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Prevalence, Symptom Severity and Factors Associated with Convergence Insufficiency among Undergraduate Students of University of Benin, Benin City, Edo State, Nigeria

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ABSTRACT
Co-ordinated binocular function is essential for comfortable near vision, and involves convergence, accommodation and sensory fusion. Prolonged near work is strongly associated with vergence dysfunction, contributing to visual eye strain. This study determined the prevalence of convergence insufficiency (CI), relationship between CI and socio-demographic characteristics, symptoms and near-work exposure among undergraduate students of the University of Benin. The cross sectional study subjects were 152 students from 14 faculties and 100–600 academic levels. Participants had near point of convergence (NPC), distance and near horizontal phoria (H) and near positive fusional vergence (PFV) assessed along with 15 item Convergence Insufficiency Symptom Survey (CISS) completed. The four criteria used to define CI were: CISS ≥21, NPC break ≥6 cm, near exophoria ≥4 prism dioptres more than distance phoria, and failure of Sheard's criterion at near. Data was analyzed descriptively, by chi-square test and Fisher's exact test, with $p < .05$ considered significant. Prevalence of CI was found to be 23.7%. There was no significant association ($p > .05$) between age, sex, faculty or academic level with CI. There was a significant association between the severity of CISS and clinical CI ($\chi^2 = 30.071$, $p < .001$). Daily reading duration was also associated with CI ($\chi^2 = 7.164$, $p = .028$), whereas daily digital-device use was not ($\chi^2 = 1.481$, $p = .477$). CI was relatively common among the study population, and was associated particularly with symptom burden and reading duration. Symptom monitoring and binocular-vision evaluation can be helpful in identifying students who are affected.

Keywords: Convergence Insufficiency, Near Point Of Convergence, Positive Fusional Vergence, Convergence Insufficiency Symptom Survey, Undergraduate Students, Near Work

INTRODUCTION

Coordinated binocular function such as convergence, accommodation and sensory fusion is required for comfortable near vision (Emurotu *et al*., 2026). Convergence is the inward movement of the eyes which helps to hold both eyes on a single target, as they converge to read, write and study from near objects such as reading materials and digital screens (Scheiman & Wick, 2014). If the convergence system fails to be able to respond, or to maintain it, then convergence insufficiency (CI) can develop. Unresolved convergence insufficiency inadvertently contribute to the global burden of near visual impairment (Moyegbone *et al*., 2026). Common signs of the disorder include receded near point of convergence (NPC), increased exophoria at near compared to distance, reduced positive fusional vergence as well as symptoms such as headache, eyestrain, blurred or double vision, and difficulty maintaining focus during near work (Gantz & Stiebel-Kalish, 2022; Rouse *et al*., 2004).

The prevalence of CI varies widely, and has been reported in school-age, university and clinical populations, but each has limitations due to sampling method and diagnostic criteria. A worldwide systemic review found a pooled prevalence of 7.98% (Mohamed & Alrasheed, 2023), while 9.7% was found among first year university students in Ghana (Darko-Takyi *et al*., 2022), 11.42% among engineering students in Nepal (Dahal *et al*., 2021), and 10% among university students in Iran (Sharif *et al*., 2014). There is also documentation of CI and related vergence dysfunctions in young adults and university students in Nigeria. Ovenseri-Ogbomo and Eguegu (2016) found a prevalence of vergence dysfunction in 12.7% of the first year students at the University of Benin, in which, the most common vergence dysfunction was CI (Ovenseri-Ogbomo & Eguegu, 2016).

Sustained near activities are a regular part of undergraduates' learning experience and with the growing reliance on digital devices, this "near" need has been exacerbated. Previous studies have indicated that near work may be relevant to CI and its symptoms, but there was no evidence of the same relevance for reading and screen exposure (Pillay & Munsamy, 2021). Importantly, the previous University of Benin study had only looked at first-year students, and so there was uncertainty about the burden of CI across all undergraduate students. The current study thus evaluated the level of CI among students of various faculties, academic levels and explored socio-demographic factors, symptom severity, and near-work duration.

