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## Original Article

## The prevalence of ocular diseases in primary and junior high school students on Orchid Island

Fang-Ling Chang<sup>a</sup>, Yi-Ching Lee<sup>a</sup>, Nancy Chen<sup>a</sup>, Hsi-Pao Hsieh<sup>b</sup>, Yi-Hwei Li<sup>c</sup>,  
Ya-Yun Yang<sup>a</sup>, Min-Muh Sheu<sup>a, d, e, \*</sup><sup>a</sup> Department of Ophthalmology, Buddhist Tzu Chi General Hospital, Hualien, Taiwan<sup>b</sup> MA Program for Psychological and Physical Disability and Assistive Technology, Department of Special Education, National Dong Hwa University, Hualien, Taiwan<sup>c</sup> Department of Public Health, Tzu Chi University, Hualien, Taiwan<sup>d</sup> Department of Ophthalmology and Visual Science, Tzu Chi University, Hualien, Taiwan<sup>e</sup> Department of Ophthalmology, Mennonite Christian Hospital, Hualien, Taiwan

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## ABSTRACT

**Objective:** To assess the prevalence of refractive error and ocular diseases in primary and junior high school students on Orchid Island.**Materials and Methods:** This is a cross-sectional study of all students in the primary and junior high schools on Orchid Island conducted within 1 week in 2008. Each student received a visual acuity examination without correction with the Landolt-C chart. An experienced ophthalmologist performed associated assessments through retinoscopy, slit lamp, and funduscopy.**Results:** Of the 403 student residents, 260 were primary school students (139 boys and 121 girls) and 143 were junior high school students (74 boys and 69 girls). Visual acuity in two eyes was < 0.1, in 14 eyes was between 0.1 and 0.3, in 34 eyes was between 0.4 and 0.7, in 225 eyes was between 0.8 and 1.0, and in 531 eyes was between 1.2 and 2.0. Myopia was found in 21 students (21/403, 5.21%; 9 primary school students and 12 junior high school students). Four students (4/403, 0.99%) had amblyopia, of whom two had anisometropia (unilateral high hyperopia), one had high astigmatism in both eyes, and the other had unilateral esotropia. Lens dislocation was found in one student (0.25%) with Marfan syndrome. Retinal vasculitis and optic atrophy were found in one student (0.25%) with systemic lupus erythematosus.**Conclusion:** Because it is a small, isolated island, Orchid Island still has a unique traditional culture and life style. Therefore the prevalence of myopia in primary school and junior high school students on Orchid Island is low, and 94% of all the students had uncorrected visual acuity above 0.8.

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## 1. Introduction

Orchid Island is a small, isolated island that is remote from Taiwan. Most residents are pure blood members of the Tao tribe, an ocean aboriginal group. Because of its culture and geographic considerations, this area is not urbanized and the Tao people have specific health conditions different from people on mainland

Taiwan. However, there are only a few reports describing ocular diseases in indigenous adults or elderly people in Taiwan [1–3]. In this study we analyzed the ocular condition and refractive status in all students on Orchid Island aged 7–15 years in 2008.

The high prevalence and incidence of myopia among students is an epidemic health concern in Asia, especially in the Far East, including Taiwan. Current observations showed that environmental factors are possibly of more importance than genetic predisposition. Much near work and fewer outdoor activities do play a role in the increased prevalence and incidence of myopia in schoolchildren. There is a significantly higher prevalence of myopia among schoolchildren in urban than in rural regions [4]. One study published in 1983 [5] revealed that mountain aboriginals in Taiwan

Conflicts of interest: none.

\* Corresponding author. Department of Ophthalmology, Mennonite Christian Hospital, 44, Min-Chuan Road, Hualien, Taiwan. Tel.: +886 9 70332336; fax: +886 3 8241603.

E-mail address: [minmuhsu@gmail.com](mailto:minmuhsu@gmail.com) (M.-M. Sheu).

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had good vision, and the myopia rate was low. However, investigation of the refractive status of mountain indigenous people 2 decades later showed that more children had become myopic, which probably resulted from urbanization and changes in lifestyle [6]. Nowadays, myopia is increasing in all areas and in all populations; it would be valuable from an epigenetic point of view to know whether there is a tendency toward school myopia in this group of people.

