Accommodation responses and refractive error

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Previous investigations have reported considerable individual differences in the resting point of accommodation. Recent independent studies in Davis, Calif., and Cardiff, Wales, indicate that part of these variations are related to refractive errors. The average dioptric value of the resting point of accommodation is lowest for corrected myopes, highest for corrected hyperopes, and intermediate for emmetropes. Another part of the variation in resting point is related to individual differences in the far point of accommodation. There appears to be no significant relationship between the resting point and near point of accommodation.

Key words: accommodation, resting point, near point, far point, myopia, hyperopia, emmetropia

Accommodation refers to the method of the eye for varying its refractive power to produce a focused image on the retina for different object distances. Accurate accommodation is dependent on several stimulus characteristics, including target luminance, contrast, and size. In the absence of an appropriate stimulus, accommodation assumes an intermediate fixed-focus condition referred to as the "resting point" or "dark focus" of accommodation. The intermediate resting point of accommodation has been shown to be responsible for the occurrence of anomalous myopias, including night myopia, empty field or space myopia, and instrument myopia.

An interesting feature of the resting point of accommodation is that it exhibits considerable variation from one individual to another, although the value for a given individual is quite stable over time. The purpose of the present investigation was to determine whether the refractive properties of the eye are related to these individual differences in the resting point of accommodation. Independent studies were conducted in Davis, Calif., and Cardiff, Wales, to examine relationships between refractive status (myopia, hyperopia, emmetropia) and the resting point of accommodation, and relationships among the far point, near point, and resting point of accommodation.

Methods

Measurements of accommodation in both studies were obtained with a laser Badal optometer, applying corrections for chromatic aberration and the position of the reference plane of stationarity. Each subject exhibited a corrected visual acuity of 20/25 or better with no history of ocular abnormality other than refractive error. All but one of the subjects were below the age of 25. Prior to testing, the accuracy of each subject’s spherical and astigmatic refractive correction was carefully checked using standard refraction techniques. Since the subjects wore their corrective lenses throughout the test, all dioptric values of accommodation.

Results

Cardiff study. The mean resting points of accommodation (and S.E.M.) for hyperopes, emmetropes, and myopes are presented in Fig. 1. These data showed a tendency for the mean resting point of accommodation to be greatest for corrected hyperopes and lowest for corrected myopes. A one-way analysis of variance revealed that the relationship between refractive status and the resting point of accommodation was not statistically significant. However, this was probably due to the small sample sizes used in the study.

Davis study. Summary data for all 40 subjects in the Davis study revealed the following: resting point of accommodation, $\bar{X} = 1.43 \text{ D}$, S.D. = 1.03 D; far point, $\bar{X} = 0.28 \text{ D}$, S.D. = 0.41 D; and near point, $\bar{X} = 10.21 \text{ D}$, S.D. = 2.10 D. Resting point and far point measurements were significantly correlated ($r = +0.48$, $p < 0.01$), indicating that part of the individual variation in the resting point of accommodation is related to individual differences in the far point of accommodation. Correlations between the resting point and near point of accommodation ($r = +0.08$) and between far point and near point of accommodation ($r = +0.07$) were not statistically significant.

Distributions of the resting point, far point, and near point of accommodation are presented in Fig. 2 for emmetropes, corrected low myopes, and corrected high myopes. Note that the distribution of measurements for the resting point of accommodation was narrower in corrected high myopes than in emmetropes or corrected low myopes. In addition, the dioptric value of the resting point of accommodation in corrected high myopes was statistically significantly lower than in emmetropes ($t' = 2.28$, df = 27, $p < 0.03$; $t'$ test for independent samples used the method of Welch, which does not assume equal variance in the two groups). No other between-group differences in resting point of accommodation were statistically significant.

Determination of the far point of accommodation were similar for all three groups of...
Accommodation responses and refractive error

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**Fig. 2.** Frequency distributions of the resting point, far point, and near point of accommodation in 20 emmetropes, 10 corrected low myopes, and 10 corrected high myopes in the Davis study. Note that the abscissas of the far point, resting point, and near point are scaled differently.

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**Fig. 3.** Frequency distributions of the amplitude of far accommodation (resting point minus far point of accommodation) in 20 emmetropes, 10 corrected low myopes, and 10 corrected high myopes in the Davis study.

