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The accuracy of photoscreening at detecting treatable ocular conditions in children with Down syndrome

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Abstract

Background—Children with Down syndrome (DS) have an increased prevalence of ocular disorders, including amblyopia, strabismus, and refractive error. Health maintenance guidelines from the DS Medical Interest Group recommend ophthalmologic examinations every 1 to 2 years for these children. Photoscreening may be a cost-effective option for subsequent examinations after an initial complete examination, but no study has evaluated the accuracy of photoscreening in children with DS. The purpose of this study is to determine the sensitivity, specificity, and positive and negative predictive values of photoscreening in detecting treatable ocular conditions in children with DS.

Methods—Photoscreening and complete ophthalmologic evaluations were performed in 50 consecutive 3- to 10-year-old children with DS. Sensitivity, specificity, and positive and negative predictive values were calculated using ophthalmologic examination findings as the reference standard.

Results—Most children were able to complete photoscreening (94% with Medical Technology and Innovations [MTI] and 90% with Visiscreen OSS-C [VR]). Many children had an identified diagnosis on ophthalmologic examination ($n = 46$, 92%). Of these, about half ($n = 27$, 54%) had one or more condition(s) requiring treatment. Both the MTI and VR photoscreening devices had a sensitivity of 93% (95% confidence interval 0.76, 0.99) for detecting treatable ocular conditions. The specificities for the MTI and VR photoscreening were 0.35 (0.18, 0.57) and 0.55 (0.34, 0.74), respectively.

Conclusions—Photoscreening is sensitive but less specific at detecting treatable ocular conditions in children with DS. In specific instances, the use of photoscreening in the DS population has the potential to save time and expense related to routine eye examinations, particularly in children with a normal baseline comprehensive examination.

Introduction

Much has been published on the increased prevalence of ocular findings in infants and children with Down syndrome (DS). The most common ocular findings reported in these

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patients are refractive error and strabismus.^{1–8} A recent comprehensive review of the literature on ophthalmic findings in DS noted reports of nystagmus, blepharitis, nasolacrimal duct obstruction, keratoconus, cataracts, glaucoma, iris Brushfield spots, optic nerve abnormalities, and retinal disorders.⁹ Because of the high prevalence of potentially vision-threatening ocular conditions, the Down Syndrome Medical Interest Group (DSMIG) has recommended that children with DS undergo a complete ophthalmologic examination every 1 to 2 years throughout life.¹⁰ Many of these children, however, have normal examinations and may not require regularly scheduled follow-up with an eye care provider.

In children without DS, the American Academy of Pediatrics, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology have jointly established vision-screening guidelines for preschool-aged children.¹¹ These guidelines include traditional screening methods, such as distance visual acuity and ocular alignment using unilateral cover and random dot E stereo tests.^{12–17} In the past 15 years, nontraditional vision screening methods have been introduced as they require significantly less cooperation from pediatric patients than traditional methods.^{18–21} These nontraditional methods therefore may be preferable for screening children who are intellectually delayed and/or disabled.

Photostrengthening is a vision screening technique used to detect amblyogenic risk factors such as strabismus, media opacities, and significant refractive errors in one or both eyes. The camera captures two images of each eye, which are interpreted based on the pupillary and red reflexes. At-risk children are referred for complete ophthalmologic evaluation based on well-established interpretation methods.²² Both screeners and image interpreters require standardized training. Previous studies have found photostrengthening effective in preschoolers and in children and young adults with severe learning disabilities and cognitive impairments.^{23,24} To our knowledge, no study has examined the feasibility and utility of photostrengthening in children with DS. The purpose of this study is to evaluate the sensitivity and specificity and positive and negative predictive values of photostrengthening in children with DS between 3 and 10 years of age.

Methods

Patient Recruitment

After obtaining approval from the Duke University Medical Center Institutional Review Board, children were consecutively recruited from the Duke University DS comprehensive specialty clinic. The study conformed to the requirements of the United States Insurance and Health Portability and Accountability Act. Children with DS from the community were also invited to participate in the study through a posting on the Triangle Down Syndrome Web site (<http://www.triangledownsyndrome.org/>). In order to be eligible for the study, children had to be between 3 and 10 years of age at the time of recruitment and have an established diagnosis of DS as determined by prior karyotyping. The children had to have undergone a complete ophthalmologic examination within the past 12 months, or their parents must have been willing for them to undergo a complete ophthalmologic examination.

