

NEAR WORK-INDUCED ACCOMMODATIVE BIAS IN YOUNG MYOPES: MAGNITUDE, RECOVERY TIME, AND DISCREPANCY BETWEEN NON-CYCLOPLEGIC AND CYCLOPLEGIC REFRACTION

Sana Shafique^{*1}, Syed Asadullah Arslan², Dr Naveed Babur³, Khurram Nasir⁴,
Dawood MustafaMajeed⁵, Hina Areej⁶

^{*1}Optometrist MS rehabilitation sciences and low vision , faculty of Allied health sciences, superior university Lahore

²Professor, Department of Physical Therapy and Rehabilitation Sciences Faculty of Allied Health Sciences Superior University Lahore

³Dean of Allied health sciences in superior university Lahore

⁴Optometrist Professor, department of optometry and vision sciences

⁵Clinical Optometrist, Ms Rehabilitation Science, Faculty of Allied Health Science Superior University Lahore

⁶Clinical optometrist MS rehabilitation sciences and low vision, faculty of Allied health sciences, superior university Lahore

¹sanashafiq562@gmail.com, ²asadshahgilani@gmail.com, ³naveed.babur@superior.edu.pk,
⁴khuram.nasir@superior.edu.pk, ⁵dawood067vhr@gmail.com, ⁶hinaareej125@gmail.com

DOI: <https://doi.org/10.5281/zenodo.22824396>

Keywords

Myopia, Near Work, Near-induced Transient Myopia, Spherical Equivalent, Accommodative Lag.

Article History

Received: 01 June 2026

Accepted: 23 August 2026

Published: 08 September 2026

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Corresponding Author: *

Sana Shafique

Abstract

BACKGROUND

Myopia is increasing rapidly worldwide, especially among students who engage in near work demands for longer periods of time. Accommodation plays an important role in determining the accurate status of the human eye, and its active state after prolonged near work may overestimate myopia in a young myopic population under non-cycloplegic conditions. Near-induced transient myopia and accommodative lag may further complicate the accuracy. Despite this, cycloplegic refraction after a sustained amount of near work is often underutilized in these students. There is limited data available on refractive variability among Pakistani students, highlighting the need for this study.

OBJECTIVE To evaluate the refractive variability after near work by comparing non-cycloplegic and cycloplegic methods among the young myopic population.

METHODOLOGY This is a quasi-experimental study design. Initial screening was done using the pen torch and slit lamp bio microscope to ensure the eligibility of the patients. The standard visual acuity chart was used to measure visual acuity. Participants were instructed to perform near work for 10 minutes under standardized conditions and at a working distance to induce a high cognitive response. Non-cycloplegic refraction was assessed using an autorefractometer for objective estimation, and the trial box was then used for subjective refraction to establish the optimal corrected visual acuity. Cycloplegia was induced using cyclopentolate 1%. After adequate cycloplegia, cycloplegic refraction was performed using a retinoscope. All findings and data were filled in on the questionnaire/Performa by the optometrist.

RESULTS The right eye's mean non-cycloplegic spherical equivalent after near work was -2.59 ± 1.46 D, with a median of -2.25 D, and the cycloplegic spherical equivalent after complete paralysis of accommodation was -1.91 ± 1.37 D, with a median of -1.50 D. The left eye's mean non-cycloplegic spherical equivalent after near work was -2.50 ± 1.42 D, with a median of -2.00 D, and the cycloplegic spherical equivalent after complete paralysis of accommodation was -1.87 ± 1.22 D, with a median of -1.50 D. The median difference between non cycloplegic and cycloplegic methods was -0.50 D for both right and left eye. These results indicate that the overestimation of myopia is caused by non-cycloplegic refraction, most likely due to active accommodation.

CONCLUSION Non-cycloplegic refraction showed a statistically significant change in spherical equivalent in both eyes, with a minimal clinically insignificant intraocular variation likely due to physiological and accommodative factors.

INTRODUCTION

Myopia is the second most prevalent cause of blindness, followed by uncorrected refractive defects. By the end of 2025, half of the world's population is predicted to have myopia, according to the WHO. In many regions of the world, like East Asia, even now, it is so common that it is referred to as a 'simple' refractive error instead of a disease. However, as we know, uncorrected or poorly handled myopia can cause severe damage to the retina and macula, eventually leading to complete blindness. Apart from its pathological aspects, it also impairs daily living activities and vastly affects the individual's quality of life (1,2).

