Ocular Dominance, Laterality, and Refraction in Singaporean Children

Audrey Chia,1,2 Arlie Jaurigue,3 Gus Gazzard,4 Yvonne Wang,5 Donald Tan,1,2 Richard A. Stone,5 and Seang Mei Saw1,3

PURPOSE. To explore the effect of dominance and laterality on refractive error and axial length.

METHODS. Ocular dominance was assessed with the hole-in-the-card test in 543 children during their 2006 follow-up visits for the Singapore Cohort study Of the Risk factors for Myopia (SCORM). Data were compared to cycloplegic refractions and axial lengths measured by ultrasound.

RESULTS. The spherical equivalent refraction was essentially the same between the right and left eyes, although there was a small but statistically significant longer axial length in the right eyes. Right and left ocular dominance was noted in 58% and 30% of the subjects, respectively, with 12% having no eye preference. There was no significant difference in spherical equivalent refraction (2.56 ± 2.46 D [mean ± SD] vs. −2.45 ± 2.52 D, P = 0.22) or axial length (24.36 ± 1.19 mm vs. 24.32 ± 1.18 mm, P = 0.05) between dominant and nondominant eyes. In subjects with anisometropia ≥0.5 D, dominant eyes were more myopic in 52%. Dominant eyes, however, had less astigmatic power (−0.88 ± 0.80 D versus −1.00 ± 0.92 D; P < 0.001).

CONCLUSIONS. Ocular laterality and dominance have no significant effect on spherical equivalent. All axial length and astigmatic differences were small and clinically insignificant. The study findings suggest that in Singaporean children, bias is not present in those investigations that restrict analyzes to right or left eyes. Although there is no apparent association between refraction and ocular dominance in young Singaporean children, more research is needed to resolve the disparate results in existing reports. (Invest Ophthalmol Vis Sci. 2007;48: 3533–3536) DOI:10.1167/iovs.06-1489

The prevalence rates of myopia have increased steadily in Asia and in many other regions of the world over recent decades.1–3 This increase has stimulated research to identify the underlying mechanisms influencing refractive development and progression of myopia. Whether ocular laterality or dominance influences refractive error has been investigated but with indeterminate results.6–9 Although some studies on laterality have shown no difference between right and left eyes, others have found increased myopia and axial length in right eyes.7–10 Studies on ocular dominance suggest that right eye dominance is present in 65% of subjects, left eye dominance in 32%, and no consistent preference in 8%.6,7 Few studies have been undertaken to examine the effect of ocular dominance on refraction. In 2004, Cheng et al.7 noted that in adult subjects with anisometropic myopia, dominant eyes had significantly greater myopia (−5.27 D vs. −3.94 D) and longer axial lengths (25.15 mm vs. 24.69 mm). These results suggest that ocular dominance may be an important factor in the progression of myopia.

We sought to learn whether the findings by Cheng et al.7 in a population of Chinese adults were applicable to a group of Singaporean schoolchildren, largely of Chinese ethnicity. We specifically evaluated eye laterality and ocular dominance in comparison to refraction and biometry.

METHODS

Nine hundred sixty-one children aged 9 years were first screened in the Singapore Cohort study Of the Risk factors for Myopia (SCORM) in 2001 in one school. Ocular dominance was assessed using the hole-in-the-card test in children during their fifth annual follow-up visit. In the hole-in-the-card test, children viewed a centrally placed target set at 6 m away through a 3-cm hole in a card held with both hands at arm’s length. In each case, the children wore their current distance glasses, if prescribed. The right eye of each child was then covered. If the target disappeared, the children were identified as fixing with the right eye. If it did not disappear, then they were identified as fixing with the left eye. The hole-in-the-card test was repeated three times: after clinic registration, after visual acuity testing, and after completion of the annual follow-up questionnaire. Ocular dominance was then assigned to a specific eye when three of three readings were the same. Children who did not provide the same result three times were classified as having no fixed ocular dominance pattern.7,11,12 Hand dominance was assigned to the hand with which the child wrote.

