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Intraocular Pressure and Central Corneal Thickness in the COMET Cohort

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Abstract

Purpose—To describe intraocular pressure (IOP) and central corneal thickness (CCT) in ethnically diverse, myopic young adults enrolled in the Correction of Myopia Evaluation Trial (COMET), and their association with ocular and demographic factors.

Methods—IOP (Goldmann tonometry), CCT (handheld pachymetry), refractive error (cycloplegic autorefraction), and ocular components (A-scan ultrasonography) were measured in 385 of the original 469 subjects (mean age of 20.3 ± 1.3 years). Summary statistics for descriptive analysis, Pearson correlation coefficients, and linear regression models to formally test the association of IOP and CCT with other covariates were employed.

Results—Mean IOP was 15.1 ± 0.1 mmHg and differed by ethnicity and CCT but did not vary by gender, magnitude of myopia, or vitreous chamber depth (VCD). Adjusting for CCT, IOP in African-Americans was 1.8 mmHg higher than in Hispanics ($p=0.0001$) and 0.8 mmHg higher than in Whites ($p=0.03$). Mean CCT was 562.4 ± 1.8 μm and differed by ethnicity, VCD and IOP after adjusting for covariates. African-Americans had thinner corneas than Asians, Whites, and Hispanics, with adjusted differences of 15.4, 11.8, and 15.3 μm ($p = 0.03$, < 0.01 and < 0.01), respectively. Eyes with shorter VCD (< 17.8 mm) had 8.0 μm thinner CCT ($p=0.03$). CCT did not vary by gender or magnitude of myopia. Overall, a modest positive correlation ($r=0.25$, $p<0.0001$) was found between IOP and CCT which varied by ethnicity in Asians ($r = 0.47$; $p = 0.008$), African-Americans ($r = 0.29$; $p = 0.002$), and Whites ($r = 0.24$; $p = 0.002$).

Conclusions—Myopic, African-American young adults had higher IOP and thinner corneas relative to other ethnic groups, suggesting that evaluation of these parameters during routine examination of these individuals should begin at a young age. Their thinner CCT should also be considered in evaluations for refractive surgery.

Keywords

myopia; refractive error; intraocular pressure; central corneal thickness; ethnicity

The Correction of Myopia Evaluation Trial (COMET), a multi-center, randomized, double-masked clinical trial of ethnically diverse myopic children, evaluated the effect of

progressive addition lenses vs. single vision lenses on myopic progression.¹ After five years, when the clinical trial phase ended, COMET became a natural history study of risk factors for myopia progression and stabilization. While intraocular pressure (IOP) has been hypothesized as a risk factor for myopia development and progression,^{2–5} IOP measurements were not included in the original COMET protocol, but were taken in a subgroup of the COMET cohort at one of the clinical centers (Houston). No association was found between IOP and myopia at baseline or with 5-year myopic progression in this subset.⁶ However, a relationship between IOP and ethnicity was found, with higher pressures observed in African-Americans than in Hispanics and Whites.⁶ Similar ethnic differences were also observed in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) study, with African-Americans having slightly higher IOP than Whites beginning at 10 years of age.⁷

One limitation of these prior data that may impact the interpretation of the IOP differences is the absence of central corneal thickness (CCT) measurements. CCT can impact tonometry results, with IOP underestimated in thinner corneas.⁸ CCT has also been reported in some studies to vary by ethnicity, with thinner CCT in African-American than in White^{9–11} or Hispanic children,^{9,11} but these populations included a range of refractive errors not limited to myopia and were younger than the COMET cohort. Hence, it is not known if ethnic-related differences in CCT may have contributed to the disparity in IOP found between ethnic groups in the COMET subset.

