Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 20s (2025)
https://www.jneonatalsurg.com

Variations in the Accommodative and Vergence Responses, in addition to Visual Discomfort, in University Optometry Students Following Prolonged Near Work

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Cite this paper as: Bidisha Bhattacharya, Dr. Anitha Arvind, (2025) Variations in the Accommodative and Vergence Responses, in addition to Visual Discomfort, in University Optometry Students Following Prolonged Near Work. *Journal of Neonatal Surgery*, 14 (20s), 61-68.

ABSTRACT

Purpose: To assess the accommodative and vergence response changes along with visual discomfort in university optometry student population after a prolonged near work. Methods:This study was done between July 1 and November 30, 2024, at Delhi Skill & Entrepreneurship University. Sixty participants with refractive error (+/- 0.50DS to +/- 3.00DS) and no prior history of orthoptics exercises were included. The Visual discomfort questionnaire (VDQ) was administered at baseline and after 7 hours of near work to evaluate asthenopic symptoms. Accommodative and vergence parameters were measured clinically pre- and post-classes. Results: Of the 60 students, 23 were male (age range of 18 to 25 years). The 47% (n=28) had Emmetropia and 53% (n=32) had Ametropia. Accommodative parameters include Monocular Estimation method (mean difference, 1.15 ± 0.10 diopters), Accommodative amplitudes (mean difference, 2.71 ± 0.62 diopters) and both Monocular and Binocular Accommodative Facility measurements (mean difference, 3.29 ± 0.19cpm) reported statistically significant differences (P<0.001) between the two measurements for both Emmetropes and Ametropes group. Vergence parameters were statistically significant (p>0.05). At baseline, 60% reported no discomfort, 25% reported discomfort occasionally, 12% often, and 2% always. Post-classes discomfort increased occasionally to 32%, but it was not statistically significant (p> 0.05). Conclusion: Our study shows a significant change in accommodative variables for both groups (Emmetropes & Ametropes). VDQ scores shows no statistically significant differences between pre and post near work. These findings suggest that prolonged near work impacts accommodative function but do not significantly alter self-reported discomfort levels.

Keywords: *Emmetropia, Ametropia, The Visual discomfort questionnaire, monocular estimation method, accommodative amplitudes, monocular and binocular accommodative facility*

1. INTRODUCTION

The near and intermediate visual tasks have significantly increased in today changing work environment and schedule, including computer work and related gazettes, reading and watching television.[1] College students are one of the groups experiencing the highest increases in digital device usage. From online classes to research, assignments, social networking, and entertainment, digital devices have become central to student life. Prolonged near work significantly affects accommodation and vergence responses in college students, leading to various visual discomforts and potential long-term implications, especially when studying for long hours or engaging in back-to-back online classes. These types of competitive and progressing academic demands are basically hampering their physical activities and general well-being.[2] Our visual system loses efficacy[3] due to extended periods of near-vision that can alter the eye's ability to focus[4] (Accommodation) and coordinate movements (Vergence). Other than refractive anomalies, Accommodative and vergence problems are the most common vision disorders in both pediatric and adult population.[5] These dysfunctions are termed under a broad umbrella "Non-strabismic binocular vision anomalies" (NSBVA). Accommodative dysfunctions[3] was the most prevalent non-strabismic anomaly of binocular vision followed by Convergence insufficiency[7.] One of the recent studies suggested that 36.71% of their medical college students NSBVA, with 8.86% being attributed to accommodation dysfunction and 27.85% to binocular abnormalities. Therefore, Visual discomfort is also common condition in college students resulting from prolonged exposure to near work tasks[3], characterized by various criteria, including observing symptoms, using a symptomatology questionnaire (Visual Discomfort Questionnaire), or conducting an assessment of the accommodative and vergence systems. Common asthenopic symptoms are like headache, eye strain, diplopia, re reading of words and focusing difficulty disrupt academic performance of students. According to a number of studies, between 46 and 91 percent of health professions students experience headaches.[8] Additionally, it was noted that the number of migraines, spine injuries, and nerve-related misalignment among students is rising.

