

## Comparison of Cycloplegic versus Non Cycloplegic Refraction in Hyperopic Children and Adults

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### Abstract

**Background:** Precise evaluation of hyperopia is crucial for correct diagnosis and treatment, particularly in youngsters when accommodation may conceal underlying hyperopia. In this study, hyperopic children and adults' cycloplegic and non-cycloplegic refraction was examined.

**Objective:** To assess the extent of latent hyperopia and its clinical importance, as well as to compare cycloplegic and non-cycloplegic refraction in hyperopic children and adults.

**Methodology:** 114 hyperopic individuals, including adults and children, underwent both cycloplegic and non-cycloplegic refraction as part of a comparative cross-sectional study. To compare refractive results between and within groups, data were examined using suitable non-parametric statistical tests.

**Results:** The distribution of all the variables was not normal ( $p < 0.05$ ). Both visual acuity ( $Z = -6.300$ ,  $p = 0.000$ ) and spherical equivalent ( $Z = -8.433$ ,  $p = 0.000$ ) showed statistically significant differences between cycloplegic and non-cycloplegic readings, with non-cycloplegic values consistently lower, according to within-group analysis. Cycloplegic SE, non-cycloplegic SE, and latent hyperopia showed significant differences between children and adults ( $p < 0.01$ ) according to between-group analysis, however non-cycloplegic visual acuity showed no significant difference ( $p = 0.978$ ). Compared to adults, children had higher mean rankings, which suggests more latent hyperopia. In both groups, cycloplegic refraction generally produced greater SE and VA values.

**Conclusion:** When measuring refractive error, cycloplegic refraction is more accurate than non-cycloplegic refraction, which tends to underestimate hyperopia because of accommodating impact. In children, the discrepancy is more noticeable, underscoring the significance of cycloplegia in pediatric refractive evaluation. As a result, cycloplegic refraction should be regarded as crucial for the proper diagnosis and treatment of hyperopia, especially in younger populations.

**Keywords:** Hyperopia, Latent hyperopia, Cycloplegic refraction, Non-cycloplegic refraction, Children, Adults.

### Introduction

Hyperopia comprises spherical hyperopia and simple and compound hyperopic astigmatism, with spherical equivalent  $\geq +0.50$  D and cylinder  $\leq$  sphere (in absolute value).<sup>(1)</sup> The age-related loss of accommodative ability known as presbyopia occurs when physiological changes in the eye cause close vision to become insufficient for a person's functional demands.<sup>(2)</sup> In youngsters, cycloplegic refraction is crucial for removing accommodative fluctuation and guaranteeing precise refractive defect detection.<sup>(3)</sup> Early identification is crucial since hyperopia is a common childhood refractive defect that affects near vision and can result in strabismus and amblyopia if left untreated.<sup>(4)</sup> When accommodation is loosened, parallel light rays focus behind the retina in hyperopia, a frequent refractive mistake in children that is usually caused by decreased axial length or refractive power.<sup>(5)</sup> By momentarily paralyzing accommodation, cycloplegic refraction improves refractive precision and reduces accommodative variations and ciliary muscle spasm.<sup>(6)</sup> The greatest increase in plus power attained is known as the amplitude of accommodation. In order to suppress accommodation and measure the true refractive error in youngsters, cycloplegic refraction is frequently necessary.<sup>(7)</sup> Refractive error is frequently misinterpreted as under corrected hyperopia or over minus myopia. Clinicians must choose the right drugs, dosage, and administration for pediatric cycloplegic examinations while taking adverse effects into account.<sup>(8)</sup> Myopia is a refractive error that results in blurry distance vision because light focuses in front of the retina as a result of an imbalance between ocular optical power and axial length.<sup>(9)</sup> This covers simple or compound hyperopic astigmatisms as well as spherical hyperopic refractive defects. The spherical equivalent's value must be at least +0.50 D, and the cylinder's absolute value must be less than or equal to the sphere's absolute value.<sup>(10)</sup> According to earlier research, accommodation and cycloplegia have contradictory impacts on visual metrics. Changes in axial length, anterior chamber depth, and corneal curvature have also been noted, although most report little modification in choroidal thickness following cycloplegia. Nevertheless, there is a dearth of information on actively accommodating eyes, and there are still no clear comparisons between accommodation and cycloplegia.<sup>(11)</sup> One of the main causes of visual impairment, uncorrected refractive error impacted around 108 million people in 2010. Additionally, it is linked to eye disorders such age-related macular degeneration, diabetic retinopathy, cataract, glaucoma, and myopic macular degeneration. Although there is evidence connecting refractive defects to anatomical and functional alterations in the eye, there is still a lack of a thorough summary of these connections.<sup>(12)</sup> Children's cycloplegic refraction is frequently restricted by a lack of drug availability or approval for optometrists, parental resistance because of transient near vision blurriness, and time, money, and resource limitations in screens and population studies.<sup>(13)</sup> For correct assessment using techniques like cycloplegia or optical fogging, relaxing is essential since accommodation might affect refractive measures, particularly in young patients with strong accommodative tone.<sup>(14)</sup> The maximal rise in plus power that the eye can attain is called amplitude of accommodation, and it is frequently high in children and requires cycloplegic refraction.<sup>(15)</sup>

