

The Prevalence and Severity of Myopia among Suburban Schoolchildren in Taiwan

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Abstract

Introduction: We aimed to determine the prevalence and severity of myopia in suburban schoolchildren. The refractive error, best corrected visual acuity (BCVA) and other ocular indices of 6069 schoolchildren (aged 6 to 15 years) from elementary and junior high schools in Chiayi County, Taiwan were examined in 2013-2015. **Materials and Methods:** Spherical equivalent (SE) was stratified into 4 categories: emmetropia, mild myopia, moderate myopia, and high myopia for underlying analysis. Chi-squared (χ^2) tests were used to determine significant associations between myopia and BCVA and age levels. To compare statistical significance among different age levels, *P* values of Bonferroni tests were calculated. Receiver operating characteristic (ROC) curves and correlation coefficient were calculated to assess the correlation between myopia and each ocular index. **Results:** The youngest subject diagnosed with myopia was a 7-year-old. Myopia had significant associations with both BCVA and age levels (95% confidence intervals [CI] = 2.553, 2.713 and -0.284, -0.248, respectively), under *P* < 0.05. Among the calculated ROC values, BCVA had the highest area of 0.676 with myopia. This further confirmed that BCVA was highly correlated with myopia in schoolchildren. Other ocular indices like intraocular pressure (IOP), pupil distance, ocular alignments, or ocular height had ROC curves below 0.5 to myopia. **Conclusion:** This study concluded that the onset of myopia started earlier and progressively worsened with years of investigation among the suburban schoolchildren. Myopia had significant associations with BCVA and age levels. To effectively reduce the prevalence and severity of myopia, it is time to take actions on eye care education for suburban schoolchildren.

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Key words: Mean refractive index, Ocular condition, Visual acuity

Introduction

The prevalence and severity of myopia has been studied in 5 large-scale, population-based, and cross-sectional surveys of schoolchildren aged 7 to 18 years old.^{1,2,3} Researchers found that the increase in prevalence of myopia among schoolchildren was caused by the onset at an early age, and then the severity was alleviated progressively with age. In Asia, the prevalence of myopia is still high, especially among the Chinese³⁻⁵ and the Japanese.^{6,7} In 1944, Motegi et al did a survey on ocular refraction in Taiwan and revealed that over 80% of the studied population were emmetropic.⁸⁻¹¹ In 1982, Chung et al studied 227 aboriginal students, aged 6 to

13 years old and residents in mountainous areas of Pingtung County, Taiwan, and found 59.3% with hypermetropia, 38.3% with emmetropia, and 2.4% with myopia.¹² In a study conducted by Chen et al in the mountainous areas of Hualien County in 1984, 366 elementary schoolchildren were examined, of whom 295 (80.6%) were aboriginal.¹³ They found that 9.73% of non-aboriginal students and 3.06% of aboriginal students had myopia.

On 15 May 2014, Taipei Times reported that myopia had become a serious health problem for elementary school students, especially for more than 35% of second grade students in Taipei. A myopia prevention programme

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organised by the Taipei City government said that 35.63% of second grade students had myopia and their parents were unaware of it. Furthermore, 3.18% of the second grade students suffered from 300 degrees or above of myopia. Taipei Veterans General Hospital reported that children with myopia in early childhood presented the most prevalent medical condition in the nation. Children with myopia at a younger age may develop myopia to 600 degrees or higher by the time they are in high school or reach adulthood.¹⁴ Myopic children were highly recommended to avoid spending long periods of time in reading at a short distance and to reduce excessive use of computers and electronic devices. They are encouraged to participate in more outdoor activities. If they have to use electronic devices, they need to take at least 10 minutes break for every 30 minutes of usage.¹⁴ On 12 March 2015, Kastner reported in *The Diplomat* that as Taiwanese children were pushed by academic institutions and parents to study for viciously long hours, 18% of first graders, 52% of sixth graders and 80% of university students on the island were myopic in early 2014.¹⁵ He also reported that the average degree of the eye's degeneration was much higher than that of schoolchildren residing in countries of the Western hemisphere. Kung, former deputy director of the Taiwanese government's Health Promotion Centre, said that most Taiwanese parents have full-time jobs that prompt their children to spend not only weekday evenings at cram schools but also during the weekends.¹⁴

Looking at the changing trends of myopia over the past 2 decades in Taiwan, the survey at various elementary and junior high schools in Chiayi County, Taiwan on ocular refraction levels among schoolchildren is investigated in this study. To facilitate appropriate comparisons of the relative prevalence of myopia, we compared our study with nationwide myopia prevalence surveys previously conducted in Taiwan by Lin et al in the years 1983, 1986, 1999, 1995 and 2000.^{2,16-19}