Sample Size Calculation

A calculation was performed to determine the sample size needed for a 95% confidence interval width of 0.2 (ie, 0.73–0.93) with an estimated sensitivity of 0.83. The predicted sensitivity was based on previous published photostrengthening studies in preschool-aged children.^{25,26} The confidence interval width of 0.2 was selected since a 10% deviation in the sensitivity would not alter the conclusions of the study. Based on these assumptions, the calculated sample size was 54 children.

Photoscreening

After informed consent from the parent was obtained by the principal investigator or the study coordinator, children were screened with both the Medical Technology and Innovations (MTI), (MTI Incorporated, Lancaster, PA) and Vision Research (VI) Visiscreen OSS-C (VR Corporation, Birmingham, AL) photoscreeners. The MTI is an off-axis photorefractor that uses black-and-white Polaroid type 337 instant film (ASA 300). The VR is also an off-axis photorefractor that uses 35 mm film. The camera order was determined at random. Photographs were performed in accordance with instructions from the manufacturers by one of three professionals who were trained and certified in photoscreening through Prevent Blindness North Carolina (<http://www.pbnc.org/>). If the photographer judged the image to be of poor quality, another photograph was taken, with a maximum of three images per subject for each camera.

MTI images were interpreted by a single experienced rater from Prevent Blindness North Carolina. MTI images were classified as follows: (1) normal, (2) watch, (3) not analyzable, or (4) refer. VR images were interpreted by expert raters at the Photograph Interpretation Center of the Department of Ophthalmology at Vanderbilt University. VR images were classified as follows: (1) no problems detected, (2) mild or insignificant problems detected, (3) possible or possibly significant problems detected, or (4) significant problems detected. The interpreters were masked to all information regarding the subject's past ocular history, ophthalmologic examination findings, or additional photoscreening results.

Ophthalmologic Examinations

All children underwent a complete ophthalmologic examination by a board-certified, fellowship-trained pediatric ophthalmologist. These examinations were conducted within one year of the vision screening date. Ophthalmologic examinations consisted of visual acuity testing, pupillary light response evaluation, motility testing, external, slit lamp and dilated fundus examinations, and cycloplegic retinoscopy. The ophthalmologists conducting the examinations were masked to the photoscreening results.

Statistical Analyses

Sensitivity, specificity, and positive and negative predictive values were calculated to determine the accuracy of photoscreening in detecting one or more treatable ocular condition(s). Sensitivity is the proportion of children with a treatable eye condition who were correctly identified as such by photoscreening. Specificity is the proportion of children without a treatable eye condition who were correctly identified as such by photoscreening. Positive predictive value is the proportion of children with a positive test who were correctly diagnosed. Conversely, negative predictive value is the proportion of children with a negative test who were correctly diagnosed. Treatable ocular conditions were defined as amblyogenic conditions, including (1) anisometropia (sphere or cylinder) >1.00 D, (2) any manifest strabismus, (3) hyperopia $> +3.50$ D in any meridian, (4) myopia > -3.00 D in any meridian, (5) astigmatism >1.50 D at 90° or 180° or >1.00 D at an oblique axis ($>10^\circ$ eccentric to 90° or 180°), (6) any media opacity ≥ 1 mm in size, or (7) ptosis ≤ 1 mm margin reflex distance.²⁷

Results

A total of 50 children with DS were enrolled in the study. Most had analyzable photographs with the MTI ($n = 47$, 94%) and VR ($n = 45$, 90%) cameras. Enrollment was not continued to 54 children because we reached our predefined confidence interval range sooner than anticipated. Most children with noninterpretable photographs were 5 years of age or younger ($n = 4$) or had severe intellectual impairment ($n = 4$). More specifically, when evaluating

testability in those 5 years of age or less, the MTI images were analyzable in 96% (22 of 23) and 83% (19 of 23) of children. The mean age at the time of photoscreening was 6.4 ± 2.5 years (range, 3.1–10.8). The demographics of the study participants are presented in Table 1. The majority of parents ($n = 34$, 68%) reported that their child had been previously diagnosed with an ocular finding (Table 1). No adverse events occurred during the photoscreening sessions.

Three screened children (6%) did not receive full ophthalmic examinations since they failed to come to scheduled appointments. The average age at the time of full examination was 6.0 ± 2.4 years, and the average time between examination and photoscreening was 0.4 years. Almost all of the children had an ophthalmologic diagnosis ($n = 46$, 92%), and more than half of the children ($n = 27$, 54%) were found to have a treatable ocular condition on complete ophthalmologic examination. The most common refractive error findings were hyperopia ($n = 17$, 36%) and astigmatism ($n = 13$, 28%). Esotropia was the most common form of strabismus observed ($n = 14$, 30%). The ocular findings identified on complete ophthalmologic examination are listed in Table 2. Screening results are shown in Table 3.