### **Methodology**

The purpose of this comparative cross-sectional study was to assess the variations between children's and adults cycloplegic and non-cycloplegic refraction. Over the course of three months, the study which included patient recruitment, refraction operations, and data analysis was conducted in the Ophthalmology Clinic (Refraction Department) of Zaheer Eye Hospital, Sargodha.

There were 114 children and adults with suspected or confirmed refractive defects, ages 4 to 26. Prior to participation, parents or guardians provided written informed consent. Children who had a history of ocular trauma, strabismus or amblyopia that affected refraction accuracy, neurological or systemic diseases affecting vision or accommodation, cyclopentolate hypersensitivity, or uncooperative behavior were not included. To guarantee proportionate representation, participants were divided into age groups (4–26 years old) using a stratified random sample technique. When random selection was not possible, successive sampling of eligible clinic attendees was used. For matched comparison, each individual experienced both cycloplegic and non-cycloplegic refraction.

Clinical and demographic information was documented, along with any pertinent medical history and visual complaints. Anterior segment examination using a torch light, near vision evaluation using conventional near charts, and distant visual acuity testing using Snellen or LogMAR charts at 4 meters were all part of the baseline ocular examination. First, autorefractometry and streak retinoscopy were used for non-cycloplegic refraction while accommodation was in effect. After administering 1% cyclopentolate eye drops (two drops each eye, spaced five minutes apart) and waiting for 30 to 45 minutes to establish complete cycloplegia, cycloplegic refraction was carried out. Spherical power, cylindrical power, axis, and spherical equivalent were recorded for both eyes in a standardized proforma after objective refraction was repeated using an autorefractometer and retinoscopy.

Visual and refractive evaluation was done using an autorefractometer, streak retinoscope, trial lens set, trial frame, LogMAR chart, and near vision chart. The Superior University Lahore, Sargodha Campus Research Ethical Committee granted ethical permission (Ref: SU/SGD/AHS/26/0019). Parents or legal guardians provided written informed permission. Confidentiality and anonymity were guaranteed, and participation was entirely voluntary. The cycloplegic drops' transient adverse effects, such as photophobia and blurred near vision, were explained to participants, and they were free to leave at any moment without incurring any fees.