The study was approved by the Ethics Committee of the Singapore Eye Research Institute, and all procedures adhered to the Declaration of Helsinki.

Reliable refraction and axial length measurements were obtained in 543 subjects. Three drops of 1% cyclopentolate were administered 10 minutes apart. Cycloplegic refraction was performed 20 minutes later with a fully calibrated autokeratorefractors (model RK5; Canon, Ltd., Tochigiken, Japan). At least five measurements were taken. Axial lengths were measured with a biometry machine (Echoscan model US-800; Nidek Co., Ltd, Tokyo, Japan; probe frequency 10 mHz after 1 drop of 0.5% proparacaine hydrochloride (Alcaine; Alcon-Courvreur, Puurs, Belgium). At least six consecutive measurements with a standard deviation of less than 0.12 mm were required. Yearly eye examinations were performed, but only 579 (60.2%) participants returned for screening in 2006.
Spherical equivalents were calculated using the formula: spherical power + (cylindrical power/2). The power vector \( J_0 \) was calculated as: \((-\text{cylindrical power}/2 \cos(2 \cdot \text{cylindrical axis})\), and \( J_{45} \) was calculated as: \((-\text{cylindrical power}/2 \sin(2 \cdot \text{cylindrical axis})\).

Hand and ocular dominance were compared by \( \chi^2 \) test. Refractive errors (spherical equivalent and cylindrical power) and axial lengths between dominant and non-dominant eyes were compared by paired \( \Delta \)test and \( \chi^2 \) test, respectively. All data are presented as the mean ± SD with significance levels set at 0.05. All analysis was performed with commercial software (Statview, ver. 5.0.1; SAS, Cary, NC).

**RESULTS**

Ocular dominance was determined to be present in 477 (89.3%) subjects. All children were aged between 12 and 13 years. Two hundred forty-eight (52%) were boys and 48% were girls. Three hundred sixty-one (75.6%) were ethnic Chinese, 69 (14.4%) Indian, 40 (8.5%) Malay, and 7 of other races. The mean spherical equivalent refractions of the two eyes ranged from +3.81 D to −11.45 D, with a population median of −2.32 D.

**Differences between Right and Left Eyes**

The mean spherical equivalent was −2.53 ± 2.42 D in the right eye and −2.49 ± 2.45 D in the left eye (\( P = 0.12 \)). The mean cylindrical power was −0.87 ± 0.79 D (range: −0.15 to −6.25) in the right eye and −1.00 ± 0.89 D (range: −0.05 to −6.40) in the left eye (\( P < 0.001 \)). The mean axial length was 24.34 ± 1.17 mm (range: 20.62–27.94 mm) and 24.29 ± 1.17 mm (range: 20.83–27.91 mm) in the right and left eyes, respectively (\( P = 0.01 \)).

**Association between Hand and Ocular Dominance**

The majority (92%) of children were right-handed and right eye dominant (58%; Table 1). Right-handed people were more likely to be right eye dominant, whereas left-handed people were more likely to be left eye dominant (\( P < 0.001 \)).

**Refractive Error and Axial Length in Dominant and Nondominant Eyes**

The mean spherical equivalent and axial length were not significantly different between dominant and nondominant eyes (Table 2). Dominant eyes were more myopic by \( \geq 0.5 \) D in 96 (20.1%) subjects and more hyperopic by \( \geq 0.5 \) D in 88 (18.4%) and had spherical equivalent within 0.5 D of the nondominant eyes in 293 (61.5%). This ratio was unchanged for both myopic and hyperopic subjects. In subjects with anisometropic myopia (i.e., bilateral myopia and anisometropia \( \geq 0.5 \) D), there was no significant difference in spherical equivalent or axial length in dominant and nondominant eyes. The mean amplitude of the astigmatism power and the mean values of the power vectors (\( J_0 \) and \( J_{45} \)) were all significantly less in dominant eyes (Table 2).

