PREVALENCE OF STRABISMUS AMONG PRESCHOOL, KINDERGARTEN, AND 1ST GRADE TOHONO O'ODHAM CHILDREN

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Abstract

Background—Although the prevalence of strabismus is 2% to 5% in European-based and African American populations, little is known about the prevalence of strabismus in Native American populations. We report the prevalence of strabismus in children who are members of a Native American tribe with a high prevalence of astigmatism.

Methods—Subjects were 594 children enrolled in Head Start, and 315 children enrolled in kindergarten or first grade (K/1) in schools on the Tohono O'odham Reservation. Distance and near cover tests were performed on each child by an ophthalmologist or optometrist, and cycloplegic refraction was obtained.

Results—Strabismus was detected in 9 Head Start children (1.5%) and 3 K/1 children (1.0%). Ratio of esotropia to exotropia was 1:3 in Head Start and 1:2 in K/1. Anisometropia ≥ 1.00 diopter (D) spherical equivalent was present in 2 children with strabismus and anisometropia ≥ 1.00 D cylinder was present in 4 with strabismus.

Conclusions—The prevalence of strabismus in Tohono O'odham children is at the low end of the prevalence range reported in studies of European-based white and African American black populations.

Keywords

strabismus; prevalence; Native American; children

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In general, population-based studies have reported a prevalence of strabismus ranging from 2% to 5% among preschool and school-aged children of European (white) heritage.[1-7] Recently, similar prevalence values for strabismus have been reported for African American populations,[8-10] although a substantially lower prevalence (1%) was found in a study of Japanese school children.[11,12] It is well documented that some Native American populations differ from European and African American populations in one aspect of ocular health: prevalence of astigmatism.[13-23] However, there are only two population-based studies of strabismus prevalence in Native American children. One study, which assessed 398 Sioux children in grades 1 through 5, indicated a prevalence of strabismus of 3.8%, with 1.8% constant strabismus and 2.0% intermittent strabismus.[24] The other study screened 225 preschool and 567 Cherokee children in grades K-8 in Oklahoma and 2,267 preschool and 2,866 Chippewa children in grades K-8 in Minnesota.[25] Prevalence of strabismus was 3.6% in preschoolers and 1.8% in grade-school children in Oklahoma, and 0.6% in preschoolers and 0.3% in grade school children in Minnesota.[25]

The purpose of the present study is to examine the prevalence of strabismus in preschool- and school-aged children who are members of a Native American tribe (Tohono O'odham) with a high prevalence of astigmatism.[21-23]

METHODS

Subjects

Subjects were 909 children, 594 of whom were enrolled in Head Start, and 315 of whom were enrolled in kindergarten or first grade in schools on the Tohono O'odham Reservation between September 2005 and November 2008. All were participants in a longitudinal study of the development and treatment of astigmatism-related amblyopia, in which participants receive an annual eye examination with cycloplegic refraction, beginning at age 3 years. Participation was offered to all children attending Head Start, kindergarten and first grade at schools on the Tohono O'odham Reservation through a letter and recruitment pamphlet sent to parents of all enrolled children.

The sample of 315 children in kindergarten and first grade can be considered population-based, as over 85% of children in kindergarten and first grade in each of the five schools on the Reservation were assessed. However, the sample of 594 younger children, who represent approximately 85% of children enrolled in Head Start in the years in which assessments were conducted, is not population-based, as not all preschool-aged tribal members are enrolled in Head Start.

The mean age of the children in the younger sample was 4.00 years (SD 0.56, range 2.99 to 5.74 years), and mean age of the kindergarten/first grade sample was 6.49 years (SD 0.77, range 4.87 to 9.42 years).

The study was approved by the Tohono O'odham Nation and by the Institutional Review Board of the University of Arizona and conformed to the requirements of the United States Health Insurance Portability and Accountability Act. Parents provided written informed consent prior to the child's participation, and filled out a questionnaire concerning the child's history of eye problems and treatment for those problems, including whether the child had ever had eye surgery.

Procedures

As part of the annual eye examination for the study, each child underwent an assessment of eye alignment at distance and near using unilateral cover tests, with a picture as the fixation target at distance and a finger puppet at near. The cover test, which was conducted by an

ophthalmologist or optometrist experienced in working with children, was performed with spectacles on if the child came to the examination wearing spectacles. To determine the presence or absence of a heterotropia, each eye was occluded for a minimum of 3 seconds at both distance and near. If any movement of the not-covered eye was observed, presence and type of heterotropia were recorded.

The eye examination also included measurement of refractive error with the Retinomax K+ autorefractor, confirmed by retinoscopy, at least 40 min after instillation of one drop of proparacaine (0.5%) and two drops of cyclopentolate (1%) in each eye.

Data Analysis

Data from each child's first study eye examination were included in the analysis. Strabismus was defined as any heterotropia at distance or near.