## 2. Methods and materials

This is a cross-sectional study of all students in the primary and junior high schools on Orchid Island conducted within 1 week in 2008. There were four primary schools in four tribes and only one junior high school on the island. All students attending school were enrolled, except for those who were absent from school on the day of examination. We retrospectively reviewed their charts and analyzed the results. The study was approved by the Human Research Ethics Committee of Tzu Chi General Hospital, Hualien, Taiwan (IRB100-86). The children underwent measurement of visual acuity with the Landolt-C chart (at a distance of 5 m), measurement of manifest refractive status with retinoscopy, assessment of ocular motility, slit-lamp biomicroscopic examination of the anterior segments of the eyes, and direct ophthalmoscopic examination of the fundi. One experienced ophthalmologist carried out all slit lamp examinations, retinoscopy, and fundoscopy. The mean spherical equivalent refractive error was used for calculation. Myopia was defined as spherical equivalent  $\leq -0.5$  diopters (D). Hyperopia was defined as a spherical equivalent  $\geq +0.5$  D. Anisometropia was defined as hyperopia or astigmatism anisometropia  $\geq 2$  D or myopia anisometropia  $\leq -3$  D in one eye. Amblyopia was defined as best-corrected visual acuity  $\leq 0.8$  without ocular diseases.

Cochran–Mantel–Haenszel tests were used to determine whether there were differences in the distributions of visual acuity between boys and girls while controlling for the children's age, and to test the association between visual acuity and age while controlling for sex.

## 3. Results

A total of 403 students were included in this study. There were 260 primary school students and 143 junior high school students. Age and sex distribution are shown in Table 1.

Visual acuity in two eyes was  $< 0.1$ , in 14 eyes was between 0.1 and 0.3, in 34 eyes was between 0.4 and 0.7, in 225 eyes was between 0.8 and 1.0, and in 531 eyes was between 1.2 and 2.0.

Four students were found to have amblyopia of whom two had anisometropia (unilateral high hyperopia), one had high astigmatism in both eyes, and the other had unilateral esotropia (Table 2).

**Table 1**  
Age and sex distribution of the students enrolled in this study.

Age (y)	No.	Boys n (%)	Girls n (%)
7	49	22 (5.45)	27 (6.69)
8	32	13 (3.22)	19 (4.71)
9	51	34 (8.43)	17 (4.21)
10	42	24 (5.95)	18 (4.46)
11	41	25 (6.20)	16 (3.97)
12	45	21 (5.21)	24 (5.95)
13	44	24 (5.95)	20 (4.96)
14	53	21 (5.21)	32 (7.94)
15	46	29 (7.19)	17 (4.21)
<b>Total</b>	<b>403</b>	<b>213 (52.85)</b>	<b>190 (47.14)</b>

**Table 2**  
Characteristics of students with amblyopia.

Case	Age (y)/sex	Involved eyes (n)	Causes of amblyopia
1	9/Girl	1	Hyperopia/esotropia
2	12/Boy	1	Hyperopia/anisometropia
3	12/Boy	1	Hyperopia/anisometropia
4	13/Boy	2	Hyperopic astigmatism

The prevalence of amblyopia among students aged 7–15 years was around 0.99% (4/403).

Two of the 403 students were found to have other ocular diseases. Lens dislocation was noted in a 12-year-old boy with Marfan syndrome. Another 12-year-old boy was diagnosed with systemic lupus erythematosus-related retinal vasculitis and optic atrophy.

Those with uncorrected visual acuity between 0.8 and 1.0 had mild hyperopic astigmatism, mild hyperopia, or mild myopia (with spherical equivalence  $< -0.5$ D).

The prevalence of myopia was 3.5% among primary schoolchildren (age 7–12 years) and 8.4% among junior high school students (age 13–15 years). The prevalence of myopia for each year of age from 7 years to 15 years in this study were 2%, 0%, 0%, 9.5%, 4.9%, 4.4%, 0%, 11.3%, and 13% (Table 3). Overall, more girls had myopia than boys (prevalence rate among girls was 7.89% and among boys was 2.81%), but the difference was not significant ( $p = 0.60$ ).

Table 4 presents the distributions of visual acuity by sex and age group. The Cochran–Mantel–Haenszel test (Chi-square = 4.93, with degrees of freedom = 1,  $p = 0.026$ ) indicated that there were significant differences in the distributions of visual acuity between boys and girls while controlling for children's age. The visual acuity of boys tended to be better than that of girls. Another Cochran–Mantel–Haenszel test (Chi-square = 23.0, with degrees of freedom = 8,  $p = 0.003$ ) indicated that the visual acuity increased significantly with children's age while controlling for sex.