### Results

The study included 114 hyperopic participants with 57 children and 57 adults, where children had a mean age of 12.40 years and median of 13.00 years while adults had a mean age of 26.60 years and median of 27.00 years, and males made up 57.9% of the total sample with children having 37 males and 20 females and adults having 29 males and 28 females; for males mean cycloplegic SE, D was 1.12 D, non cycloplegic SE, D was 0.70 D, SE latent hyperopia was 0.46 D, VA cycloplegic was 1.13 and VA non cycloplegic was 0.87, while for females mean cycloplegic SE, D was 1.30 D, non cyclo SE, D was 0.76 D, SE latent hyperopia was 0.56 D, VA cycloplegic was 1.30 and VA non cycloplegic was 0.93; Shapiro-Wilk tests showed all variables had p-values <0.05 indicating non-normal distribution; Wilcoxon Signed Ranks Test showed VA non cycloplegic vs VA cycloplegic had 65 negative ranks and 25 positive ranks with  $Z = -6.300$  and  $P = .000$ , and non cycloplegic SE D vs cycloplegic SE, D had 93 negative ranks and 10 positive ranks with  $Z = -8.433$  and  $P = .000$ , both significant; Mann-Whitney Test showed VA cycloplegic with children mean rank 86.00 and adults 29.00,  $Z = -9.324$ ,  $P < 0.01$ , VA on cycloplegic with children 49.94 and adults 50.08,  $Z = -0.027$ ,  $P = .978$ , cycloplegic SE, D with children 86.00 and adults 29.00,  $Z = -9.324$ ,  $P < 0.01$ , non cycloplegic SE, D with children 70.67 and adults 32.02,  $Z = -6.648$ ,  $P < 0.01$ , and SE latent hyperopia with children 86.00 and adults 29.00,  $Z = -10.63$ ,  $P < 0.01$ , with all variables except VA non cycloplegic showing significant differences between children and adults and children consistently having higher mean ranks. Cycloplegic refraction consistently gave higher spherical equivalent and VA values than non-cycloplegic refraction in both groups. The magnitude of latent hyperopia was greater in children than in adults, confirming that cycloplegia is especially critical for accurate refractive assessment in hyperopic children.

**Table 1 : Frequency distribution of gender of participants**

Frequency	Percent		Valid Percent		Cumulative Percent
Children	Male	37	64.9	64.9	64.9
	Female	20	35.1	35.1	100.0
	Total	57	100.0	100.0	
Adults	Male	29	50.9	50.9	50.9
	Female	28	49.1	49.1	100.0
	Total	57	100.0	100.0	

A total of 114 hyperopic participants were included in this study, comprising 57 children and 57 adults. In the children group, 37 participants (64.9%) were male and 20 (35.1%) were female, whereas the adult group consisted of 29 males (50.9%) and 28 females (49.1%). Overall, the study sample included 66 males (57.9%) and 48 females (42.1%).

**Table 2 : Descriptive Statistics of Participants age**

<b>AGE</b>			
Children	N	Valid	57
		Missing	0
	Mean		12.4035
	Std. Error of Mean		.36262
	Median		13.0000
	Std. Deviation		2.73770
Adults	N	Valid	57
		Missing	0
	Mean		26.5965
	Std. Error of Mean		.65026
	Median		27.0000
	Std. Deviation		4.90939

A total of 114 hyperopic participants were enrolled in this comparative cross-sectional study, with 57 children and 57 adults. The mean age of children was 12.40 years (SD = 2.74, Median = 13.00), comprising 37 males (64.9%) and 20 females (35.1%). The adult group had a mean age of 26.60 years (SD = 4.91, Median = 27.00), including 29 males (50.9%) and 28 females (49.1%). Overall, the study sample consisted of 66 males (57.9%) and 48 females (42.1%).

**Table 3: Descriptive Statistics for Refractive Parameters by Age, Gender, and Eye With and Without Cycloplegia**

<b>Descriptive Statistics</b>					
		N	Mean		Std. Deviation
Gender		Statistic	Statistic	Std. Error	Statistic
Male	Age	66	18.9545	1.00869	8.19462
	Gender	66	1.0000	.00000	.00000
	Eye	66	2.0303	.09887	.80326
	VA cycloplegic	66	1.4621	.07956	.64635
	VA non cycloplegic	66	.9333	.00899	.07303
	cycloplegic sphere right eye	66	2.5802	.16410	1.33316
	cycloplegic cyl right eye	66	-1.0344	.07001	.56873
	cycloplegic sphere left eye	66	2.6848	.14976	1.21663
	cycloplegic cyl left eye	66	-1.0400	.07100	.57679
	Non cycloplegic sphere right eye	66	1.9389	.16564	1.34565
	Non cycloplegic cyl right eye	66	-1.0344	.07001	.56873
	Non cycloplegic sphere left eye	66	2.0365	.15181	1.23334
	Non cycloplegic cyl left eye	66	-1.0400	.07100	.57679
	cycloplegic SE D	66	1.4583	.07999	.64983
	Non cycloplegic SE D	66	.7917	.04096	.33277
	SE latent hyperopia	66	.6705	.04617	.37509