The sensitivity of both the MTI and VR photoscreening for detecting treatable eye conditions was 0.93 (0.76, 0.99). The specificity for the MTI and VR photoscreening was 0.35 (0.18, 0.57) and 0.55 (0.34, 0.74], respectively. The positive predictive value for the MTI and VR photoscreening was 0.66 (0.50, 0.79) and 0.69 (0.53, 0.82), respectively. The negative predictive value for the MTI and VR photoscreening was 0.78 (0.44, 0.95) and 0.81 (0.51, 0.96), respectively. All images that could not be analyzed were classified as a “fail.”

Of the 27 children with treatable ocular conditions identified on examination, concordance with the results of the full examination was observed in 22 children (81%) with the MTI system and 20 children (74%) with the VR system. For both the MTI and VR system screenings, 2 children were not able to be classified and were false-negatives. One child had hyperopic astigmatism ($+1.50 + 2.00 \times 090$ in both eyes), and the other had myopic astigmatism ($-2.00 + 2.25 \times 060$ in the right eye, and $-1.75 + 2.00 \times 105$ in the left eye). The refractive errors of these false-negatives were close to the threshold used to define astigmatism and were therefore cases with “borderline” significant findings. The MTI and VR systems yielded 13 and 11 false positive results, respectively. The most common reported false-positive problems by photoscreening were astigmatism, hyperopia, and anisometropia. Almost all of the false-positives were found in children with correctly identified refractive errors that failed to meet the significant criteria.

On examination, less than half of children ($n = 19$, 40%) were able to successfully complete monocular testing of distance visual acuity with optotype methods. The children who performed visual acuity testing were older than those who did not, with average ages of 7.9 years and 5.5 years ($p = 0.0002$), respectively. Lack of patient cooperation was noted for 4 children for the ocular motility examination and 4 children for the cycloplegic refraction assessment. Despite the limited cooperation notation, these tests were ultimately completed by the pediatric ophthalmologists.

Discussion

Our success rates for screening were 94% with the MTI system and 90% with the VR system. In comparison, for those 5 years of age or less, the success rates were 96% with the MTI system and 83% with the VR system. Reported photoscreening success rates in preschool-aged children have ranged from 94–100%.²⁸ The lower success rates in our study most likely relate to screening a more challenging patient population. This compares with our success rate of 40% for performing the traditional vision screening method of visual

acuity testing with optotypes in our patient population, even with conduction of the tests in specialty pediatric ophthalmology clinics.

The operating characteristics of photoscreening in children with DS demonstrate its utility as a screening test following an initial complete ophthalmic exam. The sensitivity (the probability that a patient with the disease tested positive) and negative predictive value (the probability that a patient with a negative result did not have the disease) were very good. These results mean that few children with treatable ocular conditions were missed by photoscreening. These findings were similar to previous reports regarding photoscreening in preschool aged children without DS. Based on the high sensitivity and negative predictive value, photoscreening appears to be a suitable method to screen children with DS and normal baseline examination in terms of detecting the development of treatable ocular conditions.

These operating characteristics are dependent on the definition used for “treatable ocular conditions.” This study assumed that treatable ocular conditions are the same for children with and without DS; however, this assumption may not be the case. For instance, because of possible hypoaccommodation in children with DS, clinicians may have a lower threshold for the treatment of hyperopia. Most of the false positives were found in children with correctly identified refractive errors that failed to meet the significant criteria requiring treatment. Thus photoscreening’s sensitivity to lower amounts of hyperopia may actually be useful in the DS population.

Not surprisingly, the prevalence of ocular conditions requiring treatment was much higher in our DS patient population (60%) than that reported in preschool-aged children without DS (1% to 3%).^{29–31} The overall prevalence of ophthalmic disorders in previous studies on children with DS has ranged from 46% to 100%⁹; however, some of these studies included conditions that do not affect vision, such as slanting palpebral fissures and epicanthal folds. The prevalence of specific ophthalmic conditions reported in previous studies is listed in Table 2. These ophthalmic conditions include diagnoses that may not be detected by photoscreening such as optic nerve abnormalities and hypoaccommodation, thus making a baseline complete ophthalmologic examination imperative in this patient population.

