Differences in Visual Function and Optic Nerve Structure Between Healthy Eyes of Blacks and Whites

Lyne Racette, PhD; Catherine Boden, PhD; Shannon L. Kleinhandler, BSc; Christopher A. Girkin, MD; Jeffrey M. Liebmann, MD; Linda M. Zangwill, PhD; Felipe A. Medeiros, MD; Christopher Bowd, PhD; Robert N. Weinreb, MD; M. Roy Wilson, MD; Pamela A. Sample, PhD

Objective: To investigate differences in visual function, optic disc topography, and retinal nerve fiber layer (RNFL) thickness between healthy eyes of blacks and whites.

Methods: Visual function was assessed in healthy eyes of 50 blacks and 50 whites using standard automated perimetry, short-wavelength automated perimetry, and frequency doubling technology perimetry. Optic disc topography and RNFL thickness were measured using the Heidelberg Retina Tomograph and the optical coherence tomograph.

Results: Mean standard automated perimetry mean deviations were within the normal range for both groups. Blacks had worse mean deviation values than whites using frequency doubling technology perimetry (mean±SD, −1.8±3.2 dB vs −0.1±2.4 dB), blacks had larger optic disc areas than whites using the Heidelberg Retina Tomograph (mean±SD, 2.1±0.4 mm² vs 1.7±0.4 mm²), the RNFL of blacks was thicker than that of whites by 16.91 µm superiorly and 10.10 µm inferiorly using optical coherence tomography, and blacks had slightly higher intraocular pressures than whites (mean±SD, 16.5±2.5 mm Hg vs 15.2±3.2 mm Hg) and thinner central corneas (mean±SD, 540.5±43.2 µm vs 560.9±35.5 µm). No racial differences were found in mean RNFL thickness, pattern standard deviation on all tests, or any of the short-wavelength automated perimetry variables.

Conclusions: Minimal racial differences in visual function were found, but race significantly affected optic disc topography and superior and inferior RNFL thickness measurements in healthy eyes. The racial differences observed for intraocular pressure could theoretically increase after correcting for central corneal thickness. Prospective studies are needed to further investigate these findings.

Arch Ophthalmol. 2005;123:1547-1553

Glaucoma is one of the leading causes of blindness worldwide. It is characterized by retinal ganglion cell death that results in optic nerve damage and visual field loss. Primary open-angle glaucoma (POAG) is the most prevalent form of glaucoma. Racial differences in the prevalence of POAG are well documented and show that blacks are at higher risk for POAG than whites. The reported prevalence rates are as much as 6 times higher in blacks as in whites. Primary open-angle glaucoma is the leading cause of irreversible blindness in blacks, and blacks with POAG are more likely than whites to develop visual impairment and blindness. Furthermore, POAG progresses more rapidly and appears approximately 10 years earlier in blacks than in whites. Although blacks are disproportionately affected by POAG, the underlying causes of this heightened susceptibility are unknown. Differences in measures of structure or visual function between healthy eyes of blacks and whites may account, at least in part, for the increased prevalence of POAG observed in the black population. Likewise, racial differences in intraocular pressure (IOP) and central corneal thickness (CCT) may also be significant in understanding why blacks are more susceptible to POAG. Understanding any differences will further our knowledge of the disease, refine diagnostic decisions, and improve the management of POAG in black patients.

Racial differences in structural measures have been reported in healthy, ocular hypertensive, and glaucomatous eyes. Fewer studies have been published on racial differences in visual function. In the present study, we investigate differences in retinal structure and visual function between healthy eyes of blacks and whites. We expect to replicate the previously observed findings in structural differences between blacks and whites and to determine whether racial differences exist for any of the visual function test results.
To our knowledge, this is the first study to assess racial differences by using short-wavelength automated perimetry (SWAP) and frequency doubling technology (FDT) perimetry in healthy eyes.