In addition to the relationship of CCT with IOP and ethnicity, an association between CCT and refractive error has been reported. Thinner CCT values were observed in an ethnically diverse group of myopic children aged 0 to 17 years than in those with emmetropia or hyperopia (range -17.50D to $+13.00\text{D}$ with 64% between $+3.00$ and -1.00D).¹¹ An inverse relationship between CCT and myopia, e.g., thinner CCT associated with increasing myopia, has also been described in young (22.2 ± 4.2 years) Asian adults.¹² Understanding the relationship between refractive error and CCT may provide important information for myopic young adults seeking to reduce or eliminate their dependence on spectacles or contact lenses through keratorefractive surgery procedures that correct myopia by altering the shape and thickness of the cornea.¹³ CCT is a critical factor in determining the suitability of an eye for these refractive surgery procedures.^{13–14}

The purpose of this report is to describe the distribution of and relationship between IOP and CCT in the ethnically diverse COMET cohort of myopic young adults and explore possible associations of IOP and CCT with ethnicity, magnitude of myopia, axial length (AL), vitreous chamber depth (VCD), and other ocular and demographic parameters. These data may provide guidance for clinical management of young adults and children with myopia, a population that represents a large portion of many eye care practices.

METHODS

Subjects

Participants in this study were part of the COMET cohort who had been assessed annually for 11 years, including the initial 5 years in a multi-center, randomized, double-masked clinical trial that evaluated whether progressive addition lenses vs. single vision lenses slowed the progression of myopia. After 5 years COMET became a natural history study of risk factors for myopia progression and stabilization, including IOP and CCT. At the end of the clinical trial phase, subjects in consultation with their parents and study optometrist either remained in their original lens assignment or switched to the alternative spectacle lens type or contact lenses. The COMET cohort, at baseline, included 469 ethnically diverse children between 6 and 11 years of age (inclusive) with spherical equivalent refractive error

between -1.25 D and -4.50 D in each eye, no more than 1.50 D astigmatism, and < 1.00 D of anisometropia (spherical equivalent). Participants were recruited from four Colleges/Schools of Optometry located in Birmingham, Boston, Houston and Philadelphia. Additional details of the baseline characteristics, study design, and results have been published previously.^{1,15–18}

389 of the 469 (82%) COMET participants completed a visit in year 11 of the study, at which time IOP and CCT were added to the study protocol. Participants, ages 17 to 22 years at this visit, were re-consented for the additional measurements. Informed consent was obtained from participants who had reached the legal age of majority and from the parents of minors; assent was given by minors. The research protocols were reviewed and approved by the institutional review boards of each participating institution. The study complies with the Declaration of Helsinki.

Procedures

The measurements of interest for this report include cycloplegic autorefraction, AL and other ocular components by A-Scan ultrasonography, IOP and CCT. Age and ethnicity were provided by the parents at the baseline COMET visit.

Following subjective refraction and prior to dilation, IOP was measured by standard Goldmann tonometry (Schmidt).¹⁹ The cornea was anesthetized with Fluress (0.4% Benoxinate Hydrochloride, 0.25% Fluorescein Sodium) and two measurements were taken on each eye. If the difference between these two measurements was > 2 mmHg, a third measurement was made. Twelve (3.1%) and 19 (4.9%) of the 385 subjects with usable data (described below), required a third measurement in the right and left eye respectively. Two CCT values (handheld pachymetry with Pachmate DGH55), each the average of twenty-five measurements, were obtained for each eye. If the standard deviation of any CCT value was greater than $8\text{ }\mu\text{m}$, that measurement was discarded and repeated to ensure the precision of each reading was $3.1\text{ }\mu\text{m}$ (i.e., for an average of 25 scans half of the width of the 95% confidence interval for the reading, or $1.96 \times \text{SE}$). A third measurement was taken and the three measures averaged if a difference in CCT values of $15\text{ }\mu\text{m}$ was obtained. The criterion of $15\text{ }\mu\text{m}$ was selected based on the measurement precision of a gold standard examiner. In 51 (13.3%) and 43 (11.2%) of 385 subjects a third measurement in the right and left eye, respectively, was necessary.

