Vision Problems of Children with Individualized Education Programs

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Abstract

Background: *Much of learning is associated with visual cues, so children with vision-related problems may find it difficult to keep up with their peers in an academic setting. In order to assess the relationship between success in an academic setting and vision-related problems, we compared the prevalence of vision-related problems between children with Individualized Education Programs (IEPs) to population-based samples from the literature.*

Methods: *Eye care professionals completed refraction and cover test on children with an IEP. The prevalence of a variety of conditions exhibited by children with IEPs was compared to prevalence rates reported in the literature. Prevalence rates were compared using Chi-square tests, adjusted for multiple comparisons.*

Results: *Data were analyzed for 255 children reported to have an IEP. The average age of the children was 9.6 ± 2.9 years, and the average spherical equivalent refractive error in the right eye was +0.54 ± 2.21 D. Higher prevalence rates were reported for IEP patients than for samples from the literature for myopia (9 of 13 studies), hyperopia (10 of 13 studies), astigmatism (6 of 9 studies), anisometropia (3 of 4 studies), and strabismus (6 of 6 studies). The entering distance visual acuity of IEP patients was 20/40 or worse for 23.7% of eyes, but 7.2% of eyes still had acuity worse than 20/40 after refraction. Of the children who required some form of treatment, 124 (69.3%) had better than 20/40 entrance visual acuity in both eyes.*

Conclusion: *Children with IEPs have a significantly higher prevalence of myopia, hyperopia, astigmatism, anisometropia, and strabismus than most population-based samples in the literature. Many of these vision problems would be undetected by vision screenings based on distance visual acuity, illustrating the need for comprehensive vision examinations for children who are struggling academically.*

Key Words

anismetropia, children, individualized education program, refractive error, strabismus, visual acuity

It has been estimated that 80% of learning is obtained through vision. Although there is no scientific evidence for this statement, few disagree with the assertion. Scientists have found significantly lower achievement test scores,[1] as well as reduced letter and word recognition, receptive vocabulary, emergent orthography,[2] and verbal and performance intelligence quotients[3] among children with uncorrected hyperopia. Furthermore, children with learning disabilities exhibit a greater prevalence of vision-related problems than the entire population.[4] Most vision problems that may affect learning are related to refractive error,[4] so vision examinations may provide helpful information in the management of children with learning disabilities.

The Individuals with Disabilities Education Act was enacted in 2005. It ensures educational services for all children with disabilities. The Individuals with Disabilities Education Act resulted in the creation of Individualized Education Programs (IEPs) for all children with disabilities. An IEP is a written statement that includes a child's present levels of academic achievement and functional performance, measurable academic and functional goals, alternate assessments aligned to alternate achievement standards (if necessary), and a description of necessary special education services, supplementary aids, and accommodations. An IEP is written by a team of professionals that may include school psychologists, teachers, school nurses, speech and language teachers, and medical specialists in order to set measurable goals and establish a guide for the child's special learning needs.[5]

The Ohio revised code 3323.19 requires a student receiving an IEP for the first time to undergo a comprehensive eye examination with a licensed eye care professional within three months, unless the student has had an examination within the last nine months.[6]

