Association of Ocular Dominance and Myopia Development: A 2-Year Longitudinal Study

Zhikuan Yang, Weizhong Lan, Wen Liu, Xiang Chen, Haobui Nie, Minbin Yu, and Jian Ge

PURPOSE. To investigate the effect of ocular dominance on myopia development.

METHODS. One hundred seventy-eight myopic children (age range, 7–13 years) were recruited for a 2-year longitudinal study. The development of myopia was evaluated by the change of objective refractive error, determined with cycloplegic autorefractometry, and axial length, determined with A-scan ultrasonography. Ocular dominance was determined with the hole-in-the-card test. The change in refractive error and axial length between dominant and nondominant eyes were compared by using the paired t test.

RESULTS. Twenty-nine subjects were lost to follow-up, and 19 reported poor compliance of wearing spectacles. The mean age of the retained 130 subjects was 10.9 ± 1.6 years on entry. Sixty-nine (53.1%) subjects were boys. The mean refractive error of the two eyes was −1.73 ± 0.69 D in spherical equivalent refractive error (SE) and the average anisometropia was 0.22 ± 0.19 D. The percentages of right dominance, left dominance, and alternating ocular dominance were 64.6%, 34.6%, and 0.8%, respectively. After a 2-year follow-up, the mean change in SE was −1.34 ± 0.59 and −1.33 ± 0.64 D in the dominant and nondominant eye, respectively (P = 0.72). The mean increase in axial length was 0.67 ± 0.42 and 0.64 ± 0.37 mm, respectively (P = 0.48).

CONCLUSIONS. The findings demonstrated no statistically significant effect of ocular dominance on the development of myopia over a 2-year period. There was no sufficient evidence to support the idea that bias is introduced into myopia intervention clinical trials when myopia progression is evaluated without consideration of potential effects of ocular dominance on refractive development. (Invest Ophthalmol Vis Sci. 2008;49: 4779–4783) DOI:10.1167/iovs.07-1616

The prevalence rates of myopia have increased dramatically in the past decades in many regions of the world, and it has become, according to WHO, one of the major causes of blindness and visual impairment today. Although the history of attempts to arrest myopia progression dates back hundreds of years and a variety of interventions have been tested on human beings (for a review, see Ref. 7), with regards to methodology there is not a widely accepted standard for defining the ocular refraction of a normal individual with two functioning eyes. In many of these studies, one eye (mostly the right eye) has been chosen for analysis, with no consideration of the potential effects of ocular dominance on refractive development. Nevertheless, as hand and cerebral hemisphere dominance, the visual cortices tend to prefer visual input from the dominant eye over the nondominant eye. Recent theories regarding the etiology of myopia center around the visual input-dependant feedback mechanism (for a review, see Ref. 10). Thus, ocular dominance, which must reflect differential processing in the visual pathways from the two eyes, may have effects on ocular growth and refraction. That being the case, one could speculate that bias is present in those studies in which myopia development is evaluated by using data from only the right eyes. Moreover, Cheng et al. noted that the dominant eye has a greater myopic refractive error than the nondominant eye in myopic adults with anisometropia and thus suggested taking ocular dominance into account in the myopia intervention clinical trials. However, Chia et al., in a more recent study, found that ocular dominance had no significant effect on spherical equivalent in children and argued that bias was not present in those investigations that restrict analyses to right or left eyes. Actually, neither of these two studies determined the effect in their cross-sectional design, if any, that ocular dominance may have on the development of myopia.

In the present study, we sought to investigate this important problem through a longitudinal study, with the intention of offering a reference for the analysis of myopia development in future research.

METHODS

Between 2004 and 2005, we recruited 178 subjects (male, 51.7%) for a longitudinal study, evaluating the correlation between development of myopia and ocular dominance. The inclusion criteria, similar with those used in clinical trials, are shown in the Appendix. Subjects were recruited in the optometry clinic, and all were Chinese urban children. During the study period, subjects were required to wear spectacles constantly when they were awake and to avoid applying antimony medications. All subjects were refracted to an end point of “maximum plus” binocular subjective refraction for best visual acuity at every semiannual visit. A new prescription was issued if the change of refractive error was more than 0.5 D or was clinically indicated (e.g., scratched lens). After the 2-year follow-up visit, 29 subjects were lost, and 19 subjects reported poor compliance (e.g., inconsistent wearing of spectacles or application of antimony medications). Thus, data from 130 (73%) subjects were analyzed in the present report.