This modern era of high-speed technological progress is about 75%[9] of daily activity is affecting their musculoskeletal health problems, including pain or postural discomfort in the lower back (93.3%) and neck (86.6%), followed by wrist or hand (66%), and buttock (60%)[10]. The unidimensional logistic Visual Discomfort Scale (VDS) test scale is generally considered valid and reliable for assessing the symptomatology where headache and reading difficulty are found to be the most common.[11] This study aimed to investigate accommodative and vergence changes along with visual discomfort in Delhi university undergrad optometry student population after a period of high demand for near-vision activity. We hypothesize that both qualitative and quantitative assessments will show a similar progression towards a decreasing order of visual health symptoms due to prolonged near work exposure.

2. MATERIALS AND METHODS

A total of 100 (age range: 18 to 25 years) participants were recruited for the study. Every student was undergone both qualitative (VDQ based) and quantitative clinical assessments twice (pre and post 7 hours of academic experience) in Delhi Skill and Entrepreneurship University, India between the period of July 2024 to December 2024. All participants included in this work were adequately informed verbally and in writing of the tests to be performed on them. All patients signed an informed consent form prior to the start of the study. VA with or without correction of 0.0 logMAR or higher and refractive error less than ±3.00D were included for the study. But subjects with binocular dysfunctions, strabismus, nystagmus, amblyopia, intellectual disabilities were excluded. Of the initial enrolled population, 40 students were excluded for not filling the VDQ properly. Therefore, a total of 60 students' data were analyzed.

Materials and Measurements: This study was conducted in the Clinical Optometry Laboratory at Delhi University. Orthoptics evaluation (Figure 1) was initiated after comprehensive eye examination including objective-subjective refraction, slit lamp examination for all participants to ensure accurate baseline measurements of visual function. Accommodative response was measured by MEM (Monocular estimation method) in Diopters(D), AA (Accommodative amplitudes) in D and MAF and BAF (Monocular and Binocular Accommodative facility) (cycles per minute), evaluated with ±2 flipper lenses. Vergence function was measured by Cover test (Distance and Near), NPC (Near point of convergence) in cm, PFV (Positive fusional vergence) and NFV (Negative fusional vergence) in prism diopters estimated with horizontal prism bar.

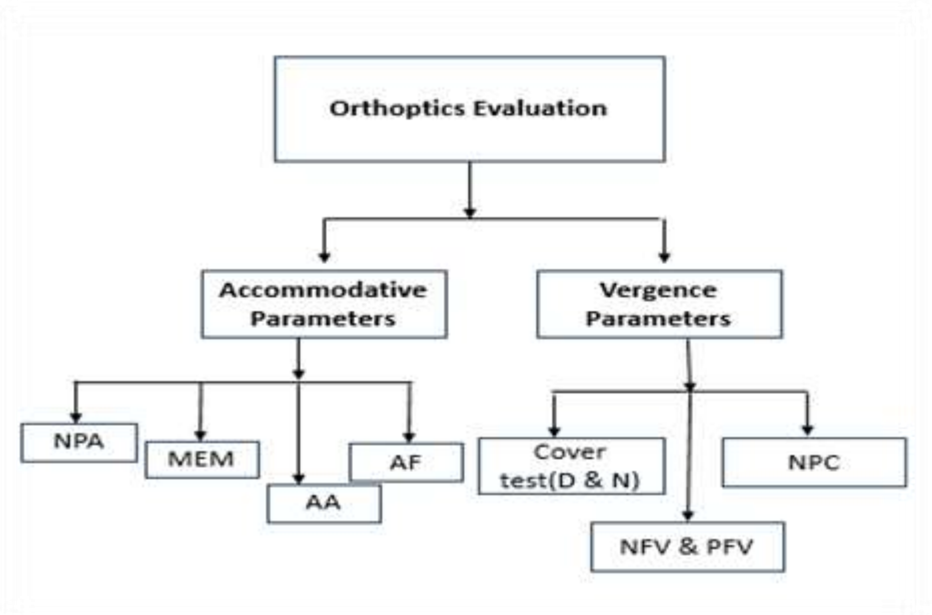

Fig. 1 Pre and Post Study Hours Comprehensive Orthoptics Evaluation: Accommodative and Vergence parameters

