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Clinical factors associated with moderate hyperopia in preschool children with normal stereopsis and visual acuity

Pediatric Eye Disease Investigator Group

Abstract

A total of 117 children 3–5 years of age with moderate hyperopia in at least one eye, age-normal unaided visual acuity, age-normal stereoacuity, no significant anisometropia or astigmatism, and no strabismus were enrolled in a 3-year randomized clinical trial to compare visual outcomes and ocular alignment in children assigned to immediate glasses or to observation and glasses if deterioration of visual acuity, stereoacuity, or alignment occurred. Pearson correlation coefficients were calculated to evaluate relationships among baseline characteristics. We found a moderate association between higher amounts of uncorrected hyperopia and greater accommodative lag ($n = 57$; $R = 0.31$; 95% CI, 0.05–0.53). Higher amounts of hyperopia were weakly associated with worse uncorrected distance visual acuity ($n = 117$; $R = 0.24$; 95% CI, 0.06–0.41), and better stereoacuity was weakly associated with better uncorrected near acuity ($n = 99$; $R = 0.24$; 95% CI, 0.04–0.42).

Although hyperopia of $> +2.50$ D has been shown to be associated with the development of strabismus and amblyopia by 4 years of age,^{1,2} there is controversy concerning early optical correction of moderate hyperopia and its effect on the prevention of strabismus or amblyopia. We are conducting a randomized, controlled, masked, multicenter clinical trial to compare visual acuity, stereoacuity, and development of strabismus in children 1–5 years of age with moderate hyperopia assigned either to immediate glasses or observation with glasses later if deterioration of visual acuity, stereoacuity, or alignment occurs. The current report describes relationships among baseline measurements in study participants 3–5 years of age.

Methods

Between April 2012 and August 2014, 67 academic- and community-based clinical sites enrolled 249 children 1–5 years of age with moderate hyperopia ($+3.00$ D to $+6.00$ D spherical equivalent [SE]) in at least one eye, astigmatism of ≤ 1.50 D in both eyes, no significant anisometropia (difference in SE refractive error ≤ 1.50 D SE), no heterotropia,

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and no previous treatment for refractive error, amblyopia, or strabismus. Consent forms compliant with the US Health Insurance Portability and Accountability Act of 1996 were approved by institutional review boards, and a parent or guardian of each child provided written informed consent.

The study consists of two primary cohorts divided by age, and data in the current report are limited to the 117 children in the older cohort (age 3–5 years). Additional eligibility criteria for the children in the older cohort were age-normal monocular distance ATS-HOTV³ visual acuity (20/50 or better for age 3 years, 20/40 or better for age 4 years, and 20/32 or better for age 5 years), age-normal stereoacuity (400 arcsec or better for 3-year-olds; 200 arcsec or better for 4- or 5-year-olds) by the Randot Preschool Test (Stereo Optical Co Inc, Chicago, IL), and 1 line of interocular difference in visual acuity. Data on binocular near visual acuity, measured using the ATS4 Near Acuity Test,⁴ were available for 99 children. Accommodative lag, the difference between the amount of accommodation accomplished versus required to focus on a near target, was measured in 57 children using monocular estimate method retinoscopy.⁵ Although accommodative lag was reported for 49% of subjects, characteristics of those with reported accommodative lag did not differ from that of those without (data not shown).

In order to measure habitual accommodation, children were tested without correction while viewing a target at 33 cm. Lenses were used momentarily to measure the accommodative response. Cycloplegic refraction was performed using drops containing cyclopentolate. All testing (protocol available at www.pedig.net) was performed by trained study-certified personnel.

Pearson correlation coefficients (R) and 95% confidence intervals were calculated to evaluate relationships among the following baseline characteristics, obtained without spectacle correction: refractive error, monocular distance visual acuity, binocular near visual acuity, accommodative lag, age, and stereoacuity. For monocular measures, averages of right and left eyes were used in analyses unless otherwise noted. Correlation strengths were interpreted using Dancey's categorization,⁶ with $R \leq 0.1$ suggesting no association and $R > 0.6$ a strong association. Analyses involving visual acuity at distance or near controlled for age. Analyses involving stereoacuity controlled for age and difference in spherical equivalent between the eyes. Analyses were performed using SAS version 9.3 (SAS Inc, Cary, NC).

