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A RANDOMIZED CONTROL TRAIL STUDY OF CYCLOPLEGIC VERSUS NON-CYCLOPLEGIC REFRACTION IN DETECTING HYPEROPIA IN CHILDREN

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Abstract

Background: Hyperopia in children may be underestimated during non-cycloplegic refraction because of strong accommodative ability. Cycloplegic refraction is commonly recommended in pediatric eye examinations; however, its advantage over non-cycloplegic refraction requires further evaluation.

Objective:

To compare spherical equivalent in both cycloplegic and non-cycloplegic auto refraction

To access the degree of hyperopia missed during non-cycloplegic auto refraction.

To compare the accuracy of cycloplegic versus non-cycloplegic auto refraction .

Methodology: This randomized controlled trial included 48 children aged 4–10 years, comprising 29 males and 19 females. Data were collected from DHQ hospital Vehari the patients were randomized by random sampling technique. Each child underwent both non-cycloplegic and cycloplegic auto refraction. Cycloplegia was achieved using tropicamide 1% cycloplegic agent. Tropicamide 1 drop after every 5 minutes was instilled in the patients eye for total duration of 30-45 mints. In 45 mint's pupil were dilated then checked visual acuity in both eyes. Visual acuity and auto refractometer values of both eyes was accessed before and after usage of drops then compared both visual acuity together for better results. The normality accessed by Shipro-wilk test and data analyzed by SPSS version 27.

Results: Cycloplegic refraction showed significantly higher hyperopic values compared to non-cycloplegic refraction in both eyes. In the right eye, the mean difference was 0.458 diopters ($t = 6.306$, $df = 47$, $p < 0.001$), while in the left eye, the mean difference was 0.375 diopters ($t = 4.561$, $df = 47$,

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p < 0.001). These findings indicate that non-cycloplegic refraction tends to underestimate hyperopia in children.

Conclusion: The study concludes that cycloplegic refraction provides more accurate detection of hyperopia than non-cycloplegic refraction in children aged 4–10 years. Therefore, cycloplegic refraction should be considered an important part of pediatric refractive assessment to avoid underestimation of hyperopia. Early and accurate detection of hyperopia may help in timely management and prevent long-term visual complications in children.

INTRODUCTION

Hyperopia is a common refractive error in both children and adults, with the potential to significantly affect daily quality of life.(1) Globally, its prevalence is estimated at 4.6% in children and 30.9% in adults, with considerable variation across different regions.(2) Although hyperopia is widespread, uncorrected hyperopia—especially when accompanied by anisometropia (a difference in refractive error between the two eyes)—poses a significant risk for developing amblyopia (lazy eye) during childhood, as demonstrated in a recent study of Romanian children.(3) Persistent amblyopia has been linked to poorer self-reported overall health and can negatively affect mental health and general well-being.(4) Hyperopia reserve refers to the natural hyperopic refractive state that typically appears before the development of emmetropia or myopia.(5,6) It is now widely recognized as an important factor in predicting the onset of myopia. Although many large, well-designed studies have examined cycloplegic refractive errors, research specifically addressing hyperopia reserve is still relatively (7)

A positive family history is an important factor influencing the likelihood of hyperopia in future generations. If hyperopia is not treated after diagnosis, complications such as amblyopia and strabismus may occur.(8,9)Axial hyperopia, the most common or simple type, occurs when the eyeball is shortened from front to back, and genetic factors play a significant role in its development.

Vol. 5 No. 2 (2026)

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Retinal edema may also cause a shift toward hyperopia, and a 1-mm reduction in axial length results in about +3 diopters of hyperopia.(10)

Curvature hyperopia develops when the cornea or lens, or both, become flatter than normal, with a 1-mm increase in the radius of curvature producing roughly +6 diopters of hyperopia. Index hyperopia arises from changes in the refractive index of the crystalline lens, typically seen in older adults or people with diabetes, where the refractive index gradually becomes higher from the center toward the periphery.Positional hyperopia can occur when the crystalline lens is displaced or absent (aphakia), whether from congenital causes or acquired conditions, including the placement or loss of an intraocular lens. This creates an aphakic area within the refractive media. Hyperopia due to post-traumatic or post-surgical aphakia is also relatively common. Certain eye disorders—such as nanophthalmos, microphthalmos, and aniridia—may likewise result in hyperopia.

