Effect of Myopia on Frequency-Doubling Perimetry

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PURPOSE. To examine the effect of myopia, occasionally associated with glaucomatous eyes, on the results obtained by frequency-doubling perimetry (FDP).

METHODS. Sixty emmetropic or myopic normal volunteers (mean age, 26.2 ± 0.35 years, mean ± SEM; range, 19–34) with good visual acuity and without glaucoma were divided into three groups. The groups were emmetropia to low-myopia (mean refractive error, −1.16 ± 0.25 D), intermediate-myopia (−4.95 ± 0.17 D), and high-myopia (−8.12 ± 0.36 D; n = 20 each). All subjects were tested on the FDP full-threshold C-20 program and the Humphrey Field Analyzer (HFA; Humphrey, Dublin, CA) full-threshold program on one randomly selected eye. FDP and the HFA test were conducted with the subjects wearing their full distance correction and with their distance correction with appropriate additional correction for near, respectively. The calculated mean sensitivity (MS), mean deviation (MD), pattern standard deviation (PSD), and test durations for FDP and the HFA test for the three groups were compared using one-way analysis of variance. The relationship between the refractive error and MS, MD, or PSD was also analyzed by simple regression analysis.

RESULTS. The MS and MD for the fields determined by the HFA decreased significantly as the refractive errors increased, but there were no significant differences in the MS, MD, and PSD for FDP between the three groups. There were no significant differences in the test durations between the three groups for both FDP and HFA testing. The refractive error was correlated with both MS and MD only for the fields determined by the HFA.

CONCLUSIONS. The results showed that lens-corrected myopia does not alter the visual fields obtained by FDP, and FDP can therefore be used regardless of the presence of myopia. (Invest Ophthalmol Vis Sci. 2001;42:1107–1110)

The recent interest in frequency-doubling technology (Welch Allyn, Skaneateles Falls, NY) was applied to develop a commercial frequency-doubling perimeter (Humphrey Systems, Dublin, CA). This perimetric technique has been reported to detect early glaucomatous visual field loss.1–3 There is evidence that different retinal functions can be selectively altered by myopia. We have found a loss of sensitivity of the short-wavelength–sensitive cones in myopic eyes by electroretinography (ERG),4 by blue-on-yellow perimetry,5 and by visually evoked cortical potentials.6 We have also found a reduction of the amplitude and a delay of the implicit times of each wave of the multifocal ERG in myopic eyes.7 It is well known that myopia is often associated with glaucomatous eyes. Thus, with increasing levels of intraocular pressure (IOP), an increasing degree of myopia has been detected,8 and there is a strong relationship between myopia and glaucoma.9 In a country with a high incidence of myopia as in Japan,10 it is especially important to distinguish the changes in retinal sensitivity induced by glaucoma from that caused by myopia. However, it has not been determined whether the visual fields determined by frequency-doubling perimetry (FDP) are altered by myopia.

In this study, we investigated the influence of myopia on the results of FDP. These data were compared with the results obtained by the conventional automated Humphrey Field Analyzer model 750 (HFA; Humphrey, Dublin, CA).

METHODS

Sixty emmetropic or myopic normal volunteers with good corrected visual acuity (20/20 or better) with a mean refractive error of −4.62 ± 0.40 D (mean ± SEM; range, 0.00 to −12.00 D) were tested. The subjects were divided into three groups according to their refractive error measured by an autorefractometer (RK-90; Topcon, Tokyo, Japan). The three groups were emmetropia to low-myopia (refractive error, −1.16 ± 0.25 D), intermediate-myopia (−4.95 ± 0.17 D), and high-myopia (−8.12 ± 0.36 D; n = 20 each; Table 1 The mean age of the subjects was 26.2 ± 0.35 years (range, 19–34). The age differences in the three groups were not significant (P = 0.13). All subjects had normal IOP (<20 mm Hg), normal-appearing optic discs, and no family history of glaucoma. This study was conducted in conformity with the tenets of the Declaration of Helsinki. The procedures were fully explained to all subjects, and informed consent was obtained in all cases before the tests.

Two types of perimetric visual fields were determined in all the subjects. Only one eye, randomly selected, was tested.

