Associations of Eye-Related Quality of Life With Vision, Visuomotor Function, and Self-Perception in Children With Strabismus and Anisometropia

Eileen E. Birch,[1,2] Yolanda S. Castañeda,[1] Christina S. Cheng-Patel,[1] Sarah E. Morale,[1] Krista R. Kelly,[1,2] Reed M. Jost,[1] Lindsey A. Hudgins,[1] David A. Leske,[3] and Jonathan M. Holmes[3]

[1]Retina Foundation of the Southwest, Dallas, Texas, United States
[2]Ophthalmology, UT Southwestern Medical Center, Dallas, Texas, United States
[3]Ophthalmology, Mayo Clinic, Rochester, Minnesota, United States

Correspondence: Eileen E. Birch, Retina Foundation of the Southwest, 9600 North Central Expressway #200, Dallas, TX 75231, USA; ebirch@rfsw.org.

Received: May 27, 2020
Accepted: August 8, 2020
Published: September 14, 2020

Citation: Birch EE, Castañeda YS, Cheng-Patel CS, et al. Associations of eye-related quality of life with vision, visuomotor function, and self-perception in children with strabismus and anisometropia. *Invest Ophthalmol Vis Sci.* 2020;61(11):22. https://doi.org/10.1167/iovs.61.11.22

Purpose. To evaluate associations between eye-related quality of life (ER-QOL) assessed by the Child Pediatric Eye Questionnaire (Child PedEyeQ) and functional measures (vision, visuomotor function, self-perception) in children with strabismus, anisometropia, or both. Our hypothesis was that children with functional deficits would have lower ER-QOL, and if so, these associations would support the convergent construct validity of the Child PedEyeQ.

Methods. We evaluated 114 children (ages 5–11 years) with strabismus, anisometropia, or both. Each child completed the Child PedEyeQ to assess four Rasch-scored domains of ER-QOL: Functional Vision, Bothered by Eyes/Vision, Social, and Frustration/Worry. In addition, children completed one or more functional tests: visual acuity ($n = 114$), Randot Preschool Stereoacuity ($n = 92$), contrast balance index (suppression; $n = 91$), Readalyzer reading ($n = 44$), vergence instability ($n = 50$), Movement Assessment Battery for Children–2 manual dexterity ($n = 57$), and Pictorial Scale of Perceived Competence and Social Acceptance for Young Children ($n = 44$).

Results. Child PedEyeQ Functional Vision domain scores were correlated with self-perception of physical competence ($r_s = 0.65$; 95% confidence interval [CI], 0.35–0.96) and reading speed ($r_s = 0.47$; 95% CI, 0.16–0.77). Bothered by Eyes/Vision domain scores were correlated with self-perception of physical competence ($r_s = 0.52$; 95% CI, 0.21–0.83). Moderate correlations were observed between Social domain scores and vergence instability ($r_s = -0.46$; 95% CI, –0.76 to –0.15) and self-perception of physical competence ($r_s = 0.43$; 95% CI, 0.12–0.73) and peer acceptance ($r_s = 0.49$; 95% CI, 0.18–0.80). Frustration/Worry domain scores were moderately correlated with self-perception of physical competence ($r_s = 0.41$; 95% CI, 0.10–0.71) and peer acceptance ($r_s = 0.47$; 95% CI, 0.16–0.77).

Conclusions. Strong and moderate correlations were observed between functional measures and Child PedEyeQ domain scores. These associations provide supporting evidence that the Child PedEyeQ has convergent construct validity.

Keywords: strabismus, anisometropia, amblyopia, quality of life, validity

Strabismus, anisometropia, and amblyopia are common pediatric eye conditions, affecting approximately 5% of children.[1] A wide range of visual function deficits have been reported in children with strabismus, anisometropia, or both, even under binocular viewing conditions. Deficits include slower reading speed,[2,3] impaired motor skills,[4–9] reduced stereoacuity,[10,11] interocular suppression,[12–14] abnormal motion perception,[15–17] and vergence instability.[18] Some deficits appear to be uniquely associated with amblyopia,[2,3,12–14] but others appear to be a result of discordant binocular experience.[4–9,15–17] Standard clinical tests of visual acuity provide only a limited measure of visual performance and may not capture the full impact of strabismus, anisometropia, and amblyopia on the daily life of the child.