**METHODS**

**PARTICIPANTS**

We tested 100 healthy eyes from 100 participants (50 blacks and 50 whites). Blacks were recruited at the University of Alabama (n=21), the New York Eye and Ear Infirmary (n=11), and the University of California at San Diego Hamilton Glaucoma Center (n=18). Measured were implemented to ensure that testing procedures were comparable at all testing sites. Recruitment was solicited at work and school fairs, at local churches, and by word-of-mouth. We compared the results obtained in blacks with those in age-matched whites selected from the ongoing longitudinal Diabetic Eye Study (DISEASES) at the University of California at San Diego. The study followed the tenets of the Declaration of Helsinki and was approved by the institutional review boards at all 3 sites. All participants provided written informed consent and were minimally compensated for their participation.

**Inclusion Criteria**

Only individuals who identified their race as either black or white (by self-report) were included. Participant eligibility was based on findings from a complete clinical examination, which included a review of relevant medical history, best-corrected visual acuity, slitlamp biomicroscopy (including gonioscopy), Goldmann applanation tonometry, dilated funduscopy, stereoscopic ophtalmoscopy of the disc using a 78 diopter (D) lens, and simultaneous stereophotographs of the fundus. An ophthalmologic examination with normal findings, with no signs of ocular disease in both eyes, was necessary for inclusion as a healthy, nonglaucomatous participant.

All participants had open angles, IOP of 22 mm Hg or less, no history of elevated IOP, best-corrected visual acuity of at least 20/40 in the studied eye, spherical refraction not greater than ±5.0 D, and cylinder correction not greater than ±3.0 D. All participants had simultaneous stereoscopic photographs of high enough quality to allow evaluation by trained graders. All participants had reliable visual field test results, defined as less than 33% of fixation losses. Participants with diabetes mellitus or a family history of glaucoma were included in the study. Stereophotographs and structural and visual function tests were performed within a 6-month window, and all visual function tests were performed within a 3-month window. The order of testing was randomized across participants.

**Exclusion Criteria**

Participants were excluded from the study if they had a history of intraocular surgery, except for uncomplicated cataract surgery. The presence of congenital color vision problems, of any intraocular disease, or of disease affecting the visual field also resulted in exclusion. Participants with both photograph-based optic disc defects and standard visual field defects (defined in the “Standard Automated Perimetry” subsection of the “Visual Function Measures” section) were excluded from the study. Some participants did not have all the test results available within the 6-month window. Thus, only a subgroup of participants was used for some analyses.

**STRUCTURAL MEASURES**

**Simultaneous Stereophotographs**

Two experienced graders evaluated the stereophotographs. Each grader was certified after correctly grading standardized simultaneous stereophotographs. The graders were masked to the identity and ethnic background of the participants, to the results of the other grader, and to all other test results. When the 2 graders disagreed, a third grader evaluated the stereophotographs to determine the status of the optic disc. For this study, normal optic discs were defined as having no more than a 0.2 cup-disc ratio asymmetry between the 2 eyes and no evidence of excavation, neuroretinal rim thinning, notching or hemorrhages, or retinal nerve fiber layer (RNFL) defects.

**Confocal Scanning Laser Ophthalmoscope**

The confocal scanning laser ophthalmoscope (Heidelberg Retina Tomograph [HRT]; Heidelberg Engineering, Dossenheim, Germany) uses confocal scanning laser technology to provide topographic measurements of the optic disc and the peripapillary retina. Detailed information concerning this instrument and a description of the variables have been provided elsewhere. The following topographic variables were measured using the HRT software: disc area, rim area, cup area, cup shape, and mean RNFL thickness. Data from 25 blacks and 44 whites were available for this analysis. A mean topographic image was obtained from 3 scans (10° field of view) centered on the optic disc using HRT software version 2.01. Corneal curvature measurements were recorded using keratometry to correct for magnification. A trained technician, relying on simultaneous stereophotographs, outlined the optic disc margin on the mean topographic image.

