

Ethnic Differences of Intraocular Pressure and Central Corneal Thickness

The Singapore Epidemiology of Eye Diseases Study

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Purpose: To determine the ethnic differences in the distribution of intraocular pressure (IOP) and central corneal thickness (CCT) in a multi-ethnic Asian population by self-reported ethnicity and genetic ancestry.

Design: Population-based, cross-sectional study.

Participants: A total of 10 033 adults (3353 Chinese, 3280 Malays, and 3400 Indians) aged >40 years.

Methods: Participants underwent standardized systemic and ocular examinations and interviewer-administered questionnaires for risk factor assessment. The IOP readings were obtained by Goldmann applanation tonometry (Haag-Streit, Konig, Switzerland) before pupil dilation. The CCT was measured with ultrasound pachymetry. Genetic ancestry was derived using principal component (PC) analysis. Regression models were used to investigate the association of IOP and CCT with potential risk factors and genetic ancestry.

Main Outcome Measures: Intraocular pressure and CCT.

Results: After excluding participants with a history of glaucoma surgery or medication, refractive surgery, corneal edema, or corneal dystrophy, IOP and CCT readings were available for 3251 Chinese, 3232 Malays, and 3317 Indians. The mean IOP readings in the Chinese, Malay, and Indian participants were 14.3 ± 3.1 , 15.3 ± 3.7 , and 15.8 ± 2.9 mmHg, respectively ($P < 0.001$). The prevalence of participants with IOP ≥ 21 mmHg was 2.6% in Chinese, 6.2% in Malays, and 4% in Indians ($P < 0.001$). In the multivariate regression analysis, the Malay and Indian participants on average had 0.81 and 1.43 mmHg higher IOP levels, respectively, than Chinese ($P < 0.001$). The mean CCT reading was 552.3 ± 33.4 μm in Chinese, 540.9 ± 33.6 μm in Malays, and 540.4 ± 33.6 μm in Indians ($P < 0.001$). The percentage of participants with CCT < 555 μm was 52.8% in Chinese, 68.5% in Malays, and 66.2% in Indians ($P < 0.001$). The IOP and CCT levels are significantly correlated with genetic ancestry in our South East Asian population.

Conclusions: Chinese have the thickest CCT but lowest IOP among the 3 major ethnic groups. In addition, there is a higher proportion of Malays with IOP ≥ 21 mmHg and CCT < 555 μm compared with the Chinese or Indians. This disparity across ethnic groups should be taken into account by future studies investigating IOP and CCT as risk factors or diagnostic tests for glaucoma in Asian populations. *Ophthalmology* 2014;121:2013-2022 © 2014 by the American Academy of Ophthalmology.

Glaucoma is one of the leading causes of irreversible blindness worldwide. Intraocular pressure (IOP) and central corneal thickness (CCT) are important clinical measurements in the diagnosis and management of glaucoma.^{1,2} Elevated IOP is a well-recognized risk factor for the development of glaucoma,^{1,3} and reduction of IOP remains the only clearly proven treatment.⁴⁻⁶ Central corneal thickness is an important factor that has a profound effect on the “true” IOP^{7,8} and risk of developing glaucoma.^{1,9,10} In light of the applications of IOP and CCT, knowledge of their distribution in different ethnic populations is critical and useful in both clinical and research settings.

Ethnic/racial variation in IOP and CCT has been reported. Studies showed that Asians have lower IOP and thicker CCT than African Americans, whereas there is hardly any difference in IOP and CCT between Asians and

Caucasians.¹¹ However, Asians are a heterogeneous population, and examining them as a whole might mask variations among ethnic subgroups. To our knowledge, only one study has examined an ethnically diverse group of Asians within the same glaucoma clinic and concluded that Japanese have thinner corneas than Chinese and Filipinos.¹² However, this study is mainly clinic-based and thus may be subjected to sampling bias.

Population-based studies examining IOP and CCT distributions are mostly conducted in isolation. Recent population-based studies in East Asia and Southeast Asia have reported various mean IOP¹³⁻²⁴ and CCT^{14-16,19-21,25,26} values. It is uncertain whether the observed variations among these populations were due to racial/ethnic difference or the discrepancies in study designs and measurement methods, thus making direct comparisons among these populations