So far, no single definitive cause has been established. Although cases are often sporadic, some genetic associations with hyperopia have been identified. (11) In addition to hereditary and environmental influences, a number of acquired conditions especially in older adults can also contribute to the development of hyperopia. The following are a few identified conditions leading to hyperopia., microdeletion(12)Myelin regulatory factor gene (MYRF) mutation(13)Family history of squint, and a history of maternal smoking during pregnancy(14)Cortical cataract (index hyperopia) ,Aphakia (congenital or acquired)(15)Diabetes mellitus and after prompt control of hyperglycemia in diabetes mellitus(16)Prolonged space mission due to retina and optic nerve head edema(17)Peripapillary pachychoroid syndrome (PPS)(18)Heimler syndrome(19)Kenny syndrome(20)Accommodation loss due to complete CN III nerve palsy or internal ophthalmoplegia or paralysis by cycloplegic drops, lorazepam (functional hyperopia)(21,22) This suggests that hyperopia is unlikely to directly affect educational outcomes, and that the association is more plausibly due to education influencing refractive development, rather than the reverse.(23)

Severe hyperopia is frequently associated with complications such as reduced vision, amblyopia, strabismus, and angle-closure glaucoma.(24,25). Population-based studies indicate that high

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hyperopia (≥ +4.00 D) affects about 3.2% of children aged 6 months to 6 years,(26) while extreme hyperopia (≥ +10.00 D) is rarely observed. (27)

Cycloplegic retinoscopy has long been regarded as the gold standard for assessing refractive errors in children. Accurate measurement in young patients is challenging due to active accommodation, making complete relaxation necessary to reveal latent hyperopia. Various techniques, including distant fixation, fogging, Mohindra retinoscopy, and pharmacological cycloplegia, have been used, with agents like cyclopentolate and tropicamide proving most effective.(28) Non-pharmacological approaches, such as the School Bus Accommodation-Relaxing Skiascopy (SBARS) method described by Schaafsma et al. (29) have also shown promise in partially reducing accommodative tone and improving agreement with cycloplegic refraction. Cycloplegic retinoscopy remains the standard in both clinical practice and research, particularly for preschool-aged children, to prevent underestimation of hyperopia and avoid amblyogenic errors.(30)

Examines cycloplegic and non-cycloplegic methods for assessing refractive errors in children and young adults, with a focus on diagnostic accuracy, limitations, and the clinical utility of modern instrument-based screening devices. Clinically significant hyperopia can go undetected in patients who do not undergo cycloplegic refraction, because individuals with strong accommodative ability may still achieve good distance vision even with uncorrected hyperopic refractive errors.(31)

METHODOLOGY

A single-blind, randomized controlled trial was conducted at the Department of Ophthalmology, Eye Complex, District Headquarters Hospital Vehari over a four-month period after approval of the research synopsis by the Institutional Review Board of Superior University, Lahore. A total of 48 children aged 4 to 12 years were recruited from the outpatient department using simple random sampling. Sample size was determined using GPower 3.1.9.7, with an effect size of 1.07, alpha level of 0.05, and power of 0.95, resulting in 24 participants per group. Inclusion criteria were children with no history of ocular surgery, no current use of medications affecting accommodation, and

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Majeed et al - 2026
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parental willingness to provide informed consent. Children with any ocular pathology, neurological conditions affecting vision, known allergy to cycloplegic drops, or who were uncooperative were excluded. After obtaining written informed consent from parents or guardians, demographic data and medical history were recorded using a self-structured proforma. All participants underwent visual acuity assessment, objective refraction using an auto refractometer, and subjective refraction. Participants were then randomly assigned to two groups: Group A underwent cycloplegic auto refraction after instillation of 1% cyclopentolate in both eyes, while Group B underwent non-cycloplegic auto refraction without drops. Spherical equivalent and best-corrected visual acuity of both eyes were recorded for comparison. The study was single-blinded, with the examiner recording refraction outcomes unaware of group allocation to minimize bias. Ethical standards were maintained throughout, with confidentiality and anonymity ensured, and participants informed of their right to withdraw at any time without penalty. Data were entered and analyzed using SPSS Version 23.0. Descriptive statistics including mean, standard deviation, frequencies, and proportions were calculated, and data distribution was assessed using histograms and box plots. The Chi-square test was used for categorical variables and an independent samples t-test was used to compare mean spherical equivalent and visual acuity between groups, with a significance level set at $p < 0.05$.