MATERIALS AND METHODS

Study Design, Study Area and Study Population

This study adopts a cross-sectional descriptive design to determine the prevalence of convergence insufficiency (CI) among undergraduate students of the University of Benin. University of Benin is a Federal University comprising a broad range of faculties and a large, diverse undergraduate population drawn from across Nigeria (Ovenseri-Ogbomo & Eguegu, 2016). Clinical assessment of participants was carried out at the Optometry Teaching Clinic, Faculty of Optometry, University of Benin, to ensure that testing took place in a controlled clinical environment with standardized equipment readily accessible to the researchers. Fourteen

faculties were represented which include: Law, Basic Medical Sciences, Arts, Education, Physical Sciences, Medicine, Life Sciences, Optometry, Social Sciences, Science Laboratory Technology, Management Sciences, Computing, Agriculture and Engineering. The study population comprises bona fide undergraduate students of the University of Benin, drawn from across the university's constituent faculties and spanning the range of academic levels from 100 to 600 level.

Sample Size Determination and Sampling Technique

A minimum sample size of was determined using Cochran formula (Cochran, 1963; Moyegbone *et al*., 2023)

$$n = \frac{Z^2 p(1-q)}{d^2}$$

Where Z is the standard normal deviate at 95% confidence level (1.96), p is the existing prevalence of CI, and d is the desired precision (margin of error), set at 5% (0.05). Based on an existing prevalence of 10% (Sharif *et al*., 2014), the estimated sample size was calculated as follows:

$$n = \frac{1.96^2 x\ 0.1(1-0.1)}{0.05^2} = 138.3 \approx 138$$

10% attrition was allow for an anticipated non-response rate, given 13.8

Therefore, n =138 + 13.8 = 151.8 ≈ 152

A two-stage sampling technique was adopted to recruit. In the first stage, the university's 21 faculties were used as strata, and a random selection of 14 faculties was made to ensure representation across broad disciplinary groupings, including science-based, arts-based, and professional/clinical programmes, since near-work demand may plausibly differ across these groupings. In the second stage, eligible and consenting students within each selected faculty irrespective of their level stratum were recruited randomly, and referred to the Optometry teaching clinic for testing and data collection.

Selection Criteria and Informed Consent

Participants aged 16 years and above, bona fide undergraduate students of the University of Benin, currently registered in the 2024/2025 academic session, students with best corrected visual acuity of 6/9 or better in each eye and signed informed consents were included into study. Participants that did not meet the above criteria and/or did complete the study were excluded. Students who have manifest strabismus, previous eye surgery, ocular trauma, or systemic or neurological disease that affects binocular vision were also excluded, as well as those currently receiving treatment for CI.

Methods of Data Collection

Assessment of Visual Acuity, Refractive Status and Ocular Integrity

Following informed consent, participants filled out a socio-demographic and near-work questionnaire, and then had visual and binocular-vision assessment. Trial lens set, autorefractometer (RM-900), distance and near snellen charts were used to measure the visual acuity as well as determine the refractive status of each selected participants. Respondents with habitual or best corrected visual acuity of ≥ 6/9 were enrolled into the study. Pen torch and ophthalmoscope were used to examine the external and internal integrity of the eyes respectively.

Assessment of Near Point of Convergence (NPC)

The participant was comfortably seated with the head upright and appropriate refractive correction, where applicable. A small accommodative target was presented along the midline at approximately 60 cm from the participant's eyes. The participant was instructed to fixate on the target and maintain single, clear binocular vision while the target was slowly moved towards the eyes along the midline. The participant was instructed to report when the target first appeared double or when single binocular fixation could no longer be maintained. This point was recorded as the break value. The target was then moved slowly away from the eyes until single binocular vision was regained, and this point was recorded as the recovery value. The NPC measurement was repeated three times, and the mean break and recovery values were recorded in centimetres. For the purpose of diagnostic classification in this study, an NPC break value of ≥ 6 cm was considered a receded NPC.

Assessment of Near and Distance Horizontal Phoria Using Prism Bars

Horizontal phoria was measured at both distance and near using the Von Graefe method. The participant was appropriately positioned and instructed to fixate on the designated Snellen chart target while a 6Δ base-up (dissociating prism) was placed before the left eye and a 12Δ base-in (measuring prism) was placed before the right eye to dissociate the two images. For the distance measurement, the participant fixated on the distance target at 6 m. The vertical dissociating prism was used to separate the images, while the horizontal prism was varied until the participant reported that the two images were vertically aligned. The amount and direction of the horizontal prism required to achieve alignment were recorded as the distance horizontal phoria.

