Necessity of Cycloplegia for Assessing Refractive Error in 12-Year-Old Children: A Population-Based Study

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PURPOSE: To compare pre- and postcycloplegic autorefraction in two separate age samples of Australian school children.

DESIGN: Population-based cross-sectional study of random cluster samples.

METHODS: Autorefraction was performed before and after cycloplegia, using 1% cyclopentolate, in the right eyes of 2,233 12-year-old and 210 6-year-old children.

RESULTS: The mean spherical equivalent (SEQ) difference between these measures was 0.84 diopters (D) (95% confidence interval (CI) 0.81 to 0.87 D), more hyperopic in post- than precycloplegic autorefractive assessments in the 12-year-old children and 1.18 D (95% CI 1.05 to 1.30 D) more hyperopic in the 6-year-old children. Precycloplegic autorefraction substantially overestimated the proportion of children with myopia, misclassifying 17.8% aged 12 years and 9.5% aged 6 years. Conversely, precycloplegic autorefraction did not detect moderate to high hyperopia in 2.28% of 12-year-olds and 17.14% of 6-year-olds.

CONCLUSIONS: Our findings reinforce the importance of using cycloplegic autorefraction in children up to age 12 years. (Am J Ophthalmol 2007;144:307–309.

INCREASINGLY, CYCLOPLEGIA USING 1% CYCLOPENTOLATE has been adopted for population-based studies of refractive error in children.[1–3] However, the age range for which cycloplegic refraction is needed is not yet established (www.ClinicalTrials.gov Identifier NCT00347347). In this article, we present data from a large population-based study on the differences in refraction in children (n = 2,500) on whom postcycloplegic autorefraction was performed.

The Sydney Myopia Study[3] sample was drawn from randomly selected schools, stratified by socioeconomic status. Written consent from at least one parent and child assent was obtained, with a participation rate of 75.3%. Pre- and postcycloplegic autorefraction data were available for 2,233 children age 12 years. A subsample of 6-year-old children (n = 210) who had precycloplegic autorefraction because of presenting visual acuity <0.2 logMAR is included for comparison.

Autorefraction measurements were made (Canon RK-F1, Tokyo, Japan) both before and after cycloplegia (cyclopentolate 1% and tropicamide 1%) after amethocaine hydrochloride (0.5%). Children with significant ocular pathology (n = 10), uncorrected visual acuity <20/200, or incomplete data (n = 47) were excluded. Myopia was defined as spherical equivalent (SE) ≤−0.50 D, emmetropia SE >−0.50 D to <+0.50 D, mild hyperopia SE ≥0.50 D to <+2.00 D and clinically significant hyperopia as SE ≥+2.00 D. Astigmatism was defined as cylinder ≥1.00 D.

The mean SE difference, with 95% confidence intervals (CI), was calculated as the postcycloplegic value minus the precycloplegic value. Kappa statistics assessed agreement on classification of refractive error before and after cycloplegia, using Statistical Analysis System software (SAS Institute, Cary, North Carolina, USA). The sensitivity and specificity of precycloplegic measurements for the diagnosis of refractive category were assessed against postcycloplegic values.

In the 12-year-old sample, the mean precycloplegic SE was myopic (−0.25 D, 95% CI −0.20 to −0.29 D), whereas the corresponding mean postcycloplegic SE was hyperopic (0.59 D, 95% CI 0.55 to 0.64 D). A mean hyperopic shift of 0.84 D (95% CI 0.81 to 0.87 D) occurred after cycloplegia. A progressive reduction in this shift with increasing myopic refraction (1.67 D in children with moderate to high hyperopia, 1.02 D in mild hyperopia, 0.50 D in emmetropia, and 0.25 D in myopia) was evident. A similar mean hyperopic shift was found for children aged 6 years (1.18 D, 95% CI 1.05 to 1.30 D).

Using precycloplegic measures to define refractive category (Table), 17.8% of 12-year-old children and 9.5% of 6-year-olds were misclassified as myopic. Similarly, 2.2% of the 12-year-old group and 17.1% of those aged 6 years with moderate to high hyperopia were misclassified as mildly hyperopic. Astigmatism was also overestimated in 3.3% of the 6-year-olds and in 1.0% in the 12-year-olds. The kappa values showed high diagnostic agreement for astigmatism, but not for other refractive errors (Table).

