Longitudinal refractive errors over 36 months in Hispanic and Black children

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SIGNIFICANCE: This study brings awareness of racial/ethnic difference of refractive error characteristics in clinics.

PURPOSE: This study aimed to assess longitudinal change in refractive errors over a 36-month period in Hispanic and Black children.

METHODS: Children (2.4 to 15 years old) were studied. Cycloplegic refraction was measured annually. Spherical equivalent was calculated. Astigmatism was evaluated by magnitude of cylinder and power vector (J_0 and J_{45}). Absolute value of interocular spherical equivalent difference was used to calculate anisometropia. Mixed-linear model was used to analyze longitudinal annual change in spherical equivalent, cylinder, J_0, and J_{45} over 36 months.

RESULTS: A total of 485 participants (310 Black, 175 Hispanic) met the criteria. At the baseline examination, prevalence of myopia, emmetropia, and hyperopia was 39% (n = 187), 31% (n = 150), and 30% (n = 148), respectively. Spherical equivalent of Black children was not significantly different from that in Hispanic children (0.10 ± 2.92 vs. −0.37 ± 2.05 D, p=0.06); however, the Hispanic children had a significantly higher cylinder compared with Black children (Hispanic: 1.46 ± 1.57 D vs. Black: 0.92 ± 1.07 D; p<0.001). Both J_0 (p<0.001) and J_{45} (p=0.01) were significantly different between two groups; the Hispanic children had more with-the-rule astigmatism and oblique astigmatism than the Black children. Prevalence of anisometropia (≥1 D) was higher in Black children (14%) compared with Hispanic children (5%, p=0.006). Over 36 months, spherical equivalent significantly decreased an average of 0.69 D (0.23 D/y, p<0.001) for both groups; neither astigmatism nor anisometropia changed significantly (p>0.05).

CONCLUSIONS: Astigmatism in the Hispanic children was significantly higher than in Black children. However, the Black children had a higher prevalence and degree of anisometropia than the Hispanic children.

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Refractive errors, including myopia, hyperopia, astigmatism, and anisometropia, vary among different racial and ethnic groups. Previously, in a cross-sectional study based on a young cohort (0.5 to 6 years old), the Multi-Ethnic Pediatric Eye Disease Study (MEPEDS) reported a higher prevalence of astigmatism (≥1.50 D) in Hispanic children (17%) than in Black children (13%).[1,2] The study found that Hispanic and Black children were more likely to develop myopia than non-Hispanic White children.[3,4] Furthermore, Hispanic and Black children had a higher prevalence of myopia and a greater degree of myopic progression (estimated to be −0.46 and −0.88 D over 36 months, respectively) compared with the non-Hispanic White children (−0.19 D over 36 months).[5] There were few studies that compared the longitudinal development of refractive errors between Hispanic and Black children.

It is crucial to understand and address these racial differences in refractive errors to provide appropriate eye care for all children, regardless of their ethnicity or background. In the United States, previously uncorrected and undercorrected refractive errors were reported in non-Caucasian race/ethnicity populations,[6] and they suggested targeted efforts for these populations as a public health strategy. The Baltimore Pediatric Eye Disease Study compared the prevalence of refractive errors in White and Black children aged 6 to 71 months.[7] Apart from the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error Study (CLEERE), few studies have investigated the longitudinal development of refractive error in Hispanic and Black children. Thus, it is important to investigate refractive errors longitudinally in Black and Hispanic children as myopia progression can lead to vision impairment and other eye-related health issues later in life. In a clinical cohort, this study assessed the longitudinal change in refractive errors over 36 months in Hispanic and Black children.

METHODS

This study is a secondary analysis of data from a prospective cohort study of 5497 children enrolled from January 2012 to December 2012 and followed up for 3 years. This research protocol and the informed consent forms were approved by the institutional review board of the Illinois College of Optometry (Chicago, IL). Health Insurance Portability and Accountability Act rules and the Declaration of Helsinki were followed during this study. Informed consent was obtained from the legal guardians of all participants; for children 7 years and older, assent was obtained.

Participants

Participants were examined in an urban eye clinic, the Illinois Eye Institute (Chicago, IL), which provides both primary and secondary/tertiary eye care.

Eligibility and inclusion criteria

(1) Children 15 years or younger who had a comprehensive eye examination at the baseline visit and cycloplegic autorefraction were qualified for the study. (2) Each participant was followed annually and had at least two visits over 36 months. (3) Because of the population distribution of this area, we included only two groups of children: non-Hispanic Black ("Black" hereafter) and Hispanic/Latino White participants ("Hispanic" hereafter). Parents or legal guardians reported race/ethnicity.

