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ORIGINAL ARTICLE

Prevalence of High Astigmatism, Eyeglass Wear, and Poor Visual Acuity Among Native American Grade School Children

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ABSTRACT

Purpose. The purpose of this study was to examine the prevalence of astigmatism and poor visual acuity and rate of eyeglass wear in grade school children who are members of a Native American tribe reported to have a high prevalence of large amounts of astigmatism.

Methods. Vision screening was conducted on 1,327 first through eighth grade children attending school on the Tohono O'odham Reservation. Noncycloplegic autorefraction was conducted on the right and left eye of each child using the Nikon Retinomax K+ autorefractor, and monocular recognition acuity was tested using ETDRS logarithm of the minimum angle of resolution (logMAR) letter charts.

Results. Tohono O'odham children had a high prevalence of high astigmatism (42% had ≥1.00 D in the right or left eye) and the axis of astigmatism was uniformly with-the-rule. However, only a small percentage of children arrived at the vision screening wearing glasses, and the prevalence of poor visual acuity (20/40 or worse in either eye) was high (35%). There was a significant relation between amount of astigmatism and uncorrected visual acuity with each additional diopter of astigmatism resulting in an additional 1 logMAR line reduction in visual acuity.

Conclusions. Uncorrected astigmatism and poor visual acuity are prevalent among Tohono O'odham children. The results highlight the importance of improving glasses-wearing compliance, determining barriers to receiving eye care, and initiating public education programs regarding the importance of early identification and correction of astigmatism in Tohono O'odham children.
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Key Words: astigmatism, prevalence, visual acuity, children, Native American

A high prevalence of large amounts of astigmatism has been documented among school-aged members of several Native American tribes.[1–10] However, there is disagreement as to whether prevalence of astigmatism increases, decreases, or remains stable across age in these populations. In the only longitudinal report of astigmatism in a Native American population that we are aware of, Dobson et al. reported that there was little change (mean of 0.04 D per year) in astigmatism among preschool Tohono O'odham children followed over an average of 1.4 years.[11] The available cross-sectional studies of Native American grade school children from other tribes have contradictory results. Some studies found no consistent increase or decrease in prevalence of astigmatism with age,[4,5,12,13] whereas others found evidence of a decrease of astigmatism with age.[2,9,14] Although the specific cause for discrepancies across studies is not clear, it is likely that differences in both genetic and environmental factors across tribes contribute to the lack of consistent findings in Native American populations.

Although there are many reports of a high prevalence of astigmatism among Native American children, several previous studies of Native American children have reported a low rate of eyeglass wear.[2,4,12,13] The high prevalence of astigmatism and low rate of eyeglass wear among Native American children of some tribes suggests that poor vision may represent a significant educational obstacle for a large number of Native American school children. Unlike children with high myopia, who can typically bring objects into focus at near, or children with hyperopia, who can typically bring objects into focus at distance and often at near, uncorrected astigmatic children experience persistent defocus because they cannot bring objects into focus at *any* viewing distances. However, little empiric data have been published concerning the effects of uncorrected astigmatism on visual acuity.[15–17]

The purpose of the present study is to examine the prevalence of astigmatism, rate of eyeglass wear, and the effects of astigmatism on visual acuity across a broad age range in grade school children who are members of the Tohono O'odham Nation, a Native American tribe in which a high prevalence of astigmatism has been reported.[7,8,10] We report the visual acuity results for the overall sample to determine the "everyday" acuity and the prevalence of poor visual acuity in this sample of children. In addition, we examine the relation between visual acuity and amount of astigmatism in children who were not wearing correction to determine the effect of various amounts of uncorrected astigmatism on visual acuity. Only refractive astigmatism measurements were used in primary data analyses, because previous reports have indicated that noncycloplegic autorefraction measurements of sphere have reduced reliability and validity.[18–24]