Following the assessment of IOP and CCT, 2 drops of 1% tropicamide, separated by 4 to 6 minutes, were instilled in each eye and cycloplegic autorefraction (Nidek ARK 700A) was performed 30 minutes later. Five consecutive, reliable measurements were obtained for each eye. After autorefraction, the eyes were anesthetized and the ocular components, including AL and VCD, were measured five times using biomicroscope-mounted A-scan ultrasonography (Sonomed A2500). A handheld probe was used if five measurements could not be achieved in the biomicroscope. Thirty-four of 384 (8.9%) and 50 of 385 (13%) of subjects' right and left eyes, respectively, had one to five measurements taken using the handheld probe; data were not available for the right eye of one subject. The value for each eye was the mean of the five measurements.

Statistical Analysis

All statistical analysis was performed using SAS v9.2. Each participant included in these analyses contributed two measurements (right and left eye) for all ocular measurements (IOP, CCT, AL and other ocular components and refractive error). The correlation between left and right eyes for IOP and CCT, estimated by the Pearson correlation coefficient, were $r=0.85$ and $r=0.97$, respectively. Based on these high correlations for all ocular

measurements, the right and left eye data were averaged for each participant for every ocular measurement and the data were analyzed at the participant level. Summary statistics for descriptive analysis (e.g. mean, median, and standard error) and additional Pearson correlation coefficients were generated to examine associations between IOP, CCT, and other covariates of interest.

Linear regression models were used to formally test the association of IOP and CCT with demographic and ocular covariates, including gender, ethnicity, magnitude of myopia, and either VCD or AL. For each model, residual plots and the Wilks test for normality were generated to examine whether the assumptions of the linear model were sufficiently met. In order to estimate both unadjusted and adjusted effects, univariate and multivariable models for IOP and CCT were used. In all models for IOP, the time of the IOP measurement (treated as a continuous predictor) was examined as a potential confounder. Categorization of continuous covariates such as AL and myopia was based on the median split. For analysis of categorical covariates, p-values corresponding to the overall F-test for association and pair-wise t-tests comparing each level of the covariate with the reference category were generated for each covariate under study. Trend tests were also performed for categorical covariates that were ordinal in nature. For each outcome, variables that were significant at the 0.10 level of significance when analyzed independently were examined simultaneously in a multivariable model. Due to the high expected collinearity between AL and VCD, multivariable models estimated for IOP and CCT included only one of the two measurements. Only those covariates that met statistical significance at the 0.05 level were retained for the final models.

RESULTS

The analysis of IOP and CCT data was based on 385 (82%) of the original COMET cohort of 469 participants. Data from four of the 389 individuals who completed the 11-year visit were excluded due to keratoconus (n=1), rigid gas permeable contact lens wear (n=1) and refractive surgery (n=2). The mean ($\pm$ SD) age of those included in these analyses was 20.3 ($\pm$ 1.3) years. The group was ethnically diverse, with 44.7% White, 27.3% African-American, 14.3% Hispanic, 8.1% Asian and 5.7% mixed ethnicity. Participants included in the current data analysis were similar to the non-participants with respect to baseline myopia, AL, age and ethnicity, but had a slightly higher proportion of females, 54.6% versus 42.9% ($p=0.05$).

IOP

Mean ($\pm$ SE) IOP was 15.1 ± 0.1 mm Hg overall and varied significantly by ethnicity, CCT, and time of IOP measurement but not by age, gender, magnitude of myopia, AL, VCD, lens, or anterior chamber depth (ACD), as shown in Table 1. Among ethnic groups, IOP was highest in African-Americans, who had a mean ($\pm$ SE) value of $15.7 (\pm 0.3)$, lowest in Hispanics (mean $14.1 (\pm 0.3)$ mm Hg), with intermediate values of $15.4 (\pm 0.5)$ mm Hg for Asians, $15.0 (\pm 0.6)$ mm Hg for mixed ethnicities and $15.1 (\pm 0.2)$ mmHg for Whites. While there were overall differences in IOP by ethnicity ($p=0.01$), when using African-Americans as the reference group, only Hispanics demonstrated a significantly different value (lower by 1.6 mm Hg, $p<0.001$). Based on a median split, IOP was 1 mm Hg higher in participants with CCT $\geq 562 \mu\text{m}$ compared with CCT $< 562 \mu\text{m}$ ($p<0.001$). Time of IOP measurement had a small, statistically significant overall effect ($p = 0.03$); measurements taken at 3 PM and later were 0.7 mm Hg lower than measurements obtained before noon ($p = 0.05$).