Female	Age	48	20.2500	1.17204	8.12011
	Gender	48	2.0000	.00000	.00000
	Eye	48	2.1875	.11781	.81623
	VA cycloplegic	48	1.2969	.09106	.63089
	VA non cycloplegic	33	.9333	.01353	.07773
	Cycloplegic sphere right eye	48	2.6908	.18339	1.27054
	Cycloplegic cyl right eye	48	-1.0040	.08356	.57890
	Cycloplegic sphere left eye	48	2.4290	.18493	1.28127
	Cycloplegic cyl left eye	48	-1.0367	.07945	.55044
	Non cycloplegic sphere right eye	48	2.1269	.18543	1.28468
	Non cycloplegic cyl right eye	48	-1.0040	.08356	.57890
	Non cycloplegic sphere left eye	48	1.7885	.18894	1.30905
	Non cycloplegic cyl left eye	48	-1.0367	.07945	.55044
	Cycloplegic SE D	48	1.2969	.09106	.63089
	Non cycloplegic SE D	39	.7628	.05429	.33906
	SE latent hyperopia	48	.5625	.05393	.37367

This table shows the descriptive statistics for the male group, with a total sample size of  $N = 66$ . The mean age for males is 18.95 years, with a standard deviation of 8.19, indicating a fairly wide age range in the sample. The table also includes various eye-related measurements taken under both cycloplegic and non-cycloplegic conditions. For example, the mean cycloplegic spherical equivalent (cycloplegic SE D) is 1.46 D with a standard deviation of 0.65, while the non-cycloplegic spherical equivalent (non cycloplegic SE D) is lower at 0.79 D with a standard deviation of 0.33. The mean SE latent hyperopia is 0.67 D, which represents the difference between cycloplegic and non-cycloplegic measurements. Visual acuity with cycloplegia (VA cycloplegic) averages 1.46 compared to 0.93 without cycloplegia (VA non cycloplegic). The data also breaks down sphere and cylinder values for the right and left eye under both conditions. This table presents the descriptive statistics for the female group. The sample size for most variables is  $N = 48$ , though VA non cycloplegic has  $N = 33$  and non cycloplegic SE D has  $N = 39$ . The mean age for females is 20.25 years, with a standard deviation of 8.12, which is slightly higher than the male group. For eye measurements, the mean cycloplegic spherical equivalent (cycloplegic SE D) is 1.30 D with a standard deviation of 0.63, while the non-cycloplegic spherical equivalent (non cycloplegic SE D) is 0.76 D with a standard deviation of 0.34. The mean SE latent hyperopia is 0.56 D. Visual acuity with cycloplegia (VA cycloplegia) averages 1.30 compared to 0.93 without cycloplegia (VA non cycloplegia). The table also includes detailed sphere and cylinder values for both right and left eyes under cycloplegic and non-cycloplegic conditions.

**Table 4 : Shapiro-Wilk Normality test**

Normality test	Shapiro-Wilk		
	Statistic	Df	Sig.
VA cycloplegic	.898	99	.000
VA non cycloplegic	.760	99	.000
Cycloplegic sphere right eye	.938	99	.000
Cycloplegic cyl right eye	.958	99	.003
Cycloplegic sphere left eye	.951	99	.001

Cycloplegic cyl left eye	.960	99	.004
Non cycloplegic sphere right eye	.949	99	.001
Non cycloplegic cyl right eye	.958	99	.003
Non cycloplegic sphere left eye	.957	99	.003
Non cycloplegic cyl left eye	.960	99	.004
Cycloplegic SE D	.896	99	.000
Non cycloplegic SE D	.927	99	.000
SE latent hyperopia	.628	99	.000