**Optical Coherence Tomograph**

The optical coherence tomograph (OCT) (Carl Zeiss Meditec Inc, Dublin, Calif), software version A3X1, uses low-coherence interferometry to assess peripapillary RNFL thickness. The temporal delay in backscattered light between the RNFL and a reference mirror is used to estimate RNFL thickness. An edge-detection algorithm is used to differentiate the RNFL from other retinal layers. Details of this instrument have been described elsewhere. In the present study, OCT was used to study mean RNFL thickness (360° measure) and temporal (316°-45° measure), nasal (136°-223° measure), superior (46°-133° measure), and inferior (226°-315° measure) quadrant thickness. Circular scans of 3.4-mm diameter centered on the optic disc were obtained for each participant. Image quality was assessed by an experienced grader masked to the identity and race of the participants and to the purpose of this study. Only images of good quality were included in the study. For most participants, the mean of 3 scans on each of the variables cited previously herein was used; however, when 3 good-quality scans were not available, the mean of 2 scans, or even a single scan, was used. Data from 42 blacks and 34 whites were available for this analysis.

**Pachymetry**

Measurements of CCT were obtained using an ultrasonic pachymeter (DGH-500 Pachette; DGH Technology Inc, Exton, Pa). Three measurements, in a 3-µm range, were averaged to obtain the CCT measurement. The CCT data were obtained from 38 blacks and 49 whites.
VISUAL FUNCTION MEASURES

We assessed participants using 3 different tests of visual function: standard automated perimetry (SAP), SWAP, and FDT perimetry. We evaluated mean deviation (MD) from age-corrected normal threshold values, pattern standard deviation, and the number of abnormal points (P<.05) on the pattern deviation plot.

Standard Automated Perimetry

Automated perimetry in the central 24° of the visual field was conducted using the Humphrey Field Analyzer II (Carl Zeiss Meditec Inc). Visual fields were considered abnormal when the P<.05 on the pattern standard deviation index or when findings from the Glaucoma Hemifield Test were “outside normal limits.” Although all participants were tested with SAP, some underwent testing using the full-threshold strategy and others using the Swedish Interactive Thresholding Algorithm (SITA). In both testing strategies, the targets consist of small (0.47°) white lights presented for 200 milliseconds on a dimly illuminated white background (10 candela [cd]/m²). The detection of this target is non-specific for a particular retinal ganglion cell subtype.

In healthy individuals, SITA has been shown to yield approximately 2 more abnormal points on the pattern deviation plot than the full-threshold strategy. Because we combined the results of the full-threshold and SITA testing strategies, and because the proportion of participants with full-threshold and SITA results was significantly different in our sample of blacks and whites (χ²=14.09; P<.001) (Table 1), we were concerned that the number of abnormal points might be biased in our groups owing to testing strategy. We therefore conducted a subanalysis in which only participants with SITA results were included. Sixty-nine healthy eyes of 69 participants (43 blacks and 26 whites) were included in this subanalysis.

Short-Wavelength Automated Perimetry

The Humphrey Field Analyzer II was used to perform SWAP on the central 24° of the visual field using the full-threshold strategy on 48 blacks and 50 whites. SWAP isolates a subpopulation of retinal ganglion cells by presenting a 1.8° blue target (440 nm) on a bright yellow background (100 cd/m²). The detection of this target is non-specific for a particular retinal ganglion cell subtype.

FDT Perimetry

We also tested 43 blacks and 50 whites using FDT perimetry (Carl Zeiss Meditec Inc, and Welch Allyn, Skaneateles Falls, NY). The target is a 0.25°-cycle/degree sinusoidal grating presented in a 10°-diameter square window that undergoes 25-Hz counterphase flicker. The dependent measure is the contrast required to detect the target. We tested our participants using the N-30 program, in which targets are presented at 18 locations in the central 30° (20° temporally and 30° nasally). Frequency doubling technology perimetry is believed to target the magnocellular retinal ganglion cells, which have larger axons, process motion and fast flicker, and represent less than 10% of the total retinal ganglion cell population.