Ocular dominance was determined with the hole-in-the-card test. Subjects, wearing their spectacles, were asked to hold a card with a 3-cm hole in the center with both hands at arm’s length and view through the central hole a centrally placed target set 6 m away. One eye was then occluded randomly. The subject was required to report immediately when he or she found that the distant target disappeared, and the occluded eye was identified as the fixating eye. Given the subjects’ young age, the test was repeated. Ocular dominance was assigned to a specific eye when the subject gave the same report immediately when he or she found that the distant target disappeared, and the occluded eye was identified as the fixating eye. Given the subjects’ young age, the test was repeated. Ocular dominance was assigned to a specific eye when the subject gave the same report immediately when he or she found that the distant target disappeared, and the occluded eye was identified as the fixating eye. Given the subjects’ young age, the test was repeated. Ocular dominance was assigned to a specific eye when the subject gave the same
result for this series of two tests. Otherwise, another series of two tests was administered to reconfirm. If the second series also gave discordant results, then ocular dominance was classified as alternating. Otherwise, the eye shown to be dominant in this series was recorded as the dominant eye.

Myopia development was determined through the change in objective refractive error, using cycloplegic autorefraction. After corneal anesthesia was obtained using 1 drop of oxybuprocaine (Santen, Osaka, Japan), cycloplegia was achieved with three drops of 0.5% tropicamide plus 0.5% phenylephrine hydrochloride (Mydip-P; Santen), spaced 5 minutes apart. Autorefraction (RM 8800; Topcon Corp. Tokyo, Japan) was undertaken at least 30 minutes after the third administration of tropicamide and only if the pupillary light reflex was absent. The mean of three consecutive reliable readings was taken as the objective refractive error. Refractive errors are expressed as the sum of three components: SE [spherical equivalent, spherical power /11001 (cylindrical power/2)], J0 [(-cylindrical power/2) · cos (2 · cylindrical axis)], and J 45 [(-cylindrical power/2) · sin (2 · cylindrical axis)].13

Axial length was determined with A-scan ultrasonography (Axis II PR; Quantel Medical, Clermont-Ferrand, France) with an 11-MHz probe. After cycloplegic autorefraction, 10 scans were made. Readings were accepted only when anterior and posterior lens reflections were observed and a sharp retinal spike was visible. Autorefraction and A-scan ultrasonography were performed by the same experienced investigator throughout the study.

Statistical Analysis
All analyses were performed with commercial software (SPSS ver. 11.0; SPSS, Chicago, IL) and the data are presented as the mean ± SD. Tests of significance were two-tailed and the level of significance was set at 0.05. Comparison of baseline demographic and ocular refraction between groups was statistically evaluated by using the $\chi^2$ test for categorical variables and the unpaired $t$-test for continuous ones. Changes in refractive error and axial length between the two eyes were statistically evaluated with the paired $t$-test, and the relationship between initial anisometropia and final anisometropia was evaluated using the Pearson’s correlation test.

RESULTS
Tables 1A and 1B show the baseline demographic and ocular refraction for the retained subjects versus lost subjects and those with poor compliance. Comparisons of these important
Although there have been several articles reporting the association between ocular dominance and refractive error, axial length, and the change in refractive error and axial length. The dominant eyes did not necessarily become more myopic than the non-dominant eyes over this period in children.

In the present study, ocular dominance was determined using the same test as in the previous two studies, but only subjects who gave discordant results in two series of two tests were classified as having alternating ocular dominance. That leads to a low percentage (0.8%) of alternating ocular dominance, compared with 12% (0% and 23.6%) in the testing by Chia et al. (hole-in-the-card test), Cheng et al. (hole-in-the-card test), and Cheng et al. (convergence near-point test), respectively. The classification methods adopted probably contributed to the difference among studies. Overall, the percentage of right eye dominance was larger than that of left eye dominance.

In adults with myopia, Cheng et al. found that dominant eyes were not more myopic than non-dominant eyes in the subjects with low anisometropia (<1.75 D). In children, Chia et al. also noted that ocular dominance was not associated with significant interocular differences in all the tested population, with a mean anisometropia of 0.04 D. The present study essentially reported that in a population with anisometropia of no more than 1 D, there was no effect of association between higher myopia and ocular dominance on study entry. Thus, these three studies give a consistent picture that, with low anisometropia, there was no association between ocular dominance and ocular refraction.

On the other hand, Cheng et al. found that dominant eyes were more myopic than non-dominant eyes in the subjects with high anisometropia (>1.75 D) and Chia et al. also noted that dominant eyes were more myopic in 56% of subjects with anisometropia ≥ 1.75 D. Overall, these two studies demonstrated that the dominant eyes tended to be significantly more myopic in myopic subjects with high anisometropia, both in adults and children. Nevertheless, given their cross-sectional design, one could not yet determine whether this significant association is the consequence of faster myopia progression in the dominant eye or because of the more myopic eye’s tendency to be the dominant eye. One of the strengths of the present study is to offer longitudinal data that throw some light on the issue. Because we found no effect of ocular dominance on development of myopia or axial elongation, one can speculate that ocular dominance is not a strong stimulator that drives ocular growth. Thus, it may be more likely that the significantly positive correlation between ocular refraction and ocular dominance is because the more myopic eye tends to become the dominant eye, rather than that the dominant eye tends to grow more and becomes more myopic.