Ethnicity, lens thickness, CCT and time of IOP measurement, all factors with an overall p value of < 0.10 by univariate screen, were evaluated further in multivariable models. As shown in Table 2, only ethnicity and CCT were retained in the final model. Time of IOP

measurement did not alter the associations of IOP with ethnicity or CCT. Ethnicity was statistically significantly associated with IOP after adjusting for CCT in the multivariate model, with significant differences between African-Americans and Hispanics ($p = 0.0001$), and African-Americans and Whites ($p = 0.03$). CCT was also significantly associated with IOP in the multivariable model ($p = 0.0001$). No interactions were observed in these analyses

CCT

The mean CCT for the entire cohort as well as by age, gender, ethnicity, magnitude of myopia, AL, VCD, ACD, lens and IOP, is shown in Table 3. The overall mean ($\pm$ SE) CCT was $562.4 (\pm 1.8) \mu\text{m}$. CCT did not vary by age or gender and was minimally associated with ethnicity ($p = 0.07$). Using African-Americans as the reference group (mean CCT = $555.3 + 3.8 \mu\text{m}$), CCT was statistically significantly thicker in Asians by $15.4 \mu\text{m}$ ($p = 0.04$), Whites by $9.5 \mu\text{m}$ ($p = 0.03$) and Hispanics by $12.0 \mu\text{m}$ ($p = 0.05$). CCT did not vary by magnitude of myopia defined by a median split. AL and its components of VCD and ACD were all associated with CCT, though lens was not. The shortest eyes, those with AL < 25.3 mm as defined by a median split, had the thinnest corneas with a mean CCT ($\pm$ SE) of $558.0 \mu\text{m} (\pm 2.7)$ compared to $566.8 \mu\text{m} (\pm 2.5)$ in longer eyes ($p = 0.02$). Similar to AL, CCT was thinner in participants with shorter VCD (< 17.8 mm) compared to longer VCD ($p = 0.04$) and with shorter ACD (< 3.9 mm) compared to deeper ACD ($p = 0.05$). Higher IOP, defined by a median split as > 15 mm Hg, was associated with thicker corneas, $568.8 (\pm 2.7)$ vs. $556.1 \mu\text{m} (\pm 2.4)$ for participants with lower IOP.

Because results for AL and VCD were similar, only those for VCD are presented in the multivariable model shown in Table 4. Ethnicity, VCD and IOP remained associated with CCT after adjustment for covariates. With African-Americans as the reference group, adjusted differences in CCT were $15.4 \mu\text{m}$ for Asians ($p = 0.03$), $15.3 \mu\text{m}$ for Hispanics ($p < 0.01$) and $11.8 \mu\text{m}$ for Whites ($p < 0.01$), with all of these groups having thicker corneas. Shorter VCD was associated with thinner corneas, with a small statistically significant difference of $8.0 \mu\text{m}$ ($p = 0.03$) between longer and shorter VCD. As expected, higher IOP, defined by a median split as > 15 mmHg, was associated with thicker corneas, with an adjusted difference of $14.4 \mu\text{m}$ ($p < 0.0001$).

To further explore the association of CCT and VCD, contact lens use was considered. A modest, but significant correlation between CCT and VCD was observed in participants who wore contact lenses most or all of the time ($r = 0.22$; $p = 0.002$) (data not shown). This relationship was observed overall and in separate analyses for males ($r = 0.24$; $p = 0.03$) and females ($r = 0.20$; $p = 0.03$). The correlation between CCT and AL showed similar results. This pattern was not observed in those who wore eyeglasses all or most of the time or in those wearing contact lenses and eyeglasses an equal amount of time.

