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<th>Title</th>
<th>Retinal Nerve Fiber Layer Thickness in Myopic, Emmetropic, and Hyperopic Children</th>
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Abstract: The purpose of this study was to investigate the peripapillary retinal nerve fiber layer (RNFL) thickness in myopic, emmetropic, and hyperopic children using optical coherence tomography.

Two-hundred one right eyes of subjects aged 4 to 18 years were divided into 3 groups based on their postcycloplegic spherical equivalent: myopes (≤1.0 D), emmetropes (≥-1.0 to ≤+1.0 D), and hyperopes (>1.0 D). The RNFL was correlated with age, spherical equivalent, and axial length. The RNFL was compared between the 3 groups before and after age adjustment.

The RNFL was thickest in the hyperopic group (107.2 ± 10.13 μm, n = 73), followed by the emmetropic group (102.5 ± 9.2 μm, n = 61), and then the myopic group (95.7 ± 10.3, n = 67) (all P < 0.0001). The myopic group (9.6 ± 3.9 years) was significantly older than the emmetropic (6.9 ± 2.7 years) and hyperopic (6.5 ± 1.9 years) groups (both P < 0.0001). When adjusted for age, myopes had a thinner RNFL than the other 2 groups (all P < 0.0001), but there was no RNFL thickness difference between the emmetropic and hyperopic groups (P > 0.05). A thinner RNFL was associated with an older age (r = -0.4, P < 0.0001), a more myopic spherical equivalent (r = 0.5, P < 0.0001), and a longer axial length (r = -0.4, P < 0.0001) on Pearson correlation analysis.

The apparently thicker RNFL in hyperopic and emmetropic children was attributed to their younger age as compared with their myopic counterparts. When adjusted for age, only myopia was associated with a thinner RNFL, with emmetropic and hyperopic children having equal RNFL thicknesses. Advancing age, a more myopic spherical equivalent, and a longer axial length were associated with a thinner RNFL in children.

Abbreviation: RNFL = retinal nerve fiber layer.

INTRODUCTION

During optic nerve development, 2.85 million nerve fibers exist, but by the third trimester, we lose about 35%, and the peripapillary retinal nerve fiber layer (RNFL) thickness will continue to decrease with advancing age. Understanding the determinants that affect the RNFL reserve in childhood helps us in the diagnosis and monitoring of optic nerve diseases. Previous studies have found that white race, lower birth weight, longer axial length, and myopia have been associated with a thinner RNFL. On the contrary, optic disc tilting and Asian or Hispanic race have been associated with a thicker RNFL. Refractive errors are common in childhood with the World Health Organization estimating that 153 million people worldwide have visual impairment caused by uncorrected refractive errors. The prevalence of myopia ranges from 22.7% to 38.7% based on large population studies, with a higher prevalence in East Asian regions. With age, the refractive status often changes from hyperopia to myopia; hence, the progressive RNFL thinning that comes with age can either be a result of age-related ganglion cell loss or due to the stretching of RNFL from the axial myopic shift in childhood. The purpose of this study was to investigate the influence of refractive errors on RNFL thickness by comparing the differences in children with myopia, emmetropia, and hyperopia.

PATIENTS AND METHODS

The study was conducted in accordance with the Declaration of Helsinki and no patient’s personal data was disclosed in the study. Study approval was obtained from the institutional review board of the Hospital Authority of Hong Kong. Informed consent was obtained from the parents or legal guardians of the subjects. The authors declare no financial or proprietary interests. This was a nonfunded study.

This cross-sectional study recruited consecutive cases of pediatric subjects aged 4 to 18 years, attending the ophthalmology specialist outpatient clinic of Caritas Medical Centre in Hong Kong Special Administrative Region, China, from 2013 to 2014. Subjects with only eye, ocular tumors, congenital glaucoma, congenital cataract, congenital nyctagmus, microphthalmos, optic nerve or retinal disease, active cornea infections, corneal scars, and severe visual impairment of any cause (Snellen best corrected visual acuity ≤0.1) were excluded. To increase the generalizability of the study, there were no exclusions based on the refractive errors or axial length of subjects.

All subjects underwent a complete ophthalmological examination including ocular alignment and motility assessments as well as anterior and posterior segment examinations after pupil dilatation with a tropicamide 1% and phenylephrine hydrochloride 2.5% ophthalmic solution (Mydri- P; Santen Pharmaceutical, Osaka, Japan).

