EFFECT OF SUSTAINED NEAR WORK ON ACCOMMODATION AND VERGENCE IN SUBJECTS WITH LOW HYPEROPIA

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NOVEMBER, 2025.

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A PROJECT SUBMITTED TO THE FACULTY OF OPTOMETRY, UNIVERSITY OF BENIN, BENIN CITY.
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF OPTOMETRY (OD) DEGREE.

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CERTIFICATION

This is to certify that this research project titled: **EFFECT OF SUSTAINED NEAR WORK ON ACCOMMODATION AND VERGENCE IN SUBJECTS WITH LOW HYPEROPIA** was carried out by **AGHEDO PROGRESS** in the Faculty of Optometry University of Benin in partial fulfillment of the requirement for the DOCTOR OF OPTOMETRY (OD) degree in the 2024/2025 Academic Session.

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DEDICATION

This research work is dedicated to God Almighty and to my family and friends for their encouragement and support in one way or another throughout my journey.

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ABSTRACT

Sustained near work has become a common visual demand in this digital era, often placing considerable strain on the accommodative and vergence systems, particularly in individuals with uncorrected refractive errors such as low hyperopia. This study aimed to evaluate the effect of sustained near work on accommodative and vergence parameters in individuals with low uncorrected hyperopia and to assess the influence of optical correction on these visual functions. Fifty-five participants consisting of 12 males and 43 females aged between 16–30 years (with mean age 20 ± 2.0 years) with low uncorrected hyperopia were assessed. Baseline measurements of amplitude of accommodation (AA), positive and negative relative accommodation (PRA, NRA), near point of convergence (NPC), and fusional vergence ranges (PFV and NFV) were obtained. Thereafter the subjects were made to read a printed text with Times New Roman font size 12 for 30 minutes first without correction and thereafter for another 30 minutes with correction. Post-task measurements for each were taken. Result obtained showed a systemic increase in mean AA (9.70 ±2.40 D to 10.30 ± 2.60 D) and PRA (-4.90 ± 1.48 D to -5.45 ± 1.36 D) and a decrease in PFV (BO to Break 20.00 ± 5.00**Δ to 17.00** ± 6.00**Δ) while there was minimal to no change in** NRA (+2.82 ± 0.76 D to +2.50 ± 0.59 D) and NFV (BI to Break 14.00 ± 4.00 **Δ**) before and after sustained near task without correction. Also, there was an increase in mean AA (9.70 ±2.40 D to 11.30 ± 3.40 D) and PRA (-4.90 ± 1.48 D to -5.78 ± 1.66 D) and a decrease in PFV (BO to Break 20.00 ± 5.00**Δ to 17.00** ± 7.00**Δ) while there was minimal to no change in** NRA (+2.82 ± 0.76 D to +2.30 ± 0.47 D) and NFV (BI to Break 15.00 ± 4.00 **Δ**) pretask and post-task with correction. The result was analyzed using Friedman's ANOVA and repeated measures ANOVA to compare pre- and post-task differences. This showed a significant difference between AA, PRA and PFV without and with correction ($Z = -3.289$, $p = 0.003$; F = 19.63, p < 0.001 and $Z = 3.194$, p < 0.001 respectively). However, there was no significant difference between pre and post task NRA, NPC and NFV without and with correction (p > 0.001). The findings suggest that sustained near work imposes temporary stress on the accommodative and vergence systems in individuals with low uncorrected hyperopia, and that optical correction effectively reduces this strain, improving visual comfort and performance during prolonged near tasks.

Keywords: Accommodation, Vergence, Low Hyperopia, Sustained Near Work, Optical Correction

CHAPTER ONE

1.0 INTRODUCTION

Human vision relies on the precise coordination of various ocular systems that enable clear, single, and sustained focus across different distances, a process brought about by the cornea and lens, which refract incoming light to form a clear image (Atchison and Smith, 2000). Accommodation and Vergence are two of the most important components in near vision tasks, both of which play a major role in reading, studying, and digital screen use.

Accommodation refers to the ability of the eye to increase the optical power of the crystalline lens to focus on near objects. This process is controlled by the contraction of the ciliary muscle, which thickens the lens to allow light to be focused accurately on the retina (Antona *et al.,* 2022). During near work, accommodation must be sustained, which increases the demand on the visual system especially in individuals whose refractive status already places additional accommodative load, such as in low uncorrected hyperopia.

Vergence, on the other hand, refers to the inward or outward movement of the eyes to achieve single binocular vision on a target. During near work, the eyes converge, a process that is neurologically and functionally linked to accommodation via the accommodative convergence to accommodation (AC/A) ratio (*Richter et al.,* 2015). This cross-linked control ensures that a change in accommodative demand is accompanied by a proportional change in vergence. Therefore, any imbalance in either system due to fatigue, refractive anomalies, or sustained visual stress can manifest as a breakdown in the other, resulting in symptoms such as diplopia, blurred near vision, and eye strain.

During prolonged near work such as reading or using smartphones, this coupled system (accommodation and vergence) is placed under continuous demand. This can lead to temporary breakdowns or fatigue, particularly if the systems are already under strain. In individuals with low uncorrected hyperopia, the eye must exert more accommodative effort even for standard near viewing distances. Consequently, the vergence system is also pushed to compensate, potentially leading to visual discomfort, asthenopia, and even transient changes in near visual function (Vienne *et al.,* 2018).

When the balance between accommodation and vergence is disrupted, symptoms like blurred near vision, headaches, eye strain, and difficulty concentrating may arise. This functional stress often goes undetected in routine eye exams, particularly in hyperopes with 6/6 distance acuity. However, research shows that even short periods (15–30 minutes) of sustained near work can lead to measurable changes in vergence range, amplitude of accommodation, and near point of convergence, even in visually "normal" individuals (Chou *et al.,* 2017).

1.1 BACKGROUND INFORMATION

1.1.1 Understanding of Near Vision

Near vision is a vital aspect of human visual function, supporting essential activities such as reading, writing, and using digital devices. This depends on the coordinated actions of the accommodative and vergence systems, which adjust both the optical power of the lens and the alignment of the eyes to maintain a clear and single image at close distances. Such coordination is mediated via the accommodation-convergence reflex, ensuring efficient focus and alignment during near tasks (Motlagh and Geetha, 2022). In young adults, these mechanisms are usually active, allowing prolonged engagement in near tasks with minimal discomfort. However, in individuals with uncorrected refractive errors such as hyperopia, the visual system is placed under additional strain, as greater accommodative effort is required to maintain clarity during sustained near work (Hussaindeen *et al.,* 2017).

The increasing prevalence of near-vision–intensive tasks, particularly the use of smartphones, tablets, and computers, has heightened the demand on the accommodative and vergence systems. Studies have shown that extended near work can lead to visual fatigue, asthenopia, and temporary changes in accommodative and binocular vision parameters, especially in populations with underlying refractive errors (Sheppard and Wolffsohn, 2018). For low uncorrected hyperopes, this demand is more pronounced, as their eyes must continuously exert accommodation to compensate for the latent hyperopic error, which over time may contribute to reduced visual comfort and functional efficiency (Hilora and Tripathy, 2025).

For effective near work, accommodation and vergence which are the key determinants in near vision are put into play and this is greatly influenced by the refractive status and degree of refractive error of the individual.

1.1.2 Accommodation

Accommodation is the physiological process by which the eye adjusts its optical power to maintain a clear retinal image when shifting focus from distant to near objects. This ability is achieved through the action of the ciliary muscles, zonular fibers, and crystalline lens, allowing the visual system to adapt efficiently to different viewing distances (Ciuffreda, 2006). It is a vital component of visual function, particularly in tasks such as reading or computer use, where sustained near focus is required (Atchison and Smith, 2017).

Process of Accommodation

Physiologically, accommodation proceeds via biomechanical changes in the anterior segment. Neural signals for accommodation travel from the retina to the midbrain (Edinger–Westphal nucleus) and back via the oculomotor nerve. This parasympathetic activation causes the ciliary muscle to contract, which relaxes tension on the lens zonules and allows the lens to thicken. As a result, the lens becomes more convex and its dioptric power increases for near vision (Motlagh and Geetha, 2022). The radii of curvature of the anterior and posterior lens surfaces also steepen with accommodation. These changes are more pronounced in hyperopic eyes, where each diopter of accommodative demand produces a larger increase in lens thickness compared to emmetropic eyes, implying greater effort for clear near vision (Uwacu *et al.,* 2025).

Measurement of Accommodation

Clinically, accommodative function can be assessed using several methods. These include: amplitude of accommodation (AoA)**,** accommodative accuracy (lag/lead)**,** and accommodative facility.

Amplitude of Accommodation

Amplitude of accommodation is defined as the eye's maximum ability to change its focus from a distant target to a near one. It represents the dioptric range between the farthest point of clear vision (when the eye is at rest) and the nearest point of clarity achieved through maximum accommodative effort. This clinical measure provides insight into the functional capacity of the accommodative system and typically decreases with age due to physiological changes in the crystalline lens and ciliary body (Antona *et al.,* 2022). It is conventionally measured monocularly using the push-up (or minus-lens) technique. The Hoffstetter's formula is used as a normative reference for amplitude of accommodation.

Accommodative Accuracy (lead/lag)

Accommodative accuracy refers to how precisely the eye's accommodative response matches the visual demand of a near task. Ideally, the accommodative response should equal the required demand (e.g., a 2.50 D response for a 40 cm task). However, in practice, small errors occur, leading to either a lag (when the accommodative response is less than the required demand, resulting in the image focusing slightly behind the retina) or a lead (when the accommodative response overshoots the demand, placing the image in front of the retina) of accommodation. This can result in blurred near vision, eyestrain, and reduced reading efficiency. Accommodative accuracy is assessed using dynamic retinoscopy techniques such as the Monocular Estimation Method (MEM) or Nott retinoscopy (Nguyen *et al.,* 2018).

Accommodative Facility

Accommodative facility is the ability of the eyes to quickly adjust focus between far and near objects. This is very essential when carrying out important tasks like reading, writing and also while using digital devices. To assess how efficiently and precisely the eye can adjust its focus, accommodative facility testing is commonly included in a comprehensive eye examination.

Accommodative facility is assessed clinically using ±2.00 diopter flipper lenses while the patient views a near target, usually at 40 cm. The number of cycles per minute (cpm) (defined as one clear focus through plus and minus lenses) represents the facility rate (Rouse *et al.,* 1987).

Relative Accommodation

This is a measure of the ability of the eye to focus on a near object when accommodative demand is increased or reduced while maintaining clear and single binocular vision It is typically divided into two components:

- **Negative Relative Accommodation:** According to Harrison and Bowers (2010), this refers to the ability of the eye to focus on a near object when accommodative demand is reduced. It is a measure of how much focusing ability is needed to maintain a single, clear and comfortable vision while performing near tasks when the eye is not accommodating but relaxing. Negative relative accommodation (NRA) occurs when the eye focuses on a point further away than the current fixation point. This mechanism involves relaxation of the ciliary muscle and flattening of the crystalline lens to reduce optical power, allowing for clear viewing of distant objects (Gilmartin, 2004).
- **Positive Relative Accommodation:** Positive relative accommodation refers to the ability of the eye to focus on a near object while accommodative demand is increased (Hoffman and Bowers, 2006). It is a measure of the maximum amount of minus lens power that can be added before an individual experiences blurred vision when looking at a near target. Positive relative accommodation (PRA) occurs when the eye focuses on a point closer to the observer than the current fixation point. This primarily involves changes in the crystalline lens shape and curvature, resulting in increased optical power to bring near objects into focus (Gilmartin, 2004).

Problems of Accommodation

Anomalies of accommodation represent significant dysfunctions of the visual system that can impair near vision, reduce efficiency, and cause considerable visual discomfort during sustained close work. These conditions are particularly relevant in pre-presbyopic populations, where accommodation is expected to be efficient but may instead present with insufficiency or excess.