Precycloplegic autorefraction had a low sensitivity to detect hyperopia (Table), but a high specificity (100%) for detecting moderate to high hyperopia. It also had a high sensitivity (99%) but low specificity (35%) for detecting myopia. In the 12-year-old sample, the mean pre- and postcycloplegia difference was similar for boys and girls (adjusted mean differences +0.83 D for boys and +0.85 D for girls, $P = .648$), and across ethnic groups (+0.81 D for Caucasian, +0.85 D for East Asian, $P = .517$), or by presence of parental myopia (+0.82 D with myopia and +0.85 D without myopia, $P = .51$).

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TABLE. Comparison of Postcycloplegic and Precycloplegic Autorefraction in 12-Year-Old Children

Refractive Status	Postcycloplegic 95% CI	Postcycloplegic n	Precycloplegic 95% CI	Precycloplegic n	Sensitivity %	Specificity %	Kappa Value
Myopia	9.8 (8.6–11.1)	219	27.6 (25.8–29.5)	617	99.1	35.2	0.30*
Emmetropia	25.9 (24.1–27.8)	579	60.6 (58.5–62.6)	1353	67.9	29.1	
Hyperopia							
Mild	60.8 (58.7–62.8)	1357	10.6 (9.3–11.9)	236	13.9	80.1	
Significant	3.5 (2.7–4.3)	78	1.2 (0.8–1.7)	27	34.6	100.0	
Astigmatism	6.4 (5.4–7.5)	142	7.4 (6.3–8.6)	165	78.9	67.9	0.70†

CI = confidence interval.

Emmetropia = spherical equivalent (SE) >-0.50 to $<+0.05$ diopters (D), myopia = SE ≤-0.05 D, mild hyperopia = SE $\geq+0.05$ to $<+2.00$ D, moderate to high hyperopia = SE >2.00 D, astigmatism = cylinder >1.00 D.

*Weighted Kappa.

†Simple Kappa.

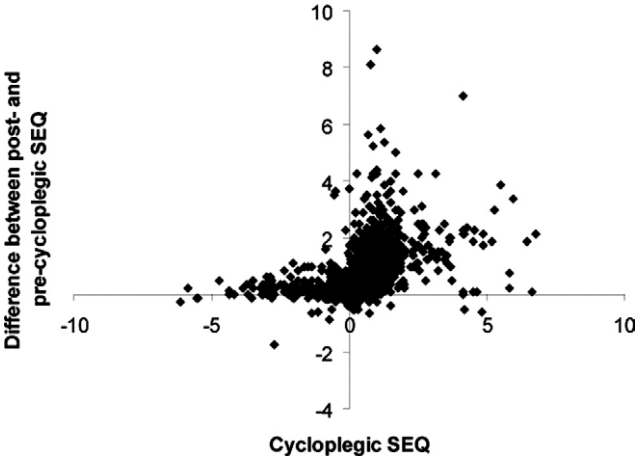

FIGURE 1. The postcycloplegic autorefractions plotted against the difference between postcycloplegic and precycloplegic autorefractive spherical equivalent (SEQ) in 12-year-old children.

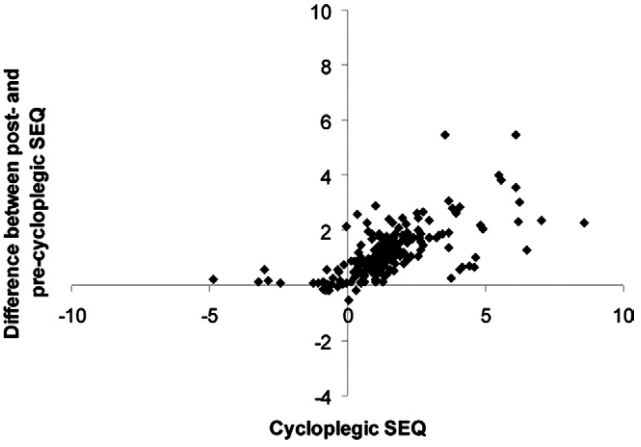

FIGURE 2. The postcycloplegic autorefractions plotted against the difference between postcycloplegic and precycloplegic autorefractive spherical equivalent (SEQ) in 6-year-old children.