Apart from genetic factors, the environment also contributes significantly to the rise in myopia prevalence, including a decrease in outdoor activities and an increase in near work. According to numerous studies, those who labor at less than 30 cm are 2.5 times more likely to develop myopia. Now, if we look at today's society, students are ones with a prolonged period of near work due to academic demands and a large shift of study materials on digital screens. Compared to children, teenagers, and young adults are more vulnerable to this academic stress. A study done on 3rd year law students concluded that near work was the cause of progression in myopia in young adults. Those students stated a demand for stronger prescription glasses (3,4).

This demand for a stronger prescription associated with constant visual discomfort, headaches, and eye strain needs to be addressed properly. It signifies the need for an accurate prescription. Even an error of 0.25D has been reported to cause headaches, especially in the late teens and young adults. These headaches are more prominent in mild to moderate myopes. An inaccurate prescription also disturbs the binocular harmony of the eye, which impairs the stereo acuity (depth perception) and most commonly leads to convergence insufficiency. It also increases the risk of accidents (5).

Accommodation is the eye's natural ability to increase its dioptric power to accommodate a target at near or reading distance. Accommodation works differently in everyone, depending on the refractive status of the eye. In myopes, particularly, the mechanism and how it works is still under observation. However, literature states that accommodation varies at different stages and types of myopia, making it harder to understand its mechanism. Like in low or mild myopes, it is active similarly to emmetropes. The evidence leads to the idea that there could be an association between the progression of myopia and unstable accommodation that should be considered further (6).

It is traditionally assumed that myopes have relaxed accommodation because the eye's natural dioptric power is already increased. However, for

many years, people have debated how accommodation affects the development of myopia. Although it was long believed that accommodative lag was the primary cause of myopia, recent perception has shifted to the idea that the lag of accommodation in myopes usually occurs after being diagnosed. Progressing myopes usually spend longer times trying to relax the accommodation induced by near work aftereffects. This dynamic response of accommodation after increased accommodative lag remains a critical area of study for understanding the myopia in modern-day Pakistani students (7).

Human eyes work through a mechanism of synkinetic reflex, which suggests that for better focus, eyes accommodate, converge, and cause constriction of the pupil all at the same time. For binocular vision, this mechanism relies on the magnitude of accommodation, inward convergence, and pupil miosis to increase the depth of focus. In emmetropic peers, this mechanism works with extreme precision, inducing a minimum lag of accommodation that is usually around 0.50-0.75D. However, in young myopic adults, it has been stated that they experience a lag of accommodation, causing a chronic blur at the retina. For near work at 25-30cm, the normal accommodative demand is 4D, so this lag is more pronounced during near work. In myopic adults, a sustained amount of near work often exceeds the compensatory limit of the brain for 4D accommodative demand. This sustained lag causes a hyperopic shift with a higher AC/A ratio. Since accommodation and convergence are neurologically linked, this magnitude of lag causes exophoria in myopic adults that results in convergence insufficiency or eyestrain because it requires extra effort from the brain to stay aligned. This broken feedback of a myopic eye to the brain creates a biomechanical environment that contributes to the elongation of the eye. So, the studies suggest that this lag of accommodation is not just static refractive error, but a failure of the binocular system, being unable to adapt to the modern age's excessive near demands. These binocular dynamics report

how the difference of accommodative lags in myopic individuals can also lead to a potential increase in refractive error as well (8,9).