Above mentioned procedures were thoroughly explained to the patient to ensure understanding and cooperation. The mean value of the three values obtained from each test was calculated to ensure accuracy and reliability. For testing and regulatory values, we relied on the manual by Scheiman and Wick[12], which provided established guidelines for evaluating accommodative function. Dynamic accommodation testing includes MEM evaluates the eye's ability to change focus rapidly and efficiently. MEM was assessed with the help of retinoscope to detect Lag or Lead of accommodation. Lag of accommodation and Lead of accommodation were indicative if dioptric value exceed +0.75D and -0.25D respectively. [12] The AA tests were performed using astron accommodative rule. Regarding normal values for accommodative amplitude (AA), Hofstetter proposed three equations that describe its variation with age: the minimum, mean, and maximum values. In this study, the equation for the mean AA was used, which corresponds to the formula: **AA mean = 18.5 − 0.3 × age (years).**[12] MAF test was performed with ±2 flipper lenses to evaluate the ability of the accommodative system to make rapid and instantaneous accommodative changes, thus checking the exertion tolerance in each time and distance. Positive lens and negative difficulty were accepted to manifest the presence of Accommodative excess and Accommodative insufficiency respectively. The normal values set were 11 ± 5 cpm for MAF and 8 ± 5 cpm for BAF as per clinical standardization.[12] In addition, vergence parameters include the magnitude of the horizontal heterophoria (Prism Diopters, Δ) was quantified with the help of prism bar cover test. Exophoria was noted as Negative Δ and Esophoria as Positive Δ. With the help of NPC, the ability of the eyes to focus on a single object at close range was measured. Accommodative target was used to check both accommodative and fusional convergence under room illumination. This test was helpful to detect Blur, Break and Recovery point in cm. Normal value of Break of 5cm and Recovery of 7cm were set to compare the abnormality. The ability of diverge and converge of eyes was evaluated through NFV and PFV respectively. Those tests were performed both for distance and near. Normal values which were accounted for comparison regarding DNFV Break: 12±5Δ, Recovery: 7±4Δ; DPFV Break:17±Δ8, Recovery: 12±7Δ; NNFV Break: 15± 11Δ, Recovery: 11±4Δ; NPFV Break: 26±10Δ, Recovery: 21±10Δ. To evaluate visual discomfort, the scale of visual discomfort questionnaire (VDQ) was used, with questions regarding reading difficulty, headache, eye pain, focus issues, blurry vision, and double vision etc. The VDQ[11] consisted of 23 items with a four-point scale: 0 = event never occurs; 1 = occasionally, a couple of times a year; 2 = often, every few weeks; and 3 = almost always. The items of the VDQ are presented in Table 1.

Table 1: Pre and Post Study Hours Qualitative Assessment through Visual Discomfort Scale

Response categories: Visual Discomfort Scale

0 = Event never occurs
1 = Occasionally. A couple of times a year
2 = Often. Every few weeks
3 = Almost always

|Never|..............................|Occasionally|..............................|Often|..............................|Almost always|

