RESEARCH ARTICLE

Comparison of cycloplegic refraction in children with different iris colour categories: A cross- sectional survey

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Abstract

Objective: To compare the cycloplegic refraction in children with different iris colour categories and age groups.

Methods: The cross-sectional study was conducted from December 2022 to June 2023 at the Eye Clinic of Sehat Medical Complex, Hanjarwal, Lahore, and Khizar Eye Centre, Lahore, Pakistan, and comprised hyperopic children aged 5-12 years of either gender. Data regarding age, gender, iris colour, auto-refraction and retinoscopy before and after cycloplegic refraction was collected using a structured proforma. Data was analysed using SPSS 21.

Results: Of the 139 subjects, 73(52.5%) were males and 60(47.5%) were females. There were 79(56.8%) subjects aged 5-8 years and 60(43.2%) aged 9-12 years. The iris colour distribution was 23(16.5%) light, 80(57.6%) medium and 36(25.9%) dark, with a mean visual acuity of 0.7±0.6. There was a significant difference in non-cycloplegic and cycloplegic refraction for different iris colours and age groups ($p<0.05$).

Conclusion: Children with light iris colour accommodated more and needed a low concentration of cyclopentolate compared to those with medium and dark iris colours. More accommodation was noted among children aged 9-12 years.

Keywords: Cycloplegic refraction, Cyclopentolate, Hyperopia, Iris, Ocular refraction, Retinoscopy.

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Introduction

Uncorrected significant refractive error is a widespread and critical issue, particularly among children.[1] It can significantly impact both educational and psychosocial development, highlighting the importance of addressing this issue.[2] Hyperopia is a prevalent cause of visual impairment in both children and adults, and has emerged as a global public health concern because of its increasing prevalence.[3] Hyperopia, also known as farsightedness, is a common refractive error in children where light is not properly focussed on the retina, but rather falls behind it. Accommodation can temporarily correct this issue, allowing for clear vision, but, over time it can lead to eye fatigue and strain.[4] Severe childhood hyperopia, accompanied by accommodation and binocular function issues, can cause motor and sensory problems, and may lead to asthenopia symptoms.[5]

Refraction plays a crucial role in paediatric eye examinations to detect and treat refractive errors in children, preventing permanent vision loss and affecting academic performance. Retinoscopy, performed with free-floating or close-range lenses, requires patient compliance and phoropter cooperation. However, it can be challenging and time-consuming, especially for young and older children.[6] Cycloplegic drugs are used to evaluate refractive errors in patients, dividing refraction into cycloplegic and non-cycloplegic categories. Cycloplegic drugs temporarily paralyse ciliary muscles, while non-cycloplegic refraction is performed without drugs, allowing for total refractive error determination.[7]

Clinical studies recommend to conduct cycloplegic refraction before finalising the spectacle prescription, especially for individuals who are using spectacles for the first time, patients who are not yet presbyopic, children, and individuals with accommodative or binocular vision issues. Post mydriatic test (PMT) involves performing subjective refraction after the effects of the cycloplegic drug have worn off to determine the appropriate spectacle prescription.[8] Cycloplegic examinations for paediatric patients require careful consideration of factors like agent choice, dosage, instillation method and side effects. However, inconsistencies in practice methods can limit results' accuracy and delay patient care.[9] Cyclopentolate is a commonly used cycloplegic agent for children, causing 1 hour of cycloplegia, similar to 3 days of atropine, making it a preferred choice in clinical settings.[10]

Assessing refractive errors is a crucial aspect of eye care, especially in cases of hyperopic children, pseudomyopia, anterior uveitis, childhood myopia treatment, idiopathic vision loss, and pre-refractive surgery examinations. This makes it a preferred choice for ophthalmologists and optometrists. Notably, these findings have been supported

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by numerous studies.[11]

Residual accommodation was observed to track the duration of cycloplegia following the administration of 1% cyclopentolate hydrochloride in the form of a single drop, which had a volume of 29.3 microliters.[12] To achieve an accurate refraction in children aged <12 years, especially when dealing with latent hyperopia or uncooperative children, full cycloplegia is recommended.[13] Cyclopentolate induces cycloplegia for 12-24h The use of these disposable eye drops for cycloplegic refraction in clinical settings is significantly more convenient and hygienic.[14] To achieve effective cycloplegia with minimal systemic side effects, an appropriate dosage of cyclopentolate is necessary.[15]

Iris colour, influenced by racial and genetic factors, protects ocular tissue by regulating melanin concentration in melanocytes. It is categorised into blue, green-hazel and brown. Iris pigments protect tissues from harmful ultraviolet (UV) rays. Darker iris individuals are at higher risk for cataracts, while lighter ones face increased macular degeneration and melanoma.[16]

The current study was planned to compare the cycloplegic refraction in children with different iris colour categories and age groups.