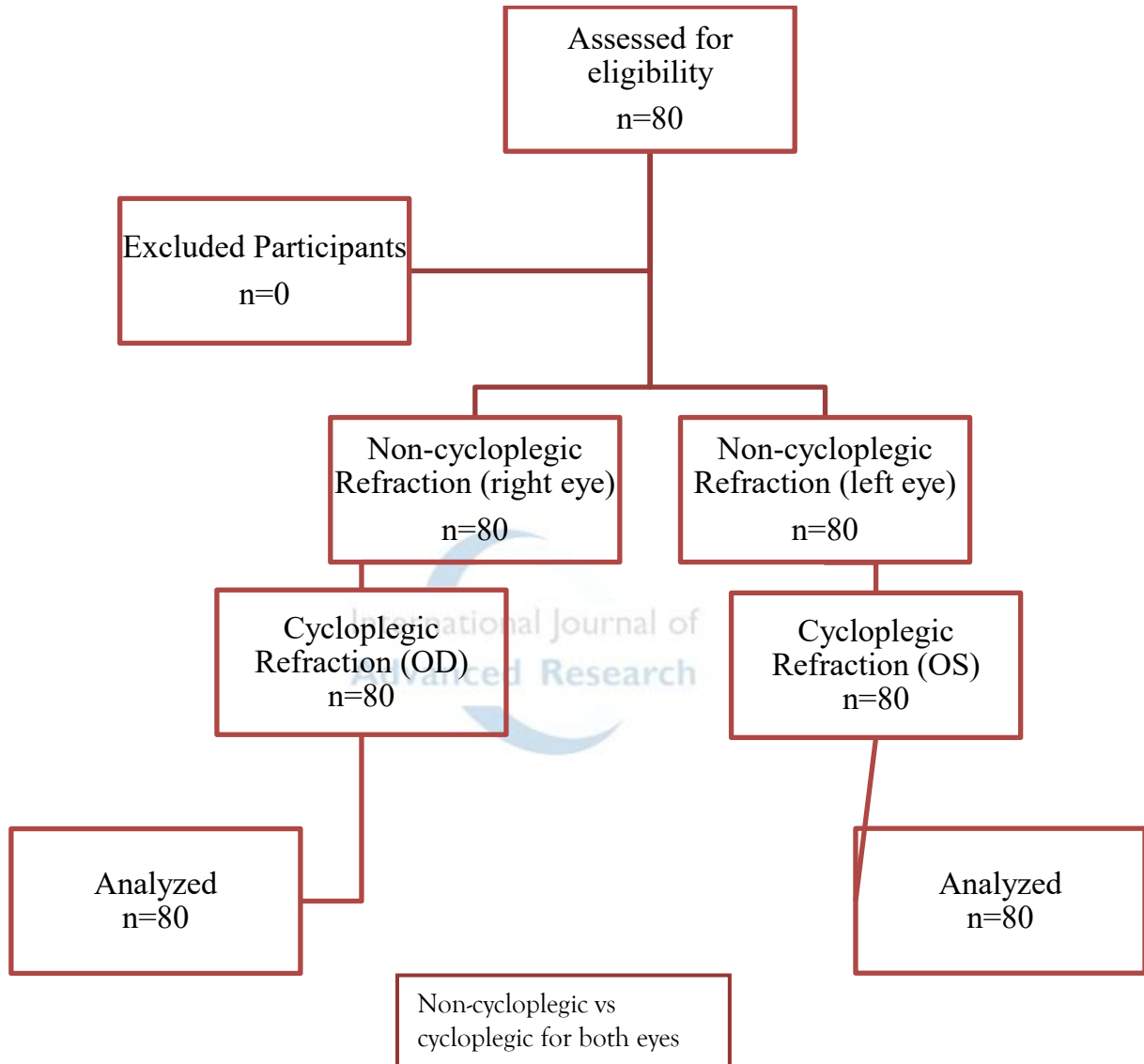
In myopes, accommodating effort during prolonged near labor may also contribute to the development of myopia. It is generally known that myopes suffer from near-induced temporary myopia and are more vulnerable to the aftereffects of near work. Unlike emmetropes, myopes require a longer time for their distance vision to clear after nearwork. This late recovery indicates that myopes have a sluggish response in transitioning between near and far distances. The myopic shift in the far point of the eye caused by prolonged accommodation is known as near-induced transient myopia. Research has documented NITM's significant adaptations immediately after the 10-minute task. While the emmetropes show some adaptation, studies have suggested that late-onset myopes and those with progressing myopia show significant changes after 10 minutes of near task. Since NITM is a cumulative effect based on time spent on the near task, the physiological changes begin as soon as the task starts becoming significant till 10 minutes. This is why 10 minutes of near work is a standard to distinguish between momentary accommodation and near-induced transient adaptation that defines the NITM. NITM also depends on the type of cognitive work introduced (like puzzle solving or solving a math problem). This type of higher cognitive work done in 10 minutes results in greater and more stable responses, which makes the 10-15 minutes timeframe of threshold even more pronounced in the real world. Emmetropes show a late response, while in myopes, even 5 minutes of near work can be enough to introduce NITM. In a clinical context, these serve as a cause for visual strain, headaches, and a need for a stronger prescription (10,11).