Accommodative insufficiency is one of the most common accommodative disorder, characterized by a reduced amplitude of accommodation or an inability to sustain adequate focus over time. It manifests clinically as blurred near vision, headaches, asthenopia, and difficulty maintaining clear vision during reading or other near tasks (Scheiman and Wick, 2019). It may arise idiopathically, but it has also been associated with systemic illnesses, psychological stress, and prolonged near work demands (Hussaindeen *et al.*, 2017). Conversely, accommodative excess or accommodative spasm occurs when there is an involuntary tendency to exert accommodation beyond the required demand. This “over-accommodation” can lead to a pseudomyopic shift, with the individual reporting blur at distance following near activity (Nguyen *et al.,* 2018). It is commonly linked with binocular vision dysfunctions, particularly convergence anomalies, and is often identified clinically as a lead of accommodation, where the measured response exceeds the stimulus demand (Hilora and Tripathy, 2025).

Management of Accommodative Problems

The management of accommodative dysfunction is multifaceted, aiming not only to relieve symptoms but also to restore efficient visual performance. The primary step involves correcting underlying refractive errors, particularly uncorrected hyperopia, which significantly contributes to accommodative stress (Ntodie *et al.,* 2021). Beyond optical intervention, structured vision therapy interventions, such as accommodative rock and Hart chart exercises, have demonstrated efficacy in improving accommodative amplitude and flexibility, thereby enhancing near-vision endurance (Scheiman *et al.,* 2019). In cases of accommodative spasm resistant to conventional therapy, short-term use of cycloplegic agents may be warranted, though their application remains limited due to potential side effects (Kavthekar *et al.,* 2017). Furthermore, the integration of ergonomical modifications such as the adoption of the 20-20-20 rule, optimal lighting, and consistent working distancesare increasingly recommended to mitigate near-work–induced strain (Sheppard and Wolffsohn, 2018).

1.1.3 Vergence

Vergence refers to the disjunctive movement of the two eyes that ensures binocular alignment and single vision at varying distances. This system plays a vital role in near visual performance, operating in conjunction with accommodation and pupillary constriction as part of the near triad. In young adults, vergence mechanisms are generally efficient; however, in individuals with uncorrected refractive errors, such as low hyperopia, sustained near tasks place an additional burden on vergence responses, often predisposing them to visual fatigue and inefficiency (Ma *et al.,* 2014; Wajuihian, 2019).

Process of Convergence

The process of convergence is primarily driven by retinal disparity cues and is supported by cross-links with the accommodative system, described by the accommodative convergence to accommodation ratio (AC/A) and convergence accommodation to convergence ratio (CA/C) relationships. Recent evidence highlights how vergence responses are influenced not only by disparity but also by blur and proximal cues, making the system highly adaptable yet vulnerable under conditions of sustained visual demand (Argilés and Cardona, 2024). Furthermore, neurophysiological studies suggest that vergence can be improved through targeted therapy, supporting the concept of plasticity in adult visual function (Alvarez *et al.,* 2020).

Measurement of Vergence

Assessment of vergence involves a range of clinical measures which include:

Near Point of Convergence (NPC): This refers to the closest point at which the eyes can maintain single, binocular vision while converging on a near object. It assesses the strength and flexibility of the vergence system and is an essential measure of binocular function (Scheiman *et al.,* 2020). NPC is evaluated by gradually bringing a target closer to the eyes until double vision (break point) occurs, followed by the recovery point where single vision returns. A receded NPC may indicate convergence insufficiency or fatigue from sustained near work (Scheiman *et al.,* 2020).

Fusional Vergence: Fusional vergence refers to the ability of the eyes to make disjunctive movements that maintain single binocular vision in the presence of a latent misalignment (heterophoria). It enables the visual system to compensate for phorias and maintain sensory fusion, even when the visual axes are naturally inclined to deviate (Scheiman *et al.,* 2020). Unlike accommodative vergence, which is linked to changes in accommodation, fusional vergence is driven primarily by retinal disparity cues and functions to align the foveae of both eyes on the same target (Alvarez *et al.,* 2020). There are two main components of fusional vergence viz:

- **Positive Fusional Vergence (PFV)**: This is the ability of the eyes to converge and maintain single binocular vision when a base-out prism is introduced to simulate an outward eye deviation. It reflects the strength of convergence reserves and is important in compensating for exophoria, particularly during near tasks such as reading or prolonged screen use. PFV is clinically assessed using prism bars or a phoropter by adding base-out prisms until the patient reports blur, diplopia (break point), followed by the recovery point, when single vision returns. Adequate PFV indicates good binocular stability, while reduced PFV is an indicator of convergence insufficiency, which can lead to symptoms like eyestrain, intermittent blur, headaches, and poor reading sustenance (Scheiman *et al.,* 2020).

- **Negative Fusional Vergence (NFV):** This is the eyes' ability to diverge while maintaining single, clear binocular vision when a base-in prism is introduced. It is essential for compensating for esophoria and stabilizing vision during tasks that stimulate divergence, such as shifting gaze from near to far or during extended near viewing when convergence adaptation is fatigued. NFV is assessed by gradually increasing base-in prism power until blur, diplopia (break point) occurs, followed by the recovery point, where single vision is restored. Poor NFV responses may lead to symptoms such as eye strain, blurred distance vision after near work, or diplopia. Measuring NFV helps detect divergence weaknesses, which are relevant in individuals with binocular vision disorders or those under high near-vision demands (Scheiman *et al.,* 2020).

  Vergence facility: This refers to the ability of the visual system to rapidly and efficiently switch between convergence and divergence demands while maintaining single and clear binocular vision. It evaluates not only the strength of the vergence system, but also its flexibility and adaptability under dynamic visual conditions (Scheiman and Wick, 2020). Clinically, vergence facility is measured using 12Δ base-out/3Δ base-in flipper prisms at a near working distance, with results expressed in cycles per minute (cpm). Each cycle represents one successful clearing of blur or diplopia through convergence (base-out) and divergence (base-in) (Carlson and Kurtz, 1990). Normal adult values are approximately 15 cpm binocularly, with reduced facility indicating difficulties in adapting to rapid shifts in vergence demand.

Problems of Vergence

Disorders of vergence are relatively common in young adults and may compromise both academic and occupational efficiency. Convergence insufficiency (CI) is the most prevalent, characterised by receded NPC, reduced PFV, and exophoria at near. CI has been strongly linked to asthenopia, difficulties in sustained reading, and impaired visual efficiency (Mohamed and Alrasheed, 2023). Other anomalies, such as vergence infacility and convergence excess, also contribute to visual discomfort during prolonged near work, especially when compounded by uncorrected hyperopia (Wiecek *et al.,* 2021).

Management of Vergence Dysfunctions

Management of vergence problems requires a tailored approach combining optical correction, prisms, structured vision therapy, and ergonomic modifications**.** Among these, vision therapy remains the most effective, evidence-based treatment**,** particularly for convergence insufficiency, while prisms and optical correction serve as valuable supportive measures.

1.1.4 Understanding Refractive Errors

Refractive errors including myopia, hyperopia, and astigmatism are among the leading causes of visual impairment globally, affecting over 50% of the world's population at different ages (Zheng *et al.,* 2021). Hyperopia, also known as farsightedness, is a condition in which parallel light rays focus behind the retina, usually due to a shorter axial length of the eye or reduced curvature of the cornea (Mavi *et al.,* 2024). This refractive condition is particularly relevant in functional vision tasks that involve sustained near focus, such as reading or digital device use.

While uncorrected myopia often presents with clear distance blur, low hyperopia typically defined as +0.50D to +2.00D may remain asymptomatic in terms of distance vision due to the compensatory effort of accommodation (Rajavi *et al.,* 2022). However, at near, this compensatory mechanism results in additional accommodative demand. During prolonged near tasks, this can lead to fatigue and excessive stimulation of the vergence system, increasing the likelihood of visual symptoms such as blur, eye strain, or headaches (Mavi *et al.*, 2024).

Uncorrected hyperopia has been associated with functional vision limitations, especially in environments that demand sustained near attention. Several studies have demonstrated that children with moderate to high hyperopia perform significantly worse in early literacy and classroom activities. The VIP-HIP Study Group (2016) found that hyperopic preschoolers without correction scored lower in visual attention and reading readiness, largely due to near vision inefficiency.

Although most clinical screenings prioritize myopia and amblyopia, hyperopia remains under-diagnosed, particularly in individuals who maintain 6/6 or better visual acuity. These individuals may not report any complaint during brief visual tasks, but exhibit symptoms of asthenopia, intermittent blur, or poor near task maintenance when reading is sustained (Rajavi *et al.,* 2022; Zheng *et al.,* 2021).

For older children and young adults, especially in academic environments, low uncorrected hyperopia presents a silent but impactful risk. Sustained near visual tasks such as studying, reading, and using smartphones are known to increase accommodative effort. In low hyperopes, this additional demand occurs on top of the baseline strain already required for clear near vision, leading to a compounded effect that may result in reduced accommodation and vergence over time (Barnes *et al.,* 2015).

In addition, recent systematic reviews show that uncorrected refractive error including low hyperopia continues to contribute significantly to global visual impairment. Despite advancements in eye care access, refractive errors remain undercorrected, especially in regions where functional vision demands are increasing due to lifestyle and digital dependency (*Zheng et al.,* 2021).

1.1.5 Relationship Between Near Vision, Accommodation, Vergence and Refractive Errors

Near vision relies on the coordinated interaction of the accommodative and vergence systems, which ensure that images of near objects are clear and single. These mechanisms are neurally cross-linked through the accommodative convergence/accommodation (AC/A) and convergence accommodation/vergence (CA/C) relationships, allowing dynamic adjustments during reading, writing, or digital device use (Wajuihian, 2022). When this balance functions effectively, visual tasks are sustained comfortably.

However, in the presence of uncorrected refractive errors such as hyperopia, the system is placed under greater strain. Low hyperopes, for instance, must exert constant accommodation even at distance, and this additional demand becomes more at near, often leading to binocular instability, fatigue, and asthenopia (Maity, 2025).

The recent increase in near-vision–intensive activities, particularly prolonged use of smartphones and computers, has amplified this demand, with research linking sustained near work to temporary reductions in amplitude of accommodation, altered vergence responses, and digital eye strain (Sheppard and Wolffsohn, 2018; Ntodie *et al.,* 2023). While emmetropic individuals may adapt to these stresses more efficiently, hyperopes are disproportionately affected because their visual system is already compensating for latent refractive error. This highlights the close interdependence between near vision, accommodation, vergence, and refractive status, and underscores the importance of investigating how sustained near tasks impact visual performance in individuals with uncorrected low hyperopia.

1.2 STATEMENT OF PROBLEM

Low uncorrected hyperopia is often overlooked due to the absence of obvious symptoms. However, during sustained near tasks, these individuals exert continuous accommodative and vergence effort, which may lead to visual fatigue and discomfort. Despite this, the impact of prolonged near work on the accommodative and vergence systems in this group remains under-investigated hence there is a need to better understand how seemingly minor refractive errors can affect visual performance under continuous demand, to support early detection and effective clinical management.

1.3 AIM AND OBJECTIVES

1.3.1 AIM OF THE STUDY

This study aims to investigate the effect of sustained near task on accommodation and vergence in subjects with low hyperopia.

1.3.2 OBJECTIVES OF THE STUDY

1. To assess accommodative function before and after 30 minutes of sustained near reading in individuals with low hyperopia, both with and without optical correction.
2. To assess vergence function before and after 30 minutes of sustained near reading in individuals with low hyperopia, both with and without optical correction.
3. To compare pre-task and post-task accommodative and vergence function in subjects with low hyperopia without optical correction to identify any significant differences due to sustained near visual demands.

4. To compare the post-task accommodation and vergence parameters with and without correction in subjects with low hyperopia.

1.4 HYPOTHESES

Null Hypothesis $(H_o)_1$: Sustained near work has no effect on accommodation in subjects with low hyperopia.

Null Hypothesis $(H_o)_2$: Sustained near work has no effect on vergence in subjects with

low hyperopia.

1.5 SIGNIFICANCE OF THE STUDY

1. The findings will help optometrists and eyecare practitioners better understand the effect of sustained near work on accommodation and vergence functions in individuals with low uncorrected hyperopia - a group that may appear asymptomatic during routine examinations.
2. The findings may highlight subtle visual dysfunctions that are often overlooked in individuals with low refractive errors, promoting early detection and management of accommodative and vergence anomalies.
3. This research adds to the limited body of knowledge on functional visual performance in low hyperopes, offering a foundation for future academic studies and discussions in optometric and vision science education.