**Effect of Anisometropia**

There were no significant differences in mean spherical equivalent refractions and axial lengths between dominant and non-dominant eyes in anisometropic subjects (Table 3). However, subjects with anisometropia \( \geq 0.5 \) D had significantly more myopia and significantly longer axial lengths in both eyes than did subjects without anisometropia (Table 3, \( P < 0.01 \)). Only 72 (15%) and 36 (7.5%) children had anisometropia of \( \geq 1.0 \) D and \( \geq 1.5 \) D, respectively. When anisometropia was \( \geq 1.75 \) D (\( n = 25 \)), dominant eyes were more myopic in 56% of subjects. Dominant eyes were more myopic in 48% of subjects with higher myopia (mean SE, \( < -4.0 \) D) and in 49% of subjects with lower myopia (mean SE, \( -0.5 \) to \( -4.0 \) D).

**Dominance and Astigmatism**

In most children (94%), astigmatic power of the two eyes measured within 1 D of each other. Where the difference was greater than 1.0 D (\( n = 30 \)), astigmatism was higher in the nondominant eye in 26 (85%) children. When the interocular difference in astigmatism power was \( > 1.3 \) D, nondominant eyes were all more astigmatic (Fig. 1).

**Table 2. Differences in Refractive Error and Axial Length between Dominant and Nondominant Eyes**

<table>
<thead>
<tr>
<th></th>
<th>Dominant Eyes</th>
<th>Nondominant Eyes</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>All subjects (( n = 47 ))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spherical equivalent (D)</td>
<td>−2.56 ± 2.46</td>
<td>−2.45 ± 2.52</td>
<td>0.22</td>
</tr>
<tr>
<td>Astigmatism (D)</td>
<td>−0.88 ± 0.80</td>
<td>−1.00 ± 0.92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>( J_0 )</td>
<td>0.304 ± 0.449</td>
<td>0.371 ± 0.489</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>( J_{45} )</td>
<td>0.027 ± 0.226</td>
<td>−0.049 ± 0.273</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>24.36 ± 1.19</td>
<td>24.52 ± 1.18</td>
<td>0.05</td>
</tr>
<tr>
<td>Subjects with anisometric myopia* (( n = 162 ))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spherical equivalent (D)</td>
<td>−3.89 ± 2.33</td>
<td>−3.92 ± 2.24</td>
<td>0.68</td>
</tr>
<tr>
<td>Astigmatism (D)</td>
<td>−1.14 ± 0.98</td>
<td>−1.33 ± 1.08</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>( J_0 )</td>
<td>0.451 ± 0.532</td>
<td>0.533 ± 0.568</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>( J_{45} )</td>
<td>0.068 ± 0.270</td>
<td>−0.085 ± 0.339</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>24.89 ± 1.14</td>
<td>24.85 ± 1.10</td>
<td>0.35</td>
</tr>
</tbody>
</table>

* Subjects with SE < 0 D in both eyes and anisometropia \( \geq 0.5 \) D.
TABLE 3. Spherical Equivalent and Axial Length in Dominant and Nondominant Eyes in Anisometropic Subjects

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Dominant Eye</th>
<th>Nondominant Eye</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anisometropia ≥ 0.5 D (n = 184)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spherical equivalent (D)</td>
<td>−3.44 ± 2.52*</td>
<td>−3.35 ± 2.52*</td>
<td>0.29</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>24.72 ± 1.19†</td>
<td>24.64 ± 1.20†</td>
<td>0.05</td>
</tr>
<tr>
<td>More myopic</td>
<td>96 (52%)</td>
<td>88 (48%)</td>
<td></td>
</tr>
<tr>
<td>Anisometropia &lt; 0.5 D (n = 293)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spherical equivalent (D)</td>
<td>−2.00 ± 2.25*</td>
<td>−1.98 ± 2.27*</td>
<td>0.38</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>24.13 ± 1.13†</td>
<td>24.12 ± 1.12†</td>
<td>0.52</td>
</tr>
<tr>
<td>More myopic†</td>
<td>149 (51%)</td>
<td>127 (43%)</td>
<td></td>
</tr>
</tbody>
</table>