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Exclusion criteria

Children with diabetes, Down syndrome, cerebral palsy, presence of ocular pathology causing reduced visual acuity, or prior ocular surgery were excluded. Because of a very small sample, non-Hispanic Whites and Asians were excluded.

Procedures

Cycloplegia and pupil dilation were induced in both eyes with one drop each of 1% tropicamide and 2.5% phenylephrine hydrochloride and two drops of 1% cyclopentolate (5 minutes apart) in both eyes. At 30 minutes following the eyedrops, autorefraction was measured using either Canon R-F10 (Canon Medical Systems USA, Inc., Tustin, CA) Topcon KR-800 (Topcon Corporation, Tokyo, Japan). Cycloplegic refraction was recorded in conventional minus cylinder form as a sphere, cylinder, and axis. The sphere and cylinder were converted to the spherical equivalent value: spherical equivalent = sphere + 0.5 × cylinder. Astigmatism was evaluated by the magnitude of cylinder and power vector[8]: J_0 (positive J_0 indicates with-the-rule [WTR] astigmatism, negative J_0 indicates against-the-rule astigmatism) and J_{45} (oblique astigmatism: positive J_{45} indicates 45° minus cylinder astigmatism, whereas negative J_{45} indicates 135° minus cylinder astigmatism). Anisometropia was the absolute value of the interocular difference of spherical equivalent.

- Myopia was defined as spherical equivalent ≤−0.50 D.
- Hyperopia was defined as spherical equivalent ≥0.75 D.
- Anisometropia was defined as interocular difference ≥1.00 D.
- Astigmatism was defined as cylinder ≥1.00 D.
- Severe astigmatism was defined as cylinder ≥3.00 D.

Visual acuity was monocularly measured with LEA Symbol chart for children younger than 6 years and with Snellen chart for children 6 years or older. At the first visit, visual acuity was measured without and with correction; during the follow-up visits, they were measured for habitual visual acuity and best-corrected visual acuity. Visual acuity testing was conducted using an electronic Snellen chart (M&S Technologies, Niles, IL). All testing was conducted in a room with a luminance of 90 to 110 cd/m². The computer screen was autocalibrated to a luminance level of 85 cd/m² using a photometer for all testing. The participants were seated 3 m away from the monitor and tested by trained clinicians.

Statistical analysis

Data analysis was performed using R 4.2 Statistics (R Core Team, R: A Language and Environment for Statistical Computing; R Foundation for Statistical Computing, 2017, Vienna, Austria; https://www.R-project.org). To categorize refractive error, spherical equivalent in the right eye was used; to evaluate astigmatism, cylinder, J_0, and J_{45} in the right eye were used, and to determine anisometropia, the absolute value of interocular spherical equivalent difference was used. The yearly change in spherical equivalent, cylinder, J_0, and J_{45} over 36 months was analyzed.

To determine the longitudinal development of refractive error in each child (i.e., spherical equivalent, cylinder, J_0, J_{45}, anisometropia), a mixed-effects linear model was used. Race/ethnicity was treated as a fixed effect and the individual as a random effect. The model provided comparisons within each group as well as comparisons between groups. $p<0.05$ was considered statistically significant.

RESULTS

Table 1 shows the characteristics of the participants who met the criteria. After excluding 35 participants who were Asian or non-Hispanic White, a total of 485 participants were studied, including 310 non-Hispanic Black participants and 175 Hispanic/Latino

TABLE 1. Demographic characteristics and refractive errors of the participants (N = 485) at the baseline visit