Methodology

This study employed a quasi-experimental research design and was conducted at Lahore General Hospital and Pakistan Air Force Hospital, Lahore, Pakistan over a period of six

months following approval of the synopsis. A total of 80 participants were recruited using a non-probability convenient sampling technique. The sample size was calculated using the formula $n=(dZ\alpha/2+Z\beta)^2$, where $Z\alpha/2=1.96$ at a 95% confidence level, $Z\beta=1.28$ for 90% power, and $d=0.37$ as derived from previous literature. The calculated sample size was 76.74, which was rounded to 77 and further adjusted to 80 participants to account for potential dropouts. Inclusion criteria comprised young students aged 16 to 25 years with low to moderate myopia in spherical equivalent, who were already using glasses and had a best corrected visual acuity of 6/6 to 6/9. Exclusion criteria included the presence of any ocular pathology, history of ocular surgery, use of medications affecting accommodation, known allergy to cycloplegic drops, and presence of strabismus or binocular vision anomalies. Data collection procedure involved an initial screening of all participants, which included assessment of medical history, visual acuity testing, and basic ocular examination to confirm eligibility. Eligible participants were then instructed to perform a

standardized, visually demanding near task in the form of a game-based activity for 10 minutes using Snellen's equivalent of near notation at a distance of 25-30 cm, under similar lighting and contrast conditions. Participants were not informed of the exact timing to minimize behavioral modifications. A 10-minute duration was selected because high cognitive demand during near work is known to induce prominent tonic accommodation, leading to significant refractive and ocular changes. Immediately following the near task, non-cycloplegic refraction was performed using both objective autorefractometry and subjective refraction. Subsequently, cycloplegic refraction was carried out after instillation of cyclopentolate 1% eye drops, administered as three doses 10 minutes apart. Cycloplegic refraction was performed 20 minutes after the last drop using retinoscopy to ensure accurate refractive measurements. All refractive findings and relevant parameters were recorded on a standardized data collection form by the optometrists conducting both non-cycloplegic and cycloplegic refractions



Results:

Table 1: Age Distribution of Participants

Age Distribution of Participants					
Variable		Frequency (n)	Percent (%)	Mean age	SD
Age Category (Years)	16-18	32	40%		
	19-21	30	38%		
	22-24	18	20%		
	24-25	2	2%		
	Total	80	100%	19.55	2.47

The study sample consisted of 80 participants with a mean age of 19.55 ± 2.47 years. The distribution across age categories showed that the

largest group of participants was in the 16-18 age range, representing 40% of the sample. This was followed by 38% in the 19-21-year range and

20% in the 22-24-year range—the smallest proportion, 3%, comprised participants aged 25 years.

Cycloplegic Refraction Findings

Among the 80 participants, the mean cycloplegic spherical equivalent of the right eye following the 40 min wait for complete paralysis of accommodation was $-1.91 \pm 1.37D$. The highest frequency was observed in -1.25 to -2.00 D

(32.5%), followed by -0.25 to -1.00 D (22.5%), and the least frequency observed was -4.25 D and above (10%).

Meanwhile, the mean cycloplegic spherical equivalent of the left eye following the 40 min wait for complete paralysis of accommodation was $-1.87 \pm 1.22D$. The highest frequency was observed in -1.25 to -2.00 D (31.3%), followed by -0.25 to -1.00 D (25%), and the least frequency observed was -4.25 D and above (11.3%).

TABLE 2:

Distribution of Cycloplegic Spherical Equivalent (OD) after Cycloplegia (n = 80)						
Variables		Frequency (n)	Percentage (%)	N	Mean	Std
Spherical Equivalent Range (Diopters) in Right Eye	-0.25 to -1.00 D	18	22.5%	80	-1.91	1.37
	-1.25 to -2.00 D	26	32.5%			
	-2.25 to -3.00 D	16	20.0%			
	-3.25 to -4.00 D	12	15.0%			
	-4.25 D and above	8	10.0%			
Distribution of Cycloplegic Spherical Equivalent (OS) after Cycloplegia (n = 80)						
Spherical Equivalent Range (Diopters) in Left Eye	-0.25 to -1.00 D	20	25.0%	80	-1.87	1.22
	-1.25 to -2.00 D	25	31.3%			
	-2.25 to -3.00 D	15	18.8%			
	-3.25 to -4.00 D	11	13.8%			
	-4.25 D and above	9	11.3%			

Normality Testing

To determine whether to use parametric tests (like a Paired t-test) or non-parametric tests (like the Wilcoxon Signed-Rank test), we conducted

Kolmogorov-Smirnov and Shapiro-Wilk

normality tests on the refractive variables and their differences.