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Subjects. This result is not surprising because all myopes wore their appropriate refractive correction for distance during testing. For measurements at the near point of accommodation, corrected low myopes (X = 11.6 D) exhibited a greater dioptric value than emmetropes (X = 9.5 D). This difference was statistically significant (t' = 2.85, df = 19; p < 0.01). The near point of accommodation in corrected high myopes was not significantly different from emmetropes or corrected low myopes.

We define amplitude of far accommodation as the difference between resting point and far point of accommodation. This has also been referred to as "negative accommodation." In view of the significant correlation between the far point and resting point of
accommodation, the amplitude of far accommodation was compared among the three subject groups in the Davis study. This comparison permits examination of the relationship between refractive status and the resting point that are independent of variations in the far point of accommodation. These data are presented in Fig. 3. The amplitude of far accommodation in corrected high myopes ($\bar{X} = 0.66$ D) was significantly smaller ($t' = 2.83; df = 25; p < 0.01$) than for emmetropes ($\bar{X} = 1.36$ D). Corrected low myopes were not significantly different from emmetropes or corrected high myopes for their amplitude of far accommodation.

The range of accommodation for each subject was calculated as the far point minus the near point of accommodation. There was no significant correlation between resting point and range of accommodation. We defined amplitude of near accommodation as the difference between the near point and resting point of accommodation. Corrected low myopes had a greater range of accommodation than emmetropes ($\bar{X} = 11.2$ D vs. $\bar{X} = 9.3$ D, $t' = 2.58, df = 19, p < 0.02$) and a greater amplitude of near accommodation ($\bar{X} = 10.0$ D vs. $\bar{X} = 7.0$ D, $t' = 2.64, df = 18, p < 0.02$). Corrected high myopes were not significantly different from corrected low myopes or emmetropes. At the present time we find it difficult to interpret these unexpected findings.

### Discussion

The main findings of this study include (1) substantial variation in the resting point of accommodation across all subjects; (2) lower average dioptric values of the resting point of accommodation for corrected myopes, higher average values for corrected hyperopes, and intermediate average values for emmetropes; (3) a significant, positive correlation between resting point and far point of accommodation; and (4) no relationship between the resting point and near point of accommodation.

The distributions of resting points for our subject populations are similar to the one reported by Leibowitz and Owens (mean = 1.52 D, S.D. = 0.77 D, and range = −0.4 to 4.0 D; N = 220). The Cardiff results show a mean of 0.95 D, S.D. of 0.64 D, and range of −0.3 to 3.0 D (N = 23), whereas the Davis findings reveal a mean of 1.43 D, S.D. of 1.03 D, a range of −0.2 to 4.4 D (N = 40). Differences in the absolute values of resting point data from Cardiff and Davis may be due to either slight methodologic differences, the small sample sizes in both studies, or variations in the general subject populations in Wales and California.

Results of the Davis study indicate that individual differences in resting point are associated with variations in far point. The simplest interpretation of this strong positive correlation is that as the far point shifts (whether due to intrinsic refractive changes or corrective lenses), all points on the accommodative spectrum shift with it. In this regard, the slope of the regression equation relating resting point to far point in the Davis study has a value near unity (1.19). However, the range of individual variation in far point is much smaller than the range for resting point, suggesting that differences in the far point only account for a portion of the variation in resting point of accommodation.

Some of the individual differences in resting point are related to differences in refractive status. The results of both studies indicate a progressive increase in the average dioptric value of the resting point of accommodation from corrected myopes to emmetropes to corrected hyperopes, implying a concomitant increase in the amplitude of far accommodation. The underlying basis for these differences among various groups of refractive error poses an interesting question. Is it related to some intrinsic difference in the ability to accommodate to far objects (i.e., physiologically based limitations on the amplitude of far accommodation)? It has been reported that the normal physiologic tone of the ciliary muscle in hyperopes is greater than in myopes. Alternatively, might it represent an active functional response to refractive error as part of an attempted physiologic compensation? In this view it is interesting to note that in the Davis myopes there was a significant negative correlation be-
tween the number of years since the initial diagnosis of myopia and both resting point \((r = -0.53, \ p < 0.02)\) and the amplitude of far accommodation \((r = -0.58, \ p < 0.01)\). The questions raised by these findings require further studies of resting point and refractive characteristics. In addition, factors such as stress\(^{14}\) and mood changes\(^{15}\) may be related to individual differences in the resting point of accommodation.

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REFERENCES