	Total N = 485	Non-Hispanic Black n = 310 (64%)	Hispanic/Latino n = 175 (36%)	Comparison of groups: Test value and *p*
Sex, n (%)				
Female	279 (58%)	195 (63%)	84 (48%)	χ^2 = 9.6, p=0.002*
Male	206 (43%)	115 (37%)	91 (52%)	
Initial age (y)				
Range	2.4–15.0	3.2–15.0	2.4–14.9	$t_{df = 326.7}$ = 0.62, p=0.50
Mean (SD)	8.7 (2.9)	8.8 (2.8)	8.6 (3.1)	
Distribution, n (%)				
Myopia (≤−0.5 D)	187 (39%)	111 (36%)	76 (43%)	χ^2 = 2.4, p=0.10
Emmetropia (>−0.5 to <+0.75 D)	150 (31%)	91 (29%)	59 (34%)	χ^2 = 0.8, p=0.40
Hyperopia (≥+0.75 D)	148 (31%)	108 (35%)	40 (23%)	χ^2 = 7.0, p=0.008*
Astigmatism (cylinder, ≥1 D)	188 (39%)	101 (33%)	87 (50%)	χ^2 = 13.0, p<0.001*
Anisometropia (≥1 D)	51 (11%)	42 (14%)	9 (5%)	χ^2 = 7.5, p=0.006*
Baseline refraction and vision		Mean ± SD (range)		
Spherical equivalent (D)	−0.07 ± 2.64 (−14.40, 14.50)	0.10 ± 2.92 (−14.40, 14.50)	−0.37 ± 2.05 (−9.13, 6.00)	$F_{df = 1,1,1481}$ = 3.81, p=0.05
Cylinder (D)	1.11 ± 1.30 (0, 8.25)	0.92 ± 1.07 (0, 8.25)	1.46 ± 1.57 (0, 6.25)	$F_{df = 1,1,1481}$ = 21.11, p<0.001*
J_0 (D)	0.58 ± 0.69 (−1.24, 4.03)	0.41 ± 0.57 (−1.24, 4.03)	0.87 ± 0.78 (−0.25, 3.12)	$F_{df = 1,1,1385}$ = 44.07, p<0.001*
J_{45} (D)	0.06 ± 0.33 (−1.49, 1.92)	0.03 ± 0.35 (−1.49, 1.92)	0.11 ± 0.27 (−0.56, 0.84)	$F_{df = 1,1,1385}$ = 6.47, p=0.01*
Anisometropia (D)	0.48 ± 0.93 (0, 9.00)	0.56 ± 1.11 (0, 9.00)	0.35 ± 0.48 (0, 5.38)	$F_{df = 1,11,479}$ = 5.41, p=0.02*
Entry visual acuity (logMAR)	0.25 ± 0.30 (0, 1.67)	0.25 ± 0.31 (0, 1.67)	0.24 ± 0.26 (0, 1.18)	$F_{df = 1,11,474}$ = 0.09, p=0.76
Best-corrected visual acuity (logMAR)	0.06 ± 0.13 (−0.13, 1.00)	0.07 ± 0.16 (0, 1.00)	0.04 ± 0.09 (−0.13, 0.60)	$F_{df = 1,1,1452}$ = 4.77, p=0.03*

*Indicates statistical significance (p<0.05). Analysis was adjusted for age and sex.

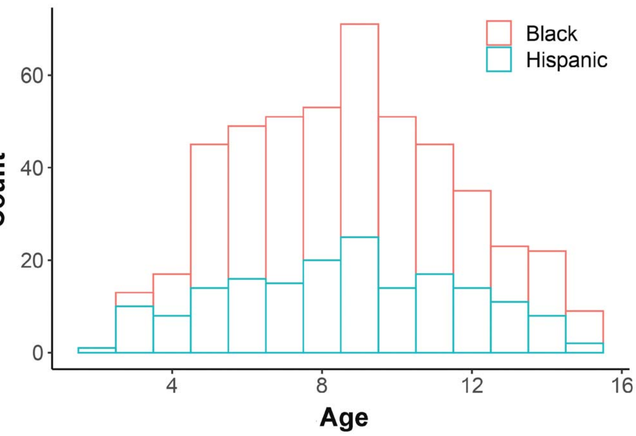

FIGURE 1. Histogram of age distribution in Black and Hispanic children at the baseline.

participants; 58% of participants were female. Age at the baseline is approximately normally distributed (Fig. 1). The mean age was 8.7 ± 2.9 years, ranging from 2.4 to 15 years old; there was no significant age difference between the two ethnic groups (independent *t* test, $t_{df = 326.7} = 0.62$, p=0.50).

Prevalence of refractive errors at baseline and 36 months

At the baseline eye examination, the prevalence of myopia, emmetropia, and hyperopia was 39 (n = 187), 31 (n = 150), and 31% (n = 148), respectively. Prevalence of hyperopia (spherical equivalent, ≥0.75 D) was higher in Black children compared with Hispanic children (Black: 35% vs. Hispanic: 23%; $\chi^2 = 7.0$, p=0.008).

Prevalence of astigmatism (cylinder, ≥1.00 D) was statistically higher in Hispanic children compared with Black children (Hispanic: 50% vs. Black: 33%; $\chi^2 = 13.0$, p<0.001). Hispanic children also showed a higher prevalence of severe astigmatism (cylinder, ≥3.00 D) than Black children (Hispanic: 23% vs. Black: 7%; $\chi^2 = 25.0$, p<0.001). Prevalence of anisometropia (≥1.00 D) was higher in Black children compared with Hispanic children (Black: 14% vs. Hispanic: 5%; $\chi^2 = 7.5$, p=0.006).

At 36 months, the prevalence of astigmatism (cylinder, ≥1.00 D) increased 10% from the baseline, and the prevalence of astigmatism was higher in Hispanic than in Black children (Hispanic: 61% vs. Black: 44%; $\chi^2 = 7.2$, p=0.007). Hispanic children also showed a higher prevalence of severe astigmatism (cylinder, ≥3.00 D) than Black children (Hispanic: 21% vs. Black: 8%; $\chi^2 = 8.7$, p=0.003).