## 4. Discussion

Approximately 2.28% (534,007) of the population of Taiwan are indigenous people. Recent research suggest that their ancestors may have been living on the islands for approximately 8000 years before the majority Han Chinese immigration began in the 17<sup>th</sup> century. Indigenous people in Taiwan are Austronesian, with linguistic and cultural ties to other Austronesian ethnic groups, such as those in The Philippines, Malaysia, Indonesia, Madagascar, Polynesia, and Oceania [7]. The bulk of contemporary Taiwanese indigenous people live in the mountains and cities.

Taiwanese indigenous people have been known to have a much better ocular condition than Han Chinese people. Informal studies done during the Japanese colonial period even found that the Tao people may have visual acuity  $> 3.0$ . Chen et al [5] screened

**Table 3**  
Prevalence of myopia among primary and secondary schoolchildren.

Age (y)	No.	Boys n (%)	Girls n (%)
7	1	0 (0.0)	1 (0.5)
8	0	0 (0.0)	0 (0.0)
9	0	0 (0.0)	0 (0.0)
10	4	0 (0.0)	4 (2.2)
11	2	2 (1.0)	0 (0.0)
12	2	0 (0.0)	2 (1.0)
13	0	0 (0.0)	0 (0.0)
14	6	1 (0.4)	5 (2.6)
15	6	3 (1.4)	3 (1.6)
<b>Total</b>	<b>403</b>	<b>6 (2.81)</b>	<b>15 (7.89)</b>

**Table 4**  
Distribution of vision acuity by sex and age group.

Age (y)	Visual acuity in boys				Visual acuity in girls			
	< 0.3	0.4–0.7	0.8–1.0	1.2–2.0	< 0.3	0.4–0.7	0.8–1.0	1.2–2.0
7	0	0	26 (59.1)	18 (40.9)	0	2 (3.7)	34 (63.0)	18 (33.3)
8	0	0	11 (42.3)	15 (57.7)	0	2 (5.3)	18 (47.4)	18 (47.4)
9	1 (1.5)	0	18 (26.5)	49 (72.1)	0	2 (5.9)	14 (41.2)	18 (52.9)
10	2 (4.2)	0	8 (16.7)	38 (79.2)	1 (2.8)	6 (16.7)	6 (16.7)	23 (63.9)
11	0	3 (6)	4 (8)	43 (86)	0	0	9 (28.1)	23 (71.9)
12	3 (7.1)	0	6 (14.3)	33 (78.6)	2 (4.2)	2 (4.2)	11 (22.9)	33 (68.8)
13	1 (2.1)	2 (4.2)	24 (50.0)	21 (43.8)	0	0	19 (47.5)	21 (52.5)
14	1 (2.4)	4 (9.5)	3 (7.1)	34 (81.0)	3 (4.7)	8 (12.5)	7 (10.9)	46 (71.9)
15	0	3 (5.17)	3 (5.17)	52 (89.66)	2 (5.88)	0	4 (11.76)	28 (82.35)
Total	8 (1.9)	12 (2.8)	103 (24.2)	303 (71.1)	8 (2.1)	22 (5.8)	122 (32.1)	228 (60.0)

Data are presented as *n* (%); the percentages were calculated within the same age group for each sex respectively.

students at a primary school in a mountain area in Hualien in 1983 and discovered that 90.27% of the indigenous children there had a visual acuity  $\geq 1.0$ , and 13.65% had an acuity  $> 2.0$ . Their refractive status showed an incidence of myopia of only 3.06% [5]. Interestingly, research done during the same period showed that the incidence of myopia in elementary school children in mainland Taiwan was approximately from 5.5% [8] to 14.9% [9] in rural areas and from 22.2% to 36.2% in urban areas [10–12], much higher rates than in indigenous children.

However, as assimilation and acculturation took place, indigenous people and other ethnic groups in Taiwan began to share a common lifestyle, which led to similar deterioration of visual acuity in the past 2 decades. In 2008, Hsu et al [6] reported that the crude prevalence of myopia was 25.6% among indigenous schoolchildren (age 7–13 years) in mountain townships of southern Taiwan. Data gathered from other parts of Taiwan showed a 21% myopia prevalence rate in children aged 7 years and 61% in those aged 12 years in 2000 [13]. Moreover, the phenomenon has not only been observed in Taiwan; indigenous schoolchildren in other parts of the world are also facing a myopic shift along with thriving industry and technology [14].