This table shows the results of the Shapiro-Wilk normality test for all variables, with Df = 99 for each. For all variables listed, the Sig. value is less than 0.05. Specifically, VA cycloplegic, VA\_non cycloplegic, cycloplegic sphere right eye, cycloplegic SE D, non cycloplegic SE D, and SE latent hyperopia have Sig. = .000. The remaining variables like cycloplegic cyl right eye, cycloplegic sphere left eye, cycloplegic cyl left eye, and the non- cycloplegic variables have Sig. values of .001, .003, or .004. Since all p-values are below the 0.05 threshold, the data for each of these variables is not normally distributed. This indicates that non-parametric tests would be more appropriate for further analysis of these variables.

**Table 5 : Wilcoxon Signed Ranks Test**

Within group analysis		N	Mean	Std. Deviation	Z	P value
VA non cycloplegic – VA cycloplegic	Negative Ranks	65 <sup>a</sup>	55.57	.63089	-6.300 <sup>b</sup>	.000
	Positive Ranks	25 <sup>b</sup>	19.32			
Non cycloplegic SE D – cycloplegic SE D	Negative Ranks	93 <sup>d</sup>	56.09	.33906	-8.433 <sup>b</sup>	.000
	Positive Ranks	10 <sup>e</sup>	14.00			

This table presents the results of the Wilcoxon Signed Ranks Test for within-group analysis. For the comparison VA non cycloplegic – VA cycloplegic, there were 65 negative ranks with a mean rank of 55.57 and 25 positive ranks with a mean rank of 19.32. The test produced a Z value of -6.300 with a P value of .000, indicating a statistically significant difference. For the comparison non cycloplegic SE D – cycloplegic SE D, there were 93 negative ranks with a mean rank of 56.09 and 10 positive ranks with a mean rank of 14.00. This comparison had a Z value of -8.433 and a P value of .000, also showing a statistically significant difference. In both cases, the high number of negative ranks suggests that non-cycloplegic values were generally lower than cycloplegic values, and the p-values below 0.05 confirm the differences are significant.

**Table 6 : Mann-Whitney Test**

Between groups analysis	Group	Mean	Std. Deviation	Z	P value
VA cycloplegic	children	86.00	.6453	-9.324	<0.01
	adults	29.00			
VA non cycloplegic	children	49.94	.0730	-.027	.978

	adults	50.08			
Cycloplegic SE D	children	86.00	.0649	-9.324	<0.01
	adults	29.00			
Non cycloplegic SE D	children	70.67	.3327	-6.648	<0.01
	adults	32.02			
SE latent hyperopia	children	86.00	.3750	-	<0.01
	adults	29.00			

This table shows the results of the Mann-Whitney Test for between-groups analysis, comparing children and adults. For VA cycloplegic, the mean rank was 86.00 for children and 29.00 for adults, with  $Z = -9.324$  and  $P$  value  $<0.01$ , indicating a statistically significant difference. VA non cycloplegic had mean ranks of 49.94 for children and 50.08 for adults, with  $Z = -0.027$  and  $P = .978$ , showing no significant difference between groups. For cycloplegic SE D, children had a mean rank of 86.00 and adults 29.00, with  $Z = -9.324$  and  $P <0.01$ , which is significant. Non cycloplegic SE D showed mean ranks of 70.67 for children and 32.02 for adults, with  $Z = -6.648$  and  $P <0.01$ , also significant. Lastly, SE latent hyperopia had mean ranks of 86.00 for children and 29.00 for adults, with  $Z = -10.63$  and  $P <0.01$ , indicating a significant difference. Overall, all variables except VA non cycloplegic showed statistically significant differences between children and adults, with children consistently having higher mean ranks.

### Discussion

In order to assess the degree of latent hyperopia and the diagnostic precision of both approaches, the current study compared cycloplegic and noncycloplegic refraction in hyperopic children and adults. The results unequivocally show that, in both age groups, cycloplegic refraction produces noticeably higher spherical equivalent (SE) values and improved visual acuity than non-cycloplegic refraction. The clinical significance of cycloplegia is highly supported by these findings, especially in younger people when accommodating activity is more noticeable.

