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Prevalence of amblyopia and strabismus in Hani school children in rural southwest China: a cross-sectional study

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ABSTRACT

Purpose To determine the prevalence rate of amblyopia and strabismus in Chinese Hani ethnic school-aged children.

Methods All grade 1 and grade 7 students in Mojiang Hani Autonomous County, located in southwest China, were invited for comprehensive eye examinations performed by experienced ophthalmologists and optometrists, including visual acuity, ocular alignment and movements, cycloplegic autorefraction, anterior segment and fundus examinations. Standard definitions of amblyopia and strabismus were applied to calculate their prevalence rate.

Results A total of 1656 (91.0% response rate) grade 1 Hani students and 1394 (92.8% response rate) grade 7 Hani students participated in the study. Amblyopia was present in 25 Hani students (0.82%, 95% CI 0.55% to 1.20%), with no significant differences in grade (p=0.42) and gender (p=0.69). Among these 25 amblyopic children, 17 had unilateral amblyopia and eight had bilateral amblyopia, including 16 anisometropic, eight binocular refractive and one strabismic. Strabismus was found in 59 Hani students (1.93%, 95% CI 1.50% to 2.48%), including 47 with intermittent exotropia, six with constant exotropia, five with constant esotropia and one with unilateral superior oblique palsy. The prevalence rate of strabismus was higher in grade 7 students than grade 1 students with borderline significance (2.44%vs1.50%, p=0.07), but was similar by gender (2.16% in boys vs 1.68% in girls, p=0.36).

Conclusion The prevalence of amblyopia and strabismus in Chinese Hani school children are both lower than that previously reported for Chinese Han children in China and for many other racial/ethnic populations from non-China studies. Refractive error is the major cause for amblyopia and intermittent exotropia is the primary strabismus type.

Strengths and limitations of this study

► This is a large school-based cohort study conducted in Mojiang Hani Autonomous County, rural southwest China.

► Mojiang has 13.5% of the total Chinese Hani population and an enrolment rate of 99% for elementary and middle schools.

► A total of 1656 grade 1 Hani students and 1394 grade 7 Hani students were analysed, with high study participation rate (>90%).

► Standard definitions of amblyopia and strabismus were applied.

► The prevalence estimates might be biased as small percent of students did not participate and children who dropped out of schools or were not enrolled into regular schools were not included.

With standard study design and diagnosis criteria, the Multi-ethnic Pediatric Eye Disease Study (MEPEDS),[1 2] the Baltimore Pediatric Eye Disease Study (BPEDS),[3] the Strabismus, Amblyopia, and Refractive Error in Singaporean Children Study (STARS),[4] the Sydney Paediatric Eye Disease Study (SPEDS),[5] the Nanjing Pediatric Vision Project (NPVP),[6] the Anyang Childhood Eye Study (ACES)[7] and the Yuhuatai Pediatric Eye Disease Study (YPEDS)[8] reported prevalence rates ranging from 0.8% to 2.6% for amblyopia and 0.8% to 5.7% for strabismus. This large variation in reported prevalence rate most likely is due to differences in the characteristics of study populations, particularly the ethnicity of participants.

The Hani, an ethnic minority group, is one of the 56 officially recognised nationalities in China. Over 90% of Hani people live in Yunnan Province, rural southwest China, which is located across mountains and is less prosperous than the eastern and southern regions in China. Previous Chinese amblyopia or strabismus prevalence studies mainly focused on the Han nationality, which accounts for 91.5% of the Chinese population, and these studies did not include the Hani nationality. However, data

INTRODUCTION

Amblyopia and strabismus are primarily paediatric eye diseases and can lead to vision loss, impaired binocular function and cosmetic consequences, which might persist through adulthood if left untreated. To develop a rational policy for early detection and management of amblyopia and strabismus, it is necessary to conduct population-based epidemiological studies to estimate their prevalence in children.

from Han populations could not be extrapolated to Hani children because of potential impact of ethnic variations and healthcare disparities on prevalences of eye diseases. Our study was designed to assess the prevalence of amblyopia and strabismus among Chinese Hani school children using standard methodology and definitions. This analysis is part of the Mojiang Myopia Progression Study (MMPS).