The same procedure was repeated at near using a line above the participant's best visual acuity as the designated near fixation target at approximately 40 cm. The horizontal prism was adjusted until the participant reported that the two images were horizontally aligned, and the resulting near horizontal phoria was recorded. The direction of the measured phoria was recorded as either exophoria or esophoria, together with its magnitude in prism dioptres (Δ). For diagnostic classification, phoria was considered abnormal if near exophoria was at least 4Δ greater than the corresponding distance exophoria.

Assessment of Near Positive Fusional Vergence (PFV)

Positive fusional vergence (PFV) at near was assessed using a horizontal base-out (BO) prism bar placed before the right eye while the participant fixated on an appropriate near accommodative target at approximately 40 cm. The participant was instructed to maintain single and clear fixation on the target while the base-out prism power was gradually increased.

The prism was increased progressively until the participant reported the first sustained blur of the target. This value was recorded as the blur point. The prism power was then increased further until the participant reported diplopia or loss of single binocular fixation. This value was recorded as the break point. The prism power was subsequently reduced until single binocular vision was regained, and this value was recorded as the recovery point. The PFV was recorded in the conventional blur/break/recovery format in prism dioptres (Δ).

The adequacy of the participant's PFV was assessed using Sheard's criterion. Sheard's criterion relates the compensating fusional reserve to the magnitude of the phoria. For near vision, the PFV blur value was compared with twice the magnitude of the near phoria. Sheard's criterion was considered satisfied when:

PFV blur ≥ 2 × near phoria

Conversely, a PFV blur value less than twice the magnitude of the near phoria was considered a failure of Sheard's criterion: i.e

PFV blur < 2 × near phoria

For the present study, failure of Sheard's criterion was considered indicative of inadequate positive fusional vergence and constituted one of the four diagnostic requirements for classification of convergence insufficiency.

Convergence Insufficiency Symptom Survey (CISS) Questionnaire

The Convergence Insufficiency Symptom Survey (CISS) Questionnaire was administered to assess the frequency and severity of symptoms associated with near visual activities. The validated questionnaire consists of 15 symptom-related questions covering common symptoms experienced during reading and other near visual tasks. Each item was scored according to the frequency with which the participant experienced the stated symptom. Responses were graded on a 5-point scale from 0 to 4, where 0 = never, 1 = infrequently, 2 = sometimes, 3 = fairly often, and 4 = always. The scores for all 15 items were summed to obtain a total CISS score, with a minimum possible score of 0 and a maximum possible score of 60. Higher scores indicate greater symptom burden. A total score of ≥21 was considered indicative of clinically significant symptoms for the study (Rouse *et al.*, 2004).

Definition of Convergence Insufficiency

For the purpose of this study, the operational definition for CI was that the subject met all four of the following: CISS ≥21, near exophoria ≥4Δ greater than distance phoria, NPC break ≥6 cm; and PFV blur <2 times the magnitude of the near phoria, i.e. failure of Sheard's criterion (Alvarez *et al.*, 2020).

Methods of Data Analysis

Data collected were entered into MS Excel and analyzed using IBM SPSS version 25. Frequencies, percent, mean and standard deviation were calculated. Chi-square tests were used to assess the associations between CI and categorical variables, and Fisher's exact test was used when the expected cell count was small. The level of significance was determined at $p < .05$.

Ethical Approval

Approval was sought from the Faculty of Optometry Research Ethics Committee, University of Benin with approval number: EC/UBEN/OPT/26/235. Written informed consent was sought from the participants of the study.

RESULTS AND DISCUSSION

Results

This study evaluated 152 undergraduate students. As seen in Table 1, most of the participants were in the age group 20 to 23 years (63.8%) with a mean age of 20.99 ± 2.16 years. Females constituted 57.9%. Of the 14 faculties whose students participated in the study, faculty of Optometry had the highest participation with a prevalence of 10.5%. According to academic level, 400 level students accounted for the highest proportion (24.3%) followed by those at 600 (7.9%) level.