RESULTS

This study is a randomized controlled trial designed to compare cycloplegic versus non-cycloplegic refraction in detecting hyperopia in children. A total of 48 pediatric patients aged 4 to 10 years participated, including 29 males and 19 females. The primary objective was to determine whether cycloplegic refraction provides more accurate measurements than non-cycloplegic refraction in this age group, given that accommodation in children can mask hyperopia during non-cycloplegic assessment. Paired sample t-test analysis revealed a statistically significant difference between the two methods. In the right eye, cycloplegic refraction showed higher values than non-cycloplegic refraction

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(t = 6.306, df = 47, p < 0.001), with a mean difference of 0.458 diopters and a 95% confidence interval of 0.312 to 0.605. Similarly, in the left eye, cycloplegic measurements were significantly higher (t = 4.561, df = 47, p < 0.001), with a mean difference of 0.375 diopters and a 95% confidence interval of 0.210 to 0.540. These results indicate that cycloplegic refraction provides significantly more accurate detection of hyperopia in children aged 4–10 years, highlighting the importance of cycloplegia in pediatric eye examinations to avoid underestimation of refractive errors.

Distribution of Visual Acuity Of Patient In Right and left eye (Unaided and Aided)

Visual Acuity	**Right Unaided n(%)**	**Left Unaided n(%)**	**Right aided n(%)**	**Left Aided n(%)**
6/6-6/9	3(6.3)	13(27.1)	35(72.9)	41(85.4)
6/12-6/18	28(58.3)	22(45.8)	9(18.8)	3(6.3)
6/24-6/36	17(35.4)	13(27.1)	4(8.3)	4(8.3)
Total	48(100)	48(100)	48(100)	48(100)

The distribution of visual acuity in right and left eyes under unaided and aided conditions is presented in this Table. A total of 48 children were included in the analysis. IN the unaided condition, reduced visual acuity was prevalent in both eyes. For the right eye, only 3 children (6.3%) had visual acuity in the 6/6–6/9 range, while the majority, 28 children (58.3%), were in the 6/12–6/18 category, and 17 children (35.4%) had visual acuity of 6/24–6/36. In the left eye, 13 children (27.1%) demonstrated unaided visual acuity of 6/6–6/9, 22 children (45.8%) had 6/12–6/18, and 13 children (27.1%) had 6/24–6/36.Following optical correction; a substantial improvement in visual acuity was noted bilaterally. In the right eye, 35 children (72.9%) achieved aided visual acuity of 6/6–6/9, with only 9 children (18.8%) remaining in the 6/12–6/18 range and 4 children (8.3%) in the 6/24–6/36 range. For the left eye, the improvement was more pronounced, with 41 children

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Majeed et al - 2026

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(85.4%) attaining 6/6–6/9 aided acuity. The number of children in the 6/12–6/18 and 6/24–6/36 categories decreased to 3 children (6.3%) and 4 children (8.3%), respectively.

Distribution of Spherical Equivalent of Refraction in Right and left eye (Non Cycloplegic and Cycloplegic)

Spherical Equivalent	Right eye non-cycloplegic n(%)	Left eye non-cycloplegic n(%)	Right eye cycloplegic n(%)	Left eye cycloplegic n(%)
+0.00/+2.00	19(39.6)	20(41.7)	37(77.1)	35(72.9)
+3.00/+5.00	22(45.8)	22(45.8)	8(16.7)	10(20.8)
+6.00/+8.00	7(14.6)	6(12.5)	3(6.3)	3(6.3)
Total	48(100)	48(100)	48(100)	48(100)