METHODS

Subjects

Subjects were grade school children enrolled in any of the six elementary schools located on the Tohono O'odham Reservation. Five of the schools are public schools, and one is a church-affiliated private school. Almost all of the children attending these schools are Native American and are members of the Tohono O'odham Tribe. Because of limited resources, we were unable to screen all the first through eighth grade children in the Tohono O'odham schools during one academic year. Therefore, our goal was to screen all grade school children over a 2-year period. Children in grades 1 and 5 through 8 were screened during the 1997/1998 school year, and children in grades 1 and 3 through 5 (i.e., children who were in kindergarten and grades 2–4 in 1997/1998) were screened during the 1998/1999 school year. Sample sizes are greater for first and fifth grade children because children in these grades were screened during both school years, and sample sizes are smaller for children in seventh to eighth grades because children from a junior high school on the reservation that included seventh and eighth graders were not screened. In addition, no second grade children were screened. Children who were in second grade during the 1997/1998 school year were screened in 1998/1999, when they were in third grade, and children who were in second grade during the 1998/1999 school year were screened in 1997/1998, when they were in first grade. Children were uniquely identified to ensure that no subject provided data more than once in the sample. For children who were screened more than once, only the data from the first screening session were included in the analyses. Of 1,491 children enrolled in the grades scheduled for screening, 1,327 (89%) participated in the vision screening (163 were absent from school on the day that their class was scheduled for screening, and the parents of one child refused to allow the child to participate).

This research followed the tenets of the Declaration of Helsinki, and approval for the study was obtained from the University of Arizona Institutional Review Board. Before the vision screening, a letter was sent home to the parents of all children explaining the study. Parents were asked to contact the researchers or their child's school if they did not want their child to participate in the vision screening or if they did not want their child's data included in the study.

Procedure

The screening procedure consisted of noncycloplegic autorefraction and monocular visual acuity assessment. Noncycloplegic autorefraction measurements were obtained for right and left eyes using the Retinomax K+ autorefractor (Nikon, Inc., Melville, N.Y., currently manufactured by Right Manufacturing Co., Tokyo, Japan), which has been shown to provide accurate measurements of refractive astigmatism without cycloplegia in comparison to cycloplegic autorefraction and retinoscopy measurements.[18–22] Measurements were obtained in "normal" rather than "quick" mode.

Monocular letter visual acuity was tested at a distance of 4 m for right and left eyes of each child using different ETDRS logMAR letter charts for each eye (Precision Vision, Inc., Villa Park, IL).[25] The ETDRS charts were used because they meet the recommendations of the Committee on Vision for assessment of recognition acuity in adults.[26] The right eye of each child was always tested first. Children who were unable to reliably identify letters verbally were asked to identify letters by pointing to the matching letter on a lap card that contained all 10 letters that appear on the ETDRS chart. Visual acuity was recorded as the logMAR value of the smallest line on the ETDRS acuity chart for which the child could correctly identify three of five letters. Children who arrived at the vision screening wearing eyeglasses were tested while wearing their eyeglasses.

RESULTS

Prevalence and Axis of Astigmatism

Autorefraction measurements were obtained for both eyes in all but one child (as a result of experimenter oversight, i.e., measurement was not attempted). The prevalence of high astigmatism, defined as ≥1.00 D, was 34.7% (460 of 1,326) for right eyes and 34.5% (458 of 1,326) for left eyes, with 41.8% (554 of 1,326) of the children having high astigmatism in at least one eye. In general, astigmatism tended to be bilateral, with 66.8% (370 of 554) of the children with right eye or left eye high astigmatism having a difference in astigmatism between eyes of <1.00 D. Table 1 summarizes the amount of right eye astigmatism across age. Results of left eye measurements were similar. Chi-squared analysis of prevalence of high astigmatism (≥1.00 D in the right eye or left eye) across age (5 to <7, 7 to <9, 9 to <11, 11 to <13, and 13–16 years old) indicated a significant effect ($X^2[4] = 10.42$, $p = 0.04$). Post hoc comparisons indicated that the 13- to 16-year age group had a greater prevalence of high astigmatism in comparison to the 9- to 11-year age group ($p = 0.016$) and the 11- to 13-year age group ($p = 0.005$), although these effects were not significant after Bonferroni correction for multiple comparisons (adjusted critical p value was $0.05/10 = 0.005$). Linear regression analyses indicated no significant relation between age and amount of astigmatism (right eye: $r = 0.001$, $p = 0.96$, left eye: $r = 0.01$, $p = 0.64$), nor was there a significant relation between age and astigmatism when

TABLE 1.
Prevalence of refractive astigmatism in grade school Tohono O'odham children[a]