Items used

(1) Do your eyes every feel watery, red, sore, strained, tired, dry, gritty, or do you rub them a lot, when viewing a striped pattern?
(2) Do your eyes every feel watery, red, sore, strained, tired, dry or gritty, after you have been reading a newspaper or magazine with clear print?
(3) Do your eyes every feel watery, red, sore, strained, tired, dry or gritty, when working under fluorescent lights?
(4) How often do you get a headache when working under fluorescent light?
(5) Do you ever get a headache from reading a newspaper or magazine with clear print.
(6) When reading, do you ever unintentionally reread the same words in a line of text?
(7) Do you have to use a pencil or your finger to keep from losing your place when reading a page of text in a novel or magazine?
(8) When reading do you ever unintentionally reread the same line?
(9) When reading do you ever have to squint to keep the words on a page of clear text from going blurry or out of focus?
(10) When reading, do the words on a page of clear text ever appear to fade into the background then reappear?
(11) Do the letters on a page of clear text ever go blurry when you are reading?
(12) Do the letters on a page ever appear as a double image when you are reading?
(13) When reading, do the words on the page ever begin to move or float?
(14) When reading, do you ever have difficulty keeping the words on the page of clear text in focus?
(15) When you are reading a page that consists of black print on white letters, does the background ever appear to overtake the letters making them hard to read?
(16) When reading black print on a white background, do you ever have to move the page around, or continually blink to avoid glare which seems to come from the background?
(17) Do you ever have difficulty seeing more than one or two words on a line in focus?
(18) Do you ever have difficulty reading the words on a page because they begin to flicker or shimmer?
(19) When reading under fluorescent lights or in bright sunlight, does the glare from bright white glossy pages cause you to continually move the page around so that you can see the words clearly?
(20) Do you have to move your eyes around the page, or continually blink or rub your eyes to keep the text easy to see when you are reading?
(21) Does the white background behind the text ever appear to move, flicker, or shimmer making the letters hard to read?
(22) When reading, do the words or letters in the words ever appear to spread apart?
(23) As a result of any of the above difficulties, do you find reading a slow task?

Results Statistical analysis was done with SPSS statistics 25.0 (IBM Corporation, Armonk, NY, USA). All visual acuity data were converted into LogMAR. The Student's t-test was applied for parametric-dependent variables. All statistical tests were performed with a 95% confidence interval ($p < 0.05$). Of the 60 students, 22 were male and 38 were female with an age range of 18 to 25 years (20±1.61). The 47% (n=28) had Emmetropia and 53% (n=32) had Ametropia. In Ametropic group, average spherical equivalent was -1.65±0.97D for RE, -1.69±0.98D for LE. Demographic details were listed in Table 2.

Table 2 Demographic details of all participants

Total No. of participants	60
Age Range	18 to 25 years (20±1.61)
No. of Male	22
No. of Female	38
No. of Emmetropes	28
No, of Ametropes	32(All of them were myopes)
Most preferred type of electronic gadget	Smart phone(53%), Laptop/Desktop(28%)
Purpose of usage of gadget	Education and entertainment(80%)

We evaluated MEM for BE individually for both the groups. For Emmetropes, pre-academic MEM was 0.50 ± 0.17D that reached to 0.77± 0.25D after period of high demand for near-vision activity. For Ametropes, PRE MEM was 0.50 ± 0.24D that Post was 1.00± 0.18D. Therefore, Figure 2 exhibited statistically significant differences between the two measurements regarding MEM (mean difference, 1.15 ± 0.10 diopters; P value <0.001).