The Child Pediatric Eye Questionnaire (PedEyeQ) allows assessment of the impact of both amblyopia and discordant binocular experience on day-to-day functioning and well-being from the child's perspective. The Child PedEyeQ is a patient-reported outcome measure designed to assess the influence of pediatric eye conditions on vision-related function and multiple dimensions of eye-related quality of life (ER-QOL).[19] This instrument has evidence of good psychometric properties, assessed in a large cohort of children with a spectrum of eye conditions,[19] and was found to have expected known-group validity with reduced domain scores among children with visual impairment.[20] We have previously reported that Child PedEyeQ scores were significantly lower (worse) for children with amblyopia[21] and for children

iovs.arvojournals.org | ISSN: 1552-5783

Investigative Ophthalmology & Visual Science

with strabismus[22] than for visually normal controls on each of the four Child PedEyeQ domains. However, the association between Child PedEyeQ domain scores and specific visual function deficits in children with strabismus and anisometropia remains unexplored.

In the present study, we evaluated associations between Child PedEyeQ domain scores and functional measures (vision, visuomotor function, self-perception) in children with strabismus, anisometropia, or both. Our hypothesis was that functional measures and self-perception should be correlated with ER-QOL as assessed by specific domains of the Child PedEyeQ. Such correlations would support the construct validity of the Child PedEyeQ and its use as a surrogate for functional measures.

Methods

Participants

Participants were a convenience sample drawn from a larger cohort participating in ongoing research studies and clinical trials for strabismus, anisometropia, or amblyopia in one vision research laboratory. Each consented to complete the ER-QOL questionnaire in addition to completing the tests required by the study protocol in which they were enrolled. In total, 114 children aged 5 to 11 years, with a current clinical diagnosis of strabismus (n = 32; 10 amblyopic), anisometropia (n = 40; 19 amblyopic), or both (n = 42; 26 amblyopic), who had ≤0.2 logMAR better-eye visual acuity, were enrolled between February 2018 and September 2019. Diagnosis of amblyopia required an interocular best-corrected visual acuity (BCVA) difference of two or more logMAR lines and amblyopic-eye visual acuity worse than published age-referenced normal values.[23,24] Exclusion criteria were significant coexistent eye disease and developmental delay. Children wore their habitual refractive correction for all tests.

Informed consent was obtained from a parent and assent from children age 10 years or older after explanation of the nature and possible consequences of the study. This research was conducted in compliance with the University of Texas Southwestern Medical Center Institutional Review Board. All procedures and data collection were conducted in a manner compliant with the Health Insurance Portability and Accountability Act, and all research procedures adhered to the tenets of the Declaration of Helsinki.

Child PedEyeQ

Each child completed the Child PedEyeQ to assess four Rasch-scored domains of ER-QOL: Functional Vision, Bothered by Eyes/Vision, Social, and Frustration/Worry. Full questionnaires with Rasch-scoring look-up tables are freely available at public.jaeb.org/pedig/view/reference#pedeyeq.

Vision, Visuomotor Function, and Self-Perception

Data from the following measures were collected at the same study time point as the Child PedEyeQ:

Monocular visual acuity was assessed by the Amblyopia Treatment Study (ATS) HOTV protocol (ages 5–6.9 years; n = 39; 18 amblyopic)[25] or the Electronic Early Treatment for Diabetic Retinopathy Study (E-ETDRS) protocol (ages 7–11 years; n = 75; 37 amblyopic)[26] as logMAR.

Stereoacuity was assessed using the Randot Preschool Stereoacuity (n = 92; 42 amblyopic)[27] and converted to log arcsec.

Contrast Balance Index (depth of suppression; n = 91; 46 amblyopic) was obtained using a dichoptic eyechart to determine the nonpreferred eye/preferred eye contrast ratio (balance point) at which the child was able to overcome interocular suppression and report letters presented to each eye with equal likelihood.[13,28]

Vergence instability (variability of eye alignment, n = 50; 22 amblyopic) was determined by recording eye positions with the EyeLink1000 (SR Research, Ottawa, Ontario, Canada) while the child fixated on a small dot (0.3-degree diameter for 20 seconds).[18] Eye alignment variability was summarized by calculating the 68% bivariate contour ellipse area in deg^2 for the interocular difference in fixation location.

Reading rate in words per minute (n = 44; 19 amblyopic) was measured during silent, binocular reading of age-appropriate paragraphs using the Readalyzer (Compevo AB, Stockholm, Sweeden) for school-age children who had completed at least first grade in school (age 7–11 years).[2] The Readalyzer consists of infrared eye movement trackers mounted in goggles worn over the child's habitual correction and a booklet with 10 standardized paragraphs of grade-level appropriate material for each grade, first through sixth. Each paragraph has 10 to 12 lines of text and approximately 100 words. The paragraphs vary in difficulty and font size depending on the grade level of the material. A normative database including more than 12,000 students in the United States is available.[29] Children with dyslexia and those enrolled in reading intervention programs were not eligible for this test. Comprehension was verified by requiring the child to answer 10 questions after completing the paragraph, with a minimum score of 80% correct answers.