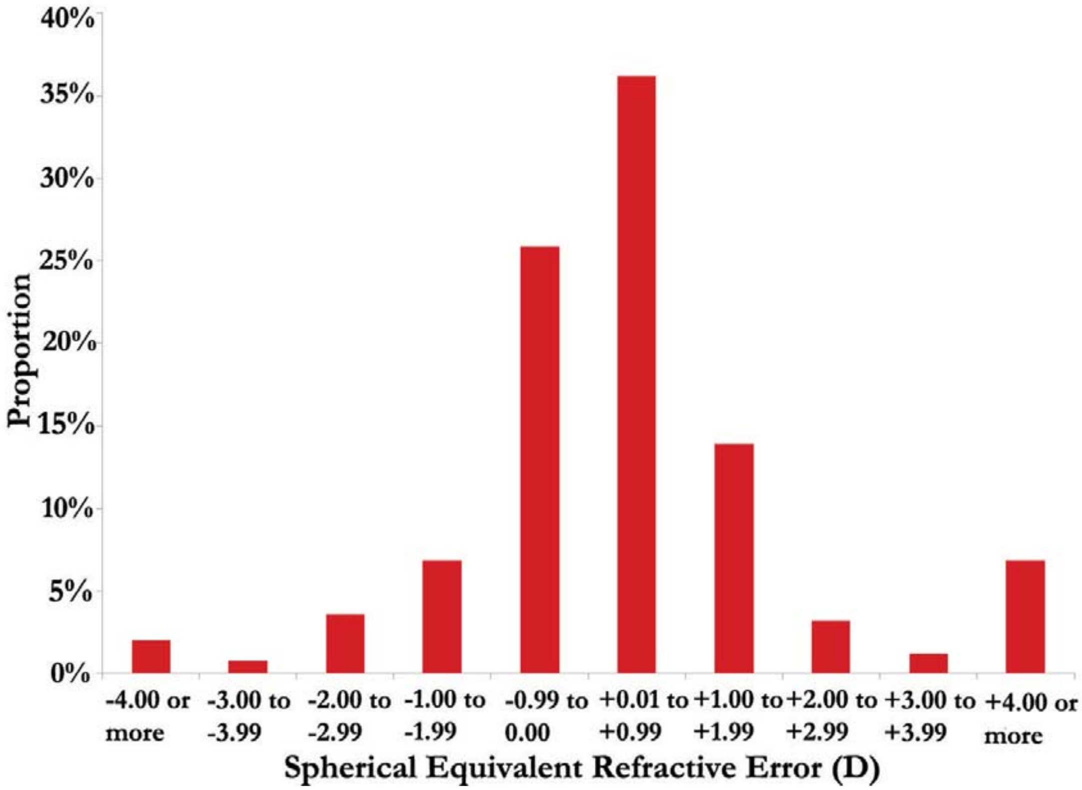
Other states have instituted mandatory eye examinations for children. Kentucky, Missouri, and Illinois require all children entering kindergarten to have an eye examination. Only Arkansas, North Carolina, Oklahoma, and Massachusetts require examinations for children who failed vision screenings, and only Ohio and Massachusetts require vision examinations for children with learning difficulties. Sixteen states do not even require vision screenings for children.[7]

In this study, we compare the prevalence of ocular findings in children who report having an IEP to the prevalence of similar findings reported in the literature.

Methods

The study was approved through The Ohio State University Biomedical Sciences Institutional Review Board, and it followed the guidelines of the Declaration of Helsinki. A waiver of consent was approved because all data were de-identified.

Figure 1. The distribution of spherical equivalent refractive error of the right eye of 252 patients with refraction data.



Eye care professionals completed an examination form. The form was either provided to parents by the school, or it was available on the Ohio Optometric Association and Ohio Ophthalmological Society websites for eye care practitioners to download. The practitioner then faxed the form to the Ohio Optometric Association for inclusion in the study. Data from the examinations forms were collected between 1 May 2006 and 30 November 2009.

Literature searches for large pediatric studies representative of the population were conducted via PubMed using key terms such as "children," "population-based," "prevalence," and each of the various conditions. The original papers were retrieved, and they were scanned for applicability and comparability. Representative samples were defined as a randomly selected group or a large group of volunteers who were not believed to represent a significantly biased sample. All relevant papers were included in the comparisons.

Data were single-entered into an Excel database, and range checks were applied to reduce deleterious effects of spurious entries. Categorical data were compared using Chi-square tests, and significance was adjusted for multiple comparisons using a conservative p-value of less than 0.05.

Results

We received 324 forms between May 2006 and November 2009. Of those forms, 55 included children younger than 5 years (they were younger than school age, so they were excluded), and 14 forms were incomplete. The remaining 255 forms were included in the analysis. The average age of the IEP patients was 9.6 ± 2.9 years (range: 5 to 18 years), and the average spherical equivalent refractive error of 252 right eyes (three forms were missing refraction data) was +0.53 ± 2.20 D (Figure 1). The average spherical equivalent refractive error of the left eye was similar to the right eye (+0.55 ± 2.19 D).

The majority of IEP patients' right eyes had no astigmatism according to the manifest refraction (Figure 2). The maximum amount of cylinder recorded was –5.75 DC. The refractive error may have been determined with either cycloplegic or non-cycloplegic refraction. Thirty-five of the 162 (21.6%) refractions were marked as cycloplegic while 93 (36.5%) were not designated.