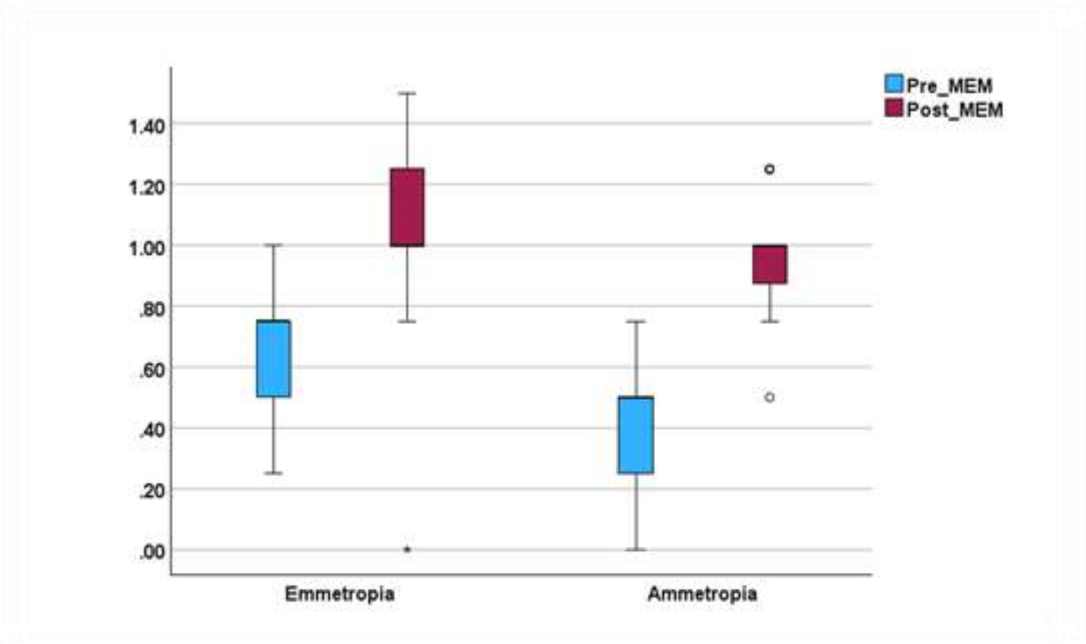

Fig 2: MEM comparative boxplots between the PRE and POST measurement for Both Emmetropes and Ametropes

Present study results demonstrated that for Emmetropes, pre-academic AA for RE was 12.2 ± 1.93D, LE 12.2 ± 1.84D and BE 12.4 ± 2.27D that reached RE 9.8 ± 1.05D, LE 10 ± 1.26D and BE 10.2 ± 1.10D after 7 hours of prolonged near work. Therefore, AA exhibited statistically significant differences between the two measurements (mean difference, 2.44 ± 0.87 diopters; P value <0.001). For Ametropes, pre-academic AA for RE was 13.79 ± 2.17D, LE 13.99 ± 2.56D and BE 14.98 ±

2.43D that reached RE 11.28 ± 1.62D, LE 11.46 ± 1.81D and BE 11.91 ± 1.86D after 7 hours of prolonged near work. Therefore, AA exhibited statistically significant differences between the two measurements (mean difference, 2.71 ± 0.62 diopters; P value <0.001). Figure 3 illustrated overall AA response showed a statistical significance between Pre and Post analysis.

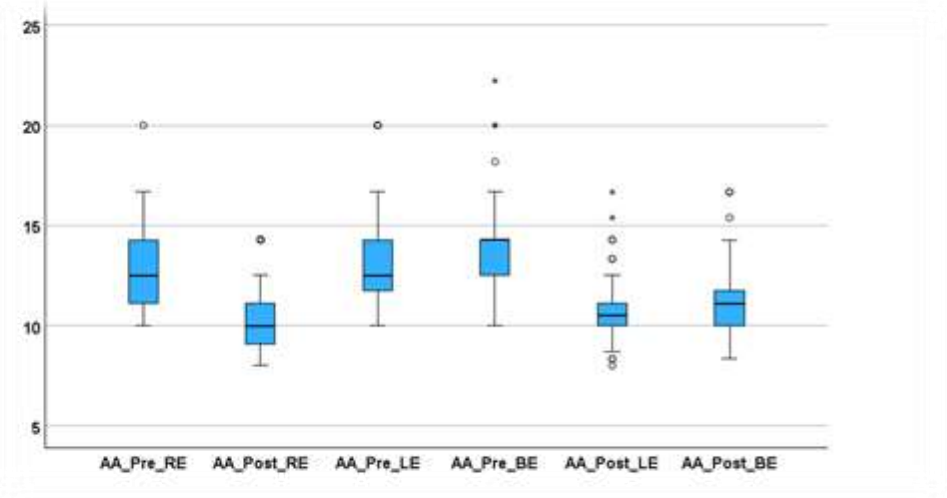

Fig 3: Accommodation Amplitude comparative boxplots between the PRE and POST measurement among RE, LE and BE