Manual dexterity (n = 57; 25 amblyopic) was assessed using the Movement Assessment Battery for Children–2 (MABC-2; Pearson Clinical Assessment, San Antonio, TX): unimanual dexterity, bimanual dexterity, and a drawing trail.[30] Raw scores were converted to standard scores. Standard scores were converted to percentile scores. The MABC-2 is one of the most widely used assessment tools by occupational therapists, physiotherapists, psychologists, and educational professionals to identify and describe impairments in the motor performance of children.[31] Test-retest reliability for the manual dexterity tasks in children as young as 3 years is excellent, with Pearson r ranging from 0.86 to 0.91 for the three tasks.[32] Raw scores were converted to standard scores. Standard scores were converted to percentile scores.

Self-perception was assessed by the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (self-perception of cognitive competence, physical competence, peer acceptance, and maternal acceptance; n = 44; 19 amblyopic) for children in pre-K through grade 2 (age 4–7 years).[4] The Pictorial Scale of Competence and Acceptance for Young Children assesses self-perception in four specific domains: cognitive competence (e.g., counting, alphabet, early reading and writing skills), physical competence (e.g., climbing, running, bouncing a ball), peer acceptance (e.g., activities with friends, sharing), and maternal acceptance (activities and social interactions with mother). Young children comprehend the pictures and response options, the psychometric properties are sound, and the item scores have moderate to good internal consistency (Cronbach's α = 0.53–0.83 for the individual scales and 0.87 for

Table 1. Characteristics of the 114 Children Who Completed the Child PedEyeQ

Characteristic	Value
Age, mean (SD); range, yr	7.5 (1.7); 5 to 11
Female	52 (46)
Race/ethnicity	
Non-Hispanic white	70 (61.4)
Hispanic white	16 (14.0)
Black/African American	7 (6.1)
Asian	8 (7.0)
American Indian/Alaskan Native	1 (0.9)
More than one	12 (10.5)
Diagnosis	
Anisometropia	40 (35.1)
Strabismus	32 (28.1)
Anisometropia and strabismus	42 (36.8)
Amblyopic	55 (48.2)
Better-eye BCVA logMAR, mean (SD); range	–0.01 (0.09); –0.1 to 0.2
Worse-eye BCVA logMAR, mean (SD); range	0.21 (0.30); –0.1 to 1.5
Stereoacuity, log arsec, mean (SD); range*	3.22 (0.92); 1.30 to 4.00
Contrast balance index, mean (SD); range	7.44 (12.7); 0.86 to 61.9
Vergence instability, deg^2, mean (SD); range	1.55 (1.43); 0.09 to 6.19
Reading rate, wpm, mean (SD); range	149 (46); 75 to 261
Manual dexterity, percentile, mean (SD); range	30.6 (26.9); 1 to 95
Cognitive competence domain score, mean (SD); range	3.64 (0.34); 2.83 to 4.00
Physical competence domain score, mean (SD); range	3.16 (0.51); 2.00 to 4.00
Peer acceptance domain score, mean (SD); range	3.05 (0.64); 1.83 to 4.00
Maternal acceptance domain score, mean (SD); range	2.78 (0.65); 1.50 to 4.00

Values are presented as number (%) unless otherwise indicated.
wpm indicates words per minute.
* Measured with the four-book version of the Randot Preschool Stereoacuity[27]; nil stereoacuity was arbitrarily assigned a value of 4.00 log arcsec.

the total scale).[33] The standard deviations are consistent with scale sensitivity to individual differences in perceived competence and acceptance among young children.[33] This instrument is widely used for research with preschool children, including the measurement of the effects of intellectual disability, stuttering, and obesity on self-concept[34–36] and the effects of physical activity programs on self-concept.[37–39]

Statistical Analysis

Associations between ER-QOL domains and vision, visuomotor function, and self-perception were assessed by Spearman rank correlations of domain scores with monocular visual acuity, stereoacuity, contrast balance index, vergence instability, reading speed, manual dexterity, and self-perception. A 95% confidence interval (CI) also was calculated for each Spearman rank correlation coefficient. Correlation coefficients were interpreted as follows: $r = 0.40–0.59$, moderate correlation; $r = 0.60–0.79$, strong correlation; and $r = 0.80–1$, very strong correlation.[40,41]