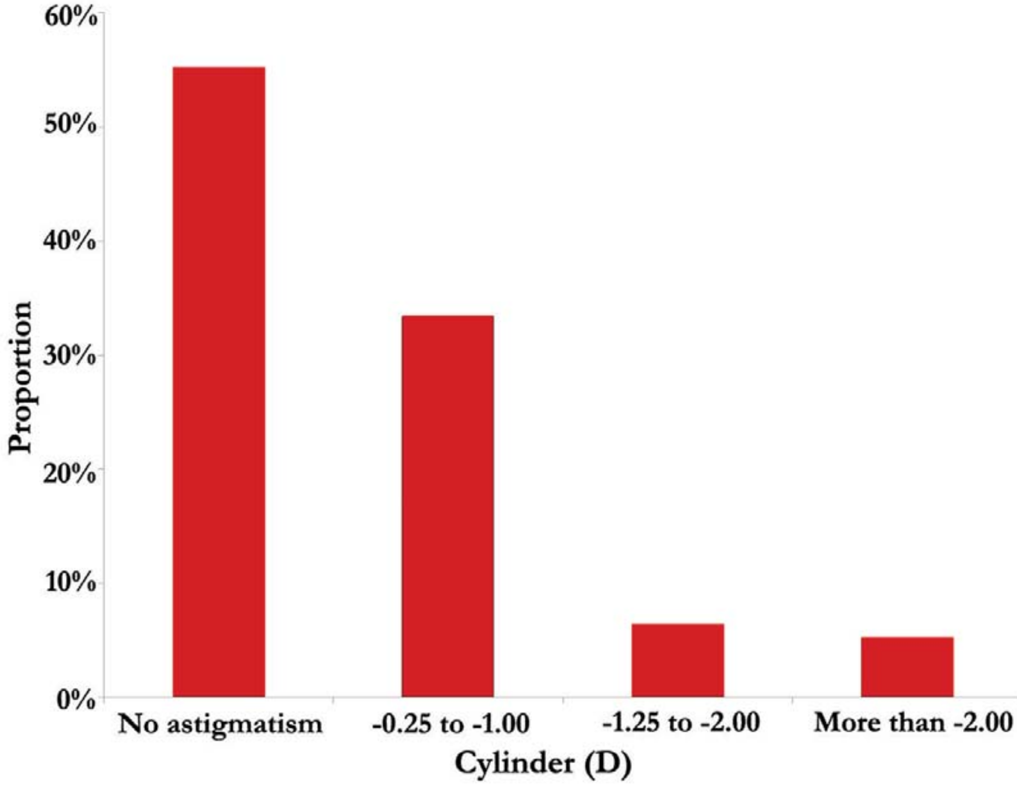
The literature-based prevalence of refractive errors in children varies widely based primarily on geographical location, definition of the refractive error, and age. In order to maximize the comparability of our data to a number of studies, we present the data according to several definitions (Table 1).

Based on the various definitions, the prevalence of myopia in the IEP patient sample ranged from 14.5% to 20.0%. Comparing the prevalence of myopia with a similar definition of myopia reported in the literature, there was a greater prevalence of myopia in the IEP patients than in nine of the 13 studies (Table 2). Three of the studies reported a greater prevalence of myopia than the IEP patients. One study reported a similar prevalence.

The proportion of clinically relevant hyperopia as defined by each study was significantly higher for the IEP patient sample than 10 of the 13 literature-based studies. It was lower for two studies (Table 2).

The prevalence of astigmatism was significantly greater for the IEP patients than for six of the nine literature-based samples that reported astigmatism prevalence. The prevalence of astigmatism was similar to that in the other three literature-based samples (Table 2).

Figure 2. The distribution of astigmatism of the right eye of 252 patients with refraction data.



Anisometropia was found in a significantly larger proportion of IEP patients than in literature-based samples for four of the seven definitions used in four literature-based samples (Table 3).

Of 430 eyes from the IEP patient sample with visual acuities recorded after the manifest refraction, 8 (1.9%) had best-corrected visual acuity worse than 20/80. This is similar to a sample of African-American and Hispanic children, with a prevalence of 25 eyes out of 2124 (1.2%) (Chi-square, $p = 0.25$).[23] The reasons for loss of acuity in the IEP patients were not collected.

Table 1. Definition-based prevalence of refractive errors for IEP patients
SE = spherical equivalent

Refractive Error	Minimum amount (D)	Analysis	Eye	Prevalence (%)
Myopia	–0.50	SE	Right	18.8
	–0.50	SE	Worse	20.0
	–0.75	SE	Worse	17.6
	–1.00	SE	Worse	14.5
	–0.50	SE	Average	19.2
	–0.75	Sphere	Worse	16.1
Hyperopia	+2.00	SE	Worse	11.8
	+2.00	SE	Right	11.0
	+2.00	SE	Average	10.6
	+1.50	SE	Right	18.8
	+1.25	SE	Right	15.3
	+1.50	Sphere	Worse	20.4

For the IEP group, if vision correction was worn to the appointment, the entering visual acuity was measured with correction, otherwise it was measured without correction. The entering distance visual acuity was 20/40 or worse for 23.7% of the 510 eyes. This proportion was reduced to 11.6% of the 430 eyes with visual acuities recorded after refraction. The near entering visual acuity was 20/40 or worse for 14.5% of the 443 eyes with recorded visual acuities.