STATISTICAL ANALYSIS

The variables in this study were analyzed using χ² tests (for non-continuous variables), Mann-Whitney rank sum tests (for continuous variables that were not normally distributed), and t tests (for continuous variables that were normally distributed) (JMP software; SAS Institute Inc, Cary, NC). Statistical significance was set at P<.05. Although many variables were included in this study, no adjustments for multiple comparisons were performed. This is justified because these adjustments test the universal null hypothesis, that is, that all groups are similar on all variables. As is often the case, the universal null hypothesis is of no genuine interest in this study. Furthermore, adjustments for multiple comparisons imply that any given comparison is evaluated differently, depending on the number of tests performed. Guarding against spurious results with Bonferroni-like adjustments may also prevent one from detecting real differences in the data.

The sample size calculation was based on measures of visual function (MD on SAP) and structural measures (disc area on HRT) for which a variety of previous studies allow to approximate the standard deviations adequately. We assumed that a difference of 0.5 dB on SAP MD between blacks and whites would be relevant in the context of this study. With α=.05, 1−β=0.80, and an SD of 1.3, approximately 100 participants were needed. We assumed that a difference of 0.4 mm² in optic disc area between blacks and whites would be relevant. With α=.05, 1−β=0.80, and an SD of 0.4, approximately 32 participants were needed overall.

RESULTS

Only healthy eyes, based on findings from a complete ophthalmologic examination, were included in this study. However, it was expected that a proportion of these eyes would show abnormalities on either the stereophotographs or the visual field tests. We included participants with normal ophthalmologic examination findings and either photographic or standard visual field defects but not both. Thirty-one blacks (62%) and 37 whites (74%) had normal photographs and SAP field test results. Of the 50 blacks, 9 (18%) had photographic defects and 10 (20%) had field defects. Of the 50 whites, 7 (14%) had photographic defects and 6 (12%) had field defects. Differences between the 2 groups were not statistically significant.

No racial differences were observed for age, spherical correction, or cylindrical correction (Table 2). A greater percentage of blacks reported a family history of glaucoma (31%) compared with whites (16%), although this was not significant (χ²=3.02; P=.08). A significantly higher percentage of blacks also reported high blood pressure (P=.01) and diabetes mellitus (P=.04) (Table 2). Blacks also had significantly higher IOP (P=.03) and lower CCT (P=.02) measurements than whites. Figure 1 illustrates...
the lack of a significant relationship between IOP and CCT for both groups. No significant racial differences in corneal curvature were observed.

Structural results are given in Table 3. Blacks had significantly larger optic disc areas than whites using the HRT. No racial differences were observed in rim area, cup shape, or mean RNFL thickness as assessed using the HRT. Using the OCT, no differences were observed in mean, nasal, and temporal RNFL thickness. However, blacks had a significantly thicker RNFL in the superior ($P = .001$) and inferior ($P = .02$) quadrants than whites (149.8 and 141.7 mm vs 132.9 and 131.6 mm).

The results of visual function testing are reported in Table 4. No significant differences were observed on any of the SAP variables (MD, pattern standard deviation, or number of abnormal points) when the full-threshold and SITA testing strategies were combined. Similar results were observed when the analysis was repeated on the subgroup in which only the SITA strategy was used (Table 5). This subanalysis showed that blacks had a worse MD than whites ($−1.52 \, \text{dB} \, \text{vs} \, −0.91 \, \text{dB}$), but the difference did not reach statistical significance. No significant differences were observed on any of the SWAP variables. The only significant racial difference in visual function was observed for the MD on FDT perimetry, for which blacks had more negative values than whites ($P = .003$).