4. By identifying a possible link between prolonged near work and reduced visual efficiency in low hyperopes, the study may support broader recommendations on safe near-work durations and visual ergonomics in schools and workplaces.

1.6 DEFINTION OF TERMS

- **Accommodation**: The process by which the eye changes its optical power to maintain a clear image as the viewing distance shifts from far to near. This is achieved through contraction of the ciliary muscle and increased lens curvature.
- **Amplitude of accommodation (AoA):** The maximum focusing ability of the eye, expressed in dioptres, representing the range between the farthest and nearest points of clear vision.
- **Vergence:** A binocular eye movement in which both eyes move in opposite directions (either converging or diverging) to maintain single vision when focusing on objects at different distances.
- **Positive fusional vergence (PFV):** The ability of the eyes to converge inward to maintain single binocular vision when a base-out prism stimulus is introduced.
- **Negative fusional vergence (NFV):** The ability of the eyes to move outward to maintain single vision in response to base-in prism demand, particularly during near-to-far shifts.
- **Near point of convergence (NPC):** The closest point at which the eyes can maintain single binocular vision while converging on a near object.
- **Sustained near work/tasks:** Visually demanding activities performed at a short working distance (usually within 33-40 cm) for extended periods, such as reading, writing, and digital screen use.

- **Low hyperopia:** A mild form of farsightedness usually ranging from +0.50 D to +2.00 D, where the eye must exert extra accommodative effort to see clearly, particularly at near.
- **Uncorrected refractive error:** A refractive condition (such as hyperopia) that has not been corrected with lenses, causing the eye to compensate internally to achieve clear vision.
- **Negative relative accommodation (NRA):** The ability of the eyes to relax accommodation while maintaining clear binocular vision at near, assessed by adding plus lenses binocularly until blur occurs.
- **Positive relative accommodation (PRA):** The ability of the eyes to increase accommodative effort while maintaining clear vision at near, assessed by adding minus lenses binocularly until blur occurs.
- **Pre- and post- task measurements:** Assessments conducted before and after specific task to evaluate any changes in accommodation and parameters. This methodology is crucial for determining the impact of the tasks performed.
- **Asthenopia:** A general term for symptoms of eye strain, including headaches, blurred vision, and discomfort during or after prolonged near visual tasks.

CHAPTER TWO

2.1 LITERATURE REVIEW

2.1.1 REVIEW OF NEAR WORK AND VISUAL STRESS

Vasudevan *et al.,* (2007) conducted a study to investigate how prolonged near work influences corneal topography, aberrations, and thickness in young adults. The study included 19 participants (10 myopic and 9 emmetropic individuals) who were instructed to read continuously for one hour at a viewing distance of 40 cm with approximately 30 degrees of downward gaze while wearing their distance correction. Corneal assessments were performed using the Orbscan II topography system at baseline and subsequently at 5, 15, 30, and 60 minutes following the reading activity to monitor variations in corneal curvature, aberrations, and thickness. The results revealed that, both before and after the reading session, myopic participants exhibited higher corneal power and greater levels of spherical aberration compared to emmetropic participants.

Gomes *et al.,* (2021) conducted a study to investigate the effect of near-vision reading task on optical quality of the eye when performed on a computer monitor and on printed paperand to identify which of the two results in greater changes. Two groups of subjects (Group 1 with 19 subjects and Group 2 with 34 subjects) were asked to read from a computer monitor and printed paper respectively for 30 minutes. Ocular, corneal, and internal wavefront aberrations (Zernike coefficients up to 6th order), root-mean-square of low- and high-order aberrations, spherical equivalent, vectoral components of ocular astigmatism (J45 and J0), and the compensation factor between internal and corneal aberrations were measured before and after the tasks and the changes were analyzed in each group and between groups. The analysis revealed significant changes in wavefront aberrations and RMS values in both groups, with more pronounced alterations occurring following the printed paper reading condition.

Additionally, a partial breakdown in the eye's compensatory mechanism and a negative shift in spherical equivalent were noted after both tasks, though the changes were statistically significant only for printed reading. No significant variations were observed in astigmatic vector components for either group. The researchers concluded that sustained near-vision reading can transiently affect the optical quality of the eye, particularly when performed with printed material.

Hue *et al.,* (2014) conducted a study to compare reading from two electronic devices (Amazon Kindle or Apple Ipod) versus hardcopy text. Two groups of 20 subjects were asked to perform 20 minutes reading session under three conditions—using an Amazon Kindle, an Apple iPod, and traditional hardcopy material. Throughout the task, both accommodative responses and reading rates were measured, and participants completed a post-task questionnaire assessing ocular symptoms. The findings showed no significant variation in overall reading rate or total symptom scores between the Kindle and hardcopy conditions; however, reports of eye fatigue and discomfort were higher when reading from the Kindle. Similarly, while symptom scores for the iPod and hardcopy did not differ significantly, reading speed was slower and accommodative lag was greater with the iPod. Based on these results, the researchers concluded that visual performance and comfort during reading differ between digital screens and printed materials, indicating that electronic devices do not fully replicate the visual experience of hardcopy reading.

Chu *et al.,* (2011) conducted a study to compare symptoms after viewing a text on a computer screen and hardcopy. The study involved 30 young adult participants who were instructed to read identical text passages aloud for 20 minutes at a fixed viewing distance of 50 cm, either from a desktop monitor or from a printed page. The font size, contrast, and luminance were standardized across both reading conditions to ensure consistency. Upon completing each session, participants filled out a questionnaire evaluating their level of ocular discomfort during the task. Analysis of responses revealed a significant increase in median symptom scores, particularly for blurred vision ($t = 147.0$; $p = 0.03$), with overall discomfort being notably greater during computer-based reading than during reading from hardcopy material.

2.1.2 REVIEW OF ACCOMMODATION AND VERGENCE FUNCTION

Syeda *et al.,* (2023) carried out a comparative investigation to evaluate the relationship between accommodation and vergence among Indian adolescents with varying degrees of myopia. The study recruited 150 participants aged 10 to 17 years, who were categorized into three refractive error groups—low, moderate, and high myopia. Each participant underwent baseline visual examination and an extensive binocular vision assessment, which included phoria measurements for distance and near using the Thorington chart, the monocular estimation method (MEM), near point of accommodation (NPA), negative and positive relative accommodation (NRA and PRA), accommodative facility (AF) using ±2.00 D flippers, near point of convergence (NPC), positive and negative fusional vergence (PFV and NFV), vergence facility (VF) with 12 base-out/3 base-in prisms, and interpupillary distance (IPD). NPA was determined using the push-up-to-blur technique, while PRA and NRA were measured binocularly by adding minus and plus lenses in 0.25D steps, respectively, until sustained blur occurred. The accommodative facility was assessed at 40 cm, and NPC was tested using the Royal Air Force ruler with a 6/9 linear accommodative target. The findings revealed that convergence insufficiency was the most prevalent dysfunction among low (75.3%) and moderate (54%) myopes, whereas high myopes (62.8%) frequently exhibited combined convergence and accommodative insufficiency, followed by accommodative dysfunction (14%) and basic exophoria (6%). A statistically significant association was observed between refractive error and binocular dysfunction in the moderate myopia group.

Moreover, participants who underwent vision therapy demonstrated significant improvement compared to the control group ($P < 0.001$).

Mohammad Masihuzzaman *et al.,* (2021) conducted a study to investigate the relationship of Negative, Positive Relative Accommodation and Negative, Positive Fusional Vergence in Ammetropes and Emmetropes in a Young Population of Nepal. The study involved 108 participants, comprising 30 myopes, 11 hyperopes, and 67 emmetropes. Each participant underwent assessments of uncorrected and corrected visual acuity, refraction, and both distance and near cover tests. Additionally, several visual function parameters were measured, including near point of convergence (NPC), amplitude and facility of accommodation, negative relative accommodation (NRA), positive relative accommodation (PRA), and vergence ranges for distance and near. These were evaluated using the push-up-to-blur technique, monocular estimation method, ±2.00 D flipper lenses, plus and minus lens tests, and prism bar respectively. The findings indicated a direct relationship between NRA and PFV among hyperopic participants.

2.1.3 RELATIONSHIP BETWEEN ACCOMMODATION, VERGENCE AND SUSTAINED NEAR WORK

Padavettan *et al.,* (2021) investigated how prolonged smartphone use influences accommodative and vergence responses in visually healthy adults. The study included 147 emmetropic participants who initially underwent comprehensive visual screening and baseline assessment of vergence and accommodation parameters. Following this, each participant was instructed to read an N6-sized text displayed on a smartphone at a distance of 40 cm for 30 minutes. Post-task measurements were then obtained and compared with baseline values. The findings revealed that sustained reading on a smartphone significantly altered both accommodative and vergence functions, with the impact being more pronounced on vergence responses.

Sreenivasan *et al*., (2012) conducted a study to examine the influence of phoria-type and myopia on changes to vergence and accommodation during prolonged near-task in children. The study involved 53 participants who were categorized according to their near phoria and cycloplegic refractive status. Measurements of near phoria, binocular accommodation (BA), and monocular accommodation (MA) were obtained before and throughout a 20-minute sustained fixation task, during which subjects viewed a high-contrast target positioned at 33 cm while wearing their optimal refractive correction. Changes in near phoria and tonic accommodation were used to quantify vergence and accommodative adaptation, respectively. The results indicated that both phoria classification and refractive condition play a significant role in determining the extent of vergence and accommodative adaptation during prolonged near tasks in children.

2.1.4 RELATIONSHIP BETWEEN HYPEROPIA AND SUSTAINED NEAR WORK

Da Costa et al. (2015) carried out a study aimed at assessing how different levels of accommodative demand influence asthenopic symptoms among individuals with varying degrees of hyperopia. A total of 69 hyperopic participants were enrolled and randomly assigned to four groups, each performing a near-vision task using corrective lenses designed to create different accommodative workloads. The findings revealed that asthenopic symptoms decreased significantly when at least 35% of the individual's accommodative amplitude was left as a functional reserve during the task. The study further indicated that the intensity of asthenopia was not directly related to the degree of hyperopic refractive error, suggesting that accommodative effort, rather than refractive magnitude alone, plays a key role in the onset of visual discomfort.

Ntodie *et al.,* (2021) conducted a study on 'Correction of Low -Moderate Hyperopia Improves Accommodative Function for Some Hyperopic Children During Sustained Near Work'. The study assessed the sustained accommodative function of 63 participants aged 5–10 years with hyperopic refractive errors ranging from +1.00 D to less than +5.00 D spherical equivalent in the less hyperopic eye. Using eccentric infrared photorefraction (PowerRef 3; PlusOptix, Germany), binocular accommodative responses were recorded while the children performed two 15-minute tasks at a 25 cm viewing distance: an active task involving reading fine print on an Amazon Kindle and a passive task involving viewing an animated movie on an LCD screen. The findings demonstrated that providing refractive correction significantly enhanced the accuracy of accommodative responses in both tasks. At the end of the study, it was concluded that correcting low-to-moderate levels of hyperopia can improve accommodative efficiency during sustained near activities and may enhance visual performance in school-aged children.

Ntodie *et al.,* (2023) conducted a study to investigate 'the accuracy and stability of accommodation and vergence responses during sustained near tasks in uncorrected hyperopes'. The study examined accommodative and vergence responses in 92 children aged 5–10 years, both with and without hyperopia (defined as cycloplegic retinoscopy values between +1.00 D and +5.00 D). Using eccentric infrared photorefraction (PowerRef 3; PlusOptix, Germany), binocular accommodation and eye position were assessed while participants performed two 15-minute tasks at a 25 cm viewing distance: reading small text on an Amazon Kindle and watching an animated film on an LCD screen. The findings revealed that, on average, accommodative and vergence response magnitudes were similar between uncorrected hyperopes and emmetropes. However, greater variability and instability in both responses were observed among uncorrected hyperopes who exhibited stronger accommodative response, suggesting that prolonged near work may contribute to visual fatigue and reduced stability in this population.

2.2 GAPS IN LITERATURE

While numerous studies have examined the effects of sustained near work on visual function, significant gaps remain particularly concerning low uncorrected hyperopia. A major limitation in the current literature is that most research concentrated on emmetropic or myopic subjects, with minimal attention given to low hyperopes. This group is often overlooked because they often achieve normal distance vision through compensatory accommodation, masking their refractive error during standard.