Approximately 97% of a sample of kindergarten, second, and fifth grade children published by Walline et al. exhibited orthophoria at distance, compared to 79.2% in the IEP sample (Chi-square, $p < 0.001$). Table 4 shows that the distribution of near phorias was similar between the IEP patients and the same sample (Chi-square, $p = 0.82$).[24]

Using a definition of convergence insufficiency (CI) of near exophoria that shows 4 or more prism diopters greater exophoria than at distance,[25] 38 of the 217 (17.5%) IEP children with cover test data had CI. Comparisons to more thorough investigations of CI were not possible because sufficient data for a comprehensive definition of CI, such as the definition used by the CITT Study,[26,27] were not reported by eye care practitioners in this study. Fifth and sixth grade children from several locations in the United States exhibited a prevalence of 8.4% using the same definition of CI (Chi-square, $p < 0.001$).[25] The method of reporting strabismus in the literature varies, so the prevalence based on several definitions of strabismus is presented for the IEP patients in Table 5.

The proportion of IEP patients with strabismus was greater than the proportion of samples from the literature based on 13 of the 16 definitions reported in six different studies. The proportion of strabismus was greater for a sample from

Table 2. Proportion with myopia, hyperopia, and astigmatism in the literature

SE = spherical equivalent; DS = diopters sphere; N/A = not applicable; * = prevalence of IEP patients significantly higher; ^ = prevalence of IEP patients significantly lower (Chi-square, $p < 0.005$)

Study	Location	Sample Size	Age (years)	Myopia Definition	%	Hyperopia Definition	%	Astigmatism Definition	%
Murthy (2002)[8]	Urban India	6447	5-15	–0.50 or more SE, right eye	6.7*	+2.00 or more SE, right eye	6.3*	0.75 or more in right eye	5.4*
Dandona (2002)[9]	Rural India	3976	7-15	–0.50 or more SE, right eye	3.8*	+2.00 or more SE, right eye	0.4*	0.75 or more in right eye	2.8*
Zadnik (2003)[10]	USA	2583	6-14+	–0.50 or more SE, right eye	11.6*	+1.25 or more SE, right eye	8.6	N/A	N/A
He (2004)[11]	Urban China	4347	5-15	–0.50 or more SE, worse eye	35.1^	+2.00 or more SE, worse eye	5.8*	0.75 or more in right eye	21.4
Donnelly (2005)[12]	UK	1582	8-9	–0.75 DS or more, worse eye	1.3*	+1.50 DS or more, worse eye	2.2*	1.00 or more, worse eye	2.3*
Junghans (2005)[13]	Australia	1936	4-12	–0.50 or more SE, right eye	8.4*	+1.50 or more SE, right eye	6.9*	N/A	N/A
Goh (2005)[14]	Malaysia	4634	7-15	–0.50 or more SE, worse eye	20.7	+2.00 or more SE, worse eye	1.6*	0.75 or more in right eye	12.2*
Fotedar (2007)[15]	Australia	2233	12	–0.50 or more SE, right eye	9.8*	+2.00 or more SE, right eye	3.5*	1.00 or more right eye	6.4*
He (2007)[16]	Rural China	2454	13-17	–0.50 or more SE, worse eye	42.5^	+2.00 or more SE, worse eye	1.2*	0.75 or more in right eye	16.7
Ip (2008)[17]	Australia	2353	11-14	–0.50 or more SE, mean eye	11.9*	+2.00 or more SE, mean eye	3.5*	N/A	N/A
Uzma (2009)[18]	India	3314	7-15	–0.50 or more SE, worse eye	34.1^	+2.00 or more SE, worse eye	1.4*	N/A	N/A
Jamali (2009)[19]	Iran	815	6	–0.50 or more SE, right eye	1.6*	+2.00 or more SE, right eye	14.0	0.75 or more in right eye	13.5*
Giordano (2009)[20]	USA	416	5-6	–1.00 or more SE, worse eye	4.3*	+2.00 or more SE, worse eye	23.8^	1.50 or more, worse eye	12.3