Table 1: Socio-demographic Characteristics of Participants (N = 152)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	< 20	35	23.0
	20 - 23	97	63.8
	24 - 27	20	13.2
Gender	Male	64	42.1
	Female	88	57.9
Faculty	Law	11	7.2
	BMS	11	7.2
	ART	9	5.9
	EDU	11	7.2
	PSC	11	7.2
	MED	11	7.2
	LSC	11	7.2
	OPT	16	10.5
	SSC	10	6.6
	SLT	10	6.6
	MGT	11	7.2
	CPT	11	7.2
	AGR	9	5.9
	ENG	10	6.6
Level	100	32	21.1
	200	31	20.4
	300	27	17.8
	400	37	24.3
	500	13	8.6
	600	12	7.9

BMS = Basic Medical Sciences; EDU = Education; PSC = Physical Sciences; MED = Medicine; LSC = Life Sciences, OPT = Optometry; SSC = Social Sciences; SLT = Science Laboratory Technology; MGT = Management Sciences, CPT = Computing; AGR = Agriculture and ENG = Engineering

Table 2 shows the mean scores for the clinical measurements obtained from the respondents for their binocular alignment: Mean NPC break was 6.62 ± 4.32 cm and Mean NPC recovery was 9.78 ± 5.01 cm. Mean phoria at distance was 2.34 ± 2.72 Δ, and Mean phoria at near was 5.24 ± 3.99 Δ. The mean values obtained for blur, break, and recovery point for Positive Fusional Vergence (PFV) tracking at near were 18.09 ± 5.71 Δ, 26.74 ± 8.56 Δ, and 16.3 ± 6.65 Δ, respectively. Finally, the average Convergence Insufficiency

Symptom Survey (CISS) score for all the studied group was 18.22 ± 10.90.

Table 2: Binocular Vision and Symptom Measures

Variable	Mean	Standard Deviation
NPC Break (cm)	6.62	4.32
NPC Recovery (cm)	9.78	5.01
Distance Phoria (Δ)	2.34	2.72
Near Phoria (Δ)	5.24	3.99
PFV Blur (Δ)	18.09	5.71
PFV Break (Δ)	26.74	8.56
PFV Recovery (Δ)	16.3	6.65
CISS Score	18.22	10.90

NPC = Near Point of Convergence; PFV = Positive Fusional Vergence; CISS = Convergence Insufficiency Symptom Survey

The study revealed that the overall prevalence of Convergence Insufficiency (CI) in the studied population was as shown in Figure 1. Of the 152 university students who were examined, 23.7% (n = 36) were clinically diagnosed to have Convergence Insufficiency.

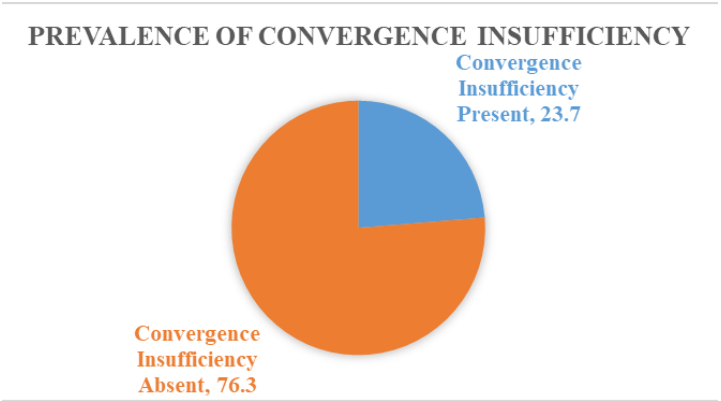


Figure 1: Prevalence of Convergence Insufficiency Among Respondents

There was no statistically significant difference between age group, sex, faculty and academic level with CI (P>0.05) as indicated in Table 3. This means that although CI was found among the studied population, its occurrence was not due to age, sex, faculty or level of study.

Table 3: Association Between Socio-demographic Characteristics and Convergence Insufficiency

Variable	Category	CI present (n)	CI absent (n)	χ^2	P-Value
Age	<20	9	26	0.23	0.891
	20–23	23	74		
	24–27	4	16		
Sex	Male	15	49	0.004	0.951
	Female	21	67		
Faculty	14 faculties combined	36	116	9.995	0.694
Academic level	100–600 combined	36	116	8.279	0.142

From Table 4, 17 participants (14%) had mild symptoms, 16 (13%) had moderate symptoms and 17 (14%) had severe symptoms. Of the 17 people with severe symptoms, 12 (70.6%) had CI compared with 17 of 119 (14.3%) with mild symptoms. The severity of CISS was found to be strongly linked to the severity of clinical CI ($\chi^2 = 30.071$, $p < .001$).