METHODS

Survey design and population

MMPS is a school-based cohort study designed to longitudinally assess the onset and progression of myopia, amblyopia, strabismus and other childhood ocular diseases in grade 1 and grade 7 students in Mojiang Hani Autonomous County, Yunnan Province, rural southwest China.[9–12] The baseline eye examination was conducted in 2016 and all grade 1 students from elementary schools and grade 7 students from middle schools in Mojiang were invited to participate in this study. This paper used data from this baseline eye examination in grade 1 and grade 7 Hani students.

Mojiang Hani Autonomous County, an area of 5312 km^2, is one of the six main residences of the Hani people in Yunnan Province, China. There were 222 174 Hani people in Mojiang as of 2010, accounting for 61.7% of the total population in Mojiang and 13.5% of the total Chinese Hani population. The compulsory 9-year mandatory education system is well executed in Mojiang with an enrolment rate of 99% for elementary and middle schools in 2014. Thus, school-based samples in Mojiang are highly representative of this school-aged population.

Ethics committee approval was obtained from the Institutional Review Board of Kunming Medical University. We carried out the study according to the tenets of the Declaration of Helsinki involving human participants and the approved guidelines. Additionally, we obtained written informed consents from at least one parent or legal guardian of each participant.

Questionnaire and eye examinations

A questionnaire was completed by the parents or legal guardians of the children to collect detailed information regarding ethnicity and medical history. Comprehensive eye examinations were performed by experienced ophthalmologists and optometrists. Uncorrected visual acuity (UCVA) was measured using the Early Treatment Diabetic Retinopathy Study visual acuity (VA) chart at a distance of 4 m. For children with UCVA ≤20/40 or at-least two-line interocular difference, subjective optometry was performed to obtain best corrected VA (BCVA). Ocular alignment was assessed by using the Hirschberg light reflex test, the cover-uncover test and the alternate cover test. Cover test was performed by using fixation targets at both distance (6 m) and near (33 cm). Binocular and monocular ocular movements were examined at nine diagnostic positions of gaze with the head in a stationary position. Strabismus magnitude was measured in prism dioptres (PDs) using the simultaneous prism and cover test. Each participant's refractive status was measured after cycloplegia using an autorefractor (RM-8000; Topcon, Tokyo, Japan) by optometrists. For cycloplegia, each participant was first administered two drops of 1% cyclopentolate (Alcon) after a 5 min interval. Thirty min later, a third drop was administered if pupillary light reflex was still present or the pupil size was less than 6.0 mm. Other ocular examinations including slit lamp examination, digital retinal photography, ocular biometry and optical coherence tomography, were conducted to exclude any abnormalities precluding normal vision.

Definitions

Unilateral amblyopia was defined as at least two-line interocular difference between eyes with BCVA ≤20/32 (≥0.2logMAR) in the worse eye and presence of at least one of the following unilateral amblyopia risk of factors: (1) strabismus on examination; (2) previous strabismus surgery; (3) anisometropia consistent with the worse eye (≥1.00 D spherical equivalent (SE) anisohyperopia, ≥3.00 D SE anisomyopia, or ≥1.50 D aniso-astigmatism); (4) past or present obstruction of visual axis (eg, cataract, corneal opacity, ptosis, eyelid haemangioma) which could not explain the vision loss directly.[2 13] Bilateral amblyopia was defined as BCVA in both eyes <20/40 (>0.3logMAR) with bilateral ametropia (≥4.00 D SE hyperopia, or ≥6.00 D SE myopia, or ≥2.50 D astigmatism) or with past or present bilateral obstruction of visual axis (see above) which could not directly explain the vision loss.[2 13]

Strabismus was defined present if any tropia was present at distance or near, with or without spectacles and was classified according to the primary direction (esotropia, exotropia and vertical) of the tropia. Strabismus is considered as constant tropia if constant at both near and distance fixation, otherwise it is considered as intermittent tropia.