Spherical Equivalent and Axial Length

All subjects received cycloplegic refraction with 3 drops of Cyclopentolate hydrochloride 1% (Bausch & Lomb, Rochester, NY) administered 5 minutes apart to relieve all accommodative component. After at least 30 minutes, postcycloplegic
TABLE 1. Differences in Age, Spherical Equivalent, Axial Length, and RNFL in Myopic, Emmetropic, and Hyperopic Children

<table>
<thead>
<tr>
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<th>Myopic Group (n = 67)</th>
<th>Emmetropic Group (n = 61)</th>
<th>Hyperopic Group (n = 73)</th>
<th>Statistical Significance</th>
</tr>
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<tbody>
<tr>
<td>Age, y</td>
<td>9.6 ± 3.9</td>
<td>6.9 ± 2.7</td>
<td>6.5 ± 1.9</td>
<td>( P \leq 0.0001 ) for myopia vs emmetropia or hyperopia; ( P &gt; 0.5 ) for emmetropia vs hyperopia</td>
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<tr>
<td>Spherical equivalent, D</td>
<td>(-3.9 \pm 2.2)</td>
<td>(+0.1 \pm 0.5)</td>
<td>(+3.0 \pm 1.6)</td>
<td>( P &lt; 0.0001 ) between all groups</td>
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<tr>
<td>Axial length, mm</td>
<td>24.2 ± 1.3</td>
<td>22.8 ± 0.8</td>
<td>21.7 ± 0.8</td>
<td>( P &lt; 0.0001 ) between all groups</td>
</tr>
<tr>
<td>RNFL, ( \mu m )</td>
<td>96.7 ± 10.3</td>
<td>102.5 ± 9.2</td>
<td>107.2 ± 10.1</td>
<td>( P &lt; 0.0001 ) between all groups</td>
</tr>
<tr>
<td>RNFL, ( \mu m ) after</td>
<td>94.1 ± 12.2</td>
<td>102.5 ± 7.8</td>
<td>107.8 ± 11.6</td>
<td>( P &lt; 0.0001 ) for myopia vs emmetropia or hyperopia; ( P &gt; 0.5 ) for emmetropia vs hyperopia</td>
</tr>
<tr>
<td>age adjustment (n = 35)</td>
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RNFL = retinal nerve fiber layer.
myopic shift (study that an advancing age in childhood was associated with a 18 years. Likewise, Tong et al6 examined 316 Singaporean with age nor spherical equivalent in a population aged 7 to 337 children aged 11 to 12 years using the Heidelberg Retinal Tomograph (Heidelberg Engineering, Heidelberg, Germany) and did not find any significant association between the RNFL and global RNFL thickness. To determine whether thinner RNFL was predominantly due to the physiological ganglion cell loss that comes with aging or due to the stretching of the RNFL that comes from the axial myopic shift, we adjusted the data for age and recomputed the differences in RNFL thickness among the 3 groups. We found that the mean global RNFL in the myopic group was still significantly thinner than the other 2 groups (both \( P < 0.0001 \)), but there was no significant difference in RNFL thickness between the emmetropic and hyperopic groups (\( P > 0.05 \)). This suggested that the thinner RNFL in the myopic group was attributed to both an older age as well as refraction-related factors. On the contrary, hyperopia did not confer a thicker RNFL as compared with those with emmetropia. The apparent RNFL difference in the hyperopic group prior to age adjustment was probably a result of the younger age of subjects in this group rather than associations with their refractive status. Our findings were consistent with that of Tas et al,19 who reported similar RNFL thicknesses in those with high hyperopia (\(+9.50 \text{ D} \geq \text{spherical equivalent} \geq +6.25 \text{ D}) versus low hyperopia (\(+3.00 \text{ D} < \text{spherical equivalent} \geq +0.50 \text{ D})

\[
\begin{align*}
\text{Inferior} & : r = -0.2 & s = 0.5 & P = 0.0004 & \text{Global} & : r = 0.1 & P = 0.0001 \\
\text{Superior} & : r = -0.2 & s = 0.5 & P = 0.0008 & \text{Nasal} & : r = -0.2 & P = 0.0004 \\
\text{Temporal} & : r = 0.1 & s = 0.5 & P = 0.009 & \text{Axial length} & : r = 0.2 & P = 0.0001 \\
\end{align*}
\]

\( * \) Statistically insignificant.