Construct validity of the Child PedEyeQ (i.e., the degree to which it measures what it purports to be measuring) can be evaluated via convergent validity and discriminant validity. Because our three recent studies have already examined the *discriminant validity* of the Child PedEyeQ,[20–22] the focus of the current study was to examine the relationship between the ER-QOL domains and vision, visuomotor function, and self-perception to address convergent validity (whether measures that should theoretically be related are in fact related). Our explicit hypothesis was that functional measures of vision and self-perception should be correlated with ER-QOL as assessed by specific domains of the Child PedEyeQ. Such correlations would support the convergent validity of the Child PedEyeQ and its use as a surrogate for functional measures.

Results

Table 1 shows that children in the cohort were 61% non-Hispanic white and 46% were female, with a mean age of 7.5 years. Diagnoses included anisometropia (35%), strabismus (28%), or both (37%), and 48% had amblyopia. Participants had a wide range of worse-eye BCVA, stereoacuity, contrast balance index, vergence instability, reading speed, manual dexterity, and self-perception domain scores. Characteristics of the children who participated in each visual function and self-perception test are provided in the e-Table.

Correlations Between ER-QOL Domains and the Visual Function and Self-Perception Tests

All correlations are shown in Table 2. Data for functional measures that had moderate or strong correlations with Child PedEyeQ domains are shown in Figures 1 and 2. A strong correlation was observed between Functional Vision domain scores and the child's self-perception of physical competence ($r = 0.63$; 95% CI, 0.41–0.78; $P < 0.001$), as well as a moderate correlation with reading speed ($r = 0.50$; 95% CI, 0.23–0.69; $P < 0.001$).

For the Bothered by Eyes/Vision domain scores, a moderate correlation was observed with the child's self-perception of physical competence ($r = 0.56$; 95% CI, 0.32–0.72, $P < 0.001$).

Table 2. Spearman Rank Correlation Coefficients, With 95% Confidence Intervals, for Associations Between Child PedEyeQ Domain Scores and Functional Measures

		PedEyeQ Domain			
Characteristic	**No.**	**Functional Vision**	**Bothered by Eyes/Vision**	**Social**	**Frustration/ Worry**
Better-eye BCVA (logMAR)	114	–0.14 (–0.33 to 0.04)	–0.18 (–0.37 to 0.00)	–0.12 (–0.30 to 0.07)	–0.15 (–0.33 to 0.04)
Worse-eye BCVA (logMAR)	114	–0.13 (–0.32 to 0.06)	–0.19 (–0.38 to 0.00)	–0.19 (–0.38 to 0.00)	–0.25 (–0.44 to –0.06)
Stereoacuity (log arsec)	92	–0.03 (–0.24 to 0.18)	–0.02 (–0.23 to 0.19)	–0.07 (–0.28 to 0.14)	–0.19 (–0.40 to 0.02)
Contrast balance index	91	–0.32 (–0.53 to –0.12)	–0.29 (–0.50 to –0.09)	–0.24 (–0.45 to –0.03)	–0.22 (–0.43 to –0.01)
Vergence instability (deg^2)	50	–0.07 (–0.38 to 0.24)	–0.26 (–0.55 to 0.05)	–0.46 (–0.76 to –0.15)	–0.28 (–0.59 to 0.03)
Reading rate (wpm)	44	0.47 (0.16 to 0.77)	0.23 (–0.08 to 0.53)	0.19 (–0.11 to 0.50)	0.20 (–0.11 to 0.51)
Manual dexterity (%tile)	57	0.27 (0.00 to 0.53)	0.11 (–0.16 to 0.38)	–0.03 (–0.30 to 0.24)	–0.04 (–0.31 to 0.23)
Self-perception	44				
Cognitive competence		0.24 (–0.07 to 0.54)	0.01 (–0.30 to 0.31)	0.07 (–0.24 to 0.38)	0.16 (–0.15 to 0.47)
Physical competence		0.65 (0.35 to 0.96)	0.52 (0.21 to 0.83)	0.43 (0.12 to 0.73)	0.41 (0.10 to 0.71)
Peer acceptance		0.39 (0.08 to 0.70)	0.32 (0.01 to 0.63)	0.49 (0.18 to 0.80)	0.47 (0.16 to 0.77)
Maternal acceptance		–0.10 (–0.40 to 0.21)	–0.04 (–0.34 to 0.27)	0.06 (–0.25 to 0.36)	–0.08 (–0.39 to 0.22)