Relationship between IOP and CCT

A modest, positive correlation ($r = 0.25$, $p < 0.0001$) was found between IOP and CCT, with thinner corneas associated with lower IOP, e.g., for each $1 \mu\text{m}$ increase in CCT, IOP increased 0.02 mm Hg, as shown in Figure 1. When analyzed separately by ethnicity, significant positive associations were found between IOP and CCT for Asians ($r = 0.47$; $p = 0.008$), African-Americans ($r = 0.29$; $p = 0.002$), and Whites ($r = 0.24$; $p = 0.002$), but not for Hispanics and those of mixed ethnicity, as shown in Figure 2.

DISCUSSION

The COMET cohort provides unique data on associations of IOP and CCT with various ocular and demographic factors in a large, ethnically diverse population of myopic young adults. While associations of IOP and CCT have been published with regard to age, gender, refractive status and AL, many of the previous reports have been limited by smaller sample size, little or no data on ethnic differences, or no evaluation of the potential effects of significant covariates. In addition, while studies may have included individuals with myopia, the refractive error results have frequently been reported in a manner that does not allow the data for myopic or other refractive error categories to be examined independently.

IOP

The IOP measured in myopic young adults in the COMET study (15.1 ± 0.1 mmHg) is similar to that reported in other studies that included subjects of similar ages with a range of refractive errors (14.1 to 16.99 mm Hg).^{7,20–21} While no other large study has included only myopic young adults, the current results suggest that on average IOP is not higher in young adults with myopia than in those with other refractive errors. However, we acknowledge that IOP measured at a single point in time in the current study may not characterize diurnal fluctuations and other variations in IOP over time.

A significant association of IOP with ethnicity was found in the current study. African-Americans (15.7 ± 0.3 mmHg) had higher measured IOP than Hispanics (14.1 ± 0.3 mmHg) and slightly higher than Whites (15.1 ± 0.2 mmHg). This finding is consistent with the results in the subset of the COMET cohort from one clinical center during the first five years of the study, where mean IOP measured with a different technique (Tonopen) was higher in African-Americans than in Hispanics and Whites.⁶

Other studies have investigated ethnic differences in IOP. The CLEERE study also reported higher IOP for African-Americans compared to Whites, with mean differences ranging from 0.91 to 1.54 mm Hg ($p = 0.001$) in 10 to 13 year olds.⁷ The Barbados Eye Study reported higher IOP in older (> 40 years) individuals of African descent than in Caucasians.²² While the differences in IOP between ethnic groups in the COMET results are small, the findings from COMET and the other studies suggest that IOP is higher in African-Americans at all ages and not just older ages when primary open angle glaucoma (POAG) is more prevalent.

IOP was not associated with age and gender in the current study, similar to other studies including young adults.^{20–21,23} However, the limited age range of the participants in the current study may hinder the identification of an age-related relationship. Likewise, IOP was not related to the magnitude of myopia, AL, or VCD. Previous studies of IOP in subjects with a limited range of refractive errors also found no association with magnitude of myopia or AL,^{24–26} while those finding an association included subjects with a wide range of refractive errors.^{7,27–28} The broad range may have contributed to the significant findings.

CCT

The mean CCT in the COMET cohort was 562.4 ± 1.8 μ m. In the present study African-Americans had thinner central corneas than Whites, Hispanics, and Asians, with CCT 11.8 and 15.2 μ m less in African-Americans compared to Whites and Hispanics, respectively. These ethnic differences are relatively small on average, with large variability. CCT for populations similar in age, ethnicity and refractive error is not available in the literature. Subjects of an age similar to the COMET cohort, though with a wide range of refractive errors, had a median CCT that was 22 μ m thinner in African-Americans than in the combined White-Hispanic group.¹¹ The COMET results provide new data on CCT and ethnicity in myopic young adults that support the association of thinner CCT in African-

Americans and are consistent with studies conducted in younger^{9–11} and older^{29–36} populations that included hyperopia and myopia.