Patients and Methods

The cross-sectional study was conducted from December 2022 to June 2023 at the Eye Clinic of Sehat Medical Complex, Hanjarwal, Lahore, and Khizar Eye Centre, Lahore, Pakistan. After approval from the ethics review committee of the University of Lahore, the sample size was determined using G*Power[17] calculator with effect size of parent study.[18] The sample was raised using non-probability purposive sampling technique. Those included were hyperopic children of either gender aged 5-12 years. Children with strabismus, amblyopia, heterochromia, nystagmus, mental disability, or any history of ocular surgery were excluded. Informed written consent was obtained from the parents of the children before collecting any data.

The data collected included age, gender, iris colour auto-refraction and retinoscopy results before and after cycloplegic refraction. A structured proforma was used to record this information. Visual acuity was recorded using a decimal acuity chart at a distance of 6 m. The iris colour was assessed and classified as light, medium or dark. The children were divided into two age groups: 5–8 years and 9–12 years. Cyclopentolate 1% was administered as the cycloplegic agent, and three drops were instilled at 20-min intervals. All participants underwent auto-refraction with a Topcon model KR800, followed by both retinoscopy with a Heine Retinoscope and subjective refraction without cycloplegia.

Data was analysed using SPSS 21. Astigmatic eye wearing a spherical lens experienced meridional balance, and this was the spherical equivalent (SE) which was calculated by adding 1/2 of the cylinder power to the sphere power algebraically to find the SE. Next, the axis and cylinder power were eliminated from the equation. Mean SE was worked out, and it was compared with different iris colour categories and age groups. Paired sample t-test was used as appropriate.

Results

Of the 139 subjects, 73(52.5%) were males and 60(47.5%) were females. There were 79(56.8%) subjects aged 5-8 years and 60(43.2%) aged 9-12 years. The iris colour distribution was 23(16.5%) light, 80(57.6%) medium and 36(25.9%) dark, with a mean visual acuity of 0.7±0.6. In both eyes with cycloplegic refraction, the mean SE difference in light iris colour was +2.00 diopter sphere (DS), +1.50 DS with medium iris colour, and +1.00 DS with dark iris colour in both eyes, indicating that children with light iris colour accommodated more and needed low concentration of cyclopeantolate 1% compared to other iris colours (Table 1).

There was a significant difference between non-cycloplegic and cycloplegic refraction for varying iris colours (Table 2), whereas the mean SE difference was +1.00 DS for children aged 5-8 years and +1.50 DS in both eyes of children aged 9-12 years (Table 3), indicating that children aged 9-12 years accommodated more compared to the other age group. The difference with regard to non-cycloplegic and cycloplegic refraction in the two age groups was significant (Table 4).

Table-1: Comparison among light, medium and dark iris colour categories regarding the spherical equivalent mean difference before and after cycloplegic refraction.

Iris Colour	Cycloplegic Refraction	Spherical Equivalent (Mean)	Mean Difference
Light	Before	+3.00D	+2.00D
	After	+5.00D	
Medium	Before	+4.00D	+1.50D
	After	+5.50D	
Dark	Before	+3.50D	+1.00D
	After	+4.50D	

Table-2: Significance of non-cycloplegic and cycloplegic refraction.

Iris colour	Paired sample t test		t-test	df	Sig. (2–tailed)
Light	Pair 1	Non Cycloplegic OS - Cycloplegic OS	-6.042	22	0.000
	Pair 2	Non Cycloplegic OS - Cycloplegic OS	-7.673	22	0.000
Medium	Pair 1	Non Cycloplegic OD - Cycloplegic OD	-16.271	79	0.000
	Pair 2	Non Cycloplegic OS - Cycloplegic OS	-14.656	79	0.000
Dark	Pair 1	Non Cycloplegic OD – Cycloplegic OD	-6.993	35	0.000
	Pair 2	Non Cycloplegic OS - Cycloplegic OS	-6.542	35	0.000

Table-3: Comparison of spherical equivalent mean differences before and after cycloplegic refraction between two age groups of children.

Age-Group	Cycloplegic Refraction	Spherical Equivalent (Mean)	Mean Difference
5-8 years	Before	+3.50D	+1.00D
	After	+4.50D	
9-12 years	Before	+4.50D	+1.50D
	After	+6.00D	

Table-4: Comparison of two age groups for non-cycloplegic and cycloplegic refraction.