Right Eye Astigmatism	Percentage Within Each Age Group With Various Amounts of Astigmatism				
	5 to <7 Years (258)	7 to <9 Years (168)	9 to <11 Years (346)	11 to <13 Years (401)	13–16 Years (153)
<1 D	62.0	66.1	68.8	68.6	53.6
1 to <2 D	12.4	12.5	13.3	13.7	24.2
2 to <3 D	10.1	8.9	7.2	4.5	9.8
3 to <4 D	6.6	8.3	3.8	5.7	3.3
4 to <5 D	5.4	3.6	4.3	3.7	3.9
5 to <6 D	3.1	0.6	1.7	3.0	3.3
6 to <7 D	0.4	0	0.6	0.7	1.3
7 to <8 D	0	0	0.3	0	0.6

[a]Numbers in parentheses represent the number of children within each age group.

cylinder was represented by J0 and J45 components in the equation. When amount of myopia (spherical equivalent [SE]) and hyperopia (SE) were added to the equation, the relation between age and astigmatism remained nonsignificant, although amount of SE myopia and SE hyperopia were significantly positively related to amount of astigmatism (p's < 0.001 for right and left eye data).

Axis of astigmatism in eyes with at least 1.00 D of astigmatism was also examined. For the right eye, 98% (453 of 460) of astigmatic children had with-the-rule astigmatism (axis $\geq$60° and $\leq$120° plus cylinder notation), four children had oblique astigmatism ($>$30° and $<$60° or $>$120° and $<$150°), and three children had against-the-rule astigmatism ($>$0° and $\leq$30° or $\geq$150° and $\leq$180°). For the left eye, 98% (449 of 458) of astigmatic children had with-the-rule astigmatism, six children had oblique astigmatism, and three children had against-the-rule astigmatism.

Glasses Wear

Information regarding glasses wear was not recorded for 16 children. The upper portion of Table 2 summarizes glasses wear across age, and the lower portion of Table 2 summarizes glasses wear for children who had at least 1.00 D of astigmatism in either eye. Overall, 6.9% (90 of 1,311) of children in the sample arrived at the vision screening wearing glasses, whereas 14.1% (77 of 547) of astigmatic children (right eye or left eye $\geq$1.00 D) arrived at the vision screening wearing eyeglasses. There was no significant relation between age group and proportion of children wearing eyeglasses for the overall sample or for the sample of high astigmats.

'Everyday' Visual Acuity

Right and left eye visual acuity measurements were not obtained for two children because they were unable to perform the acuity task and were not recorded for three children.

The distribution of acuity values obtained for right eyes is summarized for all children screened in Table 3. Results for the left eye were similar. The percentage of children with poor visual acuity, defined as 20/40 or worse, was 28.0% (370 of 1,322) for right eyes and 26.1% (345 of 1,322) for left eyes, with 34.9% having poor visual acuity in at least one eye (461 of 1,322).

Visual Acuity and Uncorrected Astigmatism

Acuity results for children who *were not* wearing eyeglasses were analyzed to examine the relation between visual acuity and amount of uncorrected astigmatism. Acuity results for children wearing correction were not analyzed separately, because we could not be sure that the children were wearing their "best correction" (eye examinations were beyond the scope of this study).

Figure 1A plots visual acuity and uncorrected astigmatism for the right eye of the 1,217 children who came to the vision screening *without* glasses. Linear regression analyses indicated a significant relation between visual acuity and amount of uncorrected astigmatism (right eye: $r = 0.60$ [$r^2 = 0.36$], $p < 0.001$, equation: logMAR acuity $= 0.04 + 0.102$ * refractive astigmatism, left eye: $r = 0.63$ [$r^2 = 0.39$], $p < 0.001$, equation: logMAR acuity $= 0.05 + 0.103$ * refractive astigmatism).