**COMMENT**

The goal of this study was to determine whether differences in optic nerve structure and visual function exist between blacks and whites with healthy eyes. Such differences would have several implications. First, these differences should be taken into account when establishing a diagnosis of POAG and when deciding on the clinical management of the disease. Second, significant differences in visual function between blacks and whites with healthy eyes would result in the need to develop race-specific normative databases. The norms currently used in many of the studied devices were developed using predominantly white participants. Finally, prospective studies should be conducted to understand the reasons behind the increased prevalence of POAG in blacks.

**STRUCTURAL MEASURES**

There is evidence that blacks with healthy eyes have larger optic discs than whites using the HRT. No significant racial differences were observed in mean neuroretinal rim area between blacks and whites. Other reported differences in optic nerve variables between healthy eyes of blacks and whites include larger cup-disc ratios and cup volumes. However, these differences must be interpreted with caution because the measurements of these optic nerve variables may depend on optic disc size. The Confocal Scanning Laser Ophthalmoscopy Ancillary Study to the Ocular Hypertension Treatment Study, for example, found that blacks have significantly larger optic discs, optic cups, neuroretinal rims, and cup-disc ratios than other groups. These differences in topographic op-

---

**Table 2. Characteristics of the Study Population by Race**

<table>
<thead>
<tr>
<th></th>
<th>Blacks</th>
<th></th>
<th>Whites</th>
<th></th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>50</td>
<td>47.13 (8.11)</td>
<td>50</td>
<td>49.18 (9.23)</td>
<td>.13*</td>
</tr>
<tr>
<td>Spherical correction, mean (SD), D</td>
<td>50</td>
<td>−0.53 (1.72)</td>
<td>50</td>
<td>−0.09 (1.69)</td>
<td>.06*</td>
</tr>
<tr>
<td>Cylindrical correction, mean (SD), D</td>
<td>50</td>
<td>0.38 (0.45)</td>
<td>50</td>
<td>0.39 (0.35)</td>
<td>.64*</td>
</tr>
<tr>
<td>Family history, %</td>
<td>48</td>
<td>31</td>
<td>49</td>
<td>16</td>
<td>.38†</td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>48</td>
<td>6</td>
<td>50</td>
<td>0</td>
<td>.04††</td>
</tr>
<tr>
<td>High blood pressure, %</td>
<td>48</td>
<td>23</td>
<td>50</td>
<td>6</td>
<td>.01††</td>
</tr>
<tr>
<td>IOP, mean (SD), mm Hg</td>
<td>49</td>
<td>16.51 (2.53)</td>
<td>50</td>
<td>15.22 (3.15)</td>
<td>.03§</td>
</tr>
<tr>
<td>CCT, mean (SD), µm</td>
<td>38</td>
<td>540.52 (43.22)</td>
<td>49</td>
<td>560.85 (35.46)</td>
<td>.02§</td>
</tr>
<tr>
<td>Corneal curvature, mean (SD), D</td>
<td>49</td>
<td>7.80 (0.25)</td>
<td>50</td>
<td>7.82 (0.51)</td>
<td>.61*</td>
</tr>
</tbody>
</table>

Abbreviations: CCT, central corneal thickness; D, diopters; IOP, intraocular pressure.

*By Mann-Whitney test.
†By $\chi^2$ test.
‡Significant at $P < .05$.
§By $t$ test.

---

©2005 American Medical Association. All rights reserved.
tic disc variables were, however, explained by the larger optic disc area in blacks.

Although it has been reported that blacks have a thinner mean RNFL than whites,\textsuperscript{27,28} we found that the mean RNFL was generally thicker in blacks than in whites, although this difference did not reach statistical significance using either HRT or OCT. Testing a larger sample may lead to statistical significance, but the sample size used in this study provided enough power to detect small differences (approximately 8 µm) in mean RNFL thickness between blacks and whites using OCT. We report significantly thicker OCT measurements of RNFL in the superior and inferior quadrants in blacks than in whites. These differences in superior and inferior RNFL thickness may be partially due to differences in optic disc size between blacks and whites because a larger disc may contain more nerve fibers. More participants need to be tested to assess this theory with certainty.