Additionally, there is a lack of studies that examine functional visual changes before and after near tasks specifically in low hyperopic individuals who are not wearing corrective lenses. Although some research highlights accommodative strain and reduced visual performance after prolonged near work, these effects have not been widely investigated within the hyperopic population. Another challenge is the inconsistency across studies in terms of task design, duration, and assessment methods, which limits the ability to generalize results or create standardized clinical practices.

Furthermore, existing research often fails to assess a broad range of visual function parameters. Key measures such as amplitude of accommodation, near point of convergence (NPC), relative accommodation (PRA and NRA), and fusional vergence are sometimes excluded or tested in isolation, resulting in incomplete evaluations of near vision function. In addition, while symptom-based tools like the Convergence Insufficiency Symptom Survey (CISS) are commonly used in binocular vision research, they are rarely applied in hyperopia-focused studies. This leaves a gap in understanding how low uncorrected hyperopes experience and report visual symptoms during sustained near work.

Lastly, most studies focus on short-term effects of near work, with little investigation into whether repeated or daily visual tasks cause cumulative visual fatigue in individuals with low uncorrected hyperopia. These limitations highlight the importance of studies like the present one, which aims to investigate both objective and subjective visual responses to sustained near activity in this underrepresented population.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY DESIGN:

This study is an experimental design which involved volunteers whose accommodation and vergence parameters was determined before and after engaging in sustained near task with and without correction.

3.2 STUDY LOCATION:

This study was carried out in Optometry Teaching Clinic in the University of Benin, Benin City, Edo state.

3.3 STUDY POPULATION:

This study was conducted among 55 undergraduate students of the University of Benin within the age range 16-30 years who met the inclusion criteria.

3.4 SAMPLING TECHNIQUE AND SAMPLE SIZE

This study utilized a convenience sampling technique to identify the study participants who met the inclusion criteria to be easily recruited from the university of Benin.

The sample size for this study was determined based on previous literature examining accommodative changes in hyperopic individuals following sustained near work. In a study by Ntodie *et al.,* (2021), a within-subjects design was used to assess accommodative response before and after near visual tasks in children with uncorrected hyperopia. The study employed paired comparisons and detected statistically significant differences in accommodative accuracy with a sample of 63 participants.

To adapt their approach for the current study, a power analysis was conducted using G Power 3.1 (Faul *et al.,* 2007)

$$n = \frac{((Z_{1-\alpha/2} + Z_{1-\beta}) \times \sigma)^2}{d^2}$$

$Z_{1-\alpha/2}$ = is the critical value of the standard normal distribution at the given significance level (for α = 0.05, $Z_{1-\alpha/2} = 1.96$)

$Z_{1-\beta}$ = is the critical value of the standard normal distribution at the given power level (for 1-β = 0.80, = $Z_{1-\beta}$ = 0.84).

Effect size (*d*) = The expected difference in means between the control and intervention phases (0.4, moderate effect)

Standard deviation (σ) = The standard deviation of the differences between paired observations (1)

$$n = \frac{((1.96 + 0.84) \times 1)^2}{0.4^2}$$

= 49

n ≈ 50

Considering a 10% non-participation rate (attrition rate),

0.1 x 50 = 5

Therefore, the final sample size would be 50 +5= **55**

3.5 RESEARCH MATERIALS

1. Royal Air Force Rule
2. Prism bars
3. Snellen chart.
4. Printed text - extracted from Art of Public Speaking- by Dale Carnegie presented in Times New Roman font, size 12 with line spacing of 1.5.
5. Stop watch.
6. Consent form
7. Excel spreadsheet
8. Near Vergence target (thin line)
9. Near point card
10. Metre rule

3.6 INCLUSION/EXCLUSION CRITERIA

3.6.1 INCLUSION CRITERIA.

1. Participants of the University of Benin community, Edo state between ages 16-35 years who agreed to participate in this study.
2. Individuals with low uncorrected hyperopia, defined as a spherical equivalent ranging from +0.50D to +2.00D in both eyes.
3. Participants with anisometropia < 1.00D.
4. Participants with astigmatism < 1.00DC.
5. Participants with visual acuity of at least 20/20.

3.6.2 EXCLUSION CRITERIA

1. Individuals presenting with ocular or systemic diseases, or using medications that could affect accommodation or vergence response (e.g. diabetes mellitus, anticholinergics).
2. Participants with history of binocular vision disorders, such as strabismus, amblyopia, or significant convergence insufficiency.

3.7 DESCRIPTION OF PROCEDURE

Participants were recruited from the University of Benin community. An initial screening was conducted using a modified symptom questionnaire developed based on items from the Symptom Questionnaire for Visual Dysfunctions (SQVD), a validated tool designed to assess symptoms related to visual dysfunctions. Participants who scored above a predetermined threshold were considered for further clinical assessments. Case history and other preliminary examinations were properly taken to ensure that the subjects meet the inclusion criteria.

The nature of the procedure was well explained to the selected subjects and informed consent was taken.

Baseline (Pre-task) accommodation and vergence parameters (Amplitude of Accommodation (AoA), Negative Relative Accommodation (NRA), Positive Relative Accommodation (PRA), Near Point of Convergence (NPC), Positive Fusional Vergence (PFV) and Negative Fusional Vergence (NFV) were assessed without optical correction. The participants were then asked to read aloud the printed text held at 40cm for 30 minutes without correction then same set of post-task vergence and accommodation parameters were assessed. The participants were asked to take a 5 minutes break to relax their eyes by looking at a distant object, thereafter they were asked to read aloud the printed text held at 40cm for another 30 minutes with their optical correction in place and the post-task accommodation and vergence parameters with correction were evaluated.

CASE HISTORY

Case history was thoroughly done and the participants were properly probed about their past ocular history and also their current drug use.

PRELIMINARY MEASUREMENTS

In this stage different visual functions, including monocular visual acuity at distance and near was assessed using the Snellen chart and N notation chart. Cover test was also performed at both distance and near to determine whether participants met the inclusion criteria for this study. Direct ophthalmoscopy was done to confirm the absence of any pathological condition. Subjective refraction was also carried out to determine the refractive error of the subjects.

1. Monocular and Binocular Visual Acuity at distance (Carlson and Kurtz, 2016).
    - The testing environment was well-lit and free from distractions, with the snellen chart at a distance of 20 feet (6 meters) from the participant.
    - The visual acuity was assessed unaided (i.e without corrected)
    - The participant was informed that they would be asked to read letters on the chart with one eye covered at a time.
    - The participants left eye was occluded with an occluder while keeping the right eye opened.

- The participant read aloud the letters on the top row of the chart to the smallest line of letters the participants could read adequately. Mistakes if any were noted.
- The process was repeated for the left eye but with the right eye occluded this time.
- The participant was then told to read the chart with both eyes opened.
- The visual acuity measurement for each eye was recorded separately. Visual acuity is usually recorded as a fraction, with the numerator representing the distance (6 meters) and the denominator representing the smallest line read correctly.

2. Monocular Visual Acuity at Near (Carlson and Kurtz, 2016).

- The testing area was well lit with adequate illumination; the near card was highly illuminated from above to avoid glare. The participant was seated comfortably at the appropriate testing distance (40 centimeters) for near vision testing.
- The participant was informed that they would be asked to read letters from a chart at close range.
- The participant’s left eye was occluded with an occluder while keeping the right eye open.
- The near visual acuity chart was presented to the patient at the designated distance (40cm). The chart was held or positioned securely and at the correct angle for optimal viewing.
- Starting from the top of the chart, the participant was asked to read the N6 line of characters aloud.
- The process was repeated for the left eye, occluding the right eye this time.

- The visual acuity measurements for each eye at near was recorded separately.
- Participants with a visual acuity of N6 or better were included and participants with less were excluded.

3. Cover test at Distance (Carlson and Kurtz, 2016).
    - The examination room had the standard lighting and the participant was seated comfortably at a distance of approximately 6 meters from a visual target.
    - The cover test procedure was explained to the participant, informing them that they would be asked to focus on the target while their eyes are alternately covered with an occluder.
    - With the participant sitting comfortably and facing the target directly with both eyes opened a hand held occluder was used to cover one eye at a time during the test.
    - While the participant fixated on the target, the uncovered right eye was watched for any movement paying attention to any movement of the uncovered eye, such as a shift in gaze or the appearance of a manifest deviation.
    - After a few seconds of observation, the occluder was quickly removed from the covered eye and the uncovered eye was observed for any movement or adjustment.
    - The procedure was repeated for the participants' other eye by covering the previously tested eye and observing the uncovered eye's response.
    - The results of the cover test were documented including any observed deviations.

Participants with Orthophoria were included and participants with manifest deviations were excluded.

4. Cover test at Near (Carlson and Kurtz, 2016).
    - The examination room had the standard lighting and the participant was seated comfortably at a near distance of approximately 40cm from an accommodative target.
    - The cover test procedure was explained to the participant informing them that they will be asked to focus on the near target while their eyes are alternately covered with an occluder.
    - With the participant seated comfortably and facing the near target directly with both eyes open a hand held occluder was used to cover one eye at a time during the test.
    - Starting with the left eye covered by placing the occluder over it. The participant was instructed keep looking at the near target with the uncovered eye.
    - While the participant fixated on the near target with the uncovered eye, the uncovered eye was observed for any movement, paying attention to any movement of the uncovered eye, such as a shift in gaze or the appearance of a manifest deviation.
    - After a few seconds of observation, the occluder was quickly removed from the covered eye and the uncovered eye was observed for any movement or adjustment.
    - The procedure was repeated for the participant's left eye by occluding the previously tested eye and observing the uncovered eye's response.

Participants with Orthophoria were included and participants with manifest deviations were excluded.

AMPLITUDE OF ACCOMMODATION

The amplitude of accommodation (AoA) was assessed binocularly using the push up-to-blur technique. Each participant was seated comfortably in a well-lit room. The individual was instructed to maintain clear focus on the near chart as it was moved slowly toward the eye. The subject was instructed to report the first point of sustained blur (where the target could no longer be cleared despite continued effort). The distance measured from the spectacle plane to the point of first sustained blur was recorded in centimeters as the near point of accommodation (NPA**.** This was then converted to its dioptric equivalent to get the Amplitude of Accommodation. (Grosvenor, 2007). This measurement was done pre-task and post reading task (without and with optical correction).

NEGATIVE RELATIVE ACCOMMODATION (NRA)

This test was first explained to the subject, thereafter, the negative relative accommodation (NRA) was determined by asking the subject to fixate and read the letters on the line of his near visual acuity on the near point card placed at 40cm. Plus lenses was then introduced binocularly in +0.25D steps with the aid of a trial lens set until the individual indicated the first sustained blur. The total amount of plus lenses added was then noted as the NRA (Carlson and Kurtz, 1990). This procedure was performed pre-task and post reading task (without and with optical correction).

POSITIVE RELATIVE ACCOMMODATION (PRA)

This was assessed after the NRA test. The procedure was first explained to the subject, thereafter, the positive relative accommodation (PRA) was determined by asking the subject to fixate and read the letters on the line of his near visual acuity on the near point card placed at 40cm. Minus lenses was then added binocularly in -0.25D steps with the aid of a trial lens set until the subject indicated the first sustained blur. The total amount of minus lenses added was then noted as the PRA (Carlson and Kurtz, 1990). This procedure was carried out pre-task and post reading task (without and with optical correction).

NEAR POINT OF CONVERGENCE (NPC)

The near point of convergence (NPC) was determined with the pencil push up technique. Participants were seated comfortably in an upright position. The fixation target was positioned horizontally at the level of the participant's eyes. Each participant was told to focus on the target as it is slowly brought toward the bridge of the nose along the rule. Each participant was asked to indicate when the target became double while the participants' eyes were observed closely and the point at which one eye deviated outward was noted, indicating a loss of binocular fusion. This point was recorded as the break point**.** Immediately after, the target was moved backward slowly until the participant reported regaining single vision or until a realignment of the eyes was observed. This point will be recorded as the recovery point**.** This procedure was done pre-task and post reading task (without and with optical correction).

