Refractive and Ocular Indices in Kindergarten Israeli Children

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Abstract

Purpose

To report normative data on paediatric refractive and ocular indices in kindergarten Israeli children.

Methods

Retrospective cross-sectional study of 101,417 Israeli children from 4–5 years old, obtained from 2013–2018. Data was collected using the PlusoptiX S12. We studied the number of referrals made for hyperopia, myopia, astigmatism and anisometropia.

Results

Mean sphere value was 0.83D ± 0.73 for the right eye and 0.85D ± 0.73 for the left eye. Mean SE was 0.56D ± 0.66 for the right eye and 0.59D ± 0.67 for the left eye. Mean cylinder value was − 0.53D ± 0.48 for the right eye and was the same, -0.53D ± 0.47, for the left eye. Mean axis values for the right and left eyes were 80.85°±55.57 and 80.42°±56.60 respectively. Mean pupil size was 5.83mm ± 0.87 for the right eye, and 5.82mm ± 0.88 for the left eye. 13.26% had anisocoria ≥ 0.4mm; of these, 0.66% had anisocoria > 1.0mm. There was no difference in pupil size between sexes or different cities. Mean IPD was 49.58mm ± 3.50, and mean gaze vector value was 2.64 ± 1.66. According to the Vision Screening Guidelines, 0.8% of children had hyperopia and 0.17% had myopia. 6.22% of children had astigmatism and 10.85% had anisometropia.

Conclusion

Amblyopia is the most common cause of unilateral vision loss in childhood. The earlier the diagnosis, the better the outcome, hence the importance of investigating the causative indices leading to amblyopia in kindergarten. After searching the literature, this is the largest study population for this topic to our knowledge.

Introduction

Amblyopia has an incidence of 1–4% (1–4) and is the leading cause of unilateral vision loss in children (5). Childhood is the critical period for diagnosis and management for the best prognosis. Amblyopia risk factors are strabismus, anisometropia and media opacity. The aim was to report normative data on paediatric refractive and ocular indices in Kindergarten Israeli children.

Methods

In this retrospective cross-sectional study, data were collected by *Lions Clubs Israel* volunteers during a screening programme to detect amblyogenic risk factors in children.

Semi-darkened, minimally illuminated examination rooms were uniformly set up across kindergartens in Israeli cities. Children were positioned one metre from the device and instructed to fixate their eyes on a *smiling face* drawing. Pupils were not dilated, and bilateral eye measurements were taken simultaneously. Measurements were saved in the device, allowing retrospective retrieval of data.

Subjects

101,417 Israeli children from 4 to 5 years old in kindergartens in major Israeli cities were included. Data were collected from 2013 to 2018, and 50.3% of our subjects were female. Exclusion criteria were those wearing glasses, and those without parental consent.

Variables

Using the PlusoptiX S12, we collected data on sphere, cylinder and axis. Spherical equivalent (SE) was calculated from sphere and cylinder. Measurements were taken on pupil size, gaze vector value, and interpupillary distance (IPD). We studied the number of referrals made for hyperopia, myopia, astigmatism and anisometropia. We chose the PlusoptiX S12 as it has high sensitivity and specificity (6) and its results correlate with the refractive results from retinoscopy, the gold standard (7).

Ethical issues

The Israeli Ministry of Health, as well as local ethical committees, approved the examinations and data collection. Informed consent was gained from the parents of all participants. All data stored contains no patient-identifiable data.

Results

The following data were obtained from 101,417 children from 2013 to 2018.

Table 1
Mean values of refractive and ocular indices in 4 to 5-year-old kindergarten Israeli children.

