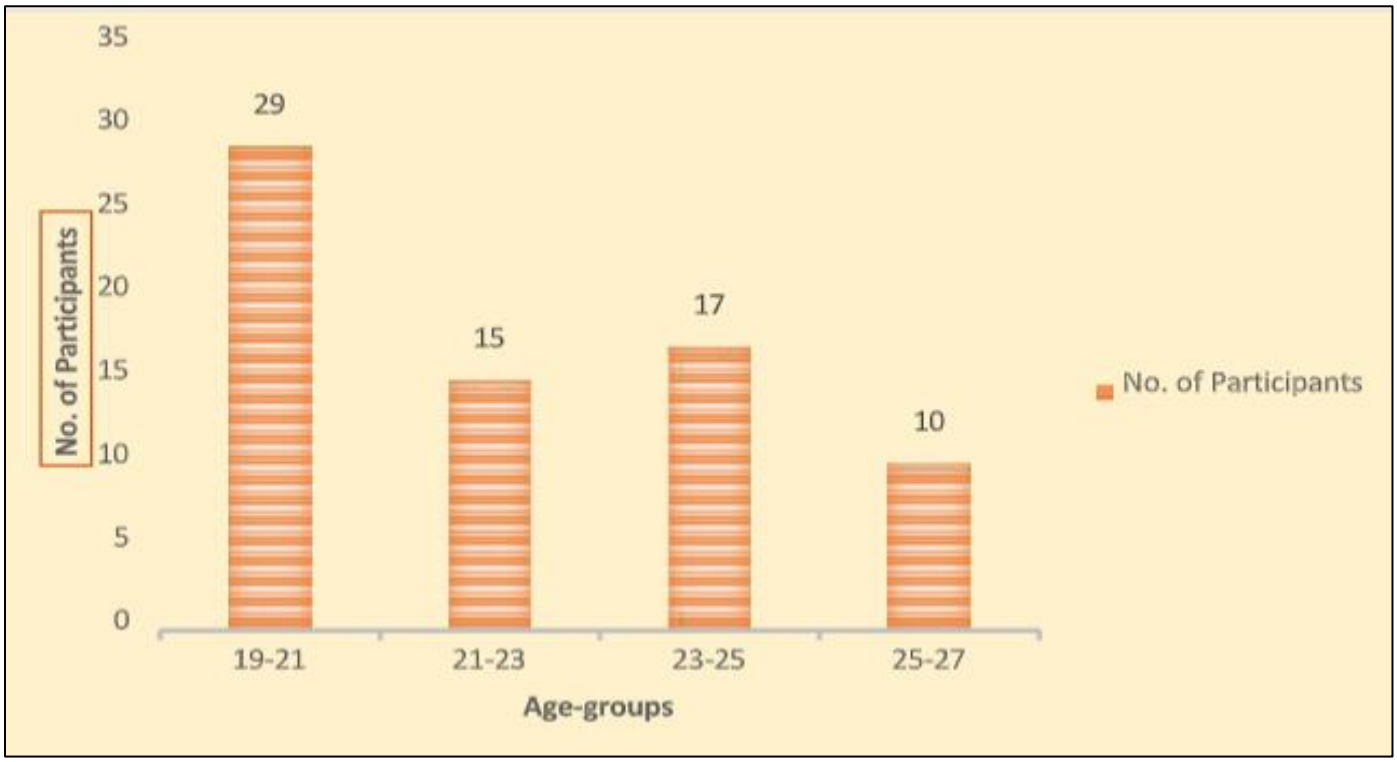

Fig 28 Distribution of Participants by Age-Group

- *Interpretation:*

The distribution of study participants by age group is displayed in the table. The age group of 19–21 years old accounted for the biggest percentage of participants (40.85% of the overall sample), suggesting that early young adults made up the majority of the study population. With 23.94% of participation, the 23–25 age group was the next most represented, followed by the 21–23 age group with 21.13%. With 14.08% of the sample, the age group of 25–27 years old had the lowest representation. Overall, the data indicates that younger people make up the majority of the research group, with participation gradually declining as age rises. When evaluating and extrapolating the results, it is important to take into account the age distribution, which implies that the findings may predominantly reflect the visual characteristics of younger persons.