NEGATIVE FUSIONAL VERGENCE (NFV)

The procedure was first explained to the subject, thereafter, the procedure was conducted binocularly at near (40 cm) using an accommodative near target (thin vertical line) under standard room illumination. Participants was instructed to maintain focus on the target while base-in prisms were gradually introduced using the horizontal prism bar. Starting with no prism, base-in prism power was introduced before both eyes. At each increment, the subject was asked to report when the target first became blurred, then the prism was still increased until the subject reported that the target appeared double. The prism power was then reduced until the subject reported the target as single. This was recorded as blur, break and recovery respectively (Scheiman and Wick, 2020). This procedure was performed pre-task and post reading task (without and with optical correction).

POSITIVE FUSIONAL VERGENCE (PFV)

Positive Fusional Vergence was tested after the NFV. The procedure was explained to the participant, thereafter, test was conducted binocularly at near (40 cm) using an accommodative near target (thin vertical line) under standard room illumination. The subject was asked to fixate on the target while base-out prisms were gradually introduced using the horizontal prism bar. Starting with no prism, base-out prism power was introduced before both eyes. At each increment, the subject was asked to report when the target initially appeared blurred, then the prisms was still increased until the subject reported that the target appeared double. The prism power was then reduced until the subject reported the target as single. This was recorded as blur, break and recovery respectively (Scheiman and Wick, 2020). This procedure was carried out pre-task and post reading task (without and with optical correction).

3.8 STATISTICAL ANALYSIS

Data was presented in tables and figures; it was analyzed using the Statistical Package for Social Sciences (SPSS version 27), Microsoft excel and also T-test to compare the variables.

3.9 LIMITATIONS OF STUDY

1. LIMITED SAMPLE SIZE: The study was conducted on 55 participants, which is sufficient for statistical analysis but may not be fully representative of the general population.

2. DURATION OF NEAR TASK: The 30-minute sustained near work period may not fully reflect the longer durations typical of academic or occupational visual activities.

3.10 ETHICAL APPROVAL

Ethical clearance was obtained from the Department Research Ethics committee of the Faculty of Optometry, University of Benin, Benin city in accordance with the tenets of the Declaration of Helsinki for the use of human subjects. The REC approval number is EC/UBEN/LSC.OPT/25/138. This was to ensure the study was not against public interest or inflicting unnecessary harm to the subjects. Informed consent were obtained from all subjects to ensure their full cooperation.

CHAPTER FOUR

4.0 RESULTS

This chapter presents the results of this study investigating the impact of sustained near work on accommodative and vergence functions in individuals with low uncorrected hyperopia. Statistical analyses were conducted and the results are systematically organized into tables and interpreted with respect to measurements taken before and after the sustained near work task. Comparisons are made to assess the effects of near work and optical correction on accommodative and vergence functions in low hyperopes.

TABLE 4.1: Demographic Characteristics of Participants

		Gender		
		Number of Females	**Number of Male**	**Total**
Age Group	16 - 18	10	3	13
	19 - 21	22	4	26
	22-24	10	5	15
	25-30	1	0	1
	Total	43(78.2%)	12(21.8%)	55(100.0%)

Table 4.1 presented the demographic characteristics of the participants. The ages ranged from 16 to 25 years with a mean age of 20 ± 2 years, indicating a predominantly young population. A total of 55 subjects (78.2% females and 21.8% were males) were used for the study indicating a female-dominant sample.

TABLE 4.2: Descriptive Statistics of Participants' Age and Refractive Error

	Mean	Standard Deviation	Minimum	Maximum
Age	20	2	16	25
Spherical Equivalent of Refractive Error	.64	.30	.50	1.75

The mean age of participants was 20 ± 2 years (16–25 years). The mean spherical equivalent of refractive error was +0.64 ± 0.30 D (range +0.50 to +1.75 D), indicating mild hyperopia among the sample.

TABLE 4.3: Summary of Visual Function Parameters Before and After Task (With and Without correction)

Visual Parameters	Mean ± S.D (Before Task)	Mean ± S.D (After Task without correction)	Mean ± S.D (After Task With correction)
Amplitude of Accommodation (AA)	9.70 ± 2.40 D	10.30 ± 2.60 D	11.80 ± 3.40 D
Negative Relative Accommodation (NRA)	+2.82 ± 0.76 D	+2.50 ± 0.59 D	+2.30 ± 0.47 D
Positive Relative Accommodation (PRA)	−4.90 ± 1.48 D	−5.45 ± 1.36 D	−5.78 ± 1.66 D
Near Point of Convergence (NPC) Break	10.00 ± 2.00 cm	10.00 ± 2.00 cm	9.00 ± 3.00 cm
Near Point of Convergence (NPC) Recovery	13.00 ± 3.00 cm	14.00 ± 3.00 cm	13.00 ± 4.00 cm
Base-Out (BO) Blur Point	12.00 ± 3.00 Δ	11.00 ± 3.00 Δ	10.00 ± 4.00 Δ
Base-Out (BO) Break Point	20.00 ± 5.00 Δ	17.00 ± 6.00 Δ	17.00 ± 7.00 Δ
Base-Out (BO) Recovery Point	14.00 ± 4.00 Δ	13.00 ± 5.00 Δ	12.00 ± 5.00 Δ
Base-In (BI) Blur Point	9.00 ± 3.00 Δ	9.00 ± 3.00 Δ	9.00 ± 4.00 Δ
Base-In (BI) Break Point	14.00 ± 4.00 Δ	14.00 ± 4.00 Δ	15.00 ± 6.00 Δ
Base-In (BI) Recovery Point	11.00 ± 3.00 Δ	11.00 ± 4.00 Δ	11.00 ± 5.00 Δ

The mean amplitude of accommodation increased from 9.70 ± 2.40 D before task to 10.30 ± 2.60 D after task without glasses and 11.80 ± 3.40 D after task with glasses. NRA decreased from 2.82 ± 0.76 D before task to 2.50 ± 0.59 D after task without glasses and 2.30 ± 0.47 D after task with glasses. PRA values increased from −4.90 ± 1.48 D before task to −5.45 ± 1.36 D after task, and further increased −5.78 ± 1.66 D with glasses. NPC break values were 10.00 ± 2.00 cm before task, 10.00 ± 2.00 cm after task, and 9.00 ± 3.00 cm with glasses. NPC recovery was 13.00 ± 3.00 cm before task, 14.00 ± 3.00 cm after task, and 13.00 ± 4.00 cm with glasses. BO blur, break, and recovery were 12.00 ± 3.00 Δ, 20.00 ± 5.00 Δ, and

14.00 ± 4.00 Δ before task; 11.00 ± 3.00 Δ, 17.00 ± 6.00 Δ, and 13.00 ± 5.00 Δ after task; and 10.00 ± 4.00 Δ, 17.00 ± 7.00 Δ, and 12.00 ± 5.00 Δ with glasses. BI blur, break, and recovery were 9.00 ± 3.00 Δ, 14.00 ± 4.00 Δ, and 11.00 ± 3.00 Δ before task; 9.00 ± 3.00 Δ, 14.00 ± 4.00 Δ, and 11.00 ± 4.00 Δ after task; and 9.00 ± 4.00 Δ, 15.00 ± 6.00 Δ, and 11.00 ± 5.00 Δ with glasses.

TABLE 4.4: Comparison of Amplitude of Accommodation (AA) Before and After Sustained Near Task without and with correction

Null Hypothesis	Test	Sig.	Decision
The distributions of Pretask Amplitude of Accommodation, Amplitude of Accommodation (AA) Value After Task (Without Glasses) and Amplitude of Accommodation (AA) Value After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

The Friedman's test revealed a significant difference ($\chi^2(2) = 23.304$, $p < .001$) among pretask AA, post-task without glasses, and post-task with glasses.

TABLE 4.4.1: Pairwise Comparison of Amplitude of Accommodation (AA) Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Pretask Amplitude of Accommodation-Amplitude of Accommodation (AA) Value After Task (Without Glasses)	-.164	.191	-.858	.391	1.000
Pretask Amplitude of Accommodation-Amplitude of Accommodation (AA) Value After Task (With Glasses)	-.791	.191	-4.148	.000	.000
Amplitude of Accommodation (AA) Value After Task (Without Glasses)-Amplitude of Accommodation (AA) Value After Task (With Glasses)	-.627	.191	-3.289	.001	.003

Table 4.4.1 shows the pairwise comparison of amplitude of accommodation (aa) before and after sustained near task without and with correction. This revealed that there was no significant difference between the pretask value (9.7 ± 2.4 D) and the post-task value without glasses (10.3 ± 2.6 D), with $Z = -0.858$ and $p = 0.391$. However, a statistically significant difference was observed between the pretask value and the post-task value with glasses ($Z = -4.148$, $p < 0.001$). Similarly, there was a significant improvement when comparing the post-task without glasses (10.3 ± 2.6 D) and post-task with glasses (11.8 ± 3.4 D) conditions, with $Z = -3.289$ and $p = 0.003$.

TABLE 4.5: Comparison of Negative Relative Accommodation (NRA) Before and After Sustained Near Task without and with correction

Null Hypothesis	Test	Sig.	Decision
The distributions of Negative Relative Accommodation (NRA) Value Before Task, Negative Relative Accommodation (NRA) Value After Task (Without Glasses) and Negative Relative Accommodation (NRA) Value After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

The test indicated a significant difference among the three NRA conditions ($\chi^2(2) = 30.345$, $p < .001$).

TABLE 4.5.1: Pairwise Comparison of Negative Relative Accommodation (NRA) Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Negative Relative Accommodation (NRA) Value After Task (With Glasses)-Negative Relative Accommodation (NRA) Value After Task (Without Glasses)	.427	.191	2.241	.025	.075
Negative Relative Accommodation (NRA) Value After Task (With Glasses)-Negative Relative Accommodation (NRA) Value Before Task	.991	.191	5.196	.000	.000
Negative Relative Accommodation (NRA) Value After Task (Without Glasses)-Negative Relative Accommodation (NRA) Value Before Task	.564	.191	2.956	.003	.009

Table 4.5.1 shows the pairwise comparison of negative relative accommodation (NRA) before and after sustained near task without and with correction. The NRA values showed no statistically significant difference between the post-task with glasses (2.30 ± 0.47 D) and post-task without glasses (2.50 ± 0.59 D) conditions ($Z = 2.241$, $p = 0.075$). However, there was a significant difference between the post-task with glasses and the pretask condition ($Z =$

5.196, $p < 0.001$), as well as between the post-task without glasses and the pretask condition ($Z = 2.956$, $p = 0.009$).

TABLE 4.6: Comparison of Positive Relative Accommodation (PRA) Before and After Sustained Near Task without and with correction

Tests of Within-Subjects Effects

Source		**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
PRA	Sphericity Assumed	22.060	2	11.030	19.628	.000
	Greenhouse-Geisser	22.060	1.619	13.628	19.628	.000
	Huynh-Feldt	22.060	1.661	13.278	19.628	.000
	Lower-bound	22.060	1.000	22.060	19.628	.000
Error(PRA)	Sphericity Assumed	60.690	108	.562		
	Greenhouse-Geisser	60.690	87.408	.694		
	Huynh-Feldt	60.690	89.716	.676		
	Lower-bound	60.690	54.000	1.124		

Mauchly's Test of Sphericity indicated (indicate appendix) that the assumption of sphericity was violated, $\chi^2(2) = 14.24$, $p = .001$. Therefore, degrees of freedom were corrected using the Greenhouse–Geisser estimate ($\varepsilon = .81$).

The results of the repeated measures ANOVA revealed a statistically significant effect of task condition on PRA, $F(1.62, 87.41) = 19.63$, $p < .001$, $\eta p^2 = .27$. This indicates that PRA differed significantly across the three test conditions - before task (pretask), after task without glasses, and after task with glasses.

TABLE 4.6.1: Tests of Within-Subjects Contrasts for Positive Relative Accommodation (PRA) Before and After Task Conditions

Source	PRA	Type III Sum of Squares	Df	Mean Square	F	Sig.
PRA	Linear	21.605	1	21.605	29.733	.000
	Quadratic	.455	1	.455	1.145	.289
Error(PRA)	Linear	39.239	54	.727		
	Quadratic	21.452	54	.397		

Table 4.6.1 presents result of Pairwise contrasts which showed a significant linear trend, $F(1, 54) = 29.73$, $p < .001$, suggesting a consistent change in PRA values across conditions (from pretask to posttask). The quadratic trend was not significant, $F(1, 54) = 1.15$, $p = .29$, implying that the change was not curvilinear but followed a steady direction.