Age	Paired sample t test		t-test	df	Sig. (2–tailed)
5-8 years	Pair 1	Non Cycloplegic OS - Cycloplegic OS	-14.902	78	0.000
	Pair 2	Non Cycloplegic OS - Cycloplegic OS	-13.330	78	0.000
9-12 years	Pair 1	Non Cycloplegic OD - Cycloplegic OD	-10.273	59	0.000
	Pair 2	Non Cycloplegic OS - Cycloplegic OS	-11.068	59	0.000

Discussion

Approximately 12.8 million children worldwide are affected by uncorrected refractive error, which plays a major role in causing visual impairment among school-age children.[19] Cycloplegic refraction is widely recognised as the most accurate method for diagnosing refractive errors in children. However, it may cause discomfort and can be time-consuming for the child.[20] A total of 139 children aged 5-12 years participated in the current study. The children's iris colour was categorised into three types: light, medium and dark. The study found that children with light iris colour had a higher level of accommodation than those with other iris colours, while children aged 9-12 years accommodated more compared to the other age group when comparing the mean SE difference. In Iran, a study investigated the relationship involving iris colour refractive errors, amblyopia and strabismus in 7-year-old children, and revealed that most participants (90%) had dark or medium brown irises. It was advised to pay special attention to individuals with yellow or green eyes during screening because they were more prone to hyperopia. In addition, when conducting refraction examinations in these children, the presence of hyperopia should be considered.[16] In 2022, a study in Chicago compared non-cycloplegic and cycloplegic refraction among school-aged individuals, and revealed that most participants (>75%) exhibited a difference of <1DS in their myopic SE when non-cycloplegic auto-refraction was used instead of cycloplegic auto-refraction.[21]

A study was conducted on hypermetropic children using 1% cyclopentolate and tropicamide in a randomised clinical trial to investigate the impact of eye colour and skin pigmentation on refractive outcome and residual accommodation. The findings revealed that skin pigmentation, rather than iris pigmentation, played a crucial role in determining the effectiveness of cycloplegics. It is essential to consider the limitations of cycloplegic regimens in children with dark irises or pigmentation.[22]

A recent study explored the impact of varying doses of 1% cyclopentolate on cycloplegic refraction in hypermetropic individuals with brown irises. The results revealed that after three doses, the mean hypermetropia was significantly greater than that after a single dose. However, there was no significant difference between the two and three doses. Factors such as gender, age, and the presence/type of horizontal deviation did not have a notable influence. Therefore, it concluded that administering two drops of 1% cyclopentolate, spaced 10 minutes apart, was sufficient to achieve adequate cycloplegia in hypermetropes.[23]

In 2018, a study to assess the precision of non-cycloplegic refraction performed at school screening camps demonstrated a certain level of inconsistency between non-cycloplegic refraction performed in school camps and in traditional eye clinics. However, the results indicated that the accuracy fell within 0.5DS of SE in 92.62% cases for refreactive error up to 4.5DS of myopia, 3DS of cylinder, and 1.5DS of hyperopia.[19]

A study in 2018 investigated the effects of cycloplegia on the measurement of refractive error in Chinese children, and indicated that non-cycloplegic auto-refraction was inadequate and imprecise for evaluating refractive error. Thus, alternative methods should be considered when studying refractive error in the Chinese children's population.[18]

Of the 15 studies comparing the accuracy of auto-refraction and cycloplegic retinoscopy in children, 13 found a small difference in SE or sphere, indicating that cycloplegic auto-refraction was suitable for population-based studies in children. However, it was also concluded that cycloplegic retinoscopy could be useful in individual clinical cases to confirm the accuracy of auto-refraction, especially when visual acuity was lower than expected or when auto-refraction results did not align with expected findings.[6]

Another study in 2017 examined the variance between cycloplegic and non-cycloplegic auto-refraction in children living in the urban areas of Beijing. The findings showed that as hyperopic refraction increased, there was a corresponding increase in the difference in SE among the children. In addition, a greater difference in SE was associated with the progression of refractive error in myopic patients, but not with the onset of myopia.[24]

The current study has limitations as the sample size was not large enough to accurately reflect the entire population. Furthermore, the study was carried out at two eye clinics in Lahore, restricting the generalisability of the findings.

Multi-centre studies with a large sample size and diverse population are needed to validate the findings.

Conclusion

Children with lighter-coloured irises tended to have a greater accommodation ability and required less cyclopentolate than those with medium or dark iris colours. Further, children aged 9-12 years tended to use more accommodation, indicating the continuous development of their visual system during this crucial developmental stage.

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Author Contribution:

AA: Concept, writing and drafting.
QMO: Methodology.
SB: Data analysis.SSZ: Data collection and editing.