Refractive error magnitudes

Fig. 2 summarizes spherical equivalent, cylinder, J_0, J_{45}, and anisometropia over 36 months. At the baseline examination, after adjusting for sex, spherical equivalent of the Black children was not different from Hispanic children (Fig. 2A, 0.10 ± 2.92 vs. −0.37 ± 2.05 D, p=0.05); however, the magnitude of astigmatism was higher in Hispanic than in Black children (Fig. 1E; Black: 0.92 ± 1.07 D vs. Hispanic: 1.46 ± 1.57 D; p<0.001). Both J_0 (p<0.001) and J_{45} (p=0.01) showed a difference between Hispanic and Black children (Figs. 2C, D); Hispanic children had more WTR astigmatism and oblique astigmatism than Black children. In addition, the mean magnitude of anisometropia was higher in the Black than in the Hispanic children (Fig. 2B; Black: 0.56 ± 1.11 D vs. Hispanic: 0.35 ± 0.48 D; p=0.02).

TABLE 2. Refractive errors and BCVA (mean ± SD [range]) at 3-year follow-up visits

Follow-up parameters	Total	Non-Hispanic Black	Hispanic/Latino	Comparison of groups: Test value and *P*
12 mo	n = 154	n = 95	n = 59	
Spherical equivalent (D)	−0.36 ± 2.84 (−10.5, 10.6)	−0.30 ± 3.03 (−10.5, 10.6)	−0.30 ± 2.51 (−8.13, 6.63)	$F_{df = 1,1,1150} = 0.09$, p=0.77
Cylinder (D)	1.62 ± 1.49 (0, 6.25)	1.19 ± 1.05 (0, 4.75)	2.28 ± 1.81 (0.25, 6.25)	$F_{df = 1,1,1131} = 21.87$, p< 0.001*
J_0 (D)	0.70 ± 0.79 (−1.24, 3.12)	0.46 ± 0.57 (−1.24, 2.10)	1.08 ± 0.92 (−0.24, 3.12)	$F_{df = 1,1,1131} = 25.22$, p<0.001*
J_{45} (D)	0.1 ± 0.32 (−0.77, 1.11)	0.07 ± 0.31 (−0.77, 1.11)	0.15 ± 0.32 (−0.60, 0.98)	$F_{df = 1,1,1131} = 2.20$, p=0.14
Anisometropia (D)	0.56 ± 0.94 (0, 6.13)	0.67 ± 1.11 (0, 6.13)	0.38 ± 0.43 (0, 3)	$F_{df = 1,1,1150} = 3.31$, p=0.07
BCVA (logMAR)	0.06 ± 0.13 (0, 0.88)	0.06 ± 0.14 (0, 0.88)	0.07 ± 0.11 (0, 0.40)	$F_{df = 1,1,1147} = 0.13$, p=0.72
24 mo	n = 243	n = 140	n = 103	
Spherical equivalent (D)	−0.58 ± 3.08 (−14.8, 12)	−0.38 ± 3.52 (−14.8, 12)	−0.85 ± 2.34 (−7.88, 5.38)	$F_{df = 1,1,1239} = 1.34$, p=0.25
Cylinder (D)	1.51 ± 1.45 (0.25, 7.75)	1.32 ± 1.37 (0.25, 7.75)	1.74 ± 1.52 (0.25, 6.25)	$F_{df = 1,1,1193} = 4.22$, p<0.05*
J_0 (D)	0.65 ± 0.75 (−1.11, 3.79)	0.50 ± 0.71 (−1.11, 3.79)	0.82 ± 0.77 (−0.30, 3.08)	$F_{df = 1,1,1193} = 9.10$, p<0.01*
J_{45} (D)	0.06 ± 0.34 (−0.96, 1.72)	0.03 ± 0.39 (−0.96, 1.72)	0.09 ± 0.26 (−0.51, 1.00)	$F_{df = 1,1,1193} = 1.53$, p=0.22
Anisometropia (D)	0.53 ± 1.19 (0, 12.8)	0.65 ± 1.53 (0, 12.8)	0.38 ± 0.37 (0, 2.38)	$F_{df = 1,1,1193} = 2.98$, p=0.09
BCVA (logMAR)	0.06 ± 0.18 (0, 1.70)	0.08 ± 0.23 (0, 1.70)	0.03 ± 0.08 (0, 0.40)	$F_{df = 1,1,1193} = 3.27$, p=0.08
36 mo	n = 363	n = 226	n = 137	
Spherical equivalent (D)	−0.75 ± 3.14 (−18.8, 12.2)	−0.57 ± 3.50 (−18.8, 12.2)	−1.04 ± 2.43 (−8.63, 5.63)	$F_{df = 1,1,1359} = 2.04$, p=0.17
Cylinder (D)	1.37 ± 1.27 (0.25, 6)	1.14 ± 1.05 (0.25, 5.5)	1.74 ± 1.48 (0.25, 6)	$F_{df = 1,1,1305} = 17.57$, p<0.001*
J_0 (D)	0.55 ± 0.67 (−0.83, 2.98)	0.38 ± 0.54 (−0.83, 2.21)	0.81 ± 0.76 (−0.24, 2.98)	$F_{df = 1,1,1305} = 32.38$, p<0.001*
J_{45} (D)	0.00 ± 0.35 (−1.75, 1.77)	−0.03 ± 0.39 (−1.75, 1.77)	0.04 ± 0.27 (−0.93, 0.97)	$F_{df = 1,1,1305} = 2.49$, p=0.11
Anisometropia (D)	0.49 ± 0.96 (0, 10.1)	0.57 ± 1.19 (0, 10.1)	0.35 ± 0.34 (0, 1.63)	$F_{df = 1,1,1359} = 4.50$, p=0.03*
Best-corrected visual acuity (logMAR)	0.035 ± 0.11 (−0.13, 1.00)	0.04 ± 0.13 (−0.13, 1.00)	0.03 ± 0.08 (−0.13, 0.48)	$F_{df = 1,1,1356} = 1.11$, p=0.30