TABLE 4.7: Comparison of Near Point of Convergence (NPC) Break Values Before and After Sustained Near Task without and with correction

Null Hypothesis	Test	Sig.	Decision
The distributions of Near Point of Convergence (NPC) Break Value Before Task, Near Point of Convergence (NPC) Break Value After Task (Without Glasses) and Near Point of Convergence (NPC) Break Value After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.062	Retain the null hypothesis.

There was no significant difference in NPC break values across conditions ($p = .062$).

TABLE 4.8: Comparison of Near Point of Convergence (NPC) Recovery Values Before and After Sustained Near Task without and with correction

Null Hypothesis	Test	Sig.	Decision
The distributions of Near Point of Convergence (NPC) Recovery Value Before Task, Near Point of Convergence (NPC) Recovery Value After Task (Without Glasses) and Near Point of Convergence (NPC) Recovery Value After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.002	Reject the null hypothesis.

There was no significant difference in NPC recovery values across conditions ($\chi^2(2) = 12.21$, $p = 0.002$).

TABLE 4.9.1: Pairwise Comparison of Near Point of Convergence (NPC) Recovery Values Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Near Point of Convergence (NPC) Recovery Value Before Task-Near Point of Convergence (NPC) Recovery Value After Task (With Glasses)	-.036	.191	-.191	.849	1.000
Near Point of Convergence (NPC) Recovery Value Before Task-Near Point of Convergence (NPC) Recovery Value After Task (Without Glasses)	-.536	.191	-2.813	.005	.015
Near Point of Convergence (NPC) Recovery Value After Task (With Glasses)-Near Point of Convergence (NPC) Recovery Value After Task (Without Glasses)	.500	.191	2.622	.009	.026

For NPC recovery, there was no significant difference between the pretask value (13 ± 3 cm) and the post-task value with glasses (13 ± 4 cm), with $Z = -0.191$ and $p = 1.000$. However, the comparison between the pretask value and the post-task value without glasses (14 ± 3 cm) revealed a significant difference ($Z = -2.813$, $p = 0.015$). Furthermore, the comparison between the post-task with glasses (13 ± 4 cm) and post-task without glasses (14 ± 3 cm) conditions was also significant ($Z = 2.622$, $p = 0.026$).

TABLE 4.10: Comparison of Base-Out (BO) Blur Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-Out (BO) Blur Point Before Task, Base-Out (BO) Blur Point After Task (Without Glasses) and Base-Out (BO) Blur Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.002	Reject the null hypothesis.

The BO blur point significantly differed across conditions ($\chi^2(2) = 12.41$, $p = 0.002$).

TABLE 4.10.1: Pairwise Comparison of Base-Out (BO) Blur Points Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Base-Out (BO) Blur Point After Task (With Glasses)-Base-Out (BO) Blur Point After Task (Without Glasses)	.318	.191	1.669	.095	.286
Base-Out (BO) Blur Point After Task (With Glasses)-Base-Out (BO) Blur Point Before Task	.609	.191	3.194	.001	.004
Base-Out (BO) Blur Point After Task (Without Glasses)-Base-Out (BO) Blur Point Before Task	.291	.191	1.526	.127	.381

Table 4.10.1 revealed The pairwise analysis of the BO blur point showed no significant difference between post-task with glasses (10 ± 4 Δ) and post-task without glasses (11 ± 3 Δ), with Z = 1.669 and p = 0.286. A significant difference, however, was observed between post-task with glasses and the pretask condition (12 ± 3 Δ), where Z = 3.194 and p = 0.004. There was no significant difference between post-task without glasses and the pretask condition (Z = 1.526, p = 0.381).

TABLE 4.11: Comparison of Base-Out (BO) Break Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-Out (BO) Break Point Before Task, Base-Out (BO) Break Point After Task (Without Glasses) and Base-Out (BO) Break Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

The BO break point also showed significant differences ($p < .001$).

TABLE 4.11.1: Pairwise Comparison of Base-Out (BO) Break Points Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Base-Out (BO) Break Point After Task (With Glasses)-Base-Out (BO) Break Point After Task (Without Glasses)	.064	.191	.334	.739	1.000
Base-Out (BO) Break Point After Task (With Glasses)-Base-Out (BO) Break Point Before Task	.673	.191	3.528	.000	.001
Base-Out (BO) Break Point After Task (Without Glasses)-Base-Out (BO) Break Point Before Task	.609	.191	3.194	.001	.004

The pairwise comparison of BO break points revealed that there was no significant difference between the post-task with glasses (17 ± 7 Δ) and post-task without glasses (17 ± 6 Δ) conditions ($Z = 0.334$, $p = 1.000$). In contrast, significant differences were observed between the post-task with glasses and pretask values (20 ± 5 Δ), with $Z = 3.528$ and $p = 0.001$, as well as between the post-task without glasses and pretask values, with $Z = 3.194$ and $p = 0.004$.

TABLE 4.12: Comparison of Base-Out (BO) Recovery Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-Out (BO) Recovery Point Before Task, Base-Out (BO) Recovery Point After Task (Without Glasses) and Base-Out (BO) Recovery Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.

A significant change occurred across conditions ($\chi^2(2) = 16.27$, $p < 0.001$).

TABLE 4.12.1: Pairwise Comparison of Base-Out (BO) Recovery Points Before and After Task Conditions

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Base-Out (BO) Recovery Point After Task (With Glasses)-Base-Out (BO) Recovery Point After Task (Without Glasses)	.391	.191	2.050	.040	.121
Base-Out (BO) Recovery Point After Task (With Glasses)-Base-Out (BO) Recovery Point Before Task	.700	.191	3.671	.000	.001
Base-Out (BO) Recovery Point After Task (Without Glasses)-Base-Out (BO) Recovery Point Before Task	.309	.191	1.621	.105	.315

The pairwise comparison of BO recovery points revealed that there was no significant difference between the post-task with glasses and post-task without glasses conditions (Z = 2.050, p = 0.121), as well as between the post-task without glasses and pretask values, with Z = 1.621 and p = 0.315. In contrast, significant differences were observed between the post-task with glasses and pretask values , with Z = 3.671 and p = 0.001.

TABLE 4.13: Comparison of Base-In (BI) Blur Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-In (BI) Blur Point Before Task, Base-In (BI) Blur Point After Task (Without Glasses) and Base-In (BI) Blur Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.023	Reject the null hypothesis.

A significant difference (p = .023) was noted across BI blur point conditions.

TABLE 4.13.1: Pairwise Comparison of Base-In (BI) Blur Points Before and After Sustained Near Task without and with correction

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Base-In (BI) Blur Point After Task (Without Glasses)-Base-In (BI) Blur Point Before Task	.118	.191	.620	.535	1.000
Base-In (BI) Blur Point After Task (Without Glasses)-Base-In (BI) Blur Point After Task (With Glasses)	-.427	.191	-2.241	.025	.075
Base-In (BI) Blur Point Before Task-Base-In (BI) Blur Point After Task (With Glasses)	-.309	.191	-1.621	.105	.315

In the BI blur point comparisons, there was no significant difference between post-task without glasses (9 ± 3 Δ) and pretask (9 ± 3 Δ) values, with $Z = 0.620$ and $p = 1.000$. Similarly, no significant differences were found between post-task without glasses and post-task with glasses (9 ± 4 Δ) conditions ($Z = -2.241$, $p = 0.075$), nor between pretask and post-task with glasses ($Z = -1.621$, $p = 0.315$).

TABLE 4.14: Comparison of Base-In (BI) Break Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-In (BI) Break Point Before Task, Base-In (BI) Break Point After Task (Without Glasses) and Base-In (BI) Break Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.059	Retain the null hypothesis.

No significant differences were observed for BI break ($p = 0.059$)

TABLE 4.15: Comparison of Base-In (BI) Recovery Points Before and After Sustained Near Task without and with correction

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of Base-In (BI) Recovery Point Before Task, Base-In (BI) Recovery Point After Task (Without Glasses) and Base-In (BI) Recovery Point After Task (With Glasses) are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.578	Retain the null hypothesis.

The Friedman's test for Base-In (BI) Recovery Point showed no statistically significant difference across the three conditions ($\chi^2(2) = 1.10$, $p = 0.578$).

CHAPTER FIVE

5.0 DISCUSSION

The increasing prevalence of near-vision–intensive activities such as reading and use of digital devices has increased concerns regarding visual fatigue and accommodative inefficiency, particularly among individuals with uncorrected hyperopia whose visual systems must exert greater effort to maintain clear and single vision at near (Sheppard and Wolffsohn, 2018). This study provides insight into how sustained near work affects both accommodative and vergence functions in this population and the role of optical correction in maintaining visual efficiency.

5.1 EFFECT OF SUSTAINED NEAR WORK ON ACCOMMODATION

Accommodation plays a vital role in maintaining clear vision during near tasks by continuously adjusting the optical power of the eye to focus on close objects. In individuals with uncorrected hyperopia, this mechanism is constantly active even for distance vision, as the eye must exert additional accommodative effort to overcome its latent refractive error. When such individuals engage in prolonged near work, this pre-existing accommodative load increases substantially, predisposing them to visual fatigue and transient changes in accommodative function.

Findings from this study revealed mild but consistent changes in accommodative parameters following 30 minutes of sustained near work. The amplitude of accommodation (AA) showed a slight increase after the task without correction (9.7 ± 2.4 D to 10.3 ± 2.6 D), while positive relative accommodation (PRA) became more negative (−4.90 ± 1.48 D to −5.45 ± 1.36 D), and negative relative accommodation (NRA) demonstrated minimal change (+2.82 ± 0.76 D to +2.50 ± 0.59 D).

The increase in both amplitude of accommodation and PRA observed after near work may reflect a short-term adaptive response which may be an attempt by the visual system to enhance focusing power to meet the sustained near demand. During sustained near work, the ciliary muscle may temporarily increase its tonus to maintain clear focus. However, this adaptation may not persist over long durations, as continued demand could ultimately lead to accommodative fatigue. These findings align with the physiological understanding that sustained near work can temporarily modify accommodative response due to ciliary muscle fatigue and adaptive changes in tonic accommodation. Previous studies have reported similar patterns, where prolonged near work leads to transient changes in accommodation and increased visual fatigue, particularly in hyperopic individuals (Hussaindeen *et al.,* 2022; Rosenfield *et al.,* 2020).

However, the NRA values remained relatively stable suggesting that the ability to relax accommodation was less affected by sustained near work. This could suggest that accommodative stress primarily affects the ability to stimulate accommodation rather than its relaxation.

When participants were assessed with spectacle correction, improvements were noted across all parameters, indicating that optical correction of hyperopia eased accommodative strain and improved efficiency. This finding supports previous report by Ntodie *et al.* (2021), who found that correcting low-to-moderate hyperopia improves accommodative accuracy and reduces visual strain during sustained near work.

5.2 EFFECT OF SUSTAINED NEAR WORK ON VERGENCE FUNCTION

Vergence plays an essential role in maintaining single and comfortable binocular vision by aligning both eyes on the same point of focus. During near tasks such as reading or smartphone use, convergence is stimulated to bring the eyes inward, while accommodation ensures a clear retinal image. These two systems are closely linked through the accommodative convergence to accommodation (AC/A) ratio, meaning that a change in one invariably influences the other. When visual demands are sustained at near for extended periods, this system becomes strained, often leading to temporary reductions in vergence efficiency and associated visual discomfort (Alvarez *et al.,* 2020; Hussaindeen *et al.,* 2022).

Findings from this study revealed that 30 minutes of sustained near work led to a noticeable decrease in positive fusional vergence (PFV) and a mild recession of the near point of convergence (NPC) among participants with low uncorrected hyperopia. These reductions indicate that the convergence system became temporarily fatigued under continuous near demand, compromising the ability to maintain single binocular vision. The hyperopic eye must exert constant accommodation to maintain clarity, and because accommodation and convergence are neurologically linked, this sustained effort also increases vergence demand, thereby resulting in fatigue (Rouse *et al.,* 2016; Sheppard and Wolffsohn, 2018).