### Table 3. Structural Differences Between Healthy Eyes of Blacks and Whites

<table>
<thead>
<tr>
<th></th>
<th>Blacks</th>
<th></th>
<th>Whites</th>
<th></th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Mean (SD)</td>
<td>No.</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>HRT optic disc area, mm\textsuperscript{2}</td>
<td>25</td>
<td>2.05 (0.40)</td>
<td>44</td>
<td>1.65 (0.44)</td>
<td>&lt;.001†‡</td>
</tr>
<tr>
<td>HRT rim area, mm\textsuperscript{2}</td>
<td>25</td>
<td>1.46 (0.31)</td>
<td>44</td>
<td>1.35 (0.33)</td>
<td>.17‡</td>
</tr>
<tr>
<td>HRT cup shape</td>
<td>25</td>
<td>−0.02 (0.08)</td>
<td>44</td>
<td>−0.23 (0.07)</td>
<td>.48†</td>
</tr>
<tr>
<td>HRT mean RNFL thickness, µm</td>
<td>25</td>
<td>300.00 (70.00)</td>
<td>44</td>
<td>270.00 (60.00)</td>
<td>.09†</td>
</tr>
<tr>
<td>OCT mean RNFL thickness, µm</td>
<td>42</td>
<td>114.86 (15.14)</td>
<td>34</td>
<td>108.50 (17.17)</td>
<td>.09†</td>
</tr>
<tr>
<td>OCT temporal RNFL thickness, µm</td>
<td>42</td>
<td>84.55 (22.55)</td>
<td>34</td>
<td>81.97 (26.50)</td>
<td>.65†</td>
</tr>
<tr>
<td>OCT nasal RNFL thickness, µm</td>
<td>42</td>
<td>82.86 (19.89)</td>
<td>34</td>
<td>88.24 (27.15)</td>
<td>.32†</td>
</tr>
<tr>
<td>OCT superior RNFL thickness, µm</td>
<td>42</td>
<td>149.79 (21.45)</td>
<td>34</td>
<td>132.88 (19.57)</td>
<td>&lt;.001†‡</td>
</tr>
<tr>
<td>OCT inferior RNFL thickness, µm</td>
<td>42</td>
<td>141.69 (20.23)</td>
<td>34</td>
<td>131.59 (15.20)</td>
<td>&lt;.02†</td>
</tr>
</tbody>
</table>

Abbreviations: HRT, Heidelberg Retina Tomograph (Heidelberg Engineering, Dossenheim, Germany); OCT, optical coherence tomograph (Carl Zeiss Meditec Inc, Dublin, Calif); RNFL, retinal nerve fiber layer.

*Significant at $P<.05$.
†By t test.
‡By Mann-Whitney test.

### Table 4. Results of Visual Function Tests for the Healthy Eyes of Blacks and Whites

<table>
<thead>
<tr>
<th></th>
<th>Blacks</th>
<th></th>
<th>Whites</th>
<th></th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Mean (SD)</td>
<td>No.</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>SAP MD, dB</td>
<td>50</td>
<td>−1.11 (1.45)</td>
<td>50</td>
<td>−0.74 (1.24)</td>
<td>.18*</td>
</tr>
<tr>
<td>SAP PSD, dB</td>
<td>50</td>
<td>1.80 (0.70)</td>
<td>50</td>
<td>1.78 (0.54)</td>
<td>.66†</td>
</tr>
<tr>
<td>SAP No. of locations &lt;5%</td>
<td>50</td>
<td>4.62 (4.54)</td>
<td>50</td>
<td>3.96 (3.56)</td>
<td>.26†</td>
</tr>
<tr>
<td>SWAP MD, dB</td>
<td>48</td>
<td>−4.11 (3.65)</td>
<td>50</td>
<td>−2.73 (4.07)</td>
<td>.08*</td>
</tr>
<tr>
<td>SWAP PSD, dB</td>
<td>48</td>
<td>3.21 (3.97)</td>
<td>50</td>
<td>3.21 (1.35)</td>
<td>.47†</td>
</tr>
<tr>
<td>SWAP No. of locations &lt;5%</td>
<td>48</td>
<td>4.15 (5.02)</td>
<td>50</td>
<td>4.30 (6.34)</td>
<td>.49†</td>
</tr>
<tr>
<td>FDT MD, dB</td>
<td>43</td>
<td>−1.84 (3.19)</td>
<td>50</td>
<td>−0.07 (2.42)</td>
<td>.003*†</td>
</tr>
<tr>
<td>FDT PSD, dB</td>
<td>43</td>
<td>4.70 (2.82)</td>
<td>50</td>
<td>4.00 (1.35)</td>
<td>.35†</td>
</tr>
<tr>
<td>FDT No. of locations &lt;5%</td>
<td>43</td>
<td>3.05 (3.74)</td>
<td>50</td>
<td>2.38 (2.37)</td>
<td>.85†</td>
</tr>
</tbody>
</table>