*Indicates statistical significance (p<0.05). Analysis was adjusted for age and sex. BCVA = best-corrected visual acuity.

Longitudinal changes over 36 months

Table 2 shows spherical equivalent, cylinder, J_0, J_{45}, and anisometropia at 12, 24, and 36 months.

Over the 36 months we observed, spherical equivalent best fit by a linear model was as follows:

$$\text{Spherical equivalent}_{\text{Black}} = 2.15 - 0.23 \times \text{age}$$
$$\text{Spherical equivalent}_{\text{Hispanic}} = 1.63 - 0.23 \times \text{age}$$

There was no difference between the two groups in the rate of change of spherical equivalent ($t_{df\,=\,759} = -0.63$, p=0.53). This model shows that spherical equivalent decreased by −0.23 D/y for both groups ($t_{df\,=\,759} = -16.80$, p<0.001) and that the Hispanic children were more myopic than Black children on average by −0.52 D ($t_{df\,=\,483} = -2.07$, p=0.04).

Cylinder best fit by a linear model was as follows:

$$\text{Cylinder}_{\text{Black}} = 0.74 + 0.02 \times age$$

$$\text{Cylinder}_{\text{Hispanic}} = 1.29 + 0.02 \times age$$

There was no difference between groups in the rate of change of cylinder ($t_{df\,=\,640} = 1.43$, p=0.15). This model shows that cylinder increased 0.02 D/y with age for both groups ($t_{df\,=\,640} = -2.66$, p=0.008). Although statistically significant, the magnitude 0.02 D/y was not clinically significant. Hispanic children had a higher magnitude of severe astigmatism than Black children on average by 0.55 D ($t_{df\,=\,483} = -4.67$, p<0.001).

J_0 did not change significantly with age ($t_{df\,=\,581} = -0.68$, p=0.49).

J_{45} best fit by a linear model was as follows:

$$J_{45\_Black} = 0.16 - 0.01 \times age$$

$$J_{45\_Hispanic} = 0.23 - 0.01 \times age$$

This model shows that J_{45} decreased by −0.01 D/y with age for both groups ($t_{df\,=\,581} = -3.17$, p=0.002), and Hispanic children had more