However, with the use of optical correction, there was partial recovery of these parameters, suggesting that reducing the accommodative demand associated with uncorrected hyperopia also mitigates the stress on vergence system. This recovery can be attributed to the way optical correction through the provision of appropriate plus lenses reduces the need for constant accommodative exertion. In low hyperopes, a portion of their hyperopic refractive error is typically compensated by increased accommodation. This excessive accommodative demand results in a corresponding increase in convergence through the AC/A link. Over time, this relationship contributes to vergence fatigue. By correcting the hyperopic error with optical correction, the accommodative effort required for clear near vision is reduced, leading to improved vergence stability and enhanced visual comfort (Rouse et al., 2016; Sheppard and Wolffsohn, 2018).

This pattern of results aligns with previous studies showing that extended near visual activity reduces convergence reserves and shifts the near point of convergence. Hussaindeen *et al*., (2022) demonstrated similar findings in young adults after prolonged near tasks, while Alvarez *et al.,* (2020) reported that vergence adaptation mechanisms, though efficient in the short term, are susceptible to temporary decompensation when continually engaged. Wajuihian (2019) also emphasized that prolonged convergence stress can temporarily reduce fusional reserves, producing symptoms such as eye strain, headaches, and blurred vision particularly in individuals with uncorrected refractive errors.

In contrast, negative fusional vergence (NFV) showed minimal changes following sustained near work. This finding is physiologically consistent because divergence movements are not significantly engaged during continuous near fixation. NFV primarily functions when the eyes relax convergence or return to distance viewing; thus, its stability here reinforces that sustained near work predominantly challenges the convergence mechanism rather than the divergence system (Wajuihian, 2019; Hussaindeen *et al.,* 2022). The minimal change in NFV therefore complements the observed decline in PFV and NPC, illustrating a clear pattern of convergence-specific fatigue induced by sustained near visual demand.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

This study investigated the impact of sustained near work on accommodation and vergence in individuals with low uncorrected hyperopia, a group often overlooked in clinical studies despite their subtle yet significant visual challenges. The study revealed that continuous engagement in near visual tasks for 30 minutes can temporarily disrupt the balance between the eye's focusing (accommodation) and alignment (vergence) systems, leading to measurable physiological strain.

The results showed that accommodative and vergence responses were both affected following sustained near work without optical correction. There was a slight increase in the amplitude of accommodation and a reduction in positive fusional vergence and near point of convergence, indicating that the accommodative and convergence mechanisms became strained. However, when optical correction was introduced, these parameters improved, showing that uncorrected hyperopia increases visual stress, while the appropriate correction of hyperopia helped relieve this burden, restoring more stable accommodative and vergence performance thereby making the eye to work more efficiently.

These findings align with growing evidence that sustained near work contributes to accommodative and binocular stress, especially in young adults who frequently engage in reading or digital device use. The results also highlight that visual fatigue is not only a product of near task duration but also of underlying refractive inefficiency. Even small uncorrected hyperopic errors can disrupt visual balance when exposed to modern visual demands.

Clinically, these results emphasize that optical correction plays a crucial role in maintaining visual comfort and functional stability in individuals exposed to high near-vision demand, such as students, office workers, and digital device users. By relieving the constant accommodative effort required to maintain clarity, optical correction enhances both accommodative and vergence efficiency.

In conclusion, the present study confirms that sustained near work places temporary but significant stress on the accommodative and vergence systems in low uncorrected hyperopes. The observed improvement following optical correction demonstrates that correcting even low levels of hyperopia can significantly reduce visual fatigue and improve overall performance during near tasks. These findings contribute to the understanding of how prolonged near activity interacts with uncorrected refractive errors and highlight the importance of correction of hyperopia in sustaining comfortable and efficient vision in today's near-vision–driven lifestyle.

6.2 RECOMMENDATION

Based on the findings of this study, the following recommendations are made:

1. Routine eye examinations should be encouraged for early detection and correction of low uncorrected hyperopia.
2. Appropriate optical correction should be prescribed to reduce accommodative and vergence strain during prolonged near tasks.
3. Individuals engaged in frequent near work should adopt good visual hygiene practices, such as the 20-20-20 rule and maintaining proper working distances.
4. Clinicians should routinely assess accommodative and vergence functions in patients presenting with symptoms of near-work–related visual fatigue.

5. Future research should investigate the long-term impact of sustained near work on accommodation and vergence across different age groups and refractive statuses.
6. Further studies should also explore digital near tasks, using objective measurement tools such as open-field autorefractors and eye trackers, to better understand accommodative-vergence interactions in real-world conditions.

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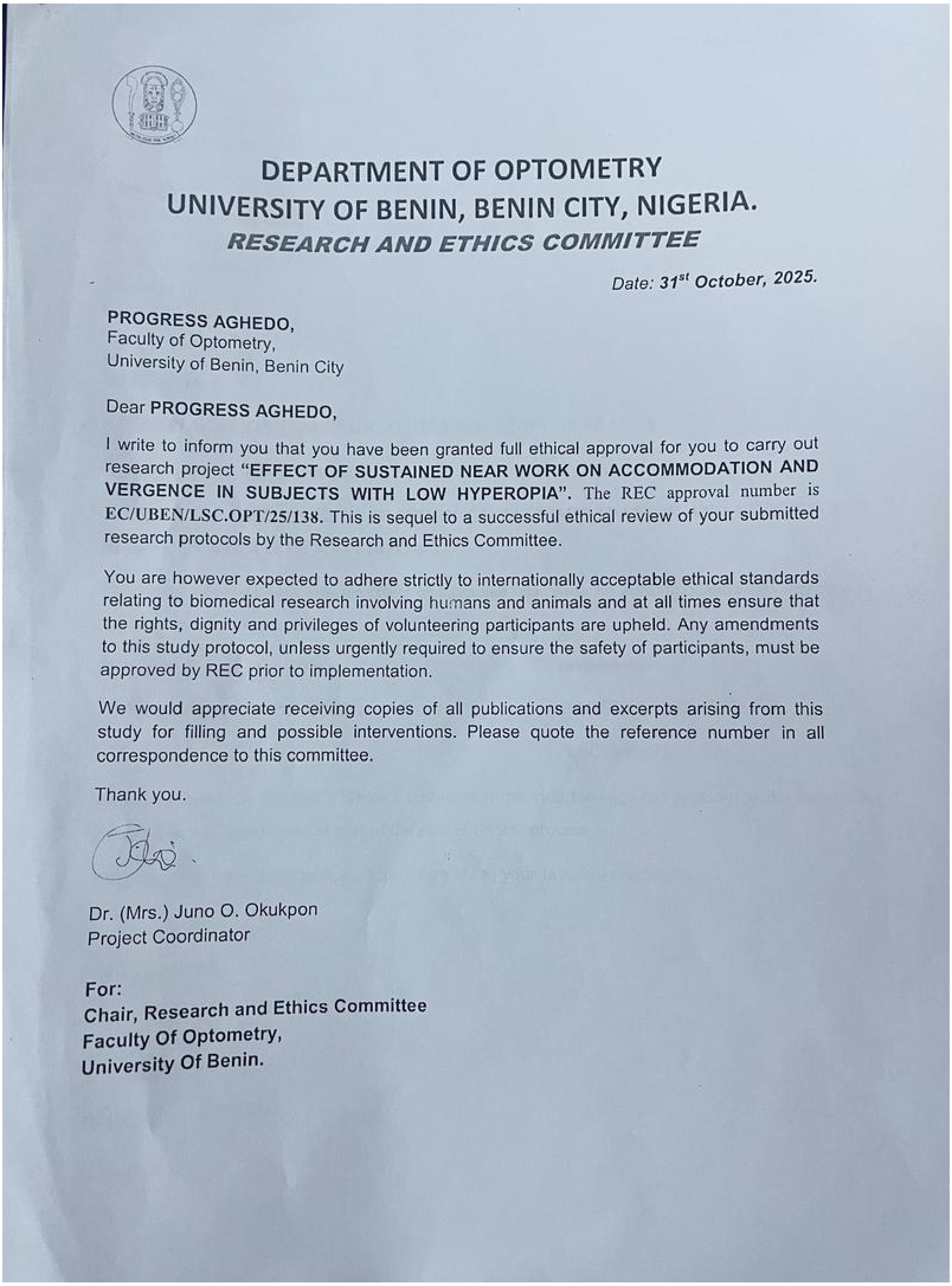
APPENDIX I

Ethical Approval



DEPARTMENT OF OPTOMETRY
UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.
RESEARCH AND ETHICS COMMITTEE

Date: 31st October, 2025.

PROGRESS AGHEDO,
Faculty of Optometry,
University of Benin, Benin City

Dear **PROGRESS AGHEDO,**

I write to inform you that you have been granted full ethical approval for you to carry out research project **"EFFECT OF SUSTAINED NEAR WORK ON ACCOMMODATION AND VERGENCE IN SUBJECTS WITH LOW HYPEROPIA".** The REC approval number is **EC/UBEN/LSC.OPT/25/138.** This is sequel to a successful ethical review of your submitted research protocols by the Research and Ethics Committee.

You are however expected to adhere strictly to internationally acceptable ethical standards relating to biomedical research involving humans and animals and at all times ensure that the rights, dignity and privileges of volunteering participants are upheld. Any amendments to this study protocol, unless urgently required to ensure the safety of participants, must be approved by REC prior to implementation.

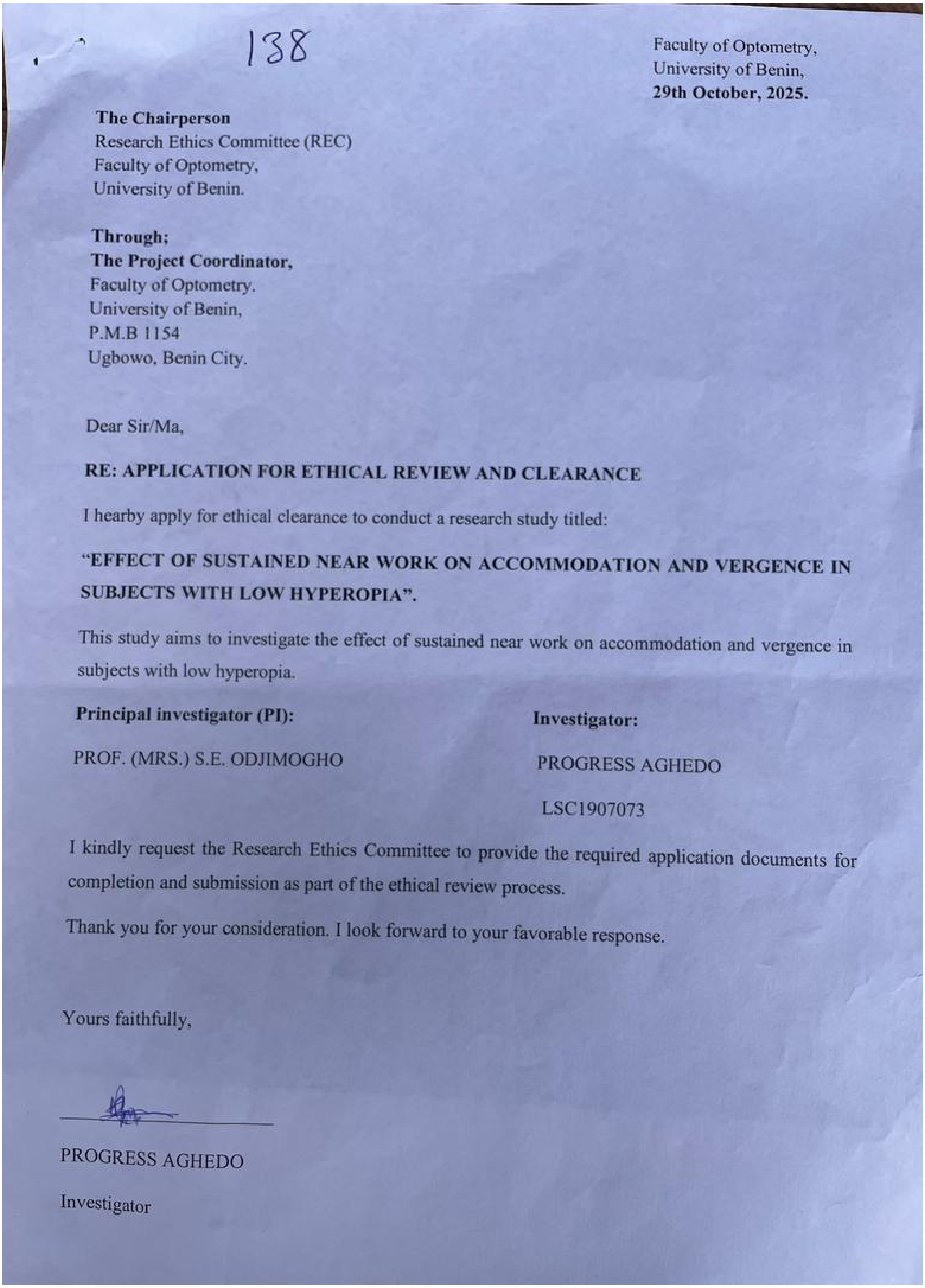
We would appreciate receiving copies of all publications and excerpts arising from this study for filling and possible interventions. Please quote the reference number in all correspondence to this committee.