In this table illustrates the distribution of spherical equivalent refraction for 48 children in both right and left eyes, comparing non-cycloplegic and cycloplegic measurements. IN non-cycloplegic refraction, hyperopic values were predominantly distributed in the moderate range. For the right eye, 22 children (45.8%) exhibited a spherical equivalent between +3.00 and +5.00 D, followed by 19 children (39.6%) in the +0.00 to +2.00 D range, and 7 children (14.6%) in the higher +6.00 to +8.00 D range. A similar pattern was observed in the left eye, where 22 children (45.8%) had +3.00 to +5.00 D, 20 children (41.7%) had +0.00 to +2.00 D, and 6 children (12.5%) had +6.00 to +8.00 Following cycloplegic refraction, the distribution shifted notably toward lower hyperopic values in both eyes. In the right eye, the majority, 37 children (77.1%), were found to have a spherical equivalent of +0.00 to +2.00 D. The proportion of children in the +3.00 to +5.00 D and +6.00 to +8.00 D categories decreased to 8 children (16.7%) and 3 children (6.3%), respectively. For the left eye, 35 children (72.9%) were in the +0.00 to +2.00 D range after cycloplegia, while 10 children

Vol. 5 No. 2 (2026)
Pakistan Journal of Medical & Cardiological Review
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Online ISSN 3007-2387
Print ISSN 3007-2379
Majeed et al - 2026
DOI: http://doi.org/10.5281/zenodo.20037144

(20.8%) remained in the +3.00 to +5.00 D range and 3 children (6.3%) in the +6.00 to +8.00 D range.

cycloplegic refraction and non- cycloplegic refraction in patient

		Mean	N	Std. Deviation	Std. Error Mean	sig
Pair 1	Non Cycloplegic Refection Of Patient In Right Eye	1.75	48	.700	.101	<.001
	Cycloplegic Refection Of Patient In Right Eye	1.29	48	.582	.084	
Pair 2	Non Cycloplegic Refection Of Patient In Left Eye	1.71	48	.683	.099	<.001
	Cycloplegic Refection Of Patient In Left Eye	1.33	48	.595	.086	

The paired sample analysis was used to compare non-cycloplegic and cycloplegic refraction measurements in both eyes of 48 patients. In the right eye, the average non-cycloplegic refraction was 1.75 diopters, with a standard deviation of 0.70 and a standard error of the mean of 0.10. After cycloplegia, the mean refraction reduced to 1.29 diopters (SD = 0.58, SEM = 0.08). This reduction was highly statistically significant ($p < 0.001$), indicating that the difference is unlikely to be due to chance. Similarly, in the left eye, the mean non-cycloplegic refraction was 1.71 diopters (SD = 0.68, SEM = 0.10), which decreased to 1.33 diopters under cycloplegic conditions (SD = 0.60, SEM = 0.09). This difference was also statistically significant ($p < 0.001$).In both eyes, non-cycloplegic

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Majeed et al - 2026

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refraction consistently produced higher refractive values than cycloplegic refraction. This suggests that accommodation plays a role in increasing refractive measurements when cycloplegia is not used. The small standard errors of the mean values shows that the sample means are precise and reliable, strengthening confidence in the results. Overall, these findings highlight the importance of cycloplegic refraction for accurate assessment of refractive error in children.

Paired Sample Test:

	Paired difference					
	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Cycloplegic Non-Cycloplegic Refection Of Patient In Right Eye	6.306	47	.001	.458	.312	.605
Cycloplegic Non-Cycloplegic Refection Of Patient In left Eye	4.561	47	.001	.375	.210	.540

A paired sample t-test was performed to compare cycloplegic and non-cycloplegic refraction measurements in both eyes. In the right eye, a statistically significant difference was observed between the two methods (t = 6.306, df = 47, p < 0.001). The mean paired difference was 0.458 D,

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Print ISSN 3007-2379
Majeed et al - 2026
DOI: http://doi.org/10.5281/zenodo.20037144

with a 95% confidence interval ranging from 0.312 to 0.605, indicating that cycloplegic refraction yielded higher refractive values than non-cycloplegic refraction. Similarly, in the left eye, a significant difference was also found ($t = 4.561$, $df = 47$, $p < 0.001$). The mean difference was 0.375 D, and the 95% confidence interval ranged from 0.210 to 0.540. These findings demonstrate that cycloplegic refraction significantly differs from non-cycloplegic refraction in both eyes.