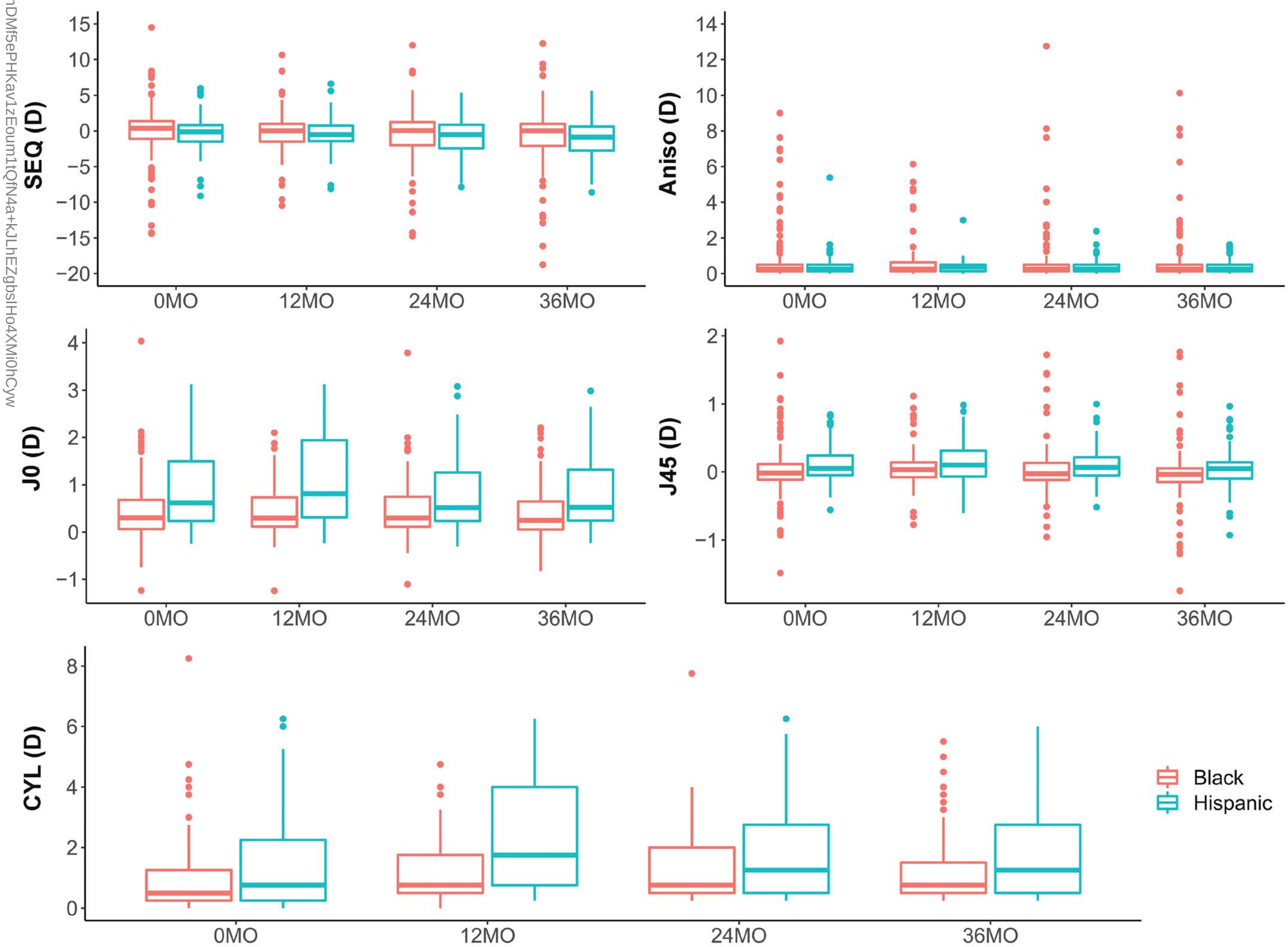

FIGURE 2. Boxplot of SEQ, J_0, J_{45}, and CYL of the right eye and anisometropia in Black (in red) and Hispanic (in cyan) children over 36 months. The box represents the IQR, which spans from the first quartile (Q1) to the third quartile (Q3). It contains 50% of the data. The line inside the box represents the median. The whiskers extend from the edges of the box to indicate the range of the data. By default, the whiskers extend to 1.5 times the IQR beyond the quartiles. Data points beyond the whiskers are considered outliers. SEQ = spherical equivalent; CYL = cylinder; IQR = interquartile range.

TABLE 3. Outlier distribution at baseline and at the 36-month follow-up visit

Criteria	Baseline: Non-Hispanic Black (n = 310)	Baseline: Hispanic/Latino (n = 175)	36-mo visit: Non-Hispanic Black (n = 226)	36-mo visit: Hispanic/Latino (n = 137)
Spherical equivalent ≤−6 D (myopia)	10 (3%)	3 (2%)	11 (5%)	3 (2%)
Spherical equivalent ≥6 D (hyperopia)	6 (2%)	1 (0.6%)	5 (2%)	0 (0)
Cylinder ≥5 D (high astigmatism)	1 (0.3%)	6 (3%)	2 (0.8%)	6 (4%)
Anisometropia ≥5 D (high anisometropia)	6 (2%)	1 (0.6%)	4 (2%)	0 (0)
Best-corrected visual acuity ≥0.6 logMAR (poorer vision than 20/80)	8 (3%)	1 (0.6%)	4 (2%)	0 (0)

oblique astigmatism than Black children on average by 0.07 D ($t_{df\,=\,445}$ = 2.27, p=0.02). Anisometropia did not change significantly with age ($t_{df\,=\,757}$ = 0.43, p=0.67).

Table 3 shows the distribution of outliers for spherical equivalent, cylinder, anisometropia, and visual acuity at baseline and at the 36-month follow-up. Except for high astigmatism, the Hispanic group had more outliers than the Black group; the Black group had a higher number of outliers in all other categories (high myopia, high hyperopia, high anisometropia, and poor vision).