The economic impact of photoscreening with follow-up examinations for referred children compared to annual or biannual complete ophthalmologic examinations for all children with DS is difficult to assess. North Carolina, the state in which the study was conducted, already has a well-established preschool photoscreening program, making the start-up cost associated with photoscreening negligible. In this established program, the cost of photoscreening per child is \$6.00 (Prevent Blindness North Carolina). This cost includes trained and certified personnel, administrative support, travel, film, and analysis. Photoscreening takes place in the schools en masse. The cost of a complete ophthalmologic examination is \$75.00 (Medicaid Fee Schedule, <http://www.cms.hhs.gov/home/medicaid.asp>). The savings per child screened in the first year after the baseline complete examination is given in e-Supplement 1 (available at jaapos.org). This saving depends not only on the cost of photoscreening and ophthalmologic examination but also on the referral rate after a normal baseline comprehensive ophthalmologic examination. The referral rate in our study was about 80%, but this rate included all comers, not just those with normal baseline complete examinations. If photoscreening was limited to “normals,” the photoscreening referral rate would likely be much lower. The cost savings with a referral rate of 80% is \$9.00 per screened child.

These data can be used to calculate a referral rate breakeven point (Figure 1). As the referral rate increases, the cost-effectiveness of screening decreases. The break-even point for

photoscreening is a 92% referral rate. As long as referral rate is less than 92%, it is cost-effective to perform screening. As mentioned previously, the referral rate is highly likely to be less than 80% in those with a normal baseline comprehensive ophthalmologic examination.

Although the cost analysis appears favorable, in states without an established photoscreening program, investing in photoscreening devices specifically for children with DS requires careful consideration. Establishing the infrastructure necessary to administer a screening program also adds to screening expense. Hence, it is important for each state to independently determine the cost of instituting such a photoscreening program in the DS population.

It seems reasonable to consider time and effort in addition to cost regarding the use of photoscreening versus complete ophthalmologic examinations for children with DS. Photoscreening is portable, fast (it usually takes less than 5 minutes), and easy to administer. When performed at school, photoscreening does not require any additional travel for the patient or patient's family. On the other hand, ophthalmologic examinations take longer (at least one hour with full cycloplegia) and require both the patient and at least one parent to travel to an ophthalmologist's office. The time required for complete ophthalmologic examinations versus baseline ophthalmologic examinations with follow-up photoscreening is given in e-Supplement 2 (available at jaapos.org). Even with a referral rate of 80%, screening saves 15 minutes per DS patient. The break-even point for time occurs at a 90.7% referral rate (Figure 2). Any referral rate of less than 90.7% saves time.

In some instances, photoscreening may miss treatable ocular disease. However, even in missed cases, screening is not a one-time occurrence, so they would likely be detected as abnormal at future screenings. A complete exam at baseline with photoscreening as a follow-up for "normals" incorporates the strengths of both approaches.

In conclusion, we found that photoscreening is feasible in children with DS. The test is very sensitive but less specific in detecting treatable ocular conditions. In North Carolina, the use of photoscreening in the DS population showed savings in terms of both time and expense related to annual or biannual eye examinations in children with a normal baseline examination. The results from this study support the inclusion of children with DS in existing school-based, photoscreening programs; however, caution must be taken in applying these findings to all states. Future study should focus on the use of the photoscreening techniques to detect new-onset disease in children with DS following a normal baseline examination.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Akinci A, Oner O, Bozkurt OH, et al. Refractive errors and strabismus in children with Down syndrome: A controlled study. *J Pediatr Ophthalmol Strabismus* 2009;46:83–6. [PubMed: 19343969]
2. Caputo AR, Wagner RS, Reynolds DR, et al. Down syndrome: Clinical review of ocular features. *Clin Pediatr (Phila)* 1989;28:355–8. [PubMed: 2527102]