MAF and BAF scores were obtained before and after prolonged near work for both the groups. For Emmetropes, RE PRE MAF was 8.98 ± 2.59cpm, LE 9.67± 2.61, BE 11.19± 2.72 and reached to RE 5.08 ± 2.26cpm, LE 4.92±2.68cpm, BE 6.57±2.48cpm. Therefore, both MAF and BAF reported statistically significant differences between the two measurements (mean difference, 4.42 ± 2.42cpm; P value<0.001). For Ametropes, RE PRE MAF was 8.53 ± 2.21cpm, LE 8.81± 1.55, BE 10.40± 1.62 and reached to RE 4.93 ± 2.07cpm, LE 5.43±1.88cpm, BE 7.5±2.02cpm. Figure 4 demonstrated both MAF and BAF reported statistically significant differences between the two measurements (mean difference, 3.29 ± 0.19cpm; P value<0.001) .

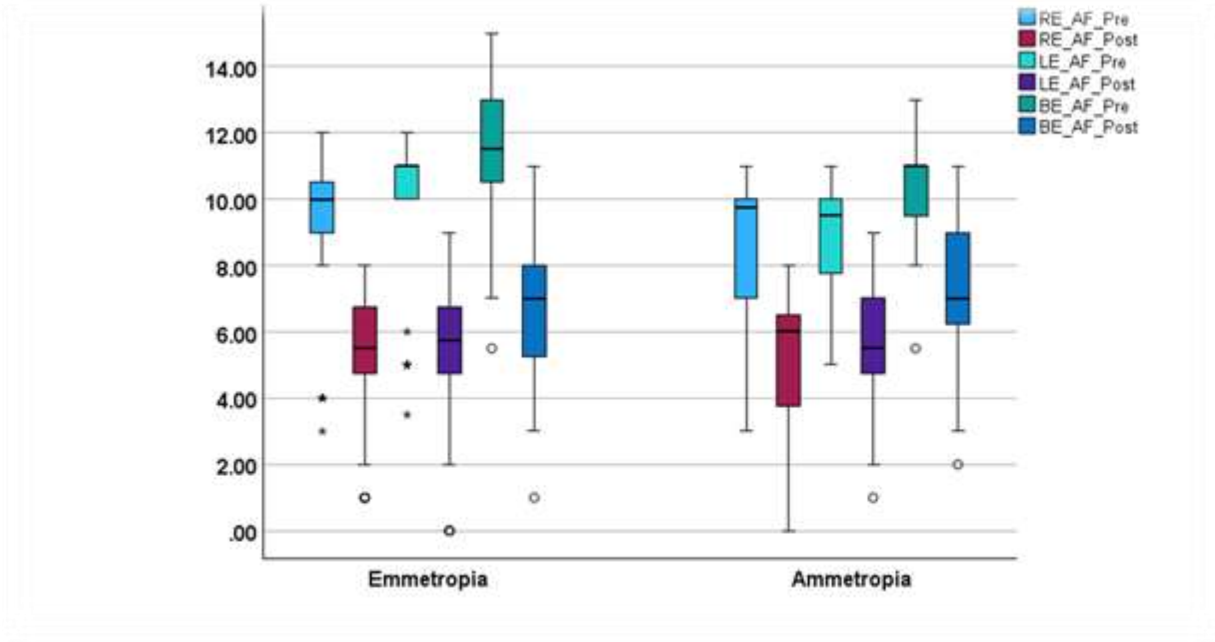

Fig 4: MAF and BAF comparative boxplots between the PRE and POST measurement for Both Emmetropes and Ametropes among RE, LE and BE

Near point of convergence and Fusional vergence response*:* Mean difference of NPC and Positive fusional vergence between Emmetropes and Ametropes was not statistically significant(P>0.05) thatswhy no more tests were performed for these two variables.