TABLE 2.
Eyeglass wear among grade school Tohono O'odham children

Sample	Percentage of Children Arriving at Screening Wearing Eyeglasses					
	5 to <7 Years	7 to <9 Years	9 to <11 Years	11 to <13 Years	13 to 16 Years	All Ages
All children	17/248	13/164	25/346	21/401	14/152	90/1,311
	6.8%	7.9%	7.2%	5.2%	9.2%	6.9%
High astigmats	17/112	13/66	18/137	15/153	14/79	77/547
(right eye or left eye ≥1 D)	15.2%	19.7%	13.1%	9.8%	17.7%	14.1%

TABLE 3.
Distribution of visual acuity measurements in grade school Tohono O'odham children[a]

Right Eye Recognition Acuity	Percentage Within Each Age Group With Various Acuity Values: 5 to <7 Years (258)	7 to <9 Years (168)	9 to <11 Years (346)	11 to <13 Years (401)	13–16 Years (153)
20/10	0	0	0	0	0.6
20/12.5	0	0.6	0.9	3.0	3.3
20/16	0.8	5.4	13.9	20.4	17.0
20/20	14.3	23.5	31.0	23.2	18.9
20/25	30.6	27.7	19.4	20.9	18.3
20/32	13.9	14.5	13.6	8.5	9.1
20/40	13.9	9.6	8.7	6.5	12.4
20/50	12.4	9.0	4.9	6.2	7.2
20/63	5.4	6.0	3.2	3.2	5.2
20/80	5.8	0.6	2.6	3.0	3.9
20/100	1.9	1.8	0.6	2.2	1.3
20/125	0.8	0.6	0.6	1.5	2.6
20/160	0	0	0.6	0.5	0
20/200	0	0	0	0.5	0
Worse than 20/200	0	0.6	0	0.2	0

[a]Numbers in parentheses represent the number of children in each age group.

To determine if the slope of the equation relating amount of astigmatism and visual acuity was influenced by the large sample of nonastigmats (who in general had better acuities than astigmats), a second set of regression analyses was conducted including only data from high astigmats. Figure 1B plots right eye visual acuity and uncorrected astigmatism for the subset of 378 Tohono O'odham children with high astigmatism ($\geq$1.00 D) in the right eye. Linear regression analyses indicated a significant relation between visual acuity and amount of uncorrected astigmatism (right eye: $r = 0.53$ [$r^2 = 0.28$], $p = 0.001$, equation: logMAR acuity = 0.14 + 0.07 * refractive astigmatism, left eye: $r = 0.61$ [$r^2 = 0.37$], $p = 0.001$, equation: logMAR acuity = 0.12 + 0.08 * refractive astigmatism).

Secondary regression analyses (one for right eye and one for left eye data) were performed to determine the effects of age and SE refractive error (amount of myopia and amount of hyperopia based on noncycloplegic autorefraction), in addition to astigmatism, on uncorrected visual acuity. The results indicated significant effects of all four predictor variables (astigmatism, SE hyperopia, SE myopia, and age, all p's < 0.001). Overall, this analysis indicates that acuity is reduced with increasing hyperopia, myopia, and astigmatism and improves with age. However, the addition of SE data and age did not notably increase the overall correlation beyond what was observed when astigmatism alone was included as a predictor (r^2 for the right eye increased from 0.36 to 0.40, and r^2 for the left eye increased from 0.39 to 0.43 with the addition of myopia, hyperopia, and age). The slope of the function relating astigmatism and uncorrected acuity was minimally affected by including SE and age in the equation (a decrease from 0.10 to 0.09 for the right eye and the left eye).

DISCUSSION

The data obtained in the present study represent the first report of prevalence of astigmatism and eyeglass wear in a large sample of Tohono O'odham grade school children. The overall prevalence of 42% for astigmatism $\geq$1.00 D in either eye found in the study sample is greater than that reported in a recent study of the prevalence of astigmatism $\geq$1.00 D in African American (20%), white (26%), and Asian (34%) children in the United States, but is similar to the prevalence reported for Hispanic children (37%) in the United States.[27]

In contrast, the prevalence of high astigmatism (42% $\geq$1.00 D) reported in the present study is *lower* than the prevalence of 87% reported by Kershner and Brick for a sample of 57 Tohono O'odham fourth and fifth grade children.[7] This difference may be the result of the small sample size in the Kershner and Brick study. The prevalence of high astigmatism reported in the present study was also lower than the prevalence of 62% reported in a sample of 100 Tohono O'odham adults and children (8 years of age and older) seen in an optometry clinic.[8] However, it is not surprising that prevalence of refractive error is greater in patients presenting at the optometry clinic than in a sample from the general population.

Within the sample reported here, there was no significant difference in prevalence of astigmatism with age for children in the 5- to 13-year age range, but the data did suggest an increased prevalence in children in the over 13-year age group. Unfortunately, the sample size for the oldest age group is smaller than the sample size for the younger age groups because the elementary school in the largest school district extended only to sixth grade, whereas the other five schools continued through the eighth grade. Therefore, this effect should be interpreted cautiously, because this sample may differ from the sample of children represented in younger grades.