3. da Cunha RP, Moreira JB. Ocular findings in Down syndrome. *Am J Ophthalmol* 1996;122:236–44. [PubMed: 8694092]
4. Ebeigbe JA, Akpalaba R. Ocular health status of subjects with Down syndrome in Benin City, Nigeria. *Afr J Med Med Sci* 2006;35:365–8. [PubMed: 17312746]
5. Kim JH, Hwang JM, Kim HJ, et al. Characteristic ocular findings in Asian children with Down syndrome. *Eye* 2002;16:710–14. [PubMed: 12439664]
6. Mohd-Ali B, Mohammed Z, Norlaila M, et al. Visual and binocular status of Down syndrome children in Malaysia. *Clin Exp Optom* 2006;89:150–54. [PubMed: 16637969]
7. Yurdakul NS, Ugurlu S, Maden A. Strabismus in Down syndrome. *J Pediatr Ophthalmol Strabismus* 2006;43:27–30. [PubMed: 16491722]
8. Wong V, Ho D. Ocular abnormalities in Down syndrome: An analysis of 140 Chinese children. *Pediatr Neurol* 1997;16:311–14. [PubMed: 9258964]
9. Creavin AL, Brown RD. Ophthalmic abnormalities in children with Down syndrome. *J Pediatr Ophthalmol Strabismus* 2009;46:76–82. [PubMed: 19343968]
10. DSMIG. Basic Medical Surveillance Essentials for People with Down's Syndrome-Ophthalmic Problems. Rev. 2006 [cited 2009].
11. Ressel GW. AAP releases policy statement on eye examinations. *Am Fam Physician* 2003;68:1664–6. [PubMed: 14596454]
12. Barry JC, Konig HH. Test characteristics of orthoptic screening examination in 3 year old kindergarten children. *Br J Ophthalmol* 2003;87:909–16. [PubMed: 12812897]
13. Lennerstrand GP, Jakobsson P, Kvarnstrom G. Screening for ocular dysfunction in children: Approaching a common program. *Acta Ophthalmol Scand Suppl* 1995;214:26–38. [PubMed: 8574881]
14. Simons K, Avery KE, Novak A. Small-target random dot stereogram and binocular suppression testing for preschool vision screening. *J Pediatr Ophthalmol Strabismus* 1996;33:104–13. [PubMed: 8965234]
15. Birch E, Williams C, Hunter J, et al. Random dot stereoacuity of preschool children. ALSPAC "Children in Focus" Study Team. *J Pediatr Ophthalmol Strabismus* 1997;34:217–22. [PubMed: 9253735]
16. Kulp MT, Mitchell GL. Randot stereoacuity testing in young children. *J Pediatr Ophthalmol Strabismus* 2005;42:360–64. [PubMed: 16382561]
17. Bertuzzi F, Orsoni JG, Porta MR, et al. Sensitivity and specificity of a visual acuity screening protocol performed with the Lea symbols 15-line folding distance chart in preschool children. *Acta Ophthalmol Scand* 2006;84:807–11. [PubMed: 17083543]
18. Arnold RW, et al. The Alaska Blind Child Discovery project: Rationale, methods, and results of 4000 screenings. *Alaska Med* 2000;42:58–72. [PubMed: 11042938]
19. Donahue SP, Gionet EG, Jastrzebski AI, et al. Lions Clubs International Foundation Core Four Photoscreening: Results from 17 programs and 400,000 preschool children. *J AAPOS* 2006;10:44–8. [PubMed: 16527679]
20. Donahue SP, Lorenz S, Johnson T. Photo screening around the world: Lions Club International Foundation experience. *Semin Ophthalmol* 2008;23:294–7. [PubMed: 19085430]
21. Kirk VG, Clausen MM, Armitage MD, et al. Preverbal photoscreening for amblyogenic factors and outcomes in amblyopia treatment: Early objective screening and visual acuities. *Arch Ophthalmol* 2008;126:489–92. [PubMed: 18413517]
22. Kovtoun TA, Arnold AW. Calibration of photoscreenings for single-subject, contact-induced hyperopic anisometropia. *J Pediatr Ophthalmol Strabismus* 2004;41:150–58. [PubMed: 15206600]
23. Watts P, Walker K, Beck L. Photoscreening for refractive errors in children and young adults with severe learning disabilities using the MTI photoscreener. *Eye* 1999;13:363–8. [PubMed: 10624435]
24. Enzenauer RW. The efficacy of photoscreening for amblyopiagenic factors in a high risk population. *Binocul Vis Strabismus Q* 2003;18:233–40. [PubMed: 14653776]