In COMET, thicker CCT was associated with longer VCD and longer AL. Only one other study has reported a positive relationship between CCT and AL, though this was in older Asian adults (40 to 80 years of age) with a full range of refractive errors, e.g., not limited to myopia.³⁷ However, other investigations in myopic adults,³⁸ young Asian myopic adults,¹² and populations of predominately myopic Asian children^{28,39} have found no relationship between CCT and AL. Several factors, including differences in age or ethnicity, different CCT instrumentation,^{28,39} and failure to examine interactions between variables^{12,38} may contribute to the conflicting results. It is important to note that in COMET additional analyses found that the association between CCT and VCD could be attributed mainly to participants wearing contact lenses most or all the time. However, this finding in contact lens wearers cannot be explained by an increase in CCT associated with contact lens use (e.g., corneal edema) since VCD, unlike AL, is not influenced by changes in CCT.

In the present investigation CCT did not vary with magnitude of myopia. While similar results have been reported in several studies of myopic children and adults,^{26,38–42} CCT has also been found to increase⁴³ or decrease¹² with increasing myopic refractive error in Asians. The magnitude of the relationship between CCT and myopia has been small regardless of whether a statistically significant difference was found.

CCT was not associated with age in COMET, as might be anticipated with the narrow age range of COMET participants, nor with gender, which is consistent with some studies^{38,41,44} but not others.^{11,39}

Relationship between IOP and CCT

In COMET thinner corneas were found to be associated with lower IOP; hence the measured IOP may underestimate the true IOP in individuals with thinner CCT. Doughty showed this same positive association in a meta-analysis of non-glaucomatous eyes.⁸ When the current unadjusted data were analyzed by ethnicity, the association between IOP and CCT were significant for African-Americans ($r = 0.29$; $p = 0.002$), Asians ($r = 0.47$; $p = 0.008$), and Whites ($r = 0.24$; $p = 0.002$). These results are consistent with results of other studies, which reported similar findings in children and in older adults where refractive error was not limited to myopia.^{23,28,32,39,44–48} The present study did not find a significant relationship between IOP and CCT for Hispanics, in contrast to previous reports.^{32,49} Differences in the populations, such as age and type of refractive error, may have contributed to these conflicting findings of the association between IOP and CCT in Hispanics.

Implications for Clinical Practice

The higher IOP of the African-Americans in the COMET cohort, combined with their thinner CCT, is an important finding in the current study and has implications for the clinical care of these patients. It is known that increased IOP is a risk factor for POAG,^{50–52} as is African descent^{50,53–54} and thinner CCT.^{51,55} Myopia, regardless of magnitude,⁵⁶ is also frequently linked to elevated risk of glaucoma in children as young as 10 years of age and adults up to 40 years of age,^{53,57} as well as adults 40 years and older.^{58–63} In addition, glaucoma is more prevalent at an earlier age in African-Americans than Whites⁵⁴ and its diagnosis may be delayed in African-Americans.³² Lastly, the assessment of the true IOP may be more difficult in African-Americans with thinner corneas who undergo refractive surgery.^{64,65} All of these risk factors suggest that early routine assessment of IOP and CCT should be considered in young myopic African-Americans.

CCT is a critical factor in determining the suitability of an eye for keratorefractive surgery procedures.^{13–14} Given that many myopic young adults seek such procedures, the COMET results suggest that the thinner corneas in African-Americans should be taken into consideration, along with other criteria when determining their eligibility for refractive surgery. A minimum thickness of the residual corneal bed after refractive surgery is necessary to reduce the risk of corneal ectasia.^{38,66}

CONCLUSIONS

The mean IOP in this group of young adults with myopia was slightly, but significantly higher in African-Americans than Whites or Hispanics. CCT was also significantly related to ethnicity, with African-American corneas thinner than those of Whites, Hispanics, or Asians. Thinner CCT in myopic African-Americans should be considered along with other criteria when determining suitability for corneal refractive surgery in young adulthood. A modest, but significant positive relationship between CCT and IOP suggests that the ethnic differences in IOP may be even greater than those observed; measured IOP may underestimate true IOP to a greater extent in African-Americans than in other ethnic groups especially following refractive surgery. Given the risk factors for POAG (e.g., higher IOP, thinner CCT, myopia, and African descent), these findings suggest that examination of myopic African-Americans should begin at a young age and include both IOP and CCT.