The results of the present study provide little evidence of change in the prevalence of high astigmatism in school-aged Tohono O'odham children. This conclusion is consistent with studies that found no significant relation between age and prevalence of astigmatism in kindergarten through sixth-grade Navajo children[12] and

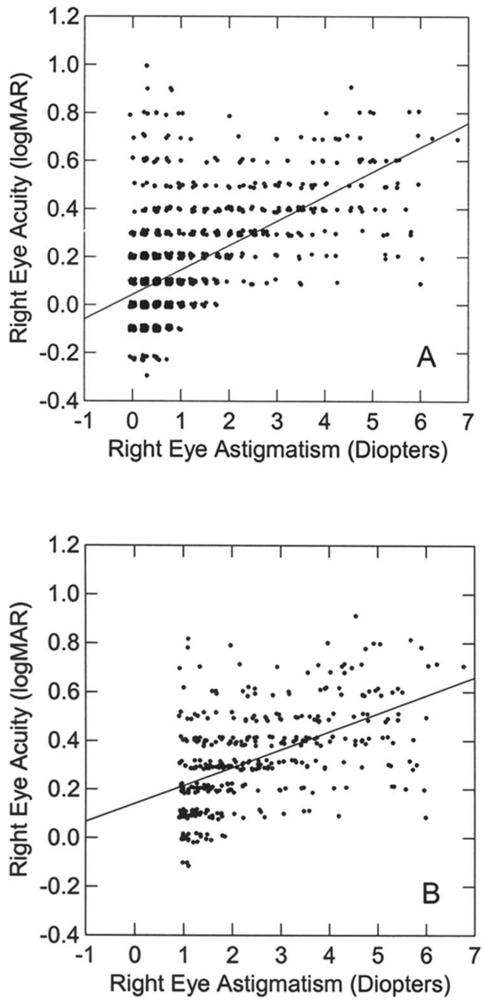

FIGURE 1.

Uncorrected visual acuity and refractive astigmatism for the right eyes of children who arrived at the vision screening without eyeglasses. (A) All children (n = 1,217). (B) Children with ≥1.00 D of astigmatism in the right eye (n = 378). Each line on the logMAR acuity chart is represented by 0.1 logMAR, with 0.0 logMAR = 20/20.

first through fifth grade Sioux children[5] but is inconsistent with results of several other studies that reported a decrease of astigmatism with age among kindergarten through sixth grade Navajo children,[2] 6- to 20-year-old Navajo children,[9] and kindergarten through 12th grade Zuni children.[14]

When the results of the present study are considered along with a previous report of astigmatism in Tohono O'odham *preschool* children,[28] they suggest a decrease in astigmatism from preschool to grade school. In a previous study of 3- to 4-year-old Tohono O'odham children participating in the Head Start program, we found a significantly higher prevalence of right eye astigmatism (44% ≥1.00 D) than we found in the present study (35%) ($X^2[1] = 6.9$, $p < 0.01$).[28] This difference may reflect a difference between the subset of children who attend Head Start and the larger proportion of the population who attend grade school. However, it may also represent a decrease in the prevalence of astigmatism between preschool and school age in Tohono O'odham children. A decrease in astigmatism would not be consistent with a study of Sioux children that found an equal prevalence of refractive astigmatism (≥1.50 D) in the 0- to 9-year and 10- to 19-year age groups,[13] and a study of Cheyenne and Crow children that found no difference in prevalence of refractive astigmatism (≥1.00 D) across grade level from *prekingarten* through 12th grade.[4] Longitudinal studies of refractive error in Native American grade school children similar to the longitudinal study of *preschool* Tohono O'odham children by Miller et al.[29] and Dobson et al.[11] will allow for stronger conclusions regarding developmental changes in refractive astigmatism and other types of refractive error. However, results of such studies may not be generalizable across tribes, because it is likely that differences in both genetic and environmental factors across tribes contribute to the lack of consistent findings in Native American populations.