Our findings confirm that noncycloplegic autorefraction overestimates the proportion with myopia[4] and underestimates significant hyperopia in children age 12 years. The hyperopic shift obtained after cycloplegia was influenced only by refractive error. We also found wide differences between pre- and postcycloplegic autorefraction measures in the 12-year-olds (Figure 1), similar to differences found in younger age groups (Figure 2).[5,6] Our findings, although limited to the use of autorefraction, are consistent with current knowledge that accommodation is stronger in younger children and presence of a hyperopic shift that decreases with age.[5–7] A shift of 0.84 D observed in children aged 12 years implies that cycloplegia remains important for autorefraction in this age group.

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Profile of the Retina by Optical Coherence Tomography in the Pediatric Age Group

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PURPOSE: To establish normative values of the retina in the pediatric population using optical coherence tomography (OCT).
DESIGN: Prospective observational case control study.
METHODS: Prospective study examining macular thickness and nerve fiber layer thickness in children with no ocular disease. After clinical examination, patients meeting the inclusion and exclusion criteria underwent OCT scanning.
RESULTS: Thirty-two eyes were examined for macular thickness and 25 eyes for nerve fiber layer thickness. Normative values are found in the Table. The average foveal thickness for children is 221 microns vs 182 microns in adults.
CONCLUSION: This study demonstrates normative values of retinal thickness and retinal nerve fiber layer (RNFL) thickness in the pediatric age group. Children have slightly thicker maculas than adults; the RNFL thickness is comparable to adults. (Am J Ophthalmol 2007;144: 309–310. © 2007 by Elsevier Inc. All rights reserved.)

OPTICAL COHERENCE TOMOGRAPHY (OCT) IS A HIGH-definition imaging system providing a high-resolution scan of the eye. This technology uses a scanning diagnostic laser, which can be used to study the retinal contour. Few reference data exist regarding normative values of retinal thickness across age distributions, ethnicities, and disease states. Preliminary studies have shown that retinal thickness changes with age and ethnicities.[1,2] The development of reference standards may allow for better investigation and detection of ocular disease in the children.

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TABLE. Retinal Profile in the Pediatric Age Group

	Mean	Standard Error	Confidence Interval 95%
Foveal thickness	221 microns	5.59	±10.9
Average total macular thickness	253 microns	2.16	±4.22
Total retinal volume	6.61 μm^3	0.104	±0.204
Average retinal nerve fiber layer thickness	100 microns	2.64	±5.18

The design of this study was one of a prospective study of healthy children with no underlying ocular disease. Patients were recruited from an outpatient ophthalmology office and received full eye examinations including a dilated fundus examination before enrolling in the study. After informed consent and parental permission, children meeting the inclusion and exclusion criteria underwent OCT scans examining macular thickness and retinal nerve fiber layer (RNFL) thickness. Patients between the ages of one and 18 were included in the study. Patients were excluded if they had an extreme refraction (greater than –7.00 diopters or +5.00 diopters), Snellen acuity worse than 20/40, history of intraocular surgery (including laser surgery), presence of a media opacity, or abnormality of the optic nerve or retina. Furthermore, patients with a history of diabetes or other systemic disease that might affect the eye were excluded.

Eighteen patients between the ages of six and 13 were recruited. Both eyes were examined for each patient, but scans of low quality, which provided uninterpretable data, were excluded from the study. Thirty-two eyes were scanned for macular thickness and 25 eyes for RNFL thickness. The average retinal thickness values are found in the Table. The average RNFL thickness (microns) is as follows per quadrant of the optic nerve: superior 122 ± 4.5; inferior 132 ± 3.9; nasal 76.4 ± 3.3; and temporal 73.5 ± 4.3.

This study demonstrates normative values of retinal thickness and RNFL thickness in the pediatric age group. These results showed that children tend to have thicker maculas than adults: children have an average foveal thickness of 221 (±10.9 microns) vs adults with a thickness of 182 (±23 microns).[3] The average RNFL thickness is comparable to adults. These normative values may help to better evaluate children with macular disease or childhood glaucoma.

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