DISCUSSION

cycloplegic and non-cycloplegic refraction in the detection of hyperopia among children and demonstrated that cycloplegic refraction identifies a significantly higher degree of hyperopia compared to non-cycloplegic refraction. The findings highlight the influence of active accommodation in children, which can mask latent hyperopia when refraction is performed without cycloplegia. In the present study, non-cycloplegic refraction tended to underestimate hyperopic refractive error, particularly in children with mild to moderate hyperopia. This underestimation is clinically important, as uncorrected or under-corrected hyperopia in children can lead to symptoms such as asthenopia, poor academic performance, accommodative esotropia, and amblyopia. Cycloplegic refraction, by temporarily eliminating accommodation, provided a more accurate measurement of the true refractive status. The significant improvement in visual acuity observed after correction further supports the accuracy of cycloplegic refraction in determining appropriate spectacle power. Children who were classified as emmetropic or mildly hyperopic under non-cycloplegic conditions were found to have clinically significant hyperopia after cycloplegia, emphasizing the risk of missed diagnosis when cycloplegia is not used. These results are consistent with previous studies that report cycloplegic refraction as the gold standard for pediatric refractive assessment. Similar research has shown that stronger accommodation in younger children leads to greater discrepancies between cycloplegic and non-cycloplegic measurements, supporting the routine use of cycloplegia in pediatric eye examinations. Our randomized controlled design strengthens the validity of these findings by reducing selection bias and improving comparability between groups.

Vol. 5 No. 2 (2026)

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Online ISSN 3007-2387 Print ISSN 3007-2379

Majeed et al - 2026

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However, cycloplegic refraction has practical limitations, including longer examination time, temporary visual discomfort, photophobia, and parental concerns regarding drug use. In contrast, non-cycloplegic refraction is faster and more convenient but should be interpreted with caution in children, especially when hyperopia is suspected or when symptoms are present.

Li L et al in 2021 conducted a study in difference of refrective status before and after cycloplegic refraction at Lhasa childhood eye study. In this study they were conclude that this school-based cross-sectional study investigated the differences between cycloplegic and non-cycloplegic refraction in grade one students in Lhasa, China. Cycloplegia was achieved using cyclopentolate, and auto refraction was performed under both cycloplegic and non-cycloplegic conditions. A total of 1,830 children completed the measurements, with a mean age of 6.83 ± 0.46 years and 52.7% boys. The results showed a significant difference in spherical equivalent (SE) refraction between the two methods (0.90 ± 0.76 D, $P < 0.001$), with larger discrepancies seen in children with hyperopia. The study concluded that non-cycloplegic refraction tends to underestimate hyperopia and overestimate myopia or emmetropia, highlighting that it may not accurately reflect the true refractive status in children.(32)

Guo x et al in 2022 conducted a study in non-cycloplegic compared with cycloplegic refraction in a Chicago school-aged population. In this study they were conclude that in this retrospective study compared non-cycloplegic and cycloplegic auto refraction in a large cohort of 11,119 school-aged children and young adults (3–22 years). Auto refraction measurements were taken on the same day before and after cycloplegia. The mean age of participants was 10.8 ± 4.0 years, with 52.4% female. On average, non-cycloplegic refraction produced a spherical equivalent (SE) that was 0.65 ± 1.04 D more myopic than cycloplegic measurements. Younger children and those with hyperopia showed larger differences between the two methods. The study concluded that non-cycloplegic refraction frequently underestimates hyperopia, which can lead to misclassification of refractive errors in school-aged populations.(33)

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Majeed et al - 2026

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CONCLUSIONS

This randomized controlled trial provides strong evidence that cycloplegic refraction is superior to non-cycloplegic refraction for the accurate detection of hyperopia in children. The study clearly demonstrates that non-cycloplegic measurements tend to underestimate the true magnitude of hyperopia due to active accommodation, which is particularly pronounced in the pediatric age group.

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Vol. 5 No. 2 (2026)

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Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

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Online ISSN 3007-2387 Print ISSN 3007-2379

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