Abbreviations: FDT, frequency doubling technology; MD, mean deviation; PSD, pattern standard deviation; SAP, standard automated perimetry; SWAP, short-wavelength automated perimetry.
*By t test.
†By Mann-Whitney test.
‡Significant at $P<.05$.

### Table 5. Results of Standard Automated Perimetry Using the SITA Strategy for the Healthy Eyes of Blacks and Whites

<table>
<thead>
<tr>
<th></th>
<th>Blacks</th>
<th></th>
<th>Whites</th>
<th></th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Mean (SD)</td>
<td>No.</td>
<td>Mean (SD)</td>
<td></td>
</tr>
<tr>
<td>SAP-SITA MD, dB</td>
<td>43</td>
<td>−1.52 (1.51)</td>
<td>26</td>
<td>−0.91 (1.37)</td>
<td>.10*</td>
</tr>
<tr>
<td>SAP-SITA PSD, dB</td>
<td>43</td>
<td>1.83 (0.73)</td>
<td>26</td>
<td>1.80 (0.68)</td>
<td>.95†</td>
</tr>
<tr>
<td>SAP No. of locations &lt;5%</td>
<td>43</td>
<td>5.37 (4.59)</td>
<td>26</td>
<td>5.46 (3.65)</td>
<td>.67†</td>
</tr>
</tbody>
</table>

Abbreviations: MD, mean deviation; PSD, pattern standard deviation; SAP, standard automated perimetry; SITA, Swedish Interactive Thresholding Algorithm.
*By t test.
†By Mann-Whitney test.
Studies on racial differences in visual function in participants with healthy eyes are few. The Salisbury Eye Evaluation used the Humphrey Field Analyzer 81-point single-intensity screening strategy over a 60° field and reported a significantly higher number of missed points in blacks than in whites. The Ocular Hypertension Treatment Study reported worse MD and pattern standard deviation values for blacks at baseline using SAP. Although the Ocular Hypertension Treatment Study required normal SAP field test results and photographs at baseline, with all MD values within the normal range.

Our results show no significant racial differences in any of the SAP variables. This result was confirmed in the subanalysis of participants tested using only the SITA strategy. Although this did not reach statistical significance, a trend was observed in which blacks had slightly worse MD values than whites on SAP in the main analysis and in the subanalysis. The number of abnormal points was higher using the SITA strategy in the subanalysis than when full-threshold and SITA testing strategies were used. Although this did not reach statistical significance, a trend was observed suggesting worse MD values for blacks than for whites.

In this study, no racial differences were observed in any of the SWAP variables, although a trend was observed suggesting worse MD values for blacks than for whites. This finding may, however, be due to a lack of statistical power. Considering the sample size we used, a difference of 1.4 dB on the MD could have been detected, assuming an SD of 3 dB. The difference in MD that we observed was 1.38. Using FDT perimetry, blacks had significantly worse MD scores than whites, although most were within the normal range. To our knowledge, this is the first study to assess racial differences among the recently developed visual function–specific tests. These tests include SWAP and FDT perimetry, which were shown to be more sensitive to early glaucomatous damage than the traditional achromatic SAP. It is possible that the sensitivity of these tests allows them to capture small deficits in visual function in blacks who otherwise seem healthy, thus enhancing the potential usefulness of these tests.