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CHAPTER FIVE
DISCUSSION

➢ *Discussion*

- Woi et al.(2024) in his study concluded that he has discussed regarding poor sleep quality negatively affects vergence in university students but in our research we found that poor sleep affects on NPC & AC/A ratio in college students.
- Our study found that NPC has decreased & AC/A ratio has increased whereas the study of Tong J et al. (2016), in his study concluded that the sleep deprivation affects binocular coordination.
- Behnke A (2001), Impact of sleep Deprivation on vergence & Accommodation/Experimental study found that lack of sleep affects vergence more than accommodation but in our study we found that NPC has been decreased & AC/A ratio has been increased.
- In summary, we discussed from all the review of literature that poor sleep affects binocular anomalies whereas from our study 3 parameters have normal values (NPA, AF & VF) & AC/A ratio has been increased also NPC has obtained normal values.

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CHAPTER SIX
CONCLUSION

➢ *Conclusion*

- In our research we are concluding that in college students having poor sleep quality demonstrates a reduced NPC with increasing AC/A Ratio.
- Sleep quality assessment during binocular vision examination in college students is recommended.
- Regulation of sleep is mandatory among college students & also in regular eye tests it is necessary to take detailed sleep quality history among college students.

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LIMITATION

➢ *Limitation*

- This study cannot represent all different types of age group because other significant health problems were excluded.
- The study was done only once not done multiple observational follow up.
- Students were taken from only one college, so results may not apply to other colleges.
- Cycloplegic drops caused side effects like blurred vision, light sensitivity were not included.

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FUTURE SCOPE

➢ *Future Scope*

- Future experimental research should be conducted to examine these possibilities, as the potential benefits of improving sleep in college students are great.
- A long-term study (follow-up over weeks or months) can be done to see how continuous poor sleep affects vergence and accommodation.
- This study can be expanded to different age groups, including school students or working adults of different locations.
- Future studies can check the effect of screen time, mobile use at night, stress, caffeine and lifestyle habits on sleep and visual functions.

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ANNEXURES

ANNEXURES -I

EFFECT OF QUALITY OF SLEEP ON VERGENCE AND ACCOMMODATION IN COLLEGE STUDENTS

Patient Consent to Take Part in Research

Consent form No: Phone Number:

I..... Voluntarily agree to participate in this research study.

I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.

I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.

I understand that participation involves performing a procedure for effect of quality of sleep on vergence and accommodation in college students I understand that I will not benefit directly from participating in this research.

I understand that all information I provided for this study will be treated confidentially.

I understand that in any report on the result of this research my identity will remain anonymous.

I understand that if I inform the researcher that myself or someone else is at risk of harm, they may have to report this to the relevant authorities – they will discuss this with me first but may be required to report with or without my permission.

I understand that signed consent forms and data will be retained safely until the study is over.

I understand that under freedom of information legalization I am entitled to access the information I have provided at any time while it is in storage as specified above.

I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Name: Miss. Sajana Kawan & Miss. Riya Chaudhary Tharu

Phone Number: 8073817151, 9108535961 / Email ID: : sajanakawan12@gmail.com tharuriya78@gmail.com UNIVERSITY: Under affiliation RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCE

COLLEGE NAME: SHRIDEVI INSTITUTE OF ALLIED HEALTH SCIENCES

GUIDE: Mrs. A.P. Nishad Begum (8073577268), Assistant Professor, Dept. of Optometry, SIAHS, Tumkur Signature of research participant:

Signature of Participant Date

Signature of Researcher:

I believe the participant is giving informed consent to participate in this study

Signature of Researcher Date

Signature of Researcher Guider Signature

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CONSENT FOR PHOTOGRAPHY

Title: Comparison of vergence and accommodation mechanism between university student with good and poor sleep quality: A cross-sectional study

Participant Name:

Gender:

Date:

I _____, hereby give my consent to [Shridevi Allied of Medical Sciences and Research Hospital] and its intern to take photographs of myself the following purposes:

☐ Medical record and documentation

☐ Treatment planning and follow-up

☐ Educational presentations / teaching

☐ Publication in scientific journals / case reports (identity concealed)

☐ Social media / website (with/without identity

I understand that:

- The photo may be used for the purposes indicated above.
- My identity will be kept confidential if used for teaching or publication unless I give permission to disclose it.
- I have the right to withdraw my consent at any time before publication or sharing.
- Refusing consent will not affect my treatment.