Visual acuity over 36 months

Fig. 3 shows habitual visual acuity at baseline and best-corrected visual acuity both at the baseline and over 36 months. At the baseline examination, after adjusting for sex, habitual visual acuity of the Black children was not different from Hispanic children (0.25 ± 0.31 vs. 0.24 ± 0.26 logMAR, $F_{df\,=\,1,11,474}$ = 0.09, p=0.76, Table 1); best-corrected visual acuity was 0.03 logMAR better in Hispanic than in Black children (Black: 0.07 ± 0.16 vs. Hispanic: 0.04 ± 0.09 logMAR) with statistical significance ($F_{df\,=\,1,1,1452}$ = 4.77, p=0.03) but not clinical significance (0.03 logMAR difference). At 36 months' visit, no significant difference was found in best-corrected visual acuity compared with baseline ($F_{df\,=\,1,1,1356}$ = 1.11, p=0.30, Table 2).

DISCUSSION

We did not find a significant difference in the prevalence or magnitude of myopia between the two groups, but the Black children had a higher prevalence of hyperopia than the Hispanic children. In contrast, the Baltimore Pediatric Eye Disease Study, a population-based study of children ranging from 0.5 to 6 years old, reported that Black children had a higher prevalence of myopia (7%) than White children (1%).[7] On the other hand, studying 2000 children from diverse ethnic backgrounds for 36 months, the CLEERE (with participants 5 to 17 years old) found that Hispanic children had a higher prevalence of myopia than Black children (13% vs. 7%).[9]

Both Hispanic and Black race/ethnicities are associated with a higher risk of having astigmatism than non-Hispanic White children.[2] A higher prevalence of astigmatism in Hispanic compared with Black children (Black: 33% vs. Hispanic: 50%) in our study matches the findings from MEPEDS (participants, 0.5 to 6 years old),[1] the Vision in Preschoolers Study Group (participants, 3 to 5 years old),[10] and the CLEERE study (Black: 20% vs. Hispanic: 37%).[9] In addition, we found that significant astigmatism in Hispanic children was due to higher WTR astigmatism (more positive J_0) and oblique astigmatism (more J_{45}). Our results are comparable to the MEPEDS report.[1]

We found a higher prevalence of anisometropia in Black children (14%) than the Hispanic children (5%). The Vision in Preschoolers Study Group of 3- to 5-year-old children in a Head Start program reported that Black children (4%) had a lower prevalence of anisometropia than the Hispanic children (7%),[10] whereas the MEPEDS study reported a similar prevalence of anisometropia (Hispanic: 4% vs. Black: 4%) in children 0.5 to 6 years old.[11] We found a much higher prevalence of anisometropia in Black children than did those two previous studies. The differences in geographic populations and/or age ranges could potentially contribute to the disparities.

In our study, both groups became more myopic at a rate of −0.23 D/y spherical equivalent change over 36 months, and cylinder decreased slightly with age, primarily due to a decrease of oblique astigmatism, but magnitude of anisometropia did not change over time. The International Myopia Institute white paper reported −0.50 D/y as a threshold for progressive myopia[12]; thus, our cohort on average was lower than this threshold. The CLEERE study showed that the 3-year spherical equivalent change was −0.46 D (−0.15 D/y) in Hispanic children and −0.88 D (−0.3 D/y) in Black children.[5] Luong et al. studied the ethnic and racial differences in myopia progression from 4 to 11 years old and reported less myopia progression in Black and Hispanic children compared with non-Hispanic White children.[13] Note that our population included not solely myopic children, whereas the CLEERE[5] studied a subset of their children, and the studies by Luong et al.[13] focused on children who had early-onset myopia (−1.00 to −6.00 D).

In our cohort, the magnitude of astigmatism decreased with age by 0.01 D/y, primarily due to a reduction of oblique astigmatism. Although statistically significant, this rate of change in cylinder was not clinically significant. The MEPEDS study also reported