Table 3. Prevalence of anisometropia in the literature and IEP patients based on two definitions

SE = spherical equivalent; * = prevalence of IEP patients significantly higher (Chi-square, $p < 0.005$)

Study	Location	Sample Size	Age (years)	Anisometropia (D) Definition	Prevalence (%)
IEP	USA	255	5-18	1.00 SE or more	7.1
				2.00 SE or more	2.4
Huynh (2006)[21]	Australia	1765	6	1.00 SE or more	1.6*
				2.00 SE or more	0.5*
Giordano (2009)[20]	USA	416	5-6	1.00 SE or more	4.5
				2.00 SE or more	0.5*
Tong (2004)[21]	Singapore	1979	7-9	1.00 SE or more	3.8
				2.00 SE or more	1.0
Jamali (2009)[22]	Iran	815	6	1.00 SE or more	2.2*

the literature than IEP patients based on only one of the 16 definitions (Table 6).

Amblyopia was a diagnosis for 35 (13.7%) of the 255 IEP children, but no specific criterion was stated for a diagnosis of amblyopia. In order to confirm this high prevalence, we defined amblyopia as visual acuity of 20/30 or worse in at least one eye with strabismus at distance and near or anisometropia of 1.00 D or more. Of the 215 patients with visual acuities recorded after refraction, 18 (8.4%) met this definition of amblyopia. In large population-based studies, the prevalence of amblyopia ranges from 1.3% to 3.6%.[12,19,28,32]

Accommodative dysfunction was reported by the eye care practitioner for 44 of the 255 IEP children (17.3%). The specific diagnosis was undefined for the IEP patients, and it could include high accommodative lag, accommodative insufficiency, accommodative spasm, accommodative infacility, or a combination of these findings. Accommodative dysfunction was reported in 9.4% to 11.0% of children in various samples reported in the literature.[25,33,34]

Of the 255 children who had vision examinations, 179 (70.2%) required some form of treatment, ranging from new lenses for current glasses to referral. Referrals were for ocular health (n = 3), vision therapy (n = 12), amblyopia (n = 9),

Table 4. Prevalence of phoria categories for IEP patients and a sample reported in the literature

	IEP	Walline (1998)[24]
Esophoria	10.1	8.9
Orthophoria	62.2	63.7
Exophoria	27.6	27.4

Table 5. Prevalence of strabismus in IEP patients according to several definitions of strabismus

Definition of strabismus	Prevalence
Any tropia at distance or near	11.5
Any esotropia at distance or near	4.9
Any exotropia at distance or near	6.6
Any esotropia ≥ 10^{Δ}	2.2
Any exotropia ≥ 15^{Δ}	3.5

Table 6. Prevalence of strabismus from samples in the literature based on several definitions. All definitions of strabismus include strabismus at either distance or near.
Exo = exotropia; Eso = esotropia; All = esotropia and exotropia; * = prevalence of IEP patients significantly higher; ^ = prevalence of IEP patients significantly lower (Chi-square, p < 0.005)

Study	Location	Sample Size	Age (years)	Strabismus Definition	%
Williams(2008)[28]	England	7538	7	All	27.0^
				Eso, 10^{Δ} or more	2.8
				Exo, 15^{Δ} or more	0.6*
Nirmalan (2003)[29]	India	10605	0-15	All	0.4*
MEPEDS (2008)[30]	USA	1080	5-6	All	3.3*
				Eso	1.8*
				Exo	1.5*
Jamali (2009)[19]	Iran	815	6	All	1.2*
				Eso	0.6*
				Exo	0.5*
Robaei (2006)[31]	Australia	1739	6	All	2.8*
				Eso	1.5*
				Exo	0.8*
Donnelly (2005)[12]	Ireland	1582	8-9	All	4.0*
				Eso	3.4
				Exo	0.6*

perceptual therapy (n = 5), mental health evaluation (n = 1), attention deficit disorder (n = 1), and fine and gross motor therapy (n = 1). Of the children who required some form of treatment, 124 (69.3%) had better than 20/40 entrance visual acuity in both eyes.

Payment source was reported for 233 of the 255 (91.4%) of the IEP examinations. The source of payment was private pay for 18.5%, medical insurance for 40.3%, vision insurance for 36.9%, and charitable contributions for 4.3% of the examinations.