Visual Discomfort: Finally, the visual discomfort questionnaire (VDQ) four-point scale score was analyzed for all the participants twice to compare the ocular symptoms PRE and POST prolonged near work. 60% of participants indicated no discomfort ("never"),25% ("occasionally"),12% ("often") &2% ("always on the scale") at the morning. After 7 hours of prolonged near work, ocular symptoms got elevated of about 32%(occasionally) but other responses remained almost the same. The most common symptoms were found to be headache, re reading of words and focusing difficulty after prolonged near tasking among that student population. Figure 5 described symptoms distribution through VDQ that was statistically insignificant between the two measurements (mean difference, 4.21±1.05, P value> 0.05).

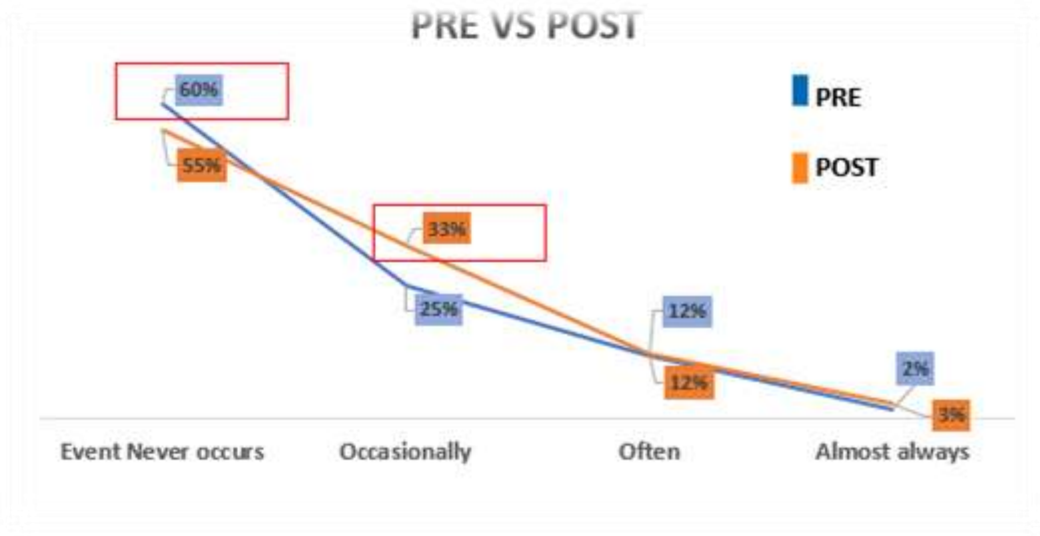

Fig 5: VDQ four-point scale analysis between the PRE and POST measurement

3. DISCUSSION

The purpose of this study was to examine the changes in accommodative and vergence responses among college subjects with visual discomfort, particularly during a longer duration of exposure to near targets. Our study indicated that all accommodative variables including MEM, AA and AF measured underwent significant changes after high demand of near tasks. This is an agreement with a study was done by Chinatsu Tosha et al., (2009) who determined that accommodative behavior associated with prolonged near work commonly seen in college students has also been suspected to be a factor in the development of visual discomfort. In our study, emmetropes and ametropes both showed a significant increase in accommodative lag of about 0.50 D to 0.75D with extended viewing which may indicate an accommodative fatigue effect. These findings suggest that the cause of visual discomfort may be attributed to an increase in the accommodative lag that is induced by prolonged near viewing stimuli. Our results contradict with the studies done by Ciuffreda et al., (1998) and Simmers et al., (2001) who found a normal stimulus response function in individuals. Despite of getting a significant accommodative lag between subjects, this response was almost same in order for both myopes and emmetropes in our study. Studies done by Abbott et al., (1998); Nakatsuka, Hasebe, Nonaka, & Ohtsuki, (2003); Seidemann & SchaeVel, (2003). also had shown a consistent result that mean lag is similar both for adult myopes and emmetropes. Concerning AA, the present work reported that AA decreases with a mean difference approximately 2.00±2.26D after prolonged near work and this was the evidence of developing accommodating insufficiency in college subjects. This result basically goes against a few studies done by De Hita et al., (2022) and García-Muñoz et al., (2016) who report that increased near-visual activity increases AA and produces an accommodative excess. These two findings conflict greatly due to the lack of standardization in the type of subjects enrolled and clinical diagnostic tests administered. Further, to determine the state of the accommodative function in detail, MAF and BAF tests needs to be performed. All the subjects irrespective of emmetropes (mean difference, 4.42 ± 2.42cpm; P value<0.001) and ametropes (mean difference, 3.29 ± 0.19cpm; P value<0.001) of our study showed a significant reduction in AF. Every participant was more prone to accommodative excess, especially consideration of usage more of electronic gadgets for a longer period of time. This observation correlates with recent few studies done by De Hita et al., (2022) and Porcar E et al., (2018). A recent study done by Malhotra V et al., (2022) among Tibetan college students of Bangalore reported that accommodative excess (15.30%) followed by convergence insufficiency (11.03%) were found to be the most common NSBVA. However, Majumder and Ling (2022) also reported convergence dysfunction (10%) were more prevalent among Malaysian college students who used visual display devices with an agreement