Table 1. Demographic and Systemic Characteristics among the Three Ethnic Groups

Characteristics	Total (n = 9800)	Chinese (n = 3251)	Malays (n = 3232)	Indians (n = 3317)	P Value*
Age, years	58.8 (10.3)	59.6 (9.9)	59.1 (11.0)	57.5 (10.0)	<0.001
Female sex	4969 (50.7)	1642 (50.5)	1683 (52.01)	1646 (49.6)	0.149
Smoking status, n (%)					
Never	6797 (69.4)	2385 (73.4)	1986 (61.5)	2426 (73.2)	<0.001
Current smoker	1582 (16.1)	436 (13.4)	655 (20.3)	491 (14.8)	
Past smoker	1412 (14.4)	430 (13.2)	586 (18.1)	396 (11.9)	
SBP, mmHg	139.9 (21.9)	136.7 (19.6)	147.5 (24.0)	135.8 (20.1)	<0.001
DBP, mmHg	78.4 (10.6)	77.6 (9.9)	79.9 (11.3)	77.7 (10.3)	<0.001
Diabetes, n (%)	2306 (23.5)	462 (14.2)	754 (23.3)	1090 (32.9)	<0.001
BMI, kg/m ²	25.4 (4.7)	23.7 (3.6)	26.3 (5.1)	26.2 (4.7)	<0.001

BMI = body mass index; DBP = diastolic blood pressure; SBP = systolic blood pressure.

Data presented are means (standard deviations) unless otherwise indicated.

*P value was obtained with 1-way analysis of variance for continuous variables and with chi-square tests for categorical variables.

challenging. Therefore, there is a need to assess the ethnic variations in IOP and CCT using uniform study designs among different ethnic groups.

The purpose of the current study was to examine the ethnic variations in the distribution of IOP and CCT among the 3 major Asian ethnic groups (Chinese, Malays, and Indians) living in Singapore stratified by both self-reported ethnicity and genetic ancestry inferred by genome-wide single nucleotide polymorphism (SNP) markers in the population-based Singapore Epidemiology of Eye Diseases (SEED) study, which used the same study protocol for all participants.

Methods

Study Population

The SEED study is a population-based study comprising 3 major ethnic groups in Singapore: Malays (the Singapore Malay Eye Study, 2004–2006), Indians (the Singapore Indian Eye Study, 2007–2009), and Chinese (the Singapore Chinese Eye Study, 2009–2011). The detailed methodology of the SEED study has been published in previous reports.^{27,28} In brief, an age-stratified (by

10-year age groups) random sampling in each ethnic group was used to select ethnic Malays, Indians, and Chinese aged 40 to 80 years living across the southwestern part of Singapore during each stipulated study period. The number of selected subjects was 4168 Malays, 4497 Indians, and 4606 Chinese. Of these, 3280 Malay persons (response rate 78.7%), 3400 Indian persons (75.6%), and 3353 Chinese persons (72.8%) participated in the study. The overall response rate for SEED was 75.6%. This study was approved by the Singapore Eye Research Institute Institutional Review Board, and the conduct of the study adhered to the Declaration of Helsinki. All participants gave informed consent.

All subjects recruited in the SEED study underwent a standardized interview and ocular examination at the Singapore Eye Research Institute.^{27,28} An interviewer-administered questionnaire was used to collect demographic data.²⁷ Self-reported ethnicity was set by the Singapore census and as indicated on the National Registration Identity Card, which is provided to all Singapore citizens and permanent residents.²⁹ Each of the participants was assigned a single ethnicity from among 3 categories: (1) Chinese (refers to persons of Chinese origin from mainland China), (2) Malay (refers to persons of Malay or Indonesian origin, such as Javanese), or (3) Indian (refers to persons with ancestry originating on the Indian subcontinent), as indicated from the government census based on their parents' ethnicity.^{27–29}

Table 2. Ocular Characteristics among the Three Ethnic Groups

Characteristics	Total (n = 19 547)	Chinese (n = 6491)	Malays (n = 6438)	Indians (n = 6618)	P Value*
IOP, mmHg	15.1 (3.3)	14.3 (3.1)	15.3 (3.7)	15.8 (2.9)	<0.001
Eyes with IOP \geq 21 mmHg, n (%)	831 (4.3)	172 (2.6)	397 (6.2)	262 (4.0)	<0.001
CCT, μ m	544.5 (34.0)	552.3 (33.4)	540.9 (33.6)	540.4 (33.6)	<0.001
Eyes with CCT <555 μ m, n (%)	12 217 (62.5)	3425 (52.8)	4410 (68.5)	4382 (66.2)	<0.001
Corneal curvature, mm	7.64 (0.3)	7.65 (0.3)	7.65 (0.3)	7.61 (0.3)	<0.001
Axial length, mm	23.6 (1.2)	23.95 (1.5)	23.54 (1.1)	23.39 (1.1)	<0.001
Lens status, n (%)					
Phakia	17 757 (90.8)	5846 (90.0)	6013 (93.5)	5898 (89.0)	<0.001
Pseudophakia	1766 (9.0)	642 (9.9)	404 (6.3)	720 (10.9)	
Aphakia	29 (0.2)	8 (0.1)	14 (0.2)	7 (0.1)	

CCT = central corneal thickness; IOP = intraocular pressure.

Data presented are means (standard deviations) unless otherwise indicated.

*P value was obtained with repeated-measures analysis of variance for continuous variables and logistic regression with generalized estimating equation for categorical variables.

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