The first perimetric test was performed with the FDP full-threshold C-20 program with 17 test areas located 20’ from the fovea (four 10° square targets per quadrant and a central 5° circular target). Each test area was made up of black and white sinusoidal gratings (0.25 cyc/deg) that flickered at 25 Hz. The contrast between dark and light phases of the vertical stripes in each stimulus pattern was changed automatically according to the response of the subjects. The contrast sensitivity was determined at each location from the log contrast sensitivity and expressed on a decibel scale. The tests were performed with the subjects wearing their distance glasses or contact lenses.

The second test was a white-on-white perimetric test using the HFA full-threshold program with 76 test points in the central 30° field. The threshold sensitivity was determined at each test point. The subjects wore their distance refraction combined with appropriate additional correction for near.

All subjects had been tested on the two perimetric tests at least once, and the second or later results were used for the analysis. The two tests were performed on different days but within a month. Results with more than 20% false positive or false negative readings or fixation losses were excluded. The left eye data were converted to the right eye format, and the two blind-spot locations from the HFA test were removed.

To evaluate the variation of the mean sensitivity (MS) with eccentricity, the FDP and HFA fields were divided into three zones: R1, the central zone; R2, the paracentral zone; and R3, the midperipheral zone.11 The variation of the MS was also evaluated for the four quadrants (superior-temporal, inferior-temporal, superior-nasal, and inferior-nasal).
The mean deviation (MD, a measure of the average departure of sensitivity at each test location from the age-corrected normal value), the pattern SD (PSD), a measure of the degree to which the shape of the measured field departed from the age-corrected normal reference field, and the test durations were obtained automatically from a printout from FDP and the HFA.

The significance of the differences in the MS, MD, PSD, and the test durations was analyzed for the three groups using a one-way analysis of variance (ANOVA). ANOVA with post hoc comparison using Fisher’s protected least-significant difference (PLSD) correction of probability was performed for multiple comparison (statistically significant level, P < 0.05). In addition, the relationship between the refraction and the MS, MD, or PSD was analyzed with a simple regression analysis (statistically significant level, P < 0.05).

RESULTS

Examples of typical visual fields obtained by FDP and the HFA test and displayed on a gray scale are shown in Figure 1 for each group. The fields for a subject in the emmetropia group (25-year-old woman, 20/20 [10:10] 5/870 , 25.4°) are shown in Figure 1A, and those for a subject in the intermediate-myopia group (28-year-old woman, 20/20 [8:12] 26.2°) in Figure 1B. The fields for a subject in the high-myopia group (25-year-old woman, 20/20 [12:8] 27.1°) in Figure 1C. A comparison of the fields for the patients from the three groups showed that the fields were very similar when tested by FDP, but with HFA testing, the sensitivity decreased as the refractive errors increased.

Mean Sensitivity

The MS of the fields obtained by the HFA in the moderately myopic and highly myopic eyes were significantly lower than that of the emmetropic eyes (P < 0.005 and P < 0.001, respectively), but the MS for all groups determined by FDP did not differ significantly (Fig. 2A). In addition, the MS for HFA testing was weakly but still significantly correlated with the refractive error (R² = 0.20, P < 0.001; Fig. 2C). The MS for the fields obtained by FDP, on the contrary, were not correlated with the refractive error (Fig. 2B).

For the different eccentricities, the MS for the fields obtained by FDP did not differ significantly for all groups (Fig. 3A). However, the MS for the fields determined HFA results for the intermediate-myopia and high-myopia groups were significantly lower than for the emmetropic eyes for all eccentricities (P < 0.005; Fig. 3B).

The MS for the fields obtained by FDP were not significantly different in the different quadrants for all groups (Fig. 3C). However, the MS for the fields determined by HFA testing in the moderately myopic and highly myopic eyes were significantly lower than that of emmetropic eyes in all quadrants (P < 0.005 and P < 0.001, respectively; Fig. 3D).

Mean Derivation

The MD of the fields obtained by FDP were not significantly different for all groups, but the MD for HFA testing in the moderately myopic and highly myopic groups were significantly lower than the MD of the emmetropic group (P < 0.001 and P < 0.0001, respectively; Fig. 4A). The coefficient of correlation between the refraction and the MD was significant only in the HFA results (R² = 0.25; P < 0.001; Fig. 4C).