TABLE3:

Statistical Analysis				
Category	Non-Cycloplegic Median (Post-Near Work)	Cycloplegic Median (True Error)	Median Difference	Net
Right Eye (OD)	-2.25 D	-1.50 D	-0.50 D	
Left Eye (OS)	-2.00 D	-1.50 D	-0.50 D	
Overall (Both Eyes)	-2.125 D	-1.563 D	-0.625 D	

TABLE4:

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Hours of Near Work	.180	80	.000	.931	80	.000
Duration of Myopia	.166	80	.000	.921	80	.000
OD Non-Cycloplegic	.165	80	.000	.927	80	.000
OD Cycloplegic	.163	80	.000	.940	80	.001
Difference (OD)	.215	80	.000	.835	80	.000
OS Non-Cycloplegic	.175	80	.000	.927	80	.000
OS Cycloplegic	.169	80	.000	.940	80	.001
Difference (OS)	.194	80	.000	.840	80	.000

individual, statistical analyses were strictly bound to the $n = 80$ participant level rather than pooling 160 eyes independently. The non-parametric Wilcoxon Signed-Rank test

remarkable consistency: the right eye (OD) demonstrated a median shift of -0.50 (with 77 hyperopic shifts and 3 ties), and the left eye (OS) similarly demonstrated a median shift of -0.50 (with 76 hyperopic shifts and 4 ties).

Statistical Analysis: Comparing Means

We evaluated the variation between Non-Cycloplegic measurements (taken after work) and

demonstrated a highly statistically significant accommodative shift across the cohort ($Z = -7.67$, $p < 0.001$) and ($Z = -7.62$, $p < 0.001$). Individually, both eyes mirrored this trend with

Cycloplegic measurements (true baseline error) using non-parametric tests.

The analysis demonstrated a highly statistically significant overall difference between the non-cycloplegic and cycloplegic methods, with a median difference of -0.50 for the right and left eye. This indicates that non-cycloplegic evaluation following near work significantly overestimates the degree of myopia due to accommodative factors.

To account for the high biological correlation between the right and left eyes of the same individual, statistical analyses were strictly bound to the $n = 80$ participant level rather than pooling 160 eyes independently. The non-parametric Wilcoxon Signed-Rank test demonstrated a highly statistically significant accommodative shift across the cohort ($Z = -7.67$,

$p < 0.001$) and ($Z = -7.62$, $p < 0.001$). Individually, both eyes mirrored this trend with remarkable consistency: the right eye (OD) demonstrated a median shift of -0.50 (with 77 hyperopic shifts and 3 ties), and the left eye (OS) similarly demonstrated a median shift of -0.50 (with 76 hyperopic shifts and 4 ties).

TABLE5:

Wilcoxon Signed-Rank Test				
		N	Mean Rank	Sum of Ranks
OD cycloplegic - OD non-cycloplegic	Negative Ranks	0 ^a	.00	.00
	Positive Ranks	77 ^b	39.00	3003.00
	Ties	3 ^c		
	Total	80		
OS cycloplegic - OS non-cycloplegic	Negative Ranks	0 ^d	.00	.00
	Positive Ranks	76 ^e	38.50	2926.00
	Ties	4 ^f		
	Total	80		
a. OD cycloplegic < OD non-cycloplegic				
b. OD cycloplegic > OD non-cycloplegic				
c. OD cycloplegic = OD non-cycloplegic				
d. OS cycloplegic < OS non-cycloplegic				
e. OS cycloplegic > OS non-cycloplegic				
f. OS cycloplegic = OS non-cycloplegic				
Test Statistics				
	OD cycloplegic - OD non-cycloplegic	OS cycloplegic - OS non-cycloplegic		
Z	-7.697 ^b	-7.629 ^b		
Asymp. Sig. (2-tailed)	<0.001	<0.001		
a. Wilcoxon Signed Ranks Test				
b. Based on negative ranks.				