However, we did not find the same tendency on Orchid Island, which is located in the western Pacific Ocean southeast of Taiwan, and is 49 miles from Taitung, Taiwan. Unlike other indigenous tribes in Taiwan, the Tao people on Orchid Island have been isolated and prohibited from cultivation and intermarriage with people on the Taiwan mainland since they landed and settled on this island about 800 years ago. The isolation is caused by both the geographic situation and a policy of the Japanese government when they occupied Taiwan and tried to preserve this area for the study of indigenous societies. This isolated group was actually an ideal subject for the study of human genetics until 1945, when the island was taken over by the Chinese government, and the isolation gradually decreased. However, the Tao people still live on the isolated island with very little communication and transportation with mainland Taiwan.

Besides a low incidence of myopia, the Tao have many distinct genetic characteristics due to a long period of endogamy. Several informal studies have disclosed that this group of people has an abnormally high prevalence of several sex-linked diseases, such as retinitis pigmentosa. However these studies could not be published because of an agreement made with the tribal council to protect their right of privacy. Valuable data in 1973 showed a rate of color defects of 12.2% among 333 males [1] on Orchid Island, which was much higher than that of other indigenous people in mainland Taiwan (3.62%) [15].

Myopia has been an increasing threat throughout the past few decades, especially in far eastern areas of the world. Morgan and Rose [16] reported six locations with a high prevalence of myopia

identified from the Organisation for Economic Cooperation and Development Program in Secondary Assessment 2009. These included Shanghai–China, Hong Kong–China, Taiwan, Singapore, Japan, and South Korea. By contrast, Australia and Finland were also in the top quartile of educational performance but did not have an elevated prevalence of myopia [16]. Questionnaires from studies investigating the cause of this worrisome trend have shown that children of East Asian ethnicity have a higher incidence of myopia than children of European Caucasian ethnicity, and they also spend less time outdoors. Time spent outdoors, near work, and parental myopia were more strongly associated with the incidence of myopia than ethnicity alone [17].

Lin et al [18] conducted an epidemiologic study of the prevalence and severity of myopia in schoolchildren in Taiwan in 2000, and discovered that the rates of myopia soared from 20% at age 7 years, to 61% at 12 years, to 81% at 15 years, and to 84% at 16–18 years. However, not all children exhibited the same change of refractive error. Children in urban areas had a higher prevalence and more severe degree of myopia than children in rural areas [18,19].

Indigenous children have even lower rates of myopia. Hsu et al [6] analyzed the refractive status of mountain aborigine schoolchildren in southern Taiwan and reported that the crude prevalence of myopia was 25.6%. Although the prevalence increased with age, the annual change in mean refractive status was slower in indigenous schoolchildren living in the mountains than Han Chinese children [5]. The significant disparity in myopic incidence between our study and that of Hsu et al [6] in indigenous children might have resulted from differences in participation in after-school tutorials and time spent outdoors between different areas. Children on Orchid Island may have low rates of myopia because of geographic isolation and their efforts at retaining a unique lifestyle and values.

There is little research on the prevalence of myopia among different indigenous groups throughout the world. Garner et al [20] analyzed refractive error in Melanesian schoolchildren in Vanuatu, and found that only 2.9% (23 out of 788) of Melanesian children had myopia  $> 0.25$  D. They also noted that although the low prevalence of ametropia was due mainly to genetic factors, the possibility of environmental factors could not be excluded.<sup>6</sup> Two further studies, one comparing ocular dimensions and refractive power in Malay and Melanesian children (4.3–0.8% at 7–8 years and 25.6–4.3% at 15–16 years) [21], and another reporting the prevalence of myopia in Sherpa and Tibetan children in Nepal (2.9–21.7%) [22] further proved this theory. Both studies demonstrated that people with a common ethnicity but widely contrasting educational and environmental conditions do have different prevalence rates of myopia. The rural lifestyle with limited near work and increased outdoor time might have contributed to the low prevalence rate of myopia in schoolchildren on Orchid Island.

## 5. Conclusion

The Tao people on Orchid Island are relatively isolated from mainland Taiwan and from modernization. We found that the incidence of myopia and major ocular genetic diseases was relatively low in children on Orchid Island compared with that in other parts of Taiwan. Ninety-four percent of all the students had uncorrected visual acuity > 0.8. Whether educational and environmental conditions rather than ethnicity play a more important role in the development of myopia remains to be elucidated in future investigation.

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