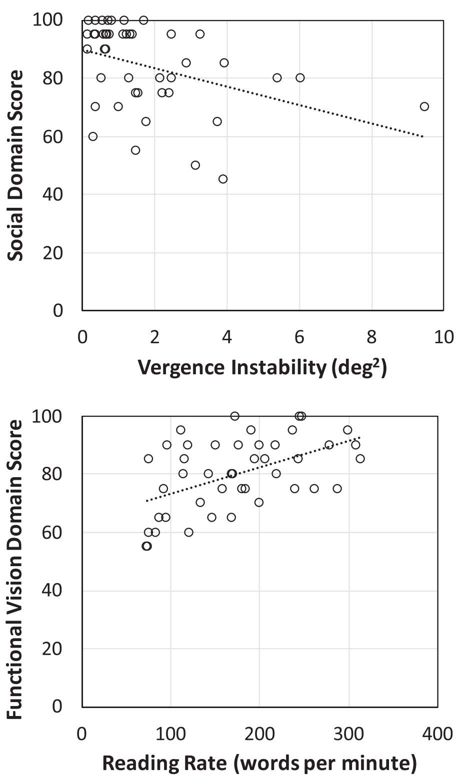

Figure 1. Moderate associations were between vergence instability and Child PedEyeQ Social domain scores and between reading speed and Child PedEyeQ Functional Vision domain scores. *Dotted lines* illustrate the linear trend; correlations were computed using Spearman rank correlation coefficients (r_s = –0.46 and +0.47, respectively).

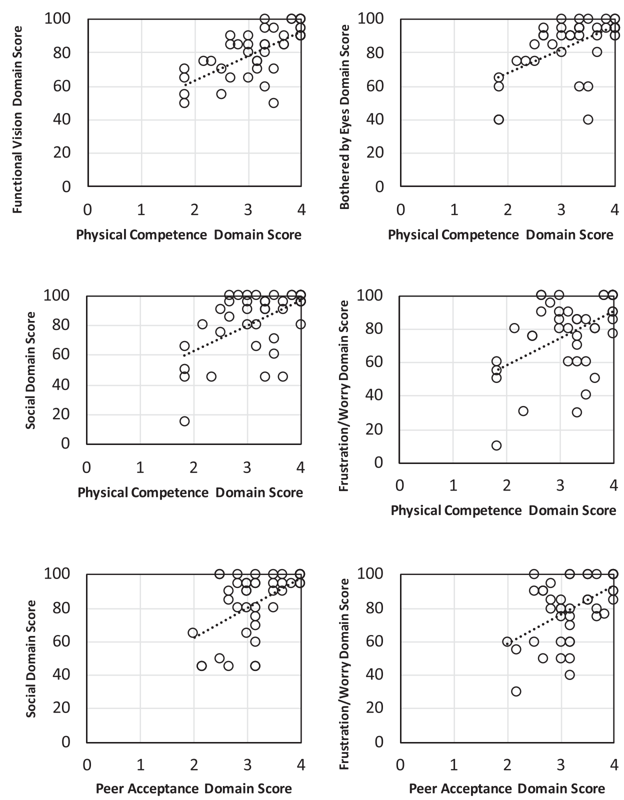

Figure 2. Moderate and strong associations were between self-perception of physical competence and Functional Vision, Bothered by Eyes, Social, and Frustration/Worry Child PedEyeQ domain scores (r_s = +0.65, +0.52, +0.43, and +0.41, respectively). Moderate associations were observed between self-perception of peer acceptance and Social and Frustration/Worry Child PedEyeQ domain scores (r_s = +0.49 and +0.47, respectively).

Moderate correlations were observed between Social domain scores and vergence instability (r = –0.41; 95% CI, –0.15 to –0.62, $P < 0.001$) and with the child's self-perception of physical competence (r = 0.46; 95% CI, 0.19–0.67, $P < 0.001$) and peer acceptance (r = 0.52; 95% CI, 0.26–0.71, $P < 0.001$).

Frustration/Worry domain scores were moderately correlated with the child's self-perception of physical competence (r = 0.45; 95% CI, 0.18–0.66, $P < 0.001$) and peer acceptance (r = 0.43; 95% CI, 0.15–0.64, P = 0.003).