of study done in China by Jai Cai et al., (2024). However, vergence response was analyzed based on the clinical data available on phoria status, NPC and vergence amplitudes in our study. Only one subject from each emmetropic and ametropic group was found to have mild exophoria and no radical change was observed between pre and post measurement. In a relation with phoria status, NPC and vergence amplitudes showed statistical insignificant result in both emmetropic and ametropic group. However, Reduced MAF with Plus lens difficulty confirms the presence of CI in individual but PFV data for near was remain same (97%) after prolonged near demand. Overall VDQ reported statistically insignificant differences ((mean difference, 4.21±1.05) between the two measurements in our study. However Borsting et al., (2008) and De Hita et al., (2022) conducted studies using a same methodology on visual discomfort scale in university students which concluded that ocular symptoms were stable in self-reported discomfort levels but clinical sign showed the deficiency in accommodative supply after prolonged near work, supporting the data of our study. Chinatsu Tosha et al., (2009) reported visual discomfort is connected with accommodative fatigue rather than insufficiency that confirms our findings too. Headache ,blurring of vision, re reading of words, eye strain, double vision was chosen as the most common symptoms by the students after high near work demand in college which supports previous studies.[2,6,10,23,24]

Students were using computers or smartphones in both bright and dark environments, which might cause headaches when the screen is too bright. It has been recommended that screen contrast and brightness be changed to maximize visibility and balance with ambient illumination. Due to their lack of regular computer breaks, kids had greater visual complaints. This fact can be explained by active accommodation and prolonged near work can lead to fatigue of accommodation. By shifting the user's focus, continuous visual accommodative spasm and glare from the monitor can be alleviated.

This study presents certain limitation that should be considered. This could be small sample size, as several participants did not fill the post visual discomfort questionnaire. Students might fill bored or exhausted while answering the same questions during post qualitative assessment. Thus further decreasing the total number of measures. Therefore, study with large sample size would be accurate to produce a good result.

4. CONCLUSIONS

This study demonstrated that prolonged near work significantly alters accommodative responses in college students, leading to measurable declines in accommodative amplitude, accommodative facility, and an increased accommodative lag. Both emmetropic and ametropic groups exhibited similar patterns of accommodative fatigue after seven hours of continuous academic near tasks, highlighting a vulnerability across refractive statuses. Although no statistically significant changes were observed in vergence parameters or self-reported visual discomfort scores, the clinical findings underscore early signs of accommodative dysfunction that could predispose individuals to future binocular vision anomalies if left unaddressed. These results emphasize the importance of implementing preventive measures such as regular visual breaks, accommodative exercises, and ergonomic modifications (must pause every 20 minutes and gaze at a 20-ft distance for 20 seconds) to sustain optimal visual performance in academic settings. Future studies should involve a larger sample size, extended monitoring periods, and additional objective assessments to further elucidate the complex interplay between prolonged near work, accommodative-vergence anomalies, and subjective visual symptoms in young adults.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Conflicts of Interest: The authors declare no conflict of interest.

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