\( P < 0.0001 \) and a positive correlation between age and axial length (\( r = 0.5, P < 0.0001 \)). There was a significant and negative correlation between axial length and spherical equivalent (\( r = -0.8, P < 0.0001 \)).

**DISCUSSION**

The mean global RNFL thickness reported in our study (101.9 ± 11.0 \( \mu \text{ m} \)) was consistent with that reported in the Anyang Childhood Eye Study (103.1 \( \mu \text{ m} \)) and the Sydney Myopia Study (103.2 \( \mu \text{ m} \)).14,15 We have reconfirmed in our study that an advancing age in childhood was associated with a myopic shift (\( r = -0.3, P < 0.0001 \)) and axial length elongation (\( r = 0.5, P < 0.0001 \)), and that a longer axial length resulted in a greater degree of myopia (\( r = -0.8, P < 0.0001 \)).

The association between myopia and a thinner RNFL has been well documented in both children and adults,14,16,17 although there are others who have reported differently. Chen et al13 did not find any association between the global RNFL with age nor spherical equivalent in a population aged 7 to 18 years. Likewise, Tong et al6 examined 316 Singaporean children aged 11 to 12 years using the Heidelberg Retinal Tomograph (Heidelberg Engineering, Heidelberg, Germany) and did not find any significant association between the RNFL with axial lengths nor myopic status. In our study, the advancement in age (\( r = -0.4, P < 0.0001 \)), a more negative (myopic) spherical equivalent (\( r = 0.5, P < 0.0001 \)), and a longer axial length (\( r = -0.4, P < 0.0001 \)) were correlated with a thinner global RNFL thickness. To determine whether thinner RNFL was predominantly due to the physiological ganglion cell loss that comes with aging or due to the stretching of the RNFL that comes from the axial myopic shift, we adjusted the data for age and recomputed the differences in RNFL thickness among the 3 groups. We found that the mean global RNFL in the myopic group was still significantly thinner than the other 2 groups (both \( P < 0.0001 \)), but there was no significant difference in RNFL thickness between the emmetropic and hyperopic groups (\( P > 0.05 \)). This suggested that the thinner RNFL in the myopic group was attributed to both an older age as well as refraction-related factors. On the contrary, hyperopia did not confer a thicker RNFL as compared with those with emmetropia. The apparent RNFL difference in the hyperopic group prior to age adjustment was probably a result of the younger age of subjects in this group rather than associations with their refractive status. Our findings were consistent with that of Tas et al,19 who reported similar RNFL thicknesses in those with high hyperopia (\(+9.50 \text{ D} \geq \text{spherical equivalent} \geq +6.25 \text{ D}) versus low hyperopia (\(+3.00 \text{ D} < \text{spherical equivalent} \geq +0.50 \text{ D})

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\begin{align*}
\text{Table 2. Correlations of RNFL (Global and Quadrant) Thicknesses With Age, Spherical Equivalent, and Axial Length}
\end{align*}
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**FIGURE 1.** Global RNFL thickness with spherical equivalent. RNFL = retinal nerve fiber layer.

**FIGURE 2.** Global RNFL thickness with age. RNFL = retinal nerve fiber layer.
to the best of our knowledge, this is one of the few studies investigating the peripapillary RNFL thickness in children along the refractive error spectrum (myopia, emmetropia, and hyperopia), with adjustments in age, as well as including children as young as 4 years old, although the findings of our results may not be generalizable to all populations. The majority of studies in the literature have reported on the RNFL thickness in myopic or hyperopic children separately or included children 6 years or older.\textsuperscript{3,6,14,15,18,19,22–25}

The peripapillary RNFL thickness varied among children with different refractive status, with hyperopes having the thickest and myopes having the thinnest RNFL. When adjusted for age, only myopic children had a significantly thinner RNFL. Thus, the apparent RNFL differences in emmetropic and hyperopic children seem to be attributed to differences in age rather than refractive status. Advancing age, a more myopic spherical equivalent, and a longer axial length were associated with a thinner RNFL in a population of Chinese children.

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REFERENCES