The results of the present study are in agreement with results from other studies of astigmatism in Native American children with regard to axis of astigmatism. Axis of astigmatism was overwhelmingly (98% for the right eye and for the left eye) with-the-rule (plus cylinder axis 90 ± 30°) consistent with the value of 92% previously reported for preschool-aged Tohono O'odham children[28] and also with data reported previously for members of the Navajo,[6,9,12,30,31] Sioux,[13] and Zuni tribes.[6]

The present study found that, despite the high prevalence of astigmatism (42%), the rate of eyeglass wear among Tohono O'odham children was just 6.9% for the overall sample and 14.1% among children with high astigmatism (≥1.00 D). The results of the study do not provide an indication of the reason for the low rate of eyeglass wear. Future work aimed at determining possible barriers to receiving eye care might provide a better indication for the low rate of eyeglass wear. In a previous report, we found that intervention (eye examinations and eyeglass-dispensing) in preschool children was associated with increased eyeglass wear in older children, although they were not directly targeted for intervention.[32] Thus, efforts toward education and increased awareness in the community may be effective interventions for increasing eyeglass wear among Tohono O'odham children.

The visual acuity results presented in Table 3 represent the first report of "everyday" visual acuity, i.e., visual acuity of children on a typical school day in a large group of Tohono O'odham grade school children. The results indicate that a high proportion of children have poor (worse than 20/40) "everyday" visual acuity. This is not unexpected given the findings of high prevalence of astigmatism and low prevalence of glasses wear. These results suggest that low rate of eyeglass wear represents a significant public health concern among Tohono O'odham children, because it results in reduced visual acuity in many children.

The high prevalence of astigmatism and the low rate of glasses wear in this population made it possible to examine the relation between visual acuity and uncorrected astigmatism in a large number of children with a wide range of astigmatism values. The resulting regression equation revealed a one-line decrease (0.1 logMAR) in acuity for each diopter of astigmatism with astigmatism accounting for 36% of the variability in acuity values. A second regression analysis including only high astigmats was conducted to determine if the slope of the first equation was simply an artifact of the large proportion of nonastigmats (who in general had good acuities) biasing the results of the equation. A comparison of the regression equations, one with the entire sample and one with only high astigmats, indicates that acuities were poorer when limited to the high astigmats only (larger constant in the "astigmats-only" equation), and the slope of the regression line was less steep. However, the regression equation remained statistically significant when only astigmats were included and still predicted approximately a one-line decrease in acuity with each additional diopter of refractive astigmatism. Secondary analyses including measurements of spherical refractive error in addition to astigmatism did not make a notable difference on the regression. However, these results should be interpreted cautiously, because measurements were obtained when children were not cyclopleged, and previous studies have indicated that noncycloplegic measurements of spherical refractive error have reduced accuracy and reliability.[18–24]

The relation between visual acuity and uncorrected refractive error was examined previously in a sample of 1,920 grade school children and optometry clinic patients in Orinda, California.[16] Comparison of the data from the Orinda study with data from Tohono O'odham children in the present study is shown in Figure 2. For the Orinda study, we used the authors' graphic representation of the results to determine the "best" acuity obtained across the entire range of spherical refractive errors for 1.00, 1.50, 2.00, 2.50, 3.00, 3.50, 4.00, and 4.50 D of refractive astigmatism. Data from the present study reflect the predicted visual acuity for varying amounts of refractive astigmatism using the regression equations derived from astigmatism and uncorrected visual acuity data from the present study (the equation derived from all data and the equation derived from only data from high astigmats). Because the regression equations approximate the average visual acuity for each amount of astigmatism, not the "best" acuity, we would expect the acuity values from the Orinda study to be better than those from the present study. However, as shown in Figure 2, the visual acuity values from the two studies are similar for astigmatism up to 2.00 D, but data from the Orinda study show poorer acuity for larger amounts of astigmatism than do the data from the present study. We also plotted, in Figure 2, the estimated acuity values for various amounts of astigmatism as reported by Bennett and Rabbets[33] and again found that the acuity deficits for highly astigmatic children in the present study were not as great as those reported previously. In a previous study of 809 grade school Navajo children, Garber also reported surprisingly good visual acuity among children with uncorrected astigmatism.[12] Of 106 children with uncorrected corneal astigmatism ≥2.00 D, 34 (32%) had acuities of 20/30 or better in both eyes.