Results

The average age of the 117 subjects was 4.4 years; 59% were female, 58% were white, 22% African American, 16% Hispanic, and 3% other. Average SE refractive error was +3.95 D in the more hyperopic eye and +3.61D in the other eye.

Greater hyperopia at baseline was moderately associated with greater accommodative lag ($N = 57$; $R = 0.31$; 95% CI, 0.05–0.53; Figure 1). When controlling for age, greater hyperopia was weakly associated with poorer monocular distance visual acuity ($N = 117$; $R = 0.24$; 95% CI, 0.06–0.41; Figure 2), and better binocular near visual acuity was moderately

associated with better monocular distance visual acuity in both the better-seeing eye ($N = 99$; $R = 0.35$; 95% CI, 0.16 to 0.51; Figure 3) and poorer-seeing eye ($N = 99$; $R = 0.34$; 95% CI, 0.15–0.51; Figure 3). Better binocular near visual acuity was weakly associated with better stereoacuity ($N = 99$; $R = 0.24$; 95% CI, 0.04–0.42) when controlling for age and difference in SE refractive error between the eyes.

The following characteristics were not associated with amount of hyperopia: age, binocular near visual acuity, stereoacuity, family history of strabismus, family history of amblyopia, and family history of either strabismus or amblyopia. There was no association between accommodative lag and binocular near visual acuity.

Discussion

In our study cohort, children with greater uncorrected hyperopia showed greater accommodative lag. Because larger amounts of hyperopia require more accommodation to focus at near, this finding is not surprising, and it is consistent with previous reports of increasing lag with increasing accommodative demand.⁷ Accommodative lag may be associated with near blur; therefore, clinicians should consider the possibility of blur with near work in children with uncorrected hyperopia and high accommodative lag despite our failure to find an association with near visual acuity.

Despite the fact that all children in this study had age-normal distance visual acuity, we found a correlation between hyperopia and uncorrected distance visual acuity. It may be that children with higher amounts of hyperopia cannot consistently sustain the accommodation necessary to perform well on visual acuity tests. Another possibility is that some of these children may have very mild reduction in visual acuity that was not severe enough to categorize them as outside the age-normal visual acuity range. However, this correlation was not observed for hyperopia and binocular near visual acuity, where a greater effect would be expected.

Our data were constrained by the eligibility criteria, which limit our ability to find associations that may be present in a population of children with normal distributions of hyperopia and visual acuity. Additionally, we can generalize only to children similar to those meeting this study's eligibility criteria: our results cannot be applied to children with larger or smaller amounts of hyperopia or poorer visual acuity or stereoacuity. Nevertheless, given the increased risk of strabismus and amblyopia associated with moderate hyperopia,^{1,2} our findings support the need for monitoring for potential problems in children with uncorrected moderate hyperopia, even in those with age-normal visual acuity and stereoacuity. Forthcoming results from the randomized trial will help answer whether there are any untoward effects resulting from delaying prescription of spectacles for children with moderate hyperopia.

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FIG 1.

Average accommodative lag versus average refractive error ($R = 0.31$). On average, 1 D more hyperopia is associated with 0.58 D more accommodative lag.

FIG 2.

Average monocular distance visual acuity versus refractive error ($R = 0.24$). On average, 1 D more hyperopia is associated with a reduction in distance visual acuity of 0.02 logMAR. This plot displays two points per child. Distance visual acuity in the right eye was plotted against spherical equivalent refractive error in the right eye; the same plot was performed for the left eye. Analyses are adjusted for age at baseline.

FIG 3.

Binocular near visual acuity versus monocular distance visual acuity in the better-seeing eye ($R = 0.35$) and separately in the poorer-seeing eye ($R = 0.34$). On average, a reduction in distance visual acuity in either the better-seeing eye or the poorer-seeing eye of 1.0 logMAR is associated with a reduction in binocular visual acuity at near of 0.48 logMAR, adjusting for age at baseline. Binocular near visual acuity was not reported for all subjects. Data was available for 99 of 117 subjects. Reasons for not completing the assessment are not known as this data was not collected.