Daily Reading Hours was statistically correlated with CI ($\chi 2 = 7.164$, $p = 0.028$). In particular, over half (53.8%) of students who read more than 7 hours a day were diagnosed with CI.

Screen time hours was not significantly associated with the occurrence of CI in total screen time hours ($\chi 2 = 1.481$, $p = 0.477$) for the Digital Device Exposure. Twenty-six participants (26.8%) reported > 7 hours of screen time and were diagnosed with CI, whereas a much larger proportion (n = 71) reported > 7 hours of screen time but did not receive a clinical diagnosis of CI, indicating that screen use alone was not an independent risk factor for clinical diagnosis of CI in this sample.

Table 4: Symptom Severity and near-work Factors Associated with Convergence Insufficiency

Measure	Category	CI present n (%)	CI absent n (%)	χ^2	P - Value
CISS severity	Mild (≤24)	17 (14.3)	102 (85.7)	30.071	<.001
	Moderate (24.5–34)	7 (43.8)	9 (56.2)		
	Severe (>34)	12 (70.6)	5 (29.4)		
Daily reading	<4 h	14 (21.2)	52 (78.8)	7.164	0.028
	4–7 h	15 (20.5)	58 (79.5)		
	>7 h	7 (53.8)	6 (46.2)		
Daily digital-device use	<4 h	3 (20.0)	12 (80.0)	1.481	0.477
	4–7 h	7 (17.5)	33 (82.5)		
	>7 h	26 (26.8)	71 (73.2)		

The survey of discomforts using the CISS revealed a few common patterns for the students sampled (Table 5). The most common symptom reported was the need to repeat lines (74.3%) ranging from infrequent to always. Another significant complaint, of those surveyed, was sleepiness when doing near tasks affecting 68.4% of participants. Also, 62.5% of the students reported that their eyes get tired when they read or near tasks. In contrast, structural symptoms, such as words moving or floating on a page (55.3% "Never") and "eye pulling sensations" (55.3% "Never") were the least reported symptoms.

Table 5: Pattern of Convergence Insufficiency Symptoms Among Respondents

Question	Never, n (%)	Infrequent, n (%)	Sometimes, n (%)	Fairly Often, n (%)	Always, n (%)
Do your eyes feel tired when reading or doing close work?	57 (37.5)	29 (19.1)	42 (27.6)	12 (7.9)	12 (7.9)
Do your eyes feel uncomfortable when reading or doing close work?	58 (38.2)	41 (27.0)	30 (19.7)	16 (10.5)	7 (4.6)
Do you have headaches when reading or doing close work?	66 (43.4)	29 (19.1)	32 (21.1)	20 (13.2)	5 (3.3)
Do you feel sleepy when reading or doing close work?	48 (31.6)	28 (18.4)	36 (23.7)	27 (17.8)	13 (8.6)
Do you lose concentration when reading or doing close work?	55 (36.2)	28 (18.4)	42 (27.6)	15 (9.9)	12 (7.9)
Do you have trouble remembering what you have read?	45 (29.6)	34 (22.4)	45 (29.6)	15 (9.9)	13 (8.6)
Do you have double vision when reading or doing close work?	75 (49.3)	37 (24.3)	29 (19.1)	9 (5.9)	2 (1.3)
Do you see the words move, jump, swim or appear to float on the page?	84 (55.3)	39 (25.7)	15 (9.9)	9 (5.9)	5 (3.3)
Do you feel like you read slowly?	54 (35.5)	30 (19.7)	38 (25.0)	16 (10.5)	14 (9.2)
Do your eyes ever hurt when reading or doing close work?	64 (42.1)	42 (27.6)	27 (17.8)	9 (5.9)	10 (6.6)
Do your eyes ever feel sore when reading or doing close work?	68 (44.7)	38 (25.0)	26 (17.1)	10 (6.6)	10 (6.6)
Do you feel a pulling sensation around your eyes when reading?	84 (55.3)	32 (21.1)	21 (13.8)	9 (5.9)	6 (3.9)
Do you notice the words blurring or coming in and out of focus?	70 (46.1)	35 (23.0)	25 (16.4)	16 (10.5)	6 (3.9)
Do you lose your place while reading or doing close work?	68 (44.7)	34 (22.4)	34 (22.4)	11 (7.2)	5 (3.3)
Do you have to re-read the same line of words when reading?	39 (25.7)	33 (21.7)	45 (29.6)	22 (14.5)	13 (8.6)