Statistical analysis

All data were analysed using SPSS V.13.0 (IBM) and two-sided $p<0.05$ was considered statistically significant. Prevalence rate for amblyopia and strabismus was calculated as the percent of children with amblyopia or strabismus among all the Hani children evaluated. Age-specific and sex-specific prevalence rate for amblyopia and strabismus was calculated; Fisher exact test was used to compare the prevalence rate between grade 1 and grade 7 and between boys and girls. The 95% CIs for prevalence rates were calculated using Wilson method.

Patient and public involvement

Patients and public were not involved in any aspects of the study including the development of study question, study design, conduct of the study and dissemination of results.

Table 1 Prevalence of unilateral and bilateral amblyopia by different causes in Hani students (n=3050)

Amblyopia type	With amblyopia, n	Prevalence (95% CI), %
Unilateral	17	0.56 (0.35 to 0.89)
Strabismic	1	0.03 (0.00 to 0.18)
Anisometropic	16	0.52 (0.32 to 0.84)
≥1.00 D SE anisohyperopia	5	0.16 (0.07 to 0.37)
≥3.00 D SE anisomyopia	4	0.13 (0.05 to 0.33)
≥1.50 D aniso-astigmatism	6	0.20 (0.09 to 0.43)
≥1.00 D SE anisohyperopia+≥1.50 D aniso-astigmatism	1	0.03 (0.00 to 0.18)
Bilateral	8	0.26 (0.13 to 0.51)
Ametropic	8	0.26 (0.13 to 0.51)
≥4.00 D SE hyperopia	3	0.10 (0.03 to 0.29)
≥6.00 D SE myopia	1	0.03 (0.00 to 0.18)
≥2.50 D astigmatism	4	0.13 (0.05 to 0.33)

SE, spherical equivalent.

Table 2 Distribution of strabismus magnitude in 58 Hani students with horizontal strabismus

Strabismus magnitude	n (%)
At near	
1–9 PD	5 (9)
10–30 PD	31 (53)
>30 PD	22 (38)
At distance	
1–9 PD	28 (48)
10–30 PD	14 (24)
>30 PD	16 (28)

PD, prism dioptre.

RESULTS

Study population

A total of 1656 (91.0% response rate) grade 1 Hani students aged 7–8 years and 1394 (92.8% response rate) grade 7 Hani students aged 13–14 years participated in the study. The mean age was 7.7±0.6 years and 13.8±0.7 years for grade 1 and 7 students, respectively. There was similar percentage of boys among grade 1 students and grade 7 students (54.6% vs 51.5%).

Prevalence of amblyopia in Hani

Based on the findings from comprehensive ocular examinations of the 3050 Hani participants, amblyopia was present in 25 students (0.82%, 95% CI 0.55% to 1.20%), including 16 grade 1 students (0.97%, 95% CI 0.59% to 1.56%) and nine grade 7 students (0.65%, 95% CI 0.34% to 1.22%). The prevalence of amblyopia did not differ between grade 1 and grade 7 (p=0.42), or between boys (0.74%, 95% CI 0.42% to 1.28%) and girls (0.91%, 95% CI 0.53% to 1.54%; p=0.69). Unilateral amblyopia was diagnosed in 17 children (0.56%, 95% CI 0.35% to 0.89%), and bilateral amblyopia was diagnosed in eight children (0.26%, 95% CI 0.13% to 0.51%). Table 1 summarises the prevalence of unilateral and bilateral amblyopia by different causes. Anisometropia was the cause in 16 of the 17 children (94.1%) with unilateral amblyopia and ametropia was the cause in all bilateral amblyopia. Nearly half of the 33 amblyopic eyes (51%, 17/33) had severe amblyopia (BCVA ≤20/100) and one-third (27%, 9/33) had BCVA ≤20/160. Based on the questionnaire responses from their parents or legal guardians, no children had been previously diagnosed with amblyopia or treated for amblyopia.