Association Between Duration of Near Work and Magnitude, Recovery Time, and Discrepancy

TABLE 6:Correlation Between Duration of Near Work and Difference in Spherical Equivalent in Right Eye (OD)

Correlation Between Duration of Near Work and Difference (OD)		
	Hours of Near Work	Difference

Spearman's rho	Hours of Near Work	Correlation Coefficient	1.000	.063
		Sig. (2-tailed)	.	.579
		N	80	80
	Difference	Correlation Coefficient	.063	1.000
		Sig. (2-tailed)	.579	.
		N	80	80

TABLE7: Correlation Between Duration of Near Work and Difference in Spherical Equivalent in Left Eye (OS)

Correlation Between Duration of Near Work and Difference (OS)				
			Hours of Near Work	Difference
Spearman's rho	Hours of Near Work	Correlation Coefficient	1.000	.175
		Sig. (2-tailed)	.	.120
		N	80	80
	Difference	Correlation Coefficient	.175	1.000
		Sig. (2-tailed)	.120	.
		N	80	80

Statistical analysis revealed no significant correlation between the daily duration of near work and the magnitude of refractive variability in the right eye ($\rho = 0.063$, $p = 0.579$) or the left eye ($\rho = 0.175$, $p = 0.120$). This suggests that the

0.625 D shift observed post-task occurred uniformly across the sample, regardless of whether participants reported low or high daily near-work volumes.

TABLE8: Correlation Between Duration of Myopia and Difference in Spherical Equivalent (OD)

Spearman's Correlation Between Duration of Myopia and Difference (OD)				
			Duration of myopia	Difference
Spearman's rho	Duration of myopia	Correlation Coefficient	1.000	.148
		Sig. (2-tailed)	.	.191
		N	80	80
	Difference	Correlation Coefficient	.148	1.000
		Sig. (2-tailed)	.191	.
		N	80	80

TABLE9: Correlation Between Duration of Myopia and Difference in Spherical Equivalent (OS)

Correlation Between Duration of Myopia and Difference (OS)				
			Duration of myopia	Difference
Spearman's rho	Duration of myopia	Correlation Coefficient	1.000	.067
		Sig. (2-tailed)	.	.552

	Difference	N	80	80
		Correlation Coefficient	.067	1.000
		Sig. (2-tailed)	.552	.
		N	80	80

Similarly, a non-significant correlation was found between the chronicity of myopia (years since diagnosis) and refractive variability for the right eye ($p = 0.148$, $p = 0.191$) and left eye ($p = 0.068$, $p = 0.552$). These results indicate that the duration of spectacle use or the time elapsed since the onset of myopia does not reliably predict the degree of accommodative spasm induced by high cognitive near-work tasks.

Overall, the findings demonstrate that cycloplegic refraction provides more significantly different results as compared to non-cycloplegic refraction, highlighting the influence of accommodation on refractive measurements. Increased near work was also associated with greater variability in refractive outcomes.

DISCUSSION

The primary objective of the study was to evaluate refractive variability after near work by comparing cycloplegic and non-cycloplegic refraction in young myopic adults. The findings demonstrated a highly statistically significant overall difference between the two methods ($p < 0.001$), with non-cycloplegic refraction systematically yielding more myopic values than cycloplegic refraction.

Because the refractive differences violated the assumptions of normality under Shapiro-Wilk testing ($p < 0.001$), a non-parametric Wilcoxon Signed-Rank test was utilized to validate these findings using median thresholds. The Wilcoxon Signed-Rank Test placed most participants in the negative rank: 77 hyperopic shifts and 3 ties for the right eye (OD), and 76 hyperopic shifts and 4 ties for the left eye (OS), indicating that patients underwent a hyperopic shift after using the cycloplegic drops. From a non-parametric perspective, the median difference calculated between non-cycloplegia and cycloplegia was **-0.50 D** for both the right and left eye.