Parameter	Right eye	Left eye
Mean sphere	0.83 D ± 0.73	0.85 D ± 0.73
Mean spherical equivalent	0.56 D ± 0.66	0.59 D ± 0.67
Mean cylinder	-0.53 D ± 0.48	-0.53 D ± 0.47
Mean axis	80.85° ± 55.57	80.42° ± 56.60
Mean pupil size	5.83mm ± 0.87	5.82mm ± 0.88
Mean interpupillary distance	49.58mm ± 3.50	
Mean gaze vector	2.64 ± 1.66	

Table 2
Number of children with anomalies detected out of 101,417 kindergarten Israeli children.

Anomalies	
Anisocoria ≥ 0.4 mm	13,448 children (13.26%)
Anisocoria 0.5–0.9 mm	6,314 children (6.23%)
Anisocoria > 1.0 mm	669 children (0.66%)
Hyperopia	807 children (0.80%)
Myopia	171 children (0.17%)
Astigmatism	6,307 children (6.22%)
Anisometropia	11,008 children (10.85%)

Discussion

Amblyopia is the most common cause of unilateral vision loss in childhood, with an incidence of 3–5% (5,8). It is susceptible to diagnosis and treatment until 10 years of age (9), and the earlier the diagnosis, the better the outcome (10), hence the importance of investigating the causative indices leading to amblyopia in kindergarten.

Larsson et al. (11) found a mean spherical equivalent (SE) of 0.64 D ± 0.70 for the right eye and 0.67 D ± 0.80 for the left in 10-year-old Swedish children, similar to our data of 0.56 D ± 0.66 for the right eye and 0.59 D ± 0.67 for the left. Sandfeld et al. (12) studied 445 Danish children from 4.5 to 7 years old, finding 1.75 D ± 0.97 and 1.72 D ± 0.96 for right and left eye, respectively. Mayer et al. (13) found a mean SE of 1.13 D ± 0.85 for both eyes in 2-year-old US children. The difference of these two studies compared to our

findings could be due to the non-standardised lighting conditions, and the fact that we used non-cycloplegic refraction, so we could not eliminate accommodation as a confounding variable. Hence, our results likely underestimated the refraction, mainly in hyperopes. A previous study from our group (7) found the differences between cycloplegic refraction and PlusoptiX photoscreening to be 0.68 D ± 2.63 and 0.25 D ± 1.31 respectively for mean SE.

Larsson et al. (11) reported a mean cylinder value of -0.43 D ± 0.26 for the right eye and − 0.44 D ± 0.28 for the left eye, similar to our findings of -0.53 D ± 0.48 for the right eye and − 0.53 D ± 0.47 for the left eye. They found with-the-rule astigmatism to equal against-the-rule, whereas Sandfeld et al. (12) found mostly with-the-rule and Mayer et al. (13) found mostly against-the-rule. The different instruments used for collecting data could be responsible for these differences, as discussed in our previous study [7], that using non-cycloplegic refraction like the PlusoptiX finds a mean cylinder of -0.66 ± 0.77, whereas cycloplegic refraction finds − 0.61 ± 0.74. Another cause of the discrepancy could be the differences in lighting conditions (14).

Few reports exist on normative data concerning pupil size, anisocoria and laterality in children. Using an infrared pupillometer, Silbert and colleagues (15) studied 1,306 children, finding an average pupil size of 5.92 mm for 4- to 7-year-old children, with no significant difference between left and right pupillary sizes. 219 children (16.77%) had anisocoria of 0.5–0.9 mm, and 30 children (2.3%) had anisocoria of > 1.0 mm. This is similar to our findings of 5.83mm ± 0.87 for the right pupil and 5.82mm ± 0.88 for the left. 13.26% (13,448 children) were found to have anisocoria ≥ 0.4mm; of these, 6.23% (6,314 subjects) had anisocoria of 0.5-0.9mm, and 0.66% (669 subjects) had anisocoria of > 1.0mm. Boev and colleagues (16) studied 90 children, finding average pupillary resting diameter in ambient lighting conditions to be 4.11 mm for 2- to 6-year-olds. The difference could be due to the fact that Silbert and colleagues [16] used a PlusoptiX device as we did, whereas Boev and colleagues (16) used a NeurOptic device. Discrepancies could also be due to the fact that we studied over 100,000 children between only 4 and 5 years old, whereas Silbert and colleagues studied children up to the age of 17 years, and Boev and colleagues up to 18 years.