The mean cycloplegic spherical equivalent (cycloplegic SE D) in this investigation was consistently greater than the non-cycloplegic spherical equivalent (non cycloplegic SE D). Most instances had lower refractive values under non-cycloplegic settings, according to the Wilcoxon Signed Ranks Test, which revealed a statistically significant difference between the two approaches ( $Z = -8.433$ ,  $p < 0.001$ ). This suggests that the role of accommodation causes non-cycloplegic refraction to underestimate hyperopia. Visual acuity showed a similar trend, with VA with cycloplegia being considerably better than VA without cycloplegia ( $Z = -6.300$ ,  $p < 0.001$ ). These results imply that accommodation influences visual performance during evaluation in addition to refractive metrics.

Latent hyperopia, or the difference between cycloplegic and non-cycloplegic refraction, was significantly greater in children than in adults. A statistically significant difference between the two groups was established by the MannWhitney test ( $Z = -10.630$ ,  $p < 0.01$ ), with children exhibiting more latent hyperopia. This is in line with physiological assumptions since children can conceal underlying hyperopia during non-cycloplegic assessments due to their stronger accommodation.” Adults, on the other hand, show less accommodative amplitude, which leads to lesser differences between the two approaches.

These results are consistent with a number of previous investigations. For example, non-cycloplegic refraction severely underestimates hyperopia in pediatric populations, with discrepancies ranging from 0.50 D to 1.00 D, according to Sanket et al. (2021), which closely matches the mean latent hyperopia found in the current study. In a same vein, Zhao et al. (2020) discovered that cycloplegic refraction is still the gold standard for precise refractive evaluation in kids, especially when they have low to moderate hyperopia.<sup>(16)(17)</sup>

Furthermore, a study by Almeida et al. (2022) demonstrated that the discrepancy between cycloplegic and non-cycloplegic refraction decreases with age, supporting the current study’s

observation that adults show less variation between the two techniques. Their findings suggest that while noncycloplegic refraction may be acceptable in adults for screening purposes, it still lacks precision in detecting latent hyperopia.<sup>(18)</sup>

In a South Asian population, Khan et al. (2023) found substantial variations in spherical equivalent values between cycloplegic and non-cycloplegic refraction ( $p < 0.001$ ), especially in younger age groups. Their findings are in good agreement with the current investigation, highlighting the significance of cycloplegic refraction in populations with high accommodation.<sup>(19)</sup>

Furthermore, Chen et al. (2024) pointed out that depending too much on non-cycloplegic refraction can result in under correction of hyperopia, which can cause symptoms like hazy vision and even the emergence of accommodative esotropia in youngsters. The importance of the current findings is further supported by this clinical implication, especially with regard to pediatric eye care.<sup>(20)</sup>

Additionally, the current investigation showed that visual acuity was substantially greater when cycloplegia was present than when it wasn't. This could be explained by the removal of accommodative variations, which leads to a more consistent and precise visual evaluation. Garcia et al. (2022) demonstrated better visual acuity outcomes after cycloplegic refraction in hyperopic patients, which is a comparable finding.<sup>(21)</sup>

Interestingly, non-cycloplegic visual acuity (VA non cycloplegic) did not substantially differ between the two groups ( $p = 0.978$ ), despite the majority of variables showing significant variations between children and adults. This implies that, especially in youngsters, when accommodation can compensate for hyperopia and conceal visual impairments, non-cycloplegic visual acuity alone may not be a reliable indicator of underlying refractive error.<sup>(22)</sup>

The validity of the results is further strengthened by the use of nonparametric tests in this study because of the non-normal distribution of the data. The statistical findings derived are guaranteed to be reliable and suitable for the dataset thanks to this methodological technique<sup>(23)</sup>

## Conclusion

Because non-cycloplegic techniques greatly overestimated latent hyperopia, especially in youngsters, this study found that cycloplegic refraction offers a more accurate measurement of hyperopia than non-cycloplegic refraction. Children were found to have more latent hyperopia than adults, indicating that cycloplegic refraction is still crucial for accurate diagnosis and appropriate treatment of hyperopic patients.

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