Discussion

Strong and moderate correlations were observed between functional measures and Child PedEyeQ domain scores. The focus of the Functional Vision domain on school-related tasks and daily activities was evident in both a moderate correlation with reading and a strong correlation with self-perception of physical competence. Similarly, the Bothered by Eyes/Vision domain, which evaluates the extent to which the child is bothered by the difficulties encountered in daily activities, also was moderately correlated with the child's self-perception of physical competence. Slow reading has previously been reported in amblyopic children,[2,3,5] and motor skills deficits have been reported in both amblyopic children and in nonamblyopic strabismic children.[4,6,9,42–44]

The Social domain of the Child PedEyeQ evaluates the child's concerns about interactions with friends and family, shyness, and teasing. A moderate correlation was observed between Social domain scores and vergence instability (unstable eye alignment). Strabismus has been previously reported to be associated with peer victimization, especially teasing and bullying.[45,46] Both the Social domain scores and the Frustration/Worry domain scores, which query whether the child feels unsure of themselves, frustrated, worried, different, or left out, were also moderately correlated with the child's self-perception of physical competence and self-perception of peer acceptance. Motor skills deficits have been widely reported in children with strabismus and amblyopia,[4,6,9,42–44] and it is well appreciated that motor skills impairment is associated with reduced social participation, withdrawal from childhood social activities, and lower self-esteem.[47,48]

We did not observe a moderate or strong correlation between either better-eye or worse-eye visual acuity and Child PedEyeQ domain scores in the current study. However, our aim was to compare Child PedEyeQ scores with functional measures (vision, visuomotor function, self-perception) in a cohort with strabismus, anisometropia, or both. As a result, participants were children with normal visual acuity in at least their better-seeing eye, and 52% of children had normal visual acuity in both eyes (see Table 1). Thus, the limited range in visual acuity may have constrained our ability to appreciate associations between visual acuity and ER-QOL. On the other hand, in our prior study of 310 children with diverse eye conditions and a wide range of visual acuities, we also report that there were only weak correlations between better-seeing eye or worse-seeing eye visual acuity and Child PedEyeQ domain scores.[49] Taken together, these results suggest that other aspects of visual function may have a stronger influence on ER-QOL than high-contrast optotype visual acuity among children with strabismus, anisometropia, or both.

Limitations of this study are that our cohort was relatively small, and as a result, we were only able to detect moderate and strong correlations. In addition, the data were obtained from only one vision research laboratory, and not all children participated in all functional tests. As a result, the study results may not be representative of the global population of children with strabismus and anisometropia.

Our prior studies have already addressed factor structure and content validity (clear and relevant questions) of the PedEyeQ.[19,50,51] In addition, our three recent studies support the *discriminant validity* of the Child PedEyeQ by known group comparisons of children with visual impairment,[20] residual amblyopia,[21] and children with strabismus[22] versus controls. The correlations between functional measures and the Child PedEyeQ reported here provide supporting evidence for *convergent validity*. Taken together, the discriminant and convergent validity support the construct validity of the Child PedEyeQ. Data supporting construct validity further establish the Child PedEyeQ as a useful outcome measure, in addition to visual acuity and stereoacuity, for clinical and clinical research settings. Further studies are planned to determine test-retest reliability and whether or not the Child PedEyeQ is responsive to expected changes following surgical or nonsurgical treatment.

Acknowledgments

This research was scheduled as a platform presentation for the 2020 Annual Meeting of the Association for Research in Vision and Ophthalmology.

Supported by National Institutes of Health Grants EY024333 (JMH, Principal Investigator (PI) and EEB, Co-Investigator (Co-I)) and EY022313 (EEB) and Mayo Foundation, Rochester, Minnesota.

Disclosure: **E.E. Birch,** None; **Y.S. Castañeda,** None; **C.S. Cheng-Patel,** None; **S.E. Morale,** None; **K.R. Kelly,** None; **R.M. Jost,** None; **L.A. Hudgins,** None; **D.A. Leske,** None; **J.M. Holmes,** None