MacLachlan C and Howland HC (17) studied interpupillary distance (IPD) of 155 males with average age 5.48 years and 144 females with average age 5.48 years, reporting a mean of 52.02 mm ± 2.55 for males and 51.03 mm ± 2.65 for females. Our results were lower, with a mean of 49.58 mm ± 3.50 for both sexes, possibly due to the measuring technique. Discrepancies could also be due to differences in the populations; little is known regarding the influence of ethnicity.

We found no statistical correlation between pupil size and SE, which had a Pearson correlation for the right eye of 0.053, and left eye of 0.033. There was also no significant correlation between pupil size and IPD, which had a Pearson correlation for the right eye of 0.192, and left eye of 0.189.

We based our amblyopia risk factor thresholds for referral on the AAPOS revised screening criteria (18); for children over two years, the threshold for hyperopia is > 3.5 D, myopia is > -1.5 D, astigmatism is > 1.5

D, and anisometropia is > 1.5 D. We had a total of 15,362 referrals (15.15%) out of 101,417 children. 807 children (0.80%) had hyperopia and 171 children (0.17%) had myopia. 6,307 children (6.22%) had astigmatism and 11,008 children (10.85%) had anisometropia. According to Dan Huang et al. (19) who studied Chinese children aged 3 to 4 years also using a PlusoptiX device, only 14 children (3.90%) out of 359 had refractive amblyopia risk factors; 2 (0.56%) had hyperopia, 10 (2.79%) had astigmatism, 3 (0.84%) had anisometropia. Their significantly lower referrals are possibly due to population differences; different ethnicities were studied, although of a similar age group. Li Deng and Jane E. Gwiazda (20) investigated anisometropia in 1,827 US Children by non-cycloplegic retinoscopy. They found a prevalence of 1.96% at 6 months, 1.27% at 5 years, and 5.77% from 12 to 15 years. Surprising, they found a lower prevalence of anisometropia despite using a lower threshold for referral of 1.0 D.

The effects of the potentially low sensitivity of the PlusoptiX S12, resulting in false negatives, may have resulted in a falsely lower number of referrals. Noelle S. *et al.* (21) studied amblyopia risk factors with the PlusoptiX S04 and found a sensitivity of 98% and a false negative rate of 1.4% based on the old AAPOS screening criteria. For further studying, the sensitivity of the PlusoptiX S12 could be investigated against the current AAPOS screening guidelines.

After searching the literature on amblyopia, paediatric normal ocular indices, refractive error in paediatric population, this is the largest study population for this topic to our knowledge, which is one of the major strengths of this study. However, this study only represents Israeli children, not the general paediatric population. We tested children of a specific age, 4 to 5 years old, denying us the opportunity to study the dynamics of changes throughout development. Data was not collected on comorbidities and drug history, potential confounding variables affecting pupil size. Although examination rooms were standardised, we were not able to provide conditions for dark adaptation. However, although pupil size is affected by varying ambient lighting, Ettinger and colleagues (14) showed that a tenfold change in luminance caused no more than a 1mm change in pupil size, so variability should not significantly affect our study.

For further studying, we propose that more data from other geographic areas and among other age groups should be done to further establish normative data, producing data that could be used worldwide.

Declarations

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no conflicts of interest to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.
- This is a retrospective cross-sectional study. The Israeli Ministry of Health, as well as local ethical committees have confirmed that no ethical approval is required, because the results obtained using

the PlusoptiX S12 device do not include the name or ID number of the participants in it, so the results are completely anonymous.

- Informed consent was gained from the parents of all participants.
- All data stored contains no patient-identifiable data.

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