RESULTS

Strabismus was detected in nine of the 594 (1.5%; 95% confidence interval (CI) 0.0% – 2.8%; 1.7% (5/289) for females and 1.3% (4/305) for males) children in the younger sample, with two (0.3%) showing esotropia (ET), six (1.0%) showing exotropia (XT), and one (0.2%) with hypertropia. Three (1.0%; 95% CI 0.7% – 2.9%; 1.8% (3/165) for females and 0% (0/150) for males) of the 315 children in the kindergarten/first grade sample had strabismus, one (0.3%) with ET and two (0.6%) with XT. For the Head Start sample, the rate of strabismus detected was 1.73% (5/289) for females and 1.31% (4/305) for males.

Cycloplegic refraction data for each of the 12 strabismic children are shown in Table 1. Anisometropia was present in four children with XT: two had ≥ 1.00 diopter (D) spherical equivalent (SE) anisometropia and ≥ 1.00 D cylinder anisometropia (one in the younger sample and one in the older sample), and two had ≥ 1.00 D cylinder anisometropia without SE anisometropia (both in the younger sample). Two children in the younger sample who had XT had myopia greater than 6.00 D SE, and one child with ET, also in the younger sample, had hyperopia greater than 4.00 D SE. Results of the parental questionnaire indicated that none of the 909 children in the study population had had prior strabismus surgery.

DISCUSSION

Prevalence of strabismus in the population-based sample of kindergarten and first grade Native American children examined in the present study was 1.0%. A similar prevalence of 1.5% was found in the younger sample of Head Start children, even though this sample was not population-based. These prevalence values are lower than the prevalences of 2% to 5% reported in studies of European-based (white) and African American populations[1-10] and lower than the prevalence value reported in one[24] of two[24,25] population-based studies of Native American children (Table 2). One other study has reported a low prevalence of strabismus (1.3%) in a Native American (Sioux) population.[27] However, that study was not population based, in that prevalence was calculated from individuals presenting at an optometry clinic as well as on the basis of school vision screenings, and the age range (0 to 61+ years) was much larger than that of the present study. As shown in Table 2, there is one population, specifically a very large Japanese population, for which a low prevalence of strabismus (1.0% to 1.3%) has previously been reported.[11,12] However, It is not clear whether the lower prevalence reported for the Japanese population is related to the Asian ethnicity of this population, or to an underestimate of prevalence due to the fact that the screening was conducted by school teachers, and the only children who were referred for an eye examination were those who scored worse than 20/20 on a visual acuity test or had "suspected eye disease".

Why is the prevalence of strabismus lower in our population than reported for some other populations? First, it is possible that the low prevalence is related to ethnicity differences between our population and populations that have been studied previously; this is the first report of prevalence of strabismus in the Tohono O'odham population, and a previous study[25] reported substantial differences in prevalence of strabismus in two Native American tribes (Table 2). However, it is also possible that our prevalence value may be an underestimate because an alternate cover test was not performed on all children. This may have resulted in failure to detect some intermittent tropias. As shown in Table 2, prevalence of strabismus is decreased if children with intermittent tropias are excluded.[5,9,24] It is unlikely that the reason that the prevalence is low is because children had had strabismus surgery at an earlier age, as no parents reported that their children had eye surgery prior to entry into the study.

As shown in Table 2, the prevalence of esotropia compared to exotropia varies considerably across studies. In the present population, exotropia was more prevalent than esotropia, in agreement with some studies,[6,9,11,12] but in contrast to other studies.[4,5,7,8] One population-based study of Native American (Sioux) children found a much higher prevalence of exotropia than esotropia (ratio 14:1) in a group of 398 children,[24] but another population-based study of Native American (Cherokee and Chippewa) children found ratios closer to 1:1.[25] Another study of Native Americans, which was not population-based and which included a broad age range (0–61+ years), reported a prevalence ratio of 1:3.3 for esotropia to exotropia,[27] a value close to our values of 1:3 for the younger cohort and 1:2 for the kindergarten/first grade cohort. It is possible that the variability in the ratio of esotropia to exotropia prevalence across studies is related to relatively small samples of strabismic children in these studies.

Refractive error data (Table 1) indicate that four of the twelve strabismic children had anisometropia, with two having SE anisometropia ≥ 1.00 D and four (including the two with SE anisometropia) having cylinder anisometropia ≥ 1.00 D. The finding that twice as many strabismic children had cylinder anisometropia as had SE anisometropia is consistent with data from this population indicating an overall prevalence of cylinder anisometropia ≥ 1.00 D (15.0%) that is approximately twice as large as the overall prevalence of SE anisometropia ≥ 1.00 D (6.7%).[26] The high myopia in two of the strabismic children is unusual in this age group. High myopia is more common in preterm than among full-term children,[28,29] but unfortunately, we did not ask parents about their children's birth status.

Strengths and Limitations

The study has several strengths. First, it provides data on a specific Native American population. Second, all children were examined by an optometrist or an ophthalmologist. In some population based studies, the only children examined by an eye care specialist are those who fail a screening conducted by individuals who are not eye care professionals.[4,8,11,12] A third strength is that there were only three examiners (KAG, DHM, JMM), which provided consistency in assessment of eye alignment.