References

1. Birch EE. Amblyopia and binocular vision. *Prog Retin Eye Res*. 2013;33:67–84.
2. Kelly KR, Jost RM, De La Cruz A, Birch EE. Amblyopic children read more slowly than controls under natural, binocular reading conditions. *J AAPOS*. 2015;19:515–520.
3. Kelly KR, Jost RM, De La Cruz A, et al. Slow reading in children with anisometropic amblyopia is associated with fixation instability and increased saccades. *J AAPOS*. 2017;21:447–451.
4. Birch EE, Castaneda YS, Cheng-Patel CS, et al. Self-perception in children aged 3 to 7 years with amblyopia and its association with deficits in vision and fine motor skills. *JAMA Ophthalmol*. 2019;137:499–506.
5. Birch EE, Castaneda YS, Cheng-Patel CS, et al. Self-perception of school-aged children with amblyopia and its association with reading speed and motor skills. *JAMA Ophthalmol*. 2019;137:167–174.
6. 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.
7. Grant S, Melmoth DR, Morgan MJ, Finlay AL. Prehension deficits in amblyopia. *Invest Ophthalmol Vis Sci*. 2007;48:1139–1148.
8. Grant S, Moseley MJ. Amblyopia and real-world visuomotor tasks. *Strabismus*. 2011;19:119–128.
9. Grant S, Suttle C, Melmoth DR, Conway ML, Sloper JJ. Age- and stereovision-dependent eye-hand coordination deficits in children with amblyopia and abnormal binocularity. *Invest Ophthalmol Vis Sci*. 2014;55:5687–5705.
10. Wallace DK, Lazar EL, Melia M, et al. Stereoacuity in children with anisometropic amblyopia. *J AAPOS*. 2011;15:455–461.
11. Birch EE, Stager DR, Sr. Long-term motor and sensory outcomes after early surgery for infantile esotropia. *J AAPOS*. 2006;10:409–413.
12. Black JM, Hess RF, Cooperstock JR, To L, Thompson B. The measurement and treatment of suppression in amblyopia. *J Vis Exp*. 2012;70:e3927.
13. Birch EE, Morale SE, Jost RM, et al. Assessing suppression in amblyopic children with a dichoptic eye chart. *Invest Ophthalmol Vis Sci*. 2016;57:5649–5654.
14. Narasimhan S, Harrison ER, Giaschi DE. Quantitative measurement of interocular suppression in children with amblyopia. *Vision Res*. 2012;66:1–10.
15. Birch EE, Jost RM, Wang YZ, Kelly KR, Giaschi DE. Impaired fellow eye motion perception and abnormal binocular function. *Invest Ophthalmol Vis Sci*. 2019;60:3374–3380.