In many epidemiologic studies or clinical intervention trials regarding the development of refractive error, only data from one eye (mostly the right eye) were selected for analysis. Our findings show no significant difference in myopia development between the right and the left eyes, except for a

### Table 2. Difference between Eyes on Study Entry

<table>
<thead>
<tr>
<th></th>
<th>Right Eyes</th>
<th>Left Eyes</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spherical equivalent (D)</td>
<td>−1.71 ± 0.67</td>
<td>−1.74 ± 0.71</td>
<td>0.35</td>
</tr>
<tr>
<td>J₀ (D)</td>
<td>−0.02 ± 0.15</td>
<td>0.04 ± 0.17</td>
<td>0.01</td>
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<tr>
<td>J₄5 (D)</td>
<td>0.02 ± 0.15</td>
<td>0.01 ± 0.18</td>
<td>0.57</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>23.80 ± 0.78</td>
<td>23.86 ± 0.73</td>
<td>0.12</td>
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</table>

### Table 3. Difference between Dominant and Nondominant Eyes on Study Entry

<table>
<thead>
<tr>
<th></th>
<th>Dominant Eyes</th>
<th>Nondominant Eyes</th>
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<tbody>
<tr>
<td>Spherical equivalent (D)</td>
<td>−1.72 ± 0.69</td>
<td>−1.74 ± 0.70</td>
<td>0.69</td>
</tr>
<tr>
<td>J₀ (D)</td>
<td>0.00 ± 0.15</td>
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<tr>
<td>J₄5 (D)</td>
<td>0.02 ± 0.15</td>
<td>0.00 ± 0.18</td>
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<tr>
<td>Axial length (mm)</td>
<td>23.82 ± 0.78</td>
<td>23.83 ± 0.75</td>
<td>0.80</td>
</tr>
</tbody>
</table>

### Table 4. Difference in Myopia Progression 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>Spherical equivalent (D)</td>
<td>−1.35 ± 0.59</td>
<td>−1.33 ± 0.64</td>
<td>0.72</td>
</tr>
<tr>
<td>J₀ (D)</td>
<td>−0.04 ± 0.24</td>
<td>−0.06 ± 0.33</td>
<td>0.64</td>
</tr>
<tr>
<td>J₄5 (D)</td>
<td>0.03 ± 0.34</td>
<td>−0.01 ± 0.29</td>
<td>0.24</td>
</tr>
<tr>
<td>Axial length (mm)</td>
<td>0.67 ± 0.42</td>
<td>0.64 ± 0.37</td>
<td>0.48</td>
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</table>
borderline significant difference in the change in axial length. The study period and inclusion criteria of the present study are the most commonly adopted criteria by clinical intervention trials for myopia. Our findings, therefore, could be used as a reference for the selection of the refractive error from two eyes for each child in future research. Goldschmidt et al. thought it most logical to take the average of the two eyes in most cases. In a recent study, on the effect of progressive addition lenses on the progression of myopia, Hyman et al. suggested evaluating the correlation of the myopic change between eyes. If the correlation coefficient was larger than 0.85 and the mean difference between eyes was not significantly different from 0,
then the eyes were judged to be highly correlated with no appreciable difference in myopia progression between them and the mean of the two eyes was used as a summary of the refractive error. Otherwise, the worse eye for each child (eye with the more myopic change) was used.

In conclusion, no significant effect of ocular dominance was found on myopia development, at least in a 2-year longitudinal study with inclusion criteria typical of clinical intervention trials. Our findings justify the use of data from one eye only or the average of both eyes, with no consideration of effects of ocular dominance on refractive development.

Acknowledgments

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References


APPENDIX

The ophthalmic and nonophthalmic criteria were as follows:

**Ophthalmic Criteria**

Spherical refractive error of −0.50 to −3.00 D (measured under cycloplegia); astigmatism of not more than 1.50 D; anisometropia of not more than 1.00 D; best corrected visual acuity of no less than 6/6; no strabismus; normal intraocular pressure (measured with Goldman tonometer); and no ocular conditions that are known to affect refractive development.

**Nonophthalmic Criteria**

Age ranges from 7 to 13 years; no parents with moderate or high (≥ −3.00 D) myopia, assessed by noncycloplegic autorefraction; birth weight of more than 1250 g; willingness to wear spectacles constantly for a minimum of 2 years; understanding random assignment and willingness not to apply other medications; no systemic conditions or use of medications that affect refractive development; and no prior use of contact lenses, bifocal spectacles, or progressive spectacle lenses.