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Figure 1.
IOP vs. CCT for all participants

Figure 2.
IOP vs. CCT by ethnicity. (A) African-Americans; (B) Asians; (C) Hispanics; (D) Whites; (E) Mixed ethnicity.

Table 1

IOP (mmHg) by Demographic and Ocular Characteristics (Univariate analysis).

Cohort Characteristics	n (%)	Mean $\pm$ SE	Difference (mmHg) from Reference Group	p-value ¹	Overall p-value ²
Overall IOP	385	15.1 $\pm$ 0.1			
Median (Min, Max)		15.0 (8.0, 27.2)			
Age (years)					0.54
17–18	37 (9.6)	15.4 $\pm$ 0.5	Reference Group		
19	67 (17.4)	14.8 $\pm$ 0.3	–0.6	0.29	
20	91 (23.6)	15.5 $\pm$ 0.3	0.1	0.91	
21	107 (27.8)	14.9 $\pm$ 0.3	–0.5	0.39	
22	83 (21.6)	15.2 $\pm$ 0.3	–0.2	0.72	
Gender					
Female	210 (54.5)	15.2 $\pm$ 0.2	Reference Group		0.37
Male	175 (45.5)	15.0 $\pm$ 0.2	–0.2	0.37	
Ethnicity					
African-American	105 (27.3)	15.7 $\pm$ 0.3	Reference Group		0.01
Asian	31 (8.1)	15.4 $\pm$ 0.5	–0.3		
Hispanic	55 (14.3)	14.1 $\pm$ 0.3	–1.6	0.58 <0.001	
Mixed	22 (5.7)	15.0 $\pm$ 0.6	–0.7	0.25	
White	172 (44.7)	15.1 $\pm$ 0.2	–0.6	0.06	
Myopia (D)					
< –4.71	191 (49.7)	15.1 $\pm$ 0.2	Reference Group		0.87
–4.71	193 (50.3)	15.1 $\pm$ 0.2	0.0	0.87	
Axial Length (mm)					
<25.3	192 (49.9)	15.2 $\pm$ 0.2	Reference Group		0.85
25.3	193 (50.1)	15.1 $\pm$ 0.2	–0.1	0.85	
VCD (mm)					
<17.8	193 (50.1)	15.2 $\pm$ 0.2	Reference Group		0.48

Cohort Characteristics	n (%)	Mean $\pm$ SE	Difference (mmHg) from Reference Group	p-value ¹	Overall p-value ²
>17.8	192 (49.9)	15.0 $\pm$ 0.2	-0.2	0.48	
ACD (mm)					
<3.9	192 (49.9)	15.2 $\pm$ 0.2	Reference Group		0.54
3.9	193 (50.1)	15.0 $\pm$ 0.2	-0.2	0.54	
Lens (mm)					
<3.5	192 (49.9)	15.4 $\pm$ 0.2	Reference Group		0.09
3.5	193 (50.1)	14.9 $\pm$ 0.2	-0.5	0.09	
CCT (μ m)					
<561.8	192 (49.9)	14.6 $\pm$ 0.2	Reference Group		<0.001
561.8	193 (50.1)	15.6 $\pm$ 0.2	1.0	<0.001	
Time of IOP					
8:54am-11:59am	114 (29.6)	15.3 $\pm$ 0.3	Reference Group		0.03
12:00pm-2:59pm	138 (35.8)	15.5 $\pm$ 0.2	0.2	0.69	
3:00pm-7:36pm	133 (34.6)	14.6 $\pm$ 0.2	-0.7	0.05	

¹ Corresponds to the pair-wise t-test for each subgroup and the reference group.

² Corresponds to the ANOVA F-test for overall effect

Table 2

Factors associated with IOP (multivariable model).