The biological correlation between the right and left eye reflects the biological relationship between both eyes in individuals with low to moderate myopia. However, this correlation does not eliminate the significant difference observed between cycloplegic and non-cycloplegic measurements. Therefore, despite the correlation, the two techniques cannot be considered interchangeable. These findings align with the systematic review on agreement of non-cycloplegic vs cycloplegic refraction (2022) by Wilson et al., which has emphasized the importance of cycloplegia in eliminating accommodative interference during refractive assessment.(12)

Our analysis also revealed an insignificant correlation between refractive variability and duration of near work. The findings suggest that the duration alone may not be a reliable predictor of refractive variability. Other factors, such as individual accommodative response, visual habits, and frequency of breaks, also play a significant role.

The lack of significant correlation between daily near-work duration and refractive variability suggests that the accommodative system reaches a state of maximum spasm relatively quickly. Rather than a linear increase based on total daily hours, our data indicates that just 10 minutes of intense near work is sufficient to induce a near-maximal error of -0.625 D across the entire sample. This identifies the acute intensity of the task, rather than the cumulative daily habit, as the primary trigger for refractive measurement error in young adults.

The results also align with the study by Sivaraman et al. on near work & accommodative induced refractive shift, which highlighted that NITM dynamics and accommodative lag are highly sensitive to immediate behavioral stress. The results of this study agree with the growing body

of evidence suggesting that environmental and behavioral factors, particularly near work, play a significant role in refractive variability. With the increasing use of digital devices among young individuals, accommodative stress has become more prevalent, further reinforcing the need for accurate refractive assessment techniques.(13)

Similarly, the correlation between the duration of myopia and refractive variability was also found to be clinically insignificant. This suggests that the number of years a person has been myopic is not a strong determinant of accommodative behavior. While long-term myopia may have structural implications, short-term refractive fluctuations are more influenced by current visual habits and accommodative demand rather than duration of spectacle use. The results align with the study of Panke et al., who noticed that excessive demand for near work may significantly skew the refractive profile in young cohorts.(14)

The findings of this study carry vital weight for clinical optometric practice and emphasize the critical role of accommodation in refractive assessment, particularly in young adults who are frequently engaged in near work activities such as reading, studying, and digital device usage. It also underscores the importance of using cycloplegia for accurate measurement of refractive error. Failure to control accommodation may lead to overcorrection of myopia, which can result in visual discomfort, headaches, and asthenopia symptoms.

Clinically, these results highlight the importance of considering accommodative factors when prescribing refractive correction. Cycloplegic refraction should be strongly considered in cases where patients report fluctuating vision, excessive near work, or symptoms of eye strain. Additionally, patient education regarding proper visual hygiene, including taking regular breaks during near work and maintaining appropriate working distances, is essential in minimizing accommodative stress. The findings also align with the comparative analysis by Hassan Hashmi et al., who concluded that when evaluating refractive errors, cycloplegic refraction is crucial, particularly for people under 25. Additionally,

several complicating factors affect subjective refraction in older persons, and it should be handled carefully.(15)

This study has many drawbacks that should be noted despite its positives. Despite being sufficient, the sample size was restricted to a particular population group, which could have an impact on generalizability. Additionally, near work duration and history of myopia were self-reported, which may introduce recall bias. To further validate these results, larger sample sizes and objective measurement instruments should be used in future research.

In conclusion, the findings directly satisfy the primary research objective by demonstrating a statistically and clinically significant difference between cycloplegic and non-cycloplegic refraction techniques following near work in young adults aged 16–25. The non-cycloplegic method yielded significantly higher myopic values, confirming that relying solely on non-cycloplegic refraction post-near work introduces an accommodative bias that cycloplegia effectively eliminates.

CONCLUSION

The current investigation demonstrated that the non-cycloplegic refraction introduces a systematic overcorrection of myopia due to the influence of uncontrolled accommodation. This transient change is triggered by 10 minutes of continuous near work. Pharmacological cycloplegia isolated the true refractive error by eliminating this accommodative component. Bilateral analysis revealed that it affected both eyes equally, and minimal interocular variation in the amount of refractive change between the two eyes is clinically negligible and is probably caused by physiological microfluctuations rather than true structural asymmetry. The study also emphasizes how accommodation affects refractive results, especially in young people whose accommodative response is more active. The work further strengthens the knowledge that non-cycloplegic refraction may cause small measurement errors, which should be evaluated carefully in both clinical and research contexts. The general

pattern of outcomes held for both eyes demonstrates the validity of the comparative evaluation methodology.

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