Discussion

The prevalence of definite CI in this study was 23.7%. This is higher than the 7.98% pooled global estimate reported by Mohamed and Alrasheed (2023), 10% for Iranian university students by Sharif *et al*. (2014), 9.7% for Ghanaian first year university students by Darko-Takyi *et al.* (2022) and 11.42% for Nepalese engineering students by Dahal *et al*. (2021). However, the result of this study is lower than the overall range reported among young adults and clinic populations, ranging from 27.5% in India (Vaishali *et al*., 2019) to 34.4% in Nepal (Godar *et al*., 2025). The difference can be due to variations in population characteristics, sampling and diagnostic definitions. The present study also included students from different faculties and different levels of study as opposed to the previous study conducted among first year Optometry students in UNIBEN (Ovenseri-Ogbomo & Eguegu, 2016).

There was no statistically significant association between CI and age, sex, faculty or academic level which is consistent with the previous students' population where gender difference was not statistically significant (Ovenseri-Ogbomo & Eguegu, 2016; Wajuihian & Hansraj, 2016). Though, some studies indicate that symptoms may get worse in adolescence and early adulthood when near-work demands get tougher, the present study did not find any significant differences between age groups or academic levels. This indicates that CI

cannot be assumed to be a condition exclusive to one particular demographic group in this sample.

This correlation between the severity of the CISS and clinical CI is clinically relevant. The clinical definition of CI was met by 70% of patients who presented with severe CISS symptoms while 14.3% who presented with mild CISS symptoms met the clinical definition. This is in line with evidence showing that university students' CISS scores are correlated with clinical measures of CI (Darko-Takyi *et al.*, 2022). However, symptom questionnaires should be used to complement clinical assessment, as symptoms can be present in other binocular and accommodative disorders.

The duration (time spent reading) was statistically associated with CI, while the duration (time spent on digital device) was not. Participants who reported reading for more than seven hours per day had more than half of them with CI. This finding agrees with that of other studies that found a relationship between chronic near work and binocular-vision symptoms (Gomes & Franco, 2024; Pan *et al*., 2025; Zachary, 2022), but the lack of an association with total screen time suggests that near work may not be a uniform exposure. Differences in task characteristics, distance from the task, breaks, posture and type of visual demand may be factors (Emurotu *et al.*, 2026; Redondo *et al.*, 2025).

Limitations of the Study

There are a number of limitations involved in this study.

i. It is a cross sectional design, which allows for prevalence and association, but not causal or temporal inferences.
ii. The data on reading and exposure to digital devices were self-reported and so may be subject to recall and estimation error.
iii. Cycloplegic refraction and a thorough accommodative work-up were not done and therefore accommodative anomalies that might have been confused with the clinical appearance of a CI were not excluded.
iv. The representativeness of the data might be restricted due to recruitment from selected faculties and/or convenience recruitment of available consenting students.
v. The results obtained in this study are specific to UNIBEN undergraduates and may not be extended to the other universities in Nigeria or non-university young adults.

CONCLUSION

Convergence insufficiency was diagnosed in 23.7% of the 152 University of Benin undergraduates tested. Age, sex, faculty and academic level were not significantly correlated with CI, suggesting that affected students were spread throughout the undergraduate population. The severity of CISS was found to be significantly correlated with clinical CI, and daily reading time with CI was also correlated. However, this sample showed no significant relation between daily use of digital devices and CI. The results provide evidence for the importance of awareness and symptom-based screening and binocular-vision evaluation for students who have persistent symptoms of near work.

RECOMMENDATION

i. University health services might consider using brief CISS-based screening of symptoms as a part of student eye-health activities, and optometric assessment if required.
ii. It is also important to provide opportunities for students to take frequent breaks from sustained near work during any extended reading program.
iii. Longitudinal studies with objective measures of near work exposure, more extensive measures of accommodation and further assessment of the replicability of the observed findings in other universities in Nigeria should be carried out.

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