Factors	Estimate	95% CI	p-value
Ethnicity			
African-American	Reference Group		
Asian	−0.4	(−1.5, 0.7)	0.48
Hispanic	−1.8	(−2.7, −0.9)	0.0001
Mixed	−0.7	(−2.0, 0.5)	0.26
White	−0.8	(−1.4, −0.1)	0.03
CCT (μm)			
<561.8	Reference Group 1.1		
561.8		(0.5, 1.6)	0.0001

Table 3CCT (μm) by Demographic and Ocular Characteristics (Univariate analysis).

Cohort Characteristics	n (%)	Mean $\pm$ SE	Difference (μm) from Reference Group	p-value ¹	Overall p-value ²
Overall CCT		562.4 $\pm$ 1.8			
Median (Min, Max)	385	561.8 (474.3, 687.7)			
Age (years)					
17–18	37 (9.6)	565.3 $\pm$ 4.5	Reference Group		0.75
19	67 (17.4)	566.2 $\pm$ 4.9	0.9	0.91	
20	91 (23.6)	561.3 $\pm$ 3.9	–4.0	0.57	
21	107 (27.8)	559.3 $\pm$ 3.3	–6.0	0.38	
22	83 (21.6)	563.4 $\pm$ 4.1	–1.9	0.79	
Gender					
Female	210 (54.5)	560.7 $\pm$ 2.6	Reference Group		0.31
Male	175 (45.5)	564.5 $\pm$ 2.5	3.8	0.31	
Ethnicity					
African-American	105 (27.3)	555.3 $\pm$ 3.8	Reference Group		0.07
Asian	31 (8.1)	570.7 $\pm$ 6.2	15.4	0.04	
Hispanic	55 (14.3)	567.3 $\pm$ 5.4	12.0	0.05	
Mixed	22 (5.7)	554.2 $\pm$ 8.8	–1.1	0.89	
White	172 (44.7)	564.8 $\pm$ 2.4	9.5	0.03	
Myopia (D)					
<–4.71	191 (49.7)	563.3 $\pm$ 2.6	Reference Group		0.59
–4.71	193 (50.3)	561.3 $\pm$ 2.6	–2.0	0.59	
Axial Length (mm)					
<25.3	192 (49.9)	558.0 $\pm$ 2.7	Reference Group		0.02
25.3	193 (50.1)	566.8 $\pm$ 2.5	8.8	0.02	
VCD (mm)					
<17.8	193 (50.1)	558.7 $\pm$ 2.7	Reference Group		0.04

Cohort Characteristics	n (%)	Mean $\pm$ SE	Difference (μ m) from Reference Group	p-value ¹	Overall p-value ²
17.8	192 (49.9)	566.1 $\pm$ 2.5	7.4	0.04	
ACD (mm)					
<3.9	192 (49.9)	558.8 $\pm$ 2.4	Reference Group		0.05
3.9	193 (50.1)	566.0 $\pm$ 2.7	7.2	0.05	
Lens (mm)					
<3.5	192 (49.9)	562.7 $\pm$ 2.7	Reference Group		0.88
3.5	193 (50.1)	562.1 $\pm$ 2.5	-0.6	0.88	
IOP (mmHg)					
15.0	194 (50.4)	556.1 $\pm$ 2.4	Reference Group		<0.001
>15.0	191 (49.6)	568.8 $\pm$ 2.7	12.7	<0.001	

¹ Corresponds to the pair-wise t-test for each subgroup and the reference group

² Corresponds to the ANOVA F-test for overall effect

Table 4

Factors associated with CCT (multivariable model).

Factors	Estimate	95% CI	p-value
Ethnicity			
African-American	Reference Group		
Asian	15.4	(1.3, 29.5)	0.03
Hispanic	15.3	(3.8, 26.9)	<0.01
Mixed	1.1	(−15.1, 17.2)	0.90
White	11.8	(3.3, 20.4)	<0.01
VCD (mm)			
<17.8	Reference Group		
17.8	8.0	(0.9, 15.1)	0.03
IOP (mmHg)			
15.0	Reference Group		
>15.0	14.4	(7.3, 21.5)	<0.0001