A limitation of the study is that heterotropias were measured only as present or absent. Prism testing was not conducted, as children were referred to non-study providers for management of strabismus. Another limitation is that alternate cover testing was not performed, which may have led to failure to detect some intermittent tropias.

In conclusion, the prevalence of strabismus among young Tohono O'odham children is relatively low (approximately 1%), compared to the prevalence of 2% to 5% reported for European-based white and African American black populations.[1-10] It is also lower than that of a population-based study of one group of Native American (Sioux) children,[24] but similar to that reported in a population-based study of Native American Cherokee and Chippewa

children.25 Additional studies of Native American populations are needed to determine whether prevalence of strabismus is also low in other Native American populations.

Acknowledgments

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Table 1

Cycloplegic refractive error data for the nine younger (Head Start [HS]) children and the three kindergarten (K)/first grade children who had strabismus

Subject Number	Cohort, Gender, and Age (years)	Strabismus	Right Eye			Left Eye			Sph Eq Anisometropia (diopters)	Cylinder Anisometropia (diopters)
			Sph	Cyl	Axis	Sph	Cyl	Axis		
1	HS F, 3.2	ET	+0.75	---	---	+0.75	−0.25	170	0.125	0.250
2	HS F, 3.3	ET	+5.75	−0.75	165	+5.50	−0.50	17	0.125	0.250
3	HS M. 4.1	XT	+1.00	−1.50	2	+1.25	−2.25	4	0.125	0.750
4	HS M, 3.1	XT	−6.75	−1.50	10	−6.00	−1.75	126	0.625	0.250
5	HS F, 5.7	XT	+1.75	−1.75	167	+1.00	---	---	0.125	1.750
6	HS F, 4.6	XT	+0.75	−0.50	162	+0.50	−0.25	165	0.125	0.250
7	HS F, 3.4	XT	−8.50	−2.25	6	−9.75	−3.50	11	1.875	1.250
8	HS M, 4.3	XT	+2.00	−0.50	170	+4.25	−3.50	163	0.750	3.000
9	HS M, 4.0	HT	+0.50	−0.50	147	+0.25	---	---	0.000	0.500
10	K F, 5.7	ET	+3.25	−1.25	168	+3.00	−1.25	180	0.250	0.000
11	First F, 7.6	XT	+0.75	−0.50	157	+4.50	−1.75	177	3.125	1.250
12	First F, 7.2	XT	+1.25	−1.75	179	+1.25	−1.50	173	0.125	0.250

F=female; M=male; ET = esotropia; XT = exotropia; HT = hypertropia; PL = plano; sph eq = spherical equivalent

Table 2

Population-based studies of strabismus prevalence in non-Native American children, published during the past 20 years, and two population-based studies of Native American children

Study	Location	N	Age (years)	Prevalence of Strabismus	Ratio of Esotropia to Exotropia
Preslan & Nowak 1996[8]	Baltimore, MD (USA)	680 (75% African American; 22% white)	4–7	3.1%	9.5:1
Kvarnström et al 2001[4]	Huddinge, Lund, & Linköping (Sweden)	3,126	10	2.7%	2.6:1
Donnelly et al 2005[5]	Newry (Northern Ireland)	1,582	<8.75	3.98% (3.6% constant)	5:1
Matsuo & Matsuo 2005[11]	Okayama Prefecture (Japan)	86,531	6–12	1.29%	1:2.5
Matsuo & Matsuo 2007[12]	Okayama Prefecture (Japan)	84,619	6–12	0.99%	1:2.8
Robaei et al 2006[6]	Sydney (Australia)	2,353	12	2.7%	1:1.3
Multi-ethnic Pediatric Eye Disease Study, 2007[9]	Los Angeles, CA (USA)	6,008 (3,003 Hispanic; 3,005 African American)	0.5–6	2.4% in Hispanic 2.5% in African American (~1% constant)	1:1.7 in Hispanic 1:1.2 in African American
Giordano et al 2008[10]	Baltimore, MD (USA)	2,298 (1,030 White; 1,268 African American)	0.5–6	3.3% in White 2.1% in African American	"equal"
Williams et al 2008[7]	Avon (England)	7,538	7	2.3%	3.5:1
Wick & Crane 1976[24]	Native American (Sioux)	398	Grades 1–5	3.8% (2.0% constant)	1:14
Maples et al 1990[25]	Native American (Cherokee)	225	Preschool	3.6%	1:1,7
	Native American (Cherokee)	567	Grades K-8	1.8%	1.5:1
	Native American (Chippewa)	2,267	Preschool	0.6%	1.6:1
	Native American (Chippewa)	2,866	Grades K-8	0.3%	1:2.4
Present study	Native American (Tohono O'odham)	594	Head Start*	1.5%	1:3

Study	Location	N	Age (years)	Prevalence of Strabismus	Ratio of Esotropia to Exotropia
Present study	Native American (Tohono O' odham)	315	Grades K and 1	1.0%	1:2

*
not a population-based sample