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**TABLE 1. Subjects**

<table>
<thead>
<tr>
<th>Refraction*</th>
<th>Number of Eyes†</th>
<th>Age (y)</th>
<th>Test Duration‡</th>
</tr>
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<tbody>
<tr>
<td>Emmetropia (−3 D)</td>
<td>−1.16 ± 0.23</td>
<td>20 (12:8)</td>
<td>273 ± 4.2</td>
</tr>
<tr>
<td>Intermediate myopia (−3 D − 6 D)</td>
<td>−4.59 ± 0.17</td>
<td>20 (8:12)</td>
<td>270 ± 2.3</td>
</tr>
<tr>
<td>High myopia (−6 D − 12 D)</td>
<td>−8.12 ± 0.36</td>
<td>20 (10:10)</td>
<td>267 ± 3.1</td>
</tr>
<tr>
<td>Total</td>
<td>−4.62 ± 0.40</td>
<td>60 (30:30)</td>
<td>270 ± 1.9</td>
</tr>
</tbody>
</table>

* Refraction is expressed as equivalent spherical power in mean diopters ± SEM.
† One eye, chosen randomly, was used from each subject. Male:female ratio is in parentheses.
‡ The mean test durations required for completing the FDP and HFA tests did not differ significantly for all groups (P = 0.18–0.79, FDP; P = 0.28–0.85, HFA). Data are expressed as mean seconds ± SEM.

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**FIGURE 1.** Examples of FDP and the HFA full-threshold program for each group. (A) Emmetropia group: 25-year-old woman, −0.25 D; (B) intermediate-myopia group: 28-year-old woman, −4.00 D; and (C) high-myopia group: 25-year-old woman, −7.50 D.

**FIGURE 2.** (A) The MS for FDP and HFA testing. The MS for HFA testing in the moderately myopic (P < 0.005) and highly myopic (P < 0.001) groups were significantly lower than in emmetropic eyes. (B) The coefficient of correlation of MS to the refractive error for FDP was not significant, whereas for the HFA (C), it was significant (P < 0.001).
Pattern Standard Deviation
The mean PSD for the fields determined by FDP and the HFA did not differ significantly for all groups (Fig. 4D). The coefficient of correlation between the refractive error and the PSD was not significant in either the FDP or the HFA results (Figs. 4E, 4F).

Test Durations
The mean test durations required for completing the FDP and HFA tests did not differ significantly for all groups ($P = 0.18$ to $0.79$ for FDP; $P = 0.28$ to $0.85$ for the HFA; Table 1).

Discussion
Although blue-on-yellow perimetry with the HFA has been shown to detect early glaucomatous damage,¹² it is also affected by myopia.⁵ Relevant to this study, even the HFA full-threshold program white-on-white perimetry has been shown to be affected by myopia⁶ as was found in this study. Thus, the effect of myopia must be taken into account when interpreting the fields obtained by the HFA.

FDP has been developed only recently, and, unfortunately, studies have not been reported on the effect of myopia on FDP. In this study, the MS, MD, and PSD of FDP were analyzed and were found not to differ significantly for the fields of the three different refractive error groups. Thus, FDP can be used regardless of the presence of myopia.

The user’s guide states that FDP may be performed with or without the patient’s correction for refractive errors of less than 7.00 D. Although a sinusoidal pattern stimulus is less affected by refractive defocus than a square-wave pattern stimulus, we corrected the refractive error for both FDP and the HFA to eliminate the effect of retinal blur on the sensitivity.¹³ In FDP, the size of the stimulus is a 10° square, whereas that for the HFA is a point of less than 1° of visual angle. Thus, the large size of the stimulus for FDP may be more easily seen than that in the HFA.

A fatigue effect in myopic eyes may be responsible for the poorer results of myopic eyes with conventional perimetry, but the two perimetric tests were performed on different days but within 1 month. We also analyzed the test duration on these two testing methods and determined that there was no significant difference in the test durations for both perimetric tests among the three different groups. Thus, we conclude that there was no fatigue effect on the myopic eyes.

The MS on differential light sensitivity (DLS) testing, such as that with the HFA, decreased with increasing myopia, indicating that the total deviations increase with higher levels of myopia. Because PSD remained unchanged, this indicates that the PSDs were not altered by myopia. It is interesting that there was a generalized, not localized, diffuse depression effect with increasing myopia on DLS testing. It should be noted, however, that we did not find a generalized diffuse depression effect on FDP results in this study.

In summary, there was no decrease in contrast MS, MD, and PSD in FDP in corrected myopic eyes. These results indicate that the effects of myopia up to −12.0 D can be ignored when using FDP.

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References