Your sincerely,

_____

Sajana Kawan

_____

Riya Chaudhary Tharu

B. OPTOMETRY
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ANNEXURES-II

QUESTIONNAIRE (Validated on- 17/06/25)

Participant Name:

Age/Gender:

➢ *Pittsburgh Sleep Quality Index (PSQI) (CC By-NC- ND 4.0) Items:*

- What time have you usually gone to bed at night?
- How long has it usually taken you to fall asleep each night?
- What time have you usually gotten up in the morning?
- How many hours of actual sleep did you get at night?
- How often have you had trouble sleeping because you:

✓ Cannot get to sleep within 30 minutes
✓ Wake up in the middle of the night or early morning
✓ Have to get up to use the bathroom
✓ Cannot breathe comfortably
✓ Cough or snore loudly
✓ Feel too cold
✓ Feel too hot
✓ Have bad dreams
✓ Have pain
✓ Other reason(s), please describe

- How often have you taken medicine to help you sleep (prescribed or "over the counter")?
- How often have you had trouble staying awake while driving, eating meals or engaging in social activity?
- How much of a problem has it been for you to keep up enough enthusiasm to get things done?
- How would you rate your sleep quality overall
- Do you have a bed partner or roommate?

Sources: Woi et al (Int J Ophthalmol)

Your sincerely,
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ANNEXURES III

PROFOMA

DEMOGRAPHIC DATA:

NAME: AGE/GENDER:

CONTACT NO.: COURSE:

- *History:*

CHIEF COMPLAIN	
OCULAR HISTORY	
SYSTEMIC HISTORY	
MEDICAL HISTORY	
FAMILY HISTORY	
SOCIAL HISTORY	

- *VisualAcuity:*

Eye	**DISTANCE VISION @ 4m**		**NEAR VISION @ 40cm**
	UNAIDED	AIDED	
OD			
OS			

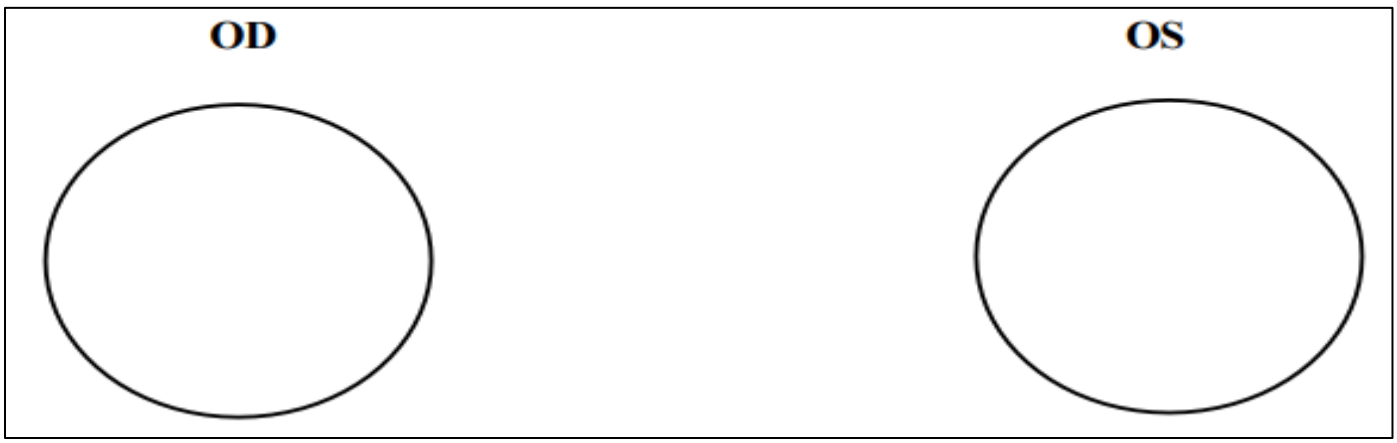
- *Refraction:*

	OD					**OS**				
	Sph	Cyl	Axis	VA Dist	Near	Sph	Cyl	Axis	VA Dist	Near
OBJ										
SUB										

- *Slitlamp Examination:*

EYE	**OD**	**OS**
EYELID		
CORNEA		
CONJUCTIVA		
SCLERA		
IRIS/PUPIL		

- *Fundus Examination: (Direct Ophthalmology)*



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➢ *Test Performed:*

Accommodation Parameters					
NPA (in cm)		R1	R2	R3	Mean
	OD				
	OS				
	OU				
Accommodation facility (in cpm)	OD				
	OS				
	OU				

Vergence Parameters					
NPC (in cm)		R1	R2	R3	Mean
	Break				
	Recovery				
Vergence Facility (in cpm)					

AC/A Ratio (Heterophoria Method)	