It is likely that differences across studies in the relation between astigmatism and visual acuity can be explained by differences in the distribution of spherical refractive errors and astigmatic axes across study samples. A study by Miller et al. demonstrated that the magnitude of visual acuity deficits associated with 2.00 D of lens-induced astigmatism is dependent on both the spherical component of the refraction and the axis of the astigmatism. [17] The data from the study by Miller et al. are plotted in Figure 3. An analysis (RM ANOVA) of the data provided in Miller et al. yielded significant effects of type of astigmatism (compound hyperopic, mixed, compound myopic) and astigmatic axis (against-the-rule, with-the-rule, oblique), but no significant interaction. Post hoc analyses indicated that acuity was poorer with induced myopic astigmatism, presumably because subjects could not accommodate to bring the more myopic meridian into better focus, relative to hyperopic and mixed astigmatism, presumably as a result of subjects' ability to accommodate between to two extreme focal planes. Post hoc analysis on axis of astigmatism indicated that oblique astigmatism resulted in significantly poorer acuity than against-the-rule astigmatism. Thus, a greater prevalence of myopic astigmatism or oblique astigmatism in non-Native American populations relative to Native American populations could contribute to the differences in acuities observed.

Although the present study cannot provide definitive analysis of the effects of astigmatism, axis, and spherical error on uncorrected visual acuity (as a result of the lack of accurate measurements of spherical refractive error), it does raise some interesting questions for further study about the relative contributions of spherical and astigmatic refractive errors, and the axis of astigmatic refractive errors on uncorrected visual acuity. In addition, the present study did not determine uncorrected visual acuity in children who arrived wearing eyeglasses. It would be interesting to see if these children, who had adapted to wearing eyeglasses, might perform more poorly on uncorrected visual acuity testing than children who were habitually uncorrected.

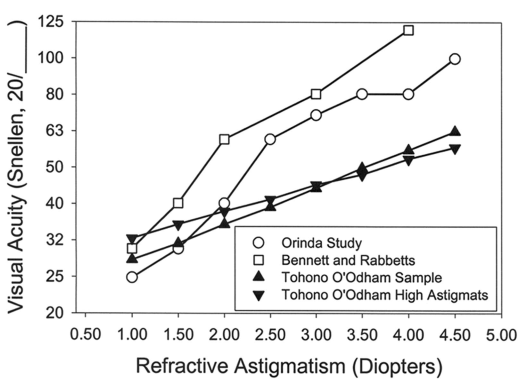

FIGURE 2.

Visual acuity and amount of uncorrected astigmatism. Data obtained in the Orinda study[9] (○) reflect the best Snellen visual acuity for astigmatism values across entire range of spherical refractive error (Blum et al., p. 100).[9] Data from Bennett and Rabbetts (□) reflect predicted visual acuity.[33] Data from the Tohono O'odham sample reflect the predicted ETDRS visual acuity from regression equation based on data from right eyes of all subjects (▲) and predicted ETDRS visual acuity from regression equation based on right eye data from only subjects with right eye astigmatism ≥1.00 D (▼).

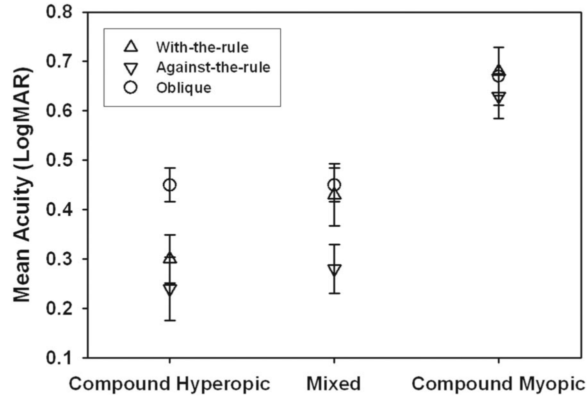

FIGURE 3.

Data on effects of 2.00 D of induced astigmatism on visual acuity plotted from Miller et al.[17]

CONCLUSIONS

The results of astigmatism and visual acuity screening indicate that uncorrected astigmatism and poor visual acuity are prevalent among Tohono O'odham children. The data highlight the importance of further efforts directed toward developing effective screening methods for populations with a high prevalence of astigmatism and improving glasses wearing in this population by determining barriers to receiving eye care and by initiating public education programs regarding the importance of early identification and correction of astigmatism.

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