25. Arnold RW, Stark L, Leman R, et al. Tent photoscreening and patched HOTV visual acuity by school nurses: Validation of the ASD-ABCD protocol (Anchorage School District-Alaska Blind Child Discovery program). *Binocul Vis Strabismus Q* 2008;23:83–94. [PubMed: 18702611]
26. Arthur BW, Riyaz R, Rodriguez S, et al. Field testing of the plusoptiX S04 photoscreener. *J AAPOS* 2009;13:51–7. [PubMed: 19121596]
27. Donahue SP, Arnold RW, Ruben JB, et al. Preschool vision screening: What should we be detecting and how should we report it? Uniform guidelines to reporting results of preschool vision screening studies. *J AAPOS* 2003;7:314–16. [PubMed: 14566312]
28. Salcido AA, Bradley J, Donahue SP. Predictive value of photoscreening and traditional screening of preschool children. *J AAPOS* 2005;9:114–20. [PubMed: 15838437]
29. Friedman DS, Repka MX, Katz J, et al. Prevalence of amblyopia and strabismus in white and African American children aged 6 through 71 months the Baltimore Pediatric Eye Disease Study. *Ophthalmology* 2009;116:2128–34. [PubMed: 19762084]
30. Tarczy-Hornoch K, Varma R, Cotter S, et al. Prevalence of amblyopia and strabismus in African American and Hispanic children ages 6 to 72 months the multi-ethnic pediatric eye disease study. *Ophthalmology* 2008;115:1229–36. [PubMed: 17953989]
31. Robaei D, Rose KA, Kifley A, et al. Factors associated with childhood strabismus: Findings from a population-based study. *Ophthalmology* 2006;113:1146–53. [PubMed: 16675019]

FIG 1.

Break-even point in terms of cost for photoscreening in children with DS (in a cohort of 40 patients). The cost of full examination is \$75.00 and the cost of photoscreening is \$6.00. The total cost is shown on the x-axis and the referral rate is shown on the y-axis. The break-even point occurs at a referral rate of 92%.

FIG 2.

Break-even point in terms of time for photoscreening in children with DS (in a cohort of 40 patients). The time for a full examination is 140 minutes and cost of photoscreening is 13 minutes. The total time is shown on the x-axis and the referral rate is shown on the y-axis. The break-even point occurs at a referral rate of 90.7%. Full examination total time is assumed to be 140 minutes: patient, 60 minutes; parent(s), 60 minutes (including transportation); ophthalmologist, 10 minutes; technician, 10 minutes. Photoscreening total time is assumed to be 13 minutes: patient, 5 minutes (at school); technician (including photography and interpretation), 8 minutes.

Table 1

Demographics and previously diagnosed ocular findings of DS children participating in the study (n = 50)

Age, mean $\pm$ standard deviation years (range)		6.4 $\pm$ 2.5 (3.1–10.8)
Gender, number (percent)	Male	22 (44%)
	Female	28 (56%)
Race, number (percent)	Caucasian	36 (72%)
	Black	11 (22%)
	Hispanic	2 (4%)
	Caucasian/Black	1 (2%)
Previously diagnosed ocular findings based on parent report, number (percent)	Overall	34 (68%)
	Refractive error	27 (54%)
	Strabismus	18 (36%)
	Amblyopia	7 (14%)
	Nystagmus	3 (6%)
	Other	1 (2%)
	Optic nerve abnormality	1 (2%)
	Nasolacrimal duct obstruction	1 (2%)
	Macular degeneration	1 (2%)
	Cataract	1 (2%)

Table 2

Prevalence of eye findings on complete ophthalmologic examination.

Ocular Finding	n = 46	Percent	Previously Reported Prevalence
Hyperopia **	17	36%	4–59%
Esotropia	14	30%	15–52%
Astigmatism *	13	28%	6–60%
Myopia †	6	13%	8–41%
NLDO	6	13%	
Pseudostrabismus	5	11%	
Anisometropia ‡	4	9%	
Nystagmus	4	9%	
Optic Nerve Anomaly	3	6%	
Amblyopia	2	4%	
Exotropia	1	2%	0–11%
Ptosis	1	2%	
Telecanthus	1	2%	
Macular Dystrophy	1	2%	
Pre-Presbyopia	1	2%	
Anisocoria	1	2%	
Blepharitis	1	2%	
Cataract	1	2%	
Choroidal Pigment Changes	1	2%	

* Astigmatism is defined as > 1.50 D at 90° or > 1.00 D at oblique axis;

** Hyperopia is defined as ≥ 3.50 D in any meridian;

† Myopia is defined as < -3.00 D in any meridian;

‡ Anisometropia is defined as (sphere or cylinder) > 1.00 D.

Table 3

Characteristics of screened DS children (n = 50)

	MTI	VR
Testable	47 (94%)	45 (90%)
Non-testable	3 (6%)	5 (10%)
Pass	10 (20%)	12 (24%)
Refer [*]	40 (80%)	38 (76%)

* Any child who was not testable was considered a “refer.”