Discussion

The IEP patients had a greater prevalence of nearly all vision-related problems examined in this study compared to literature-based pediatric samples. Higher prevalence rates were reported for IEP patients than for samples from the literature for myopia (9 of 13 studies), hyperopia (10 of 13 studies), astigmatism (6 of 9 studies), anisometropia (3 of 4 studies), and strabismus (6 of 6 studies).

Myopia is not associated with school problems,[3,35,36] but myopic children who dislike wearing glasses report improved academic self-perceptions when corrected with contact lenses. On the other hand, children who like wearing glasses do not report similar academic self-perception improvements when corrected with contact lenses.[37] This may lend credence to the theory that difficulty reading the board may lead to problems in school, and uncorrected myopia may negatively affect children's perceptions about their abilities to learn. The effects of hyperopia depend greatly on the magnitude of hyperopia, the age of the individual, visual demands, and the status of the accommodative and binocular systems. Uncorrected hyperopia has frequently been associated with school difficulties,[1-3,38,39] but it frequently goes undiagnosed until children present with problems in school or complain of eyestrain. Uncorrected astigmatism may lead to blurred vision at both distance and near, eyestrain, and headaches. These problems may adversely affect school performance.[40] Anisometropia, although it may not affect binocular visual acuity, often leads to eyestrain, headaches, and poor depth perception. These visual function issues may lead to decreased fine motor and visual motor skills that are important for learning.[41] Accommodative and convergence problems are often associated and may lead to visual symptoms[42-44] and behaviors associated with poor school performance.[45] Likewise, amblyopia may adversely affect vision-related tasks and certain aspects of school performance.[41,46-48] There is considerable association between ocular anomalies and poor school performance. These problems are illustrated by the high prevalence of a variety of eye problems experienced by the patients with IEPs.

In fact, only 29.8% of the IEP patients did not require any treatment. Out of the 179 IEP patients who required some form of treatment, 124 (69.3%) would have passed a distance visual acuity screening program. They may not have received the treatment necessary to eliminate the potential visual obstacles that may harm a child's ability to learn. Inadequate vision may cause children to become frustrated with learning, enhancing the likelihood of need for special education or underachieving. These children may develop a negative self-image, may exhibit behavior problems, and may ultimately drop out of school. A study of juvenile delinquents in Ohio found that 58% had undetected vision problems, and only 17% of these problems would have been detected with a vision screening.[33] Similarly, a Virginia study of 119 juvenile delinquents found that 70% had visual perception problems which would not be detected by vision screenings.[49] Passing distance visual acuity vision screenings does not adequately insure that children have no need for vision treatment. Despite good ability to see far away, they may not be able to see clearly at near, or they may suffer from symptoms not addressed by distance visual acuity screenings.

Limitations

While this investigation does not prove that correcting vision-related problems in children with IEPs would improve their academic standing, it does illustrate an increased probability of a high prevalence of vision-related problems in this group. More formal studies of the benefits of vision correction for students who struggle academically must be conducted to determine the true effects of vision problems on learning-related problems.

Eye examination results were not available for all Ohio children with IEPs. The vast majority of children with IEPs in Ohio were not examined, the doctors did not send examination forms, or unusable forms were used to collect data. Although Ohio law mandates comprehensive vision examinations for all children with IEPs, it lacks a means of enforcement. Some school districts specifically mandate the vision examination, while others simply provide information about having a child's eyes examined. This may influence the number of examinations that are performed, but it is unlikely to bias the results of the examinations toward only children with significant eye problems, since it is a district-wide problem, not a problem of individual patients.

Vision examinations were not conducted according to a standardized protocol. Most of the refractions were non-cycloplegic, which may underestimate the prevalence of significant hyperopia. Some of the forms provided incomplete data, and the formation of IEPs was not verified.

Furthermore, the individual comparison groups collected from population-based samples in the literature may also differ from the IEP patients in terms of age and ethnicity, which could influence the prevalence of refractive error. However, the age and location of the comparison samples were included so that readers can assess the validity of the comparison themselves. While every attempt was made to provide a meaningful comparison, it is acknowledged that some are more valid than others.

While the data may not be complete or collected by a standardized protocol, there is little reason to believe that the data are significantly biased toward including more IEP patients with ocular anomalies or that the population-based samples in the literature are biased toward including more subjects free of ocular anomalies. Although the results may not definitively prove that children struggling in school are more likely to have vision problems, it does provide motivation to evaluate the prevalence of vision-related problems in children with IEPs.