Lowercase superscript: * Subjects with anisometropia ≥0.5 D were significantly more myopic than subjects with anisometropia <0.5D (P < 0.01).
Lowercase superscript: † Subjects with anisometropia ≥0.5 D significantly longer axial lengths than subjects with anisometropia <0.5D (P < 0.01).
Lowercase superscript: ‡ Seven of the subjects had exactly the same spherical equivalent in both eyes.

DISCUSSION
Theories and concepts regarding the control of ocular growth and the etiology of myopia still remain unresolved. In many of the studies on myopia, one eye (usually the right) was chosen for study, with no consideration of potential effects of ocular dominance on refractive development. In our study, eye laterality and dominance had no significant effect on spherical equivalent. Axial lengths in right eyes were significantly longer, and dominant eyes were significantly less astigmatic, but these differences were small (0.05 mm and 0.2 D) and of little clinical significance.

Right ocular dominance was present in 58% of our subjects, left ocular dominance in 30%, and no consistent preference in 12%. This pattern is similar to the 65:32:8 ratio quoted in the literature. The debate on the physiologic implications of ocular dominance ranges from whether it is a casual habitual relationship to whether it is an essential response to cope with binocular overlap and rivalry. Much of the literature on ocular dominance has addressed understanding when, how, and why eyes become dominant. Few studies have attempted to examine the effect of ocular dominance on the eye’s refractive parameters.

In 2004, Cheng et al. studied 55 adult subjects with anisometropia who presented to their clinics between 2001 and 2002, and noted that dominant eyes were more myopic

(−5.27 ± 2.45 D) than nondominant eyes (−3.94 ± 3.10 D, P < 0.001). Axial length was also significantly longer (25.15 ± 0.96 mm versus 24.69 ± 1.17 mm, P < 0.001) in dominant eyes. When anisometropia was ≥1.75 D, dominant eyes were all more myopic. They proposed that increased visual usage of the dominant eye with the resultant tonic near-work accommodation and accommodative lag may have resulted in greater eye growth and a myopic refractive shift.

Dominance was tested at a single setting using the hole-in-the-card test in both our study and that by Cheng et al. It is uncertain whether dominance, as measured, changes over time. Findings in some studies suggest that ocular dominance is difficult to change and that shifts occurred only after subjects are forced by circumstance to increase input to the nondominant eye. Yet other studies have demonstrated shifts in dominance with horizontal gaze and image size. Visual fixation in real life may even be a dynamic scanning process, with active switching between eyes before one is selected for use. A long-term prospective study would be needed to determine whether sighting dominance, as measured by the hole-in-the-card test, with a single-sized target positioned centrally, will alter over time in children.

Astigmatism was significantly lower in dominant eyes in this study (Tables 2, 3); and when interocular difference in cylinder were greater than 1 D, dominant eyes were more likely to have less astigmatism (85%). Unlike spherical equivalence, astigmatism did not change significantly over a 3-year period in 7- to 9-year-old Singaporean children. It is possible that interocular astigmatic error differences, present since a young age, may result in eyes with less astigmatism (or better vision) becoming more dominant.

In conclusion, our study suggests that in Singaporean children aged 12 to 13 years, ocular dominance and eye laterality is not associated with significant interocular differences in the most commonly used measure of myopia, the spherical equivalence. The strong association between dominance and myopia demonstrated by Cheng et al. in Chinese adults was not found in our study of Asian children. At least in refractive studies of Singaporean children, bias does not seem to have been introduced in those investigations that restrict analyses to right eyes. Our study found no association of ocular dominance with refractive parameters in young Singaporean children, but the findings in the literature on this topic are controversial, perhaps at least partly because of population differences in the available studies. Further research is needed to decide what role, if any, ocular dominance may play in influencing refractive development.

References