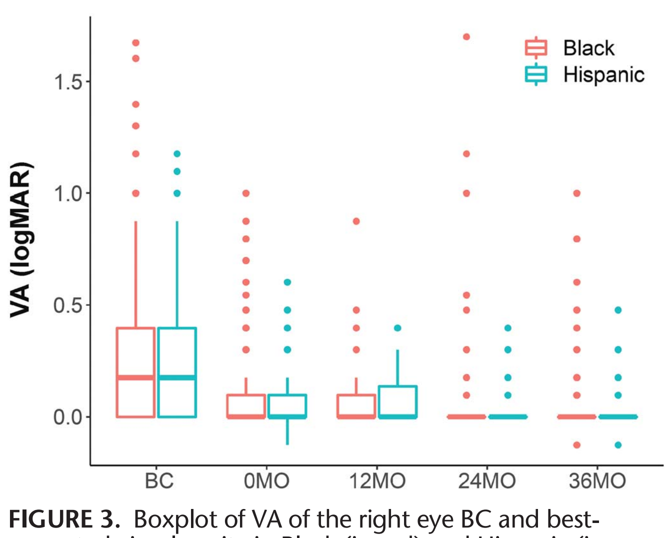

FIGURE 3. Boxplot of VA of the right eye BC and best-corrected visual acuity in Black (in red) and Hispanic (in cyan) children at baseline (0MO) and at follow-up visits over 36 months. BC = before correction; VA = visual acuity.

a significant decreasing trend in the prevalence of astigmatism with age.[1] This trend might be related to a longitudinal decrease in the astigmatism of individuals.

As expected, uncorrected visual acuity (0.25 ± 0.30 logMAR) was significantly poorer than best-corrected visual acuity in our population. The CLEERE study of 2212 children aged 6 to 14 years reported that uncorrected visual acuity was 0.19 ± 0.23 logMAR,[14] which was three letters better than that in our population. This small difference is likely due to the difference in cohorts. Our study focused on a cohort of children of various ages who were examined in the clinic, whereas the CLEERE enrolled school-aged children.

Limitations of this study include the following. (1) Definition of race and ethnicity—The standard racial designations defined by National Institutes of Health are American Indian/Alaska Native, Asian, Native Hawaiian or other Pacific Islanders, Black or African American, White, more than one race, and unknown or not reported; the standard ethnic designations are Hispanic/Latino and non-Hispanic/Latino. Harewood and Rosenfield[15] pointed out the complexity of defining race and ethnicity; for instance, definitions of race and ethnicity vary among countries. Our study used the common classification but may have oversimplified the designation.[15] Furthermore, because of the population distribution in the area of our clinic, we classified our participants into non-Hispanic Black participants and Hispanic/Latino White participants due to smaller numbers of White or Asian or mixed populations (a total of 35 of them were excluded). A more comprehensive classification in the future might elucidate further insights. (2) Follow-up and missing data—All follow-up visits had missing data; therefore, caution is required in the interpretation. At 36 months, the Black group missing-data rate was 27%, and the Hispanic group missing-data rate was 22%. There was no significant difference ($c^2 = 1.45$, p=0.23). Although the sample size was reduced due to the missing data, we assume that the missing data were random and might not impact the study's conclusions related to the difference between two groups. This situation may be related to the socioeconomic and/or health insurance status of this cohort.[16] (3) Age selection—Infants (aged from 0 to <2 years) were not seen in this urban clinic. Because this study was to follow up at 36 months, children older than 15 years would be over 18 years old before the end of the study; thus, the age range selected was 2 to 15 years old. If we separate the cohort into two age groups: preschool (n = 139) and school-aged (n = 346), the preschool group has a relatively smaller sample size, making further comparison of racial groups (Black: n = 85; Hispanic: n = 54) challenging. Given the limited sample size in the preschool group, we prefer not to overinterpret these data to avoid drawing potentially misleading conclusions. We included these results in the supplementary materials (Appendix Fig. A1, available at http://links.lww.com/OPX/A762, and Appendix Fig. A2, available at http://links.lww.com/OPX/A763) for readers who are interested in this comparison.

Clinical significance

The racial/ethnic differences in refractive error found in this study might provide a new reference for clinical practice. The higher prevalence of astigmatism in Hispanic children indicates a higher risk of meridional amblyopia, but a higher risk of corneal ectatic conditions such as keratoconus was not reported in this population.[17] In Black children, the higher prevalence of anisometropia indicates a higher risk of unilateral amblyopia; additionally, the presence of more outliers with high myopia, high hyperopia, and poor vision indicates a higher risk of amblyopia. Applying these racial/ethnic differences is meaningful in clinical practice regarding amblyopia screening examinations and amblyopia risk stratification. Magnitude of myopia increased over time in both groups, which indicates that myopia management is also important in both Hispanic and Black children. As suggested, children should receive an eye examination at the beginning of elementary school to diagnose the onset of myopia.[18] Future genetic or anatomical studies of ethnic differences in children might supply more insights into the reasons that Black children have more anisometropia and Hispanic children have more astigmatism. Additionally, these findings may reflect underlying disparities in access to eye care services and other social determinants of health.

CONCLUSIONS

In our cohort, the prevalence and magnitude of astigmatism in the Hispanic children were significantly higher than in the Black children. However, the Black children had more anisometropia than did the Hispanic children. Over a period of 36 months, both ethnic groups of children became more myopic at approximately a quarter diopter per year.

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