Prevalence of strabismus in Hani

A total of 59 (1.93%, 95% CI 1.50% to 2.48%) children were found to have strabismus, including 25 grade 1 students (1.50%, 95% CI 1.01% to 2.20%) and 34 grade 7 students (2.44%, 95% CI 1.75% to 3.38%). The prevalence of strabismus was higher in grade 7 students than grade 1 students with borderline significance (2.44% vs 1.50%, p=0.07), but was similar in boys and girls (2.16% and 1.68%, respectively, p=0.36). Of the 59 strabismic students, 47 (80%) had intermittent exotropia, six (10%) had constant exotropia, five (8%) had constant esotropia, one (2%) had unilateral superior oblique palsy, five of the intermittent exotropia and one of constant esotropia had bilateral inferior oblique muscle overaction. The distribution of strabismus magnitude in 58 students with horizontal strabismus is shown in table 2. Nearly one-third of the horizontal strabismic students had more than 30 PD strabismus magnitude at near or at distance. Based on the questionnaire responses from the parents or legal guardians, no children had been previously diagnosed with or treated for strabismus.

DISCUSSION

In this school-based sample of Hani school children in China, we found a low (0.82%) prevalence rate of amblyopia. Amblyopia definitions can have significant impact on amblyopia prevalence estimate. Using the same standard amblyopia definition as MEPEDS, BPEDS, STARS, SPEDS, NPVP, ACES and YPEDS studies, the amblyopia prevalence in Hani children was lower than all these studies, including these in Chinese Han children (table 3). Compared with a study from Western China in school children that used different amblyopia definition from this study,[14] the amblyopia prevalence rate in Hani school children was lower.

The multi-country Refractive Error Study in Children study,[15] also using different amblyopia definition, reported higher amblyopia prevalence rates in Hispanic and Chinese (predominantly Han) school children and lower amblyopia

Table 3 Prevalence of amblyopia and strabismus in different studies

Study	Country	Age, years (n)	Ethnicity	Prevalence of amblyopia*	Prevalence of strabismus
MEPEDS, 2008	USA	2.5–6 (3350)	African American (1663)	1.5%	2.5%
			Hispanic/Latino (1687)	2.6%	2.4%
MEPEDS, 2013	USA	2.5–6 (1883)	Asian American (938)	1.8%	3.6%
			Non-Hispanic White (945)	1.8%	3.2%
BPEDS, 2009	USA	2.5–6 (1546)	Non-Hispanic White (673)	1.8%	3.3%
			African American (873)	0.8%	2.1%
STARS, 2010	Singapore	2.5–6 (1682)	Singaporean Chinese	1.2%	0.8%
SPEDS, 2012	Australia	2.5–6 (1422)	Predominantly white	1.9%	N/A†
NPVP, 2015	China	3–6 (5667)	Chinese Han	1.2%	5.7%
ACES, 2014	China	6–9 (2893)	Chinese Han	1.0%	N/A†
YPEDS, 2018	China	3–4 (1695)	Chinese Han	1.47%	N/A†
MMPS, 2018	China	7–8 (1656), 13–14 (1394)	Chinese Hani	0.82%	1.93%

*Same definition of amblyopia was used.
†No strabismus data.
ACES, Anyang Childhood Eye Study ; BPEDS, Baltimore Paediatric Eye Disease Study; MEPEDS, Multi-ethnic Paediatric Eye Disease Study; MMPS, Mojiang Myopia Progression Study; NPVP, Nanjing Paediatric Vision Project; SPEDS, Sydney Paediatric Eye Disease Study; STARS, Strabismus, Amblyopia, and Refractive Error in Singaporean Children Study ; YPEDS, Yuhuatai Paediatric Eye Disease Study.