Thank you.

Dr. (Mrs.) Juno O. Okukpon
Project Coordinator

For:
Chair, Research and Ethics Committee
Faculty Of Optometry,
University Of Benin.

Letter of Application for Ethical Clearance



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Faculty of Optometry,
University of Benin,
29th October, 2025.

The Chairperson
Research Ethics Committee (REC)
Faculty of Optometry,
University of Benin.

Through;
The Project Coordinator,
Faculty of Optometry.
University of Benin,
P.M.B 1154
Ugbowo, Benin City.

Dear Sir/Ma,

RE: APPLICATION FOR ETHICAL REVIEW AND CLEARANCE

I hearby apply for ethical clearance to conduct a research study titled:

"EFFECT OF SUSTAINED NEAR WORK ON ACCOMMODATION AND VERGENCE IN SUBJECTS WITH LOW HYPEROPIA".

This study aims to investigate the effect of sustained near work on accommodation and vergence in subjects with low hyperopia.

Principal investigator (PI):
PROF. (MRS.) S.E. ODJIMOGHO

Investigator:
PROGRESS AGHEDO
LSC1907073

I kindly request the Research Ethics Committee to provide the required application documents for completion and submission as part of the ethical review process.

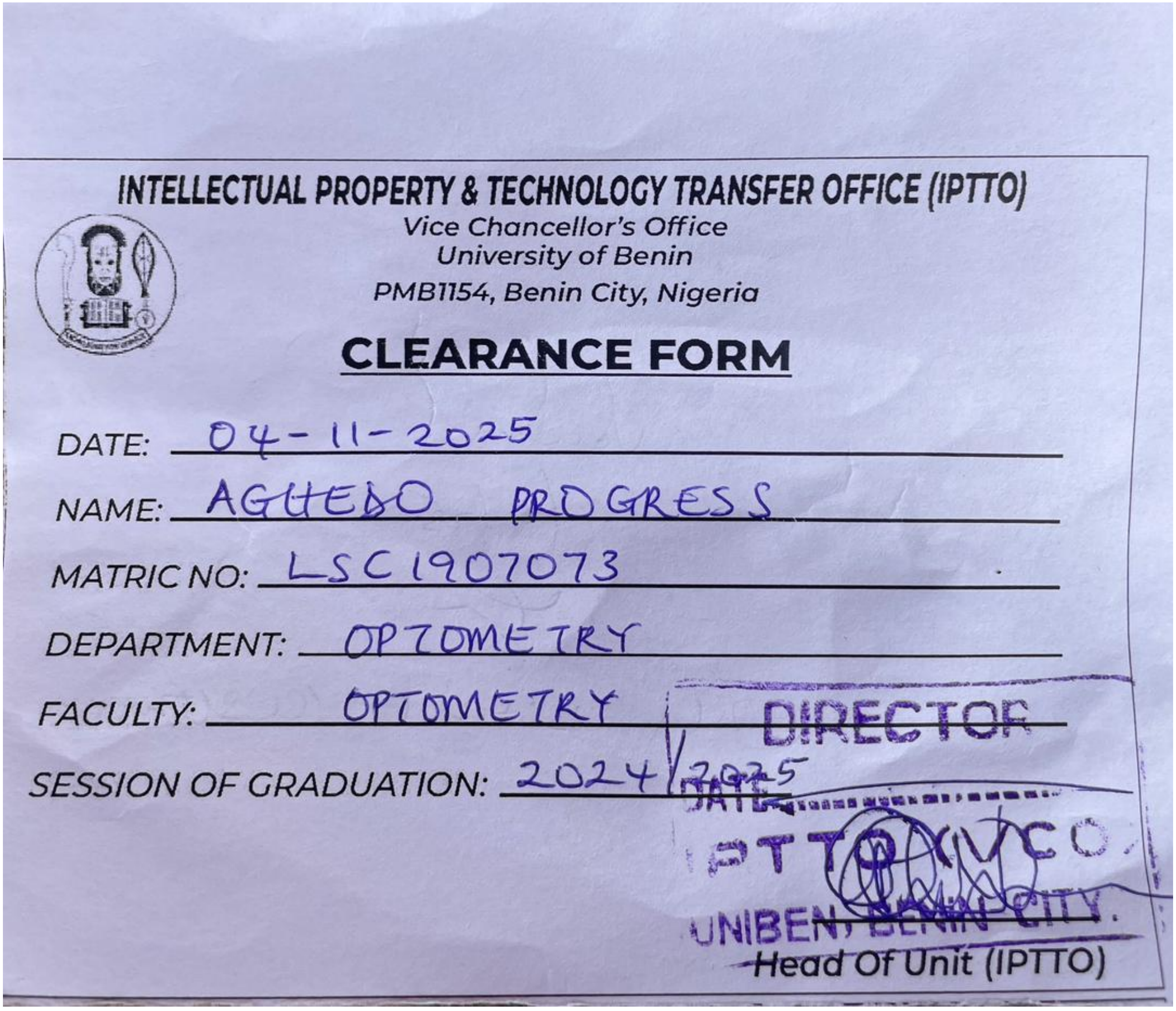
Thank you for your consideration. I look forward to your favorable response.

Yours faithfully,

PROGRESS AGHEDO

Investigator

Plagiarism Clearance form



INTELLECTUAL PROPERTY & TECHNOLOGY TRANSFER OFFICE (IPTTO)

Vice Chancellor's Office
University of Benin
PMB1154, Benin City, Nigeria

CLEARANCE FORM

DATE: 04-11-2025

NAME: AGHEDO PROGRESS

MATRIC NO: LSC1907073

DEPARTMENT: OPTOMETRY

FACULTY: OPTOMETRY

SESSION OF GRADUATION: 2024/2025

DIRECTOR
DATE
IPTTO (VCO)
UNIBEN, BENIN CITY.

Head Of Unit (IPTTO)

APPENDIX II

Setup for Research Data Collection

APPENDIX III

Tests of Normality for Baseline Visual Parameters

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
Age	.188	55	.000	.958	55	.052
Spherical Equivalent of Refractive Error	.455	55	.000	.519	55	.000
Pretask Amplitude of Accommodation	.134	55	.015	.953	55	.030
Negative Relative Accommodation (NRA) Value Before Task	.172	55	.000	.944	55	.012
Positive Relative Accommodation (PRA) Value Before Task	.087	55	.200*	.976	55	.353
Near Point of Convergence (NPC) Break Value Before Task	.187	55	.000	.875	55	.000
Near Point of Convergence (NPC) Recovery Value Before Task	.125	55	.032	.948	55	.019
Base-Out (BO) Blur Point Before Task	.138	55	.010	.941	55	.009
Base-Out (BO) Break Point Before Task	.179	55	.000	.937	55	.006
Base-Out (BO) Recovery Point Before Task	.136	55	.012	.936	55	.006
Base-In (BI) Blur Point Before Task	.272	55	.000	.900	55	.000
Base-In (BI) Break Point Before Task	.218	55	.000	.904	55	.000
Base-In (BI) Recovery Point Before Task	.221	55	.000	.913	55	.001

Tests of Normality for Visual Parameters After Task (Without Glasses)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
Amplitude of Accommodation (AA) Value After Task (Without Glasses)	.175	55	.000	.956	55	.043
Negative Relative Accommodation (NRA) Value After Task (Without Glasses)	.158	55	.002	.907	55	.000
Positive Relative Accommodation (PRA) Value After Task (Without Glasses)	.093	55	.200*	.964	55	.095
Near Point of Convergence (NPC) Break Value After Task (Without Glasses)	.197	55	.000	.882	55	.000
Near Point of Convergence (NPC) Recovery Value After Task (Without Glasses)	.156	55	.002	.911	55	.001
Base-Out (BO) Blur Point After Task (Without Glasses)	.125	55	.032	.958	55	.054
Base-Out (BO) Break Point After Task (Without Glasses)	.149	55	.004	.958	55	.054
Base-Out (BO) Recovery Point After Task (Without Glasses)	.140	55	.009	.933	55	.004
Base-In (BI) Blur Point After Task (Without Glasses)	.279	55	.000	.882	55	.000
Base-In (BI) Break Point After Task (Without Glasses)	.286	55	.000	.828	55	.000
Base-In (BI) Recovery Point After Task (Without Glasses)	.330	55	.000	.821	55	.000

Tests of Normality for Visual Parameters After Task (With Glasses)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
Amplitude of Accommodation (AA) Value After Task (With Glasses)	.190	55	.000	.923	55	.002
Negative Relative Accommodation (NRA) Value After Task (With Glasses)	.154	55	.002	.920	55	.001
Positive Relative Accommodation (PRA) Value After Task (With Glasses)	.095	55	.200*	.966	55	.127
Near Point of Convergence (NPC) Break Value After Task (With Glasses)	.165	55	.001	.882	55	.000
Near Point of Convergence (NPC) Recovery Value After Task (With Glasses)	.156	55	.002	.927	55	.003
Base-Out (BO) Blur Point After Task (With Glasses)	.198	55	.000	.930	55	.003
Base-Out (BO) Break Point After Task (With Glasses)	.170	55	.000	.908	55	.000
Base-Out (BO) Recovery Point After Task (With Glasses)	.134	55	.016	.961	55	.068
Base-In (BI) Blur Point After Task (With Glasses)	.174	55	.000	.915	55	.001
Base-In (BI) Break Point After Task (With Glasses)	.153	55	.002	.903	55	.000
Base-In (BI) Recovery Point After Task (With Glasses)	.156	55	.002	.934	55	.005

Friedman’s ANOVA Summary for Amplitude of Accommodation

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	23.304
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.000

Friedman's ANOVA Summary for Negative Relative Accommodation

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	30.345
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.000

Mauchly's Test of Sphericity for Positive Relative Accommodation

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

					Epsilon[b]		
Within Subjects Effect	**Mauchly's W**	**Approx. Chi-Square**	**Df**	**Sig.**	**Greenhouse-Geisser**	**Huynh-Feldt**	**Lower-bound**
PRA	.764	14.238	2	.001	.809	.831	.500

Friedman's ANOVA Summary for Near-Point of Convergence Break

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	5.550[a]
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.062

a. Multiple comparisons are not performed because the overall test retained the null hypothesis of no differences.

Friedman's ANOVA Summary for Near-Point of Convergence Recovery

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	12.213
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.002

Friedman's ANOVA Summary for Base-Out Blur Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	12.409
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.002

Friedman's ANOVA Summary for Base-Out Break Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	18.859
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.000

Friedman’s ANOVA Summary for Base-Out Recovery Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	16.273
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.000

Friedman's ANOVA Summary for Base-In Blur Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	7.503
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.023

Friedman's ANOVA Summary for Base-In Break Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	5.656[a]
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.059

a. Multiple comparisons are not performed because the overall test retained the null hypothesis of no differences.

Friedman's ANOVA Summary for Base-In Recovery Point

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks Summary

Total N	55
Test Statistic	1.096[a]
Degree Of Freedom	2
Asymptotic Sig.(2-sided test)	.578

a. Multiple comparisons are not performed because the overall test retained the null hypothesis of no differences.