16. Giaschi DE, Regan D, Kraft SP, Hong XH. Defective processing of motion-defined form in the fellow eye of patients with unilateral amblyopia. *Invest Ophthalmol Vis Sci*. 1992;33:2483–2489.
17. Ho CS, Giaschi DE. Low- and high-level motion perception deficits in anisometropic and strabismic amblyopia: evidence from fMRI. *Vision Res*. 2009;49:2891–2901.
18. Kelly KR, Cheng-Patel CS, Jost RM, Wang YZ, Birch EE. Fixation instability during binocular viewing in anisometropic and strabismic children. *Exp Eye Res*. 2019;183:29–37.
19. Hatt SR, Leske DA, Castañeda YS, et al. Development of pediatric eye questionnaires for children with eye conditions. *Am J Ophthalmol*. 2019;200:201–217.
20. Leske DA, Hatt SR, Castañeda YS, et al. Validation of the Pediatric Eye Questionnaire in children with visual impairment. *Am J Ophthalmol*. 2019;208:124–132.
21. Hatt SR, Leske DA, Castañeda YS, et al. Understanding the impact of residual amblyopia on functional vision and eye-related quality of life using the PedEyeQ. *Am J Ophthalmol*. 2020;218:173–181.
22. Hatt SR, Leske DA, Castañeda YS, et al. Association of strabismus with functional vision and eye-related quality of life in children. *JAMA Ophthalmol*. 2020;138:1–8.
23. Drover JR, Felius J, Cheng CS, Morale SE, Wyatt L, Birch EE. Normative pediatric visual acuity using single surrounded HOTV optotypes on the Electronic Visual Acuity Tester following the Amblyopia Treatment Study protocol. *J AAPOS*. 2008;12:145–149.
24. Pan Y, Tarczy-Hornoch K, Cotter SA, et al. Visual acuity norms in pre-school children: the Multi-Ethnic Pediatric Eye Disease Study. *Optom Vis Sci*. 2009;86:607–612.
25. Holmes JM, Beck RW, Repka MX, et al. The amblyopia treatment study visual acuity testing protocol. *Arch Ophthalmol*. 2001;119:1345–1353.
26. Beck R, Moke P, Turpin A, et al. A computerized method of visual acuity testing: adaptation of the early treatment of diabetic retinopathy study testing protocol. *Am J Ophthalmol*. 2003;135:194–205.
27. Birch E, Williams C, Drover J, et al. Randot Preschool Stereoacuity Test: normative data and validity. *J AAPOS*. 2008;12:23–26.
28. Webber AL, Wood JM, Thompson B, Birch EE. From suppression to stereoacuity: a composite binocular function score for clinical research. *Ophthalmic Physiol Opt*. 2019;39:53–62.
29. Taylor SE. *National Study of Fluency in the Primary Grades*. Huntington Statation, NY, USA: Instruction Communication Technology, Inc.; 1976–1978.
30. Kelly KR, Morale SE, Wang SX, Stager DR, Jr., Birch EE. Impaired fine motor skills in children following extraction of a dense congenital or infantile unilateral cataract. *J AAPOS*. 2019;23:330e331–336.
31. Barnett AL, Henderson SE. *An Annotated Bibliography of Studies Using the Movement ABC: 1984–1996*. London, UK: The Psychological Corporation; 1998.
32. Henderson SE, Sugden DA, Barnett AL. *Movement Assessment Battery for Children–2 Second Edition [Movement ABC-2]*. London, UK: The Psychological Corporation; 2007.
33. Harter S, Pike R. The pictorial scale of perceived competence and social acceptance for young children. *Child Dev*. 1984;55:1969–82.
34. Hertsberg N, Zebrowski PM. Self-perceived competence and social acceptance of young children who stutter: initial findings. *J Commun Disord*. 2016;64:18–31.
35. Fiasse C, Nader-Grosbois N. Perceived social acceptance, theory of mind and social adjustment in children with intellectual disabilities. *Res Dev Disabil*. 2012;33:1871–1880.
36. Spessato BC, Gabbard C, Robinson L, Valentini NC. Body mass index, perceived and actual physical competence: the relationship among young children. *Child Care Health Dev*. 2013;39:845–850.
37. Crane JR, Naylor PJ, Cook R, Temple VA. Do perceptions of competence mediate the relationship between fundamental motor skill proficiency and physical activity levels of children in kindergarten? *J Phys Act Health*. 2015;12:954–961.
38. Folleto JC, Pereira KR, Valentini NC. The effects of yoga practice in school physical education on children's motor abilities and social behavior. *Int J Yoga*. 2016;9:156–162.
39. Vazou S, Mantis C, Luze G, Krogh JS. Self-perceptions and social-emotional classroom engagement following structured physical activity among preschoolers: a feasibility study. *J Sport Health Sci*. 2017;6:241–247.
40. Correlation and regression. *BMJ*. Available at: https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/11-correlation-and-regression.. Accessed May 13, 2020.
41. Evans J. *Straightforward Statistics for the Behavioral Sciences*. Pacific Grove, CA: Brooks/Cole; 1996.
42. Kelly KR, Jost RM, De La Cruz A, Birch EE. Multiple-choice answer form completion time in children with amblyopia and strabismus. *JAMA Ophthalmol*. 2018;136:938–941.
43. Caputo R, Tinelli F, Bancale A, et al. Motor coordination in children with congenital strabismus: effects of late surgery. *Eur J Paediatr Neurol*. 2007;11:285–291.
44. Suttle CM, Melmoth DR, Finlay AL, Sloper JJ, Grant S. Eye-hand coordination skills in children with and without amblyopia. *Invest Ophthalmol Vis Sci*. 2011;52:1851–1864.
45. Horwood J, Waylen A, Herrick D, Williams C, Wolke D. Common visual defects and peer victimization in children. *Invest Ophthalmol Vis Sci*. 2005;46:1177–1181.
46. Lecouturier J, Clarke M, Errington G, Hallowell N, Murtagh M, Thomson R. Treating childhood intermittent distance exotropia: a qualitative study of decision making. *BMC Ophthalmol*. 2015;15:112.
47. Gagnon-Roy M, Jasmin E, Camden C. Social participation of teenagers and young adults with developmental coordination disorder and strategies that could help them: results from a scoping review. *Child Care Health Dev*. 2016;42:840–851.
48. Zwicker J, Harris S, Klassen A. Quality of life domains affected in children with developmental coordination disorder: a systematic review. *Child Care Health Dev*. 2012;39:562–580.
49. Leske DA Hatt SR, Wernimont SM, et al. Association of visual acuity with eye-related quality of life and functional vision across childhood eye conditions. Abstract for presentation at the 2020 Annual ARVO meeting; *JAAPOS*. 2020, under review.
50. Hatt SR, Leske DA, Castaneda YS, et al. Patient-derived questionnaire items for patient-reported outcome measures in pediatric eye conditions. *J AAPOS*. 2018;22:445–448 e422.
51. Hatt SR, Leske DA, Wernimont SM, Birch EE, Holmes JM. Comparison of rating scales in the development of patient-reported outcome measures for children with eye disorders. *Strabismus*. 2017;25:33–38.