prevalence rates in African and south Asian (Indian) school children than that in this study.[15] General loss of pigmentation in Hispanic and Chinese Han people might be associated with high amblyopia prevalence, because that many studies have reported the associations between low pigmentation and refractive errors, especially astigmatism.[16–18] Chinese Hani people live near south Asia and have more pigmentation than Chinese Han and Hispanic, which might be a possible reason for the low amblyopia prevalence in Hani group. In a recent Israel study among young adults, the prevalence of amblyopia was 0.8% in the population born between 1986 and 1994, which is similar to the rate in our study.[19] Besides the difference in amblyopia definition, the implementation of mandatory vision screening and the universal healthcare provided to all Israel citizens by legislation might explain the low prevalence rate of amblyopia in Israel.

In this study, we found that age and gender was not significantly associated with amblyopia prevalence rate while refractive error, particularly anisometropia, was the major cause for amblyopia. These findings are consistent with the results from MEPEDS, STARS, SPEDS, NPVP, ACES and YPEDS.

Globally, the prevalence rate of strabismus (1.90%) in the Hani sample was lower than rates in school children from other countries, including England (2.3%),[20] Australia (2.7%–2.8%),[21 22] Mexico (2.3%)[23] and Sweden (2.7%).[24] The strabismus prevalence rate in our study was also lower than most Chinese school children in China, including 2.8% from Shunyi (representative of rural northern China),[25] 3.0% from Guangzhou (representative of urban southern China),[26] 2.5% from Maqin (representative of rural Tibetan area)[27] and 5.0% from Anyang (representative of rural central China).[28] The strabismus prevalence rate in our

study was also lower than those from studies in preschool children (table 3). Differences in genetic susceptibility, environmental factors and lifestyle may contribute to the lower rate of strabismus in Chinese Hani students.

Our study found that about 90% of the strabismus was exotropia. Previous studies have found that east Asian populations had higher exotropia: esotropia ratio than Caucasians, which might be due to less hyperopia in east Asian population than Caucasians.[1–4 6 22 24 29 30] Our previous research found that exotropia was associated with astigmatism, myopia and low to moderate hyperopia, while esotropia was associated with hyperopia in a dose-response manner.[31] Thus, difference in refractive error distribution may be responsible for higher exotropia: esotropia ratio in the study compared with other studies. Consistent with the MEPEDS and NPVP studies that found higher prevalence of strabismus in older preschool children,[1 2 6] our study found that prevalence rate of strabismus was higher in grade 7 students than grade 1 students, although the difference is only borderline significant (2.44% vs 1.50%, p=0.07). This finding suggests that strabismus might increase with age. Consistent with other studies,[2 5 6 20–22] our study did not find any significant difference in prevalence rate of strabismus between boys and girls.

Our study has some limitations. First, the study is school-based rather than population-based. The prevalence estimates might be biased as small percent of school children did not participate in this study and children who dropped out of schools or did not attend regular schools were not included into the study. However, we expect that this small percent of children not in our study will not substantially bias our prevalence estimate. Second, small-angle or intermittent strabismus may have been missed given the nature

of both conditions. Third, the study used the cycloplegic autorefraction instead of cycloplegic retinoscopy, and it could potentially bias the refractive error measure. However, a recent study among school children found that the two methods had a strong correlation and agreement, and the differences between their measures were clinically insignificant.[32] Finally, information on the history of amblyopia or strabismus was collected by questionnaires, which might be potentially inaccurate due to recall biases.

CONCLUSIONS

In this large school-based study of Chinese Hani school children, we found that amblyopia affects 0.82% children and strabismus affects 1.93% children. These prevalence rates are both lower than those previously reported for Chinese Han children and for many other racial/ethnic populations from non-China studies. Further studies are needed to explore why Chinese Hani children have low prevalence of amblyopia and strabismus.

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