Conclusion

Children with IEPs likely have a greater prevalence of nearly all vision-related problems compared to pediatric samples representative of the general population reported in the literature. Because students with IEPs are likely to experience vision-related problems more often than the general population, these children should undergo comprehensive vision examinations to identify and treat these conditions. The greater proportion of vision-related problems for children with IEPs and the relatively poor performance of vision screenings in detecting these problems necessitate the need for comprehensive vision examinations for children with IEPs.

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References

1. Rosner J. The relationship between moderate hyperopia and academic achievement: How much plus is enough? J Am Optom Assoc 1997;68:648-50.
2. Shankar S, Evans MA, Bobier WR. Hyperopia and emergent literacy of young children: Pilot study. Optom Vis Sci 2007;84:1031-8.
3. Williams SM, Sanderson GF, Share DL, Silva PA. Refractive error, IQ and reading ability: A longitudinal study from age seven to 11. Dev Med Child Neurol 1988;30:735-42.
4. Das M, Spowart K, Crossley S, Dutton GN. Evidence that children with special needs all require visual assessment. Arch Dis Child 2010;95:888-92.
5. de Fur S. IEP transition planning-from compliance to quality. Exceptionality 2003;11:115-28.
6. Gardner R. Comprehensive Eye Examination. http://codes.ohio.gov/orc/3323.19 Last Accessed February 14, 2011.
7. National Commission on Vision and Health. Vision Exams for Children Prior To Entering School. http://www.visionandhealth.org/documents/FactsheetVisionexams123008MAS26.pdf Last Accessed February 15, 2012.
8. Murthy GV, Gupta SK, Ellwein LB, Munoz SR, et al. Refractive error in children in an urban population in New Delhi. Invest Ophthalmol Vis Sci 2002;43:623-31.
9. Dandona R, Dandona L, Srinivas M, Sahare P, et al. Refractive error in children in a rural population in India. Invest Ophthalmol Vis Sci 2002;43:615-22.
10. Zadnik K, Manny RE, Yu JA, Mitchell GL, et al. Ocular component data in schoolchildren as a function of age and gender. Optom Vis Sci 2003;80:226-36.
11. He M, Zeng J, Liu Y, Xu J, et al. Refractive error and visual impairment in urban children in southern China. Invest Ophthalmol Vis Sci 2004;45:793-9.
12. Donnelly UM, Stewart NM, Hollinger M. Prevalence and outcomes of childhood visual disorders. Ophthalmic Epidemiol 2005;12:243-50.
13. Junghans BM, Crewther SG. Prevalence of myopia among primary school children in eastern Sydney. Clin Exp Optom 2003;86:339-45.
14. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. Ophthalmol 2005;112:678-85.
15. Fotedar R, Rochtchina E, Morgan I, Wang JJ, et al. Necessity of cycloplegia for assessing refractive error in 12-year-old children: A population-based study. Am J Ophthalmol 2007;144:307-9.
16. He M, Huang W, Zheng Y, Huang L, et al. Refractive error and visual impairment in school children in rural southern China. Ophthalmol 2007;114:374-82.