It is important to assess these differences because the normative databases against which the results of visual function tests are evaluated were developed using a predominantly white population. If healthy eyes of blacks and whites differ, the use of a predominantly white normative database may not be optimal for identifying values outside normal limits for other ethnicities. There may be a need to develop race-specific norms.

Because only participants with healthy eyes were included in this study, we expected to obtain results within the normal range of values on each of the tests we performed. Mean results were well within the range of normality for all structural measures and tests of visual function in blacks and whites. However, participants with visual field defects were not excluded from the study. We therefore expected that some participants would be outside the normal range on measures of visual function. As shown in Figure 2, more blacks were outside the normal range.

### IOP AND CCT

Although IOP is an important risk factor for POAG, the literature provides conflicting reports on race-specific differences in IOP. Some studies report elevated IOP in healthy blacks, whereas studies from the population-based Baltimore Eye Survey showed no differences. However, lower IOP levels were reported for untreated blacks at their initial examination for POAG compared with untreated whites. Lower IOP, if present at glaucoma onset, may delay POAG detection and reduce the aggressiveness of treatment, possibly contributing to the faster progression of glaucoma in blacks. Differences in selection criteria and sources of patients make comparisons among studies difficult.

The IOP levels reported for blacks may be artifactual and may depend on CCT. A positive correlation between IOP

---

**Figure 2.** Box plots for mean deviation (A), pattern standard deviation (B), and number of test locations less than 5% on the pattern deviation plot (C) are presented for frequency doubling technology (FDT) perimetry, standard automated perimetry (SAP), and short-wavelength automated perimetry (SWAP). The box represents the interquartile range, which contains 50% of all values. The horizontal line within the box indicates the median, and the whiskers extend from the box to the highest and lowest values, excluding the outliers (circles) and the extreme scores (asterisks). Outliers were defined as scores that were 1.5 to 3.0 box lengths from the upper or lower edge of the box, and extreme scores were defined as scores that were more than 3.0 box lengths from the upper or lower edge of the box. Although the mean values were within the normal range, more blacks than whites had values in the abnormal range.
The results of this study show that blacks with healthy eyes have larger optic discs, poorer MD values on FDT perimetry, higher IOP levels, and thinner corneas than whites. These differences are in line with previous studies of optic disc size, IOP, and CCT. Potential study limitations include the relatively small number of participants tested, particularly on some of the tests. As a result, statistical power was inconsistent across comparisons. This study is not a population-based survey, and caution should be used when generalizing the results. Prospective studies with more participants are needed to confirm our results and to determine whether racial differences in measures of visual function warrant the need to develop race-specific reference values.

Submitted for Publication: April 15, 2004; accepted February 9, 2005.

Correspondence: Pamela A. Sample, PhD, Department of Ophthalmology, University of California at San Diego, 9500 Gilman Dr, La Jolla, CA 92039-0946 (p sample@glaucoma.ucsd.edu).

Financial Disclosure: Drs Weinreb and Sample have received research support from Carl Zeiss Meditec Inc, Dublin, Calif.

Funding/Support: This study was supported by R01 grants EY08208 (Dr Sample) and EY11008 (Dr Zangwill) from the National Eye Institute, National Institutes of Health, Bethesda, Md; the Glaucoma Research Foundation, San Francisco, Calif (Dr Sample); the EyeSight Foundation of Alabama, Birmingham (Dr Girkin); and K23 grant EY13959-01 from the National Eye Institute, National Institutes of Health (Dr Girkin).

Conclusions


Piersner TV. What’s wrong with Bonferroni adjustments. BMJ. 1998;316:1236.