17. Ip JM, Huynh SC, Robaei D, Kifley A, et al. Ethnic differences in refraction and ocular biometry in a population-based sample of 11-15-year-old Australian children. Eye (Lond) 2008;22:649-56.
18. Uzma N, Kumar BS, Khaja Mohinuddin Salar BM, Zafar MA, et al. A comparative clinical survey of the prevalence of refractive errors and eye diseases in urban and rural school children. Can J Ophthalmol 2009;44:328-33.
19. Jamali P, Fotouhi A, Hashemi H, Younesian M, et al. Refractive errors and amblyopia in children entering school: Shahrood, Iran. Optom Vis Sci 2009;86:364-9.
20. Giordano L, Friedman DS, Repka MX, Katz J, et al. Prevalence of refractive error among preschool children in an urban population: The Baltimore pediatric eye disease study. Ophthalmol 2009;116:739-46, 46 e1-4.
21. Huynh SC, Wang XY, Ip J, Robaei D, et al. Prevalence and associations of anisometropia and aniso-astigmatism in a population based sample of 6 year old children. Br J Ophthalmol 2006;90:597-601.
22. Tong L, Saw SM, Chia KS, Tan D. Anisometropia in Singapore school children. Am J Ophthalmol 2004;137:474-9.
23. Multi-ethnic Pediatric Eye Disease Study Group. Prevalence and causes of visual impairment in African-American and Hispanic preschool children: The multi-ethnic pediatric eye disease study. Ophthalmology 2009;116:1990-2000.
24. Walline JJ, Mutti DO, Zadnik K, Jones LA. Development of phoria in children. Optom Vis Sci 1998;75:605-10.
25. Rouse MW, Borsting E, Hyman L, Hussein M, et al. Frequency of convergence insufficiency among fifth and sixth graders. The convergence insufficiency and reading study (CIRS) group. Optom Vis Sci 1999;76:643-9.
26. CITT Study Group. The convergence insufficiency treatment trial: Design, methods, and baseline data. Ophthalmic Epidemiol 2008;15:24-36.
27. CITT Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. Arch Ophthalmol 2008;126:1336-49.
28. Williams C, Northstone K, Howard M, Harvey I, et al. Prevalence and risk factors for common vision problems in children: Data from the ALSPAC study. Br J Ophthalmol 2008;92:959-64.
29. Nirmalan PK, Vijayalakshmi P, Sheeladevi S, Kothari MB, et al. The Kariapatti pediatric eye evaluation project: Baseline ophthalmic data of children aged 15 years or younger in Southern India. Am J Ophthalmol 2003;136:703-9.
30. Multi-ethnic Pediatric Eye Disease Study Group. Prevalence of amblyopia and strabismus in African American and Hispanic children ages 6 to 72 months the multi-ethnic pediatric eye disease study. Ophthalmol 2008;115:1229-36.
31. Robaei D, Kifley A, Rose KA, Mitchell P. Refractive error and patterns of spectacle use in 12-year-old Australian children. Ophthalmol 2006;113:1567-73.
32. Robaei D, Kifley A, Rose KA, Mitchell P. Impact of amblyopia on vision at age 12 years: Findings from a population-based study. Eye (Lond) 2008;22:496-502.
33. Abdi S, Lennerstrand G, Pansell T, Rydberg A. Orthoptic findings and asthenopia in a population of Swedish schoolchildren aged 6 to 16 years. Strabismus 2008;16:47-55.
34. Lara F, Cacho P, Garcia A, Megias R. General binocular disorders: Prevalence in a clinic population. Ophthalmic Physiol Opt 2001;21:70-4.
35. Grosvenor T. Refractive state, intelligence test scores, and academic ability. Am J Optom Arch Am Acad Optom 1970;47:355-61.
36. Rosner M, Belkin M. Intelligence, education, and myopia in males. Arch Ophthalmol 1987;105:1508-11.
37. Walline JJ, Jones LA, Sinnott L, Chitkara M, et al. Randomized trial of the effect of contact lens wear on self-perception in children. Optom Vis Sci 2009;86:222-32.
38. Krumholtz I. Results from a pediatric vision screening and its ability to predict academic performance. Optometry 2000;71:426-30.
39. Rosner J, Rosner J. Comparison of visual characteristics in children with and without learning difficulties. Am J Optom Physiol Opt 1987;64:531-3.
40. Garber JM. High corneal astigmatism in Navajo school children and its effect on classroom performance. J Am Optom Assoc 1981;52:583-6.
41. Webber AL, Wood JM, Gole GA, Brown B. The effect of amblyopia on fine motor skills in children. Invest Ophthalmol Vis Sci 2008;49:594-603.
42. Borsting E, Rouse MW, Deland PN, Hovett S, et al. Association of symptoms and convergence and accommodative insufficiency in school-age children. Optometry 2003;74:25-34.
43. Rouse MW, Hyman L, Hussein M, Solan H. Frequency of convergence insufficiency in optometry clinic settings. Optom Vis Sci 1998;75:88-96.
44. Scheiman M, Mitchell GL, Cotter S, Rouse M, et al. Accommodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. Optom Vis Sci 2006;83:857-8; author reply 858-9.
45. Borsting E, Rouse M, Chu R. Measuring ADHD behaviors in children with symptomatic accommodative dysfunction or convergence insufficiency: A preliminary study. Optometry 2005;76:588-92.
46. Engel-Yeger B. Evaluation of gross motor abilities and self perception in children with amblyopia. Disabil Rehabil 2008;30:243-8.
47. Li RW, Young KG, Hoenig P, Levi DM. Perceptual learning improves visual performance in juvenile amblyopia. Invest Ophthalmol Vis Sci 2005;46:3161-8.
48. Webber AL, Wood JM, Gole GA, Brown B. Effect of amblyopia on the developmental eye movement test in children. Optom Vis Sci 2009;86:760-6.
49. Schwartz SH. Vision Perception: A Clinical Orientation. 2nd ed. Stamford, CT: Appleton & Lange; 1999.

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