Materials and Methods

From September 2013 to May 2015, 6069 participants aged 6 to 15 years old were enrolled from numerous elementary and junior high schools in Chiayi County, Taiwan. Written informed consent was obtained from all parents or guardians. The Institutional Review Board of the Chang Gung Foundation (IRB-102-4827B) had approved this study. The research was conducted according to the principles of the Declaration of Helsinki. A detailed personal history, general paediatric health examination, ophthalmological assessment, and lifestyle questionnaire were conducted for all participants. Hospital and school authorities scheduled dates for the examinations. All data were collected from temporary setup clinical environments in each school where various examinations for different

ocular indices were conducted by Dr Lai, co-author of this paper, her assistants and some clinical staff from the Chang Gung Memorial Hospital.

In this study, spherical equivalent (SE) was stratified into 4 categories: emmetropia ($SE = 0D$), mild myopia ($-3D < SE < 0D$), moderate myopia ($-6D < SE = -3D$), and high myopia ($SE = -6D$).²⁰ We measured best corrected visual acuity (BCVA) in decimal values by using the instrument Topcon kr-800/rm800 (Topcon Corporation, Japan), and IOP by using Tonopachy NT-530P (Nidek, Gamagori, Japan). We conducted various examinations on students regarding their right and left eye vision, pupil distance (PD), medications usage, glasses condition, height, and weight. Intraocular pressure (IOP) values ranged from 2 mmHg to 55 mmHg for the right eyes and 1 mmHg to 40 mmHg for the left eyes. PD values ranged from 11 cm to 99 cm. The values of visual acuity ranged from -0.3 to 1.3 (LogMAR) for both eyes.

Data Analysis

All data were analysed using IBM SPSS version 21.0 (IBM, Armonk, New York). Chi-squared (χ^2) test and linear regression models were used to calculate statistically significant differences among data. The Bonferroni multiple comparisons in analysis of variance (ANOVA) were used to cross compare different age categories. Bonferroni was used to reduce the chance of obtaining false-positive results. Receiver operating characteristic (ROC) analysis was applied to determine the sensitivity and specificity of different ocular indices to myopia.

Results

Table 1 shows the age distribution of students from 5 separate surveys¹ in 1983-2000 and our study in 2013-2015. The 5 surveys were conducted by the Department of Epidemiology, National Taiwan University while our study in 2013-2015 was conducted by the Department of Ophthalmology, Chang Gung Memorial Hospital, Chiayi County. Table 1 also shows the distribution of mean refractive index (D) corresponding to each age group from those 5 surveys and from our study. The past surveys indicated that mean refractive index drifted toward myopia at the age of 11 in 1983 and progressively started at a younger age of 9 in 1995 and 8 in 2000. Our study in 2013-2015 showed that the mean refractive index started at the early age of 7 and progressively increased year after year. This study revealed that the initial age of myopia started earlier than the previous study. This confirmed the prevalence and severity of myopia among suburban schoolchildren.

Table 2 shows the mean refractive index studied by Lin et al in 2004 for schoolchildren aged 7 to 18 years old with respect to the 10 development levels of urbanisation.¹ For

Table 1. Distribution of Age and Mean Refractive Index (D) from 5 Surveys and Our Study

Age (Years)	1983	1986	1990	1995	2000	2013 – 2015
6	-	-	-	-	-	79 (1.30%) 0.19 ($\pm$ 0.95)
7	260 (6.30%) 0.52 ($\pm$ 0.98)	737 (7.02%) 0.66 ($\pm$ 1.01)	774 (8.93%) 0.52 ($\pm$ 0.97)	996 (8.91%) 0.52 ($\pm$ 1.01)	924 (8.24%) 0.17 ($\pm$ 1.00)	621 (10.23%) -0.22 ($\pm$ 1.04)
8	265 (6.42%) 0.45 ($\pm$ 1.03)	774 (7.37%) 0.50 ($\pm$ 1.10)	792 (9.14%) 0.38 ($\pm$ 1.04)	920 (8.23%) 0.18 ($\pm$ 1.31)	915 (8.41%) -0.15 ($\pm$ 1.40)	730 (12.03%) -0.62 ($\pm$ 1.50)
9	263 (6.38%) 0.08 ($\pm$ 1.11)	752 (7.16%) 0.33 ($\pm$ 1.23)	713 (8.23%) 0.04 ($\pm$ 1.25)	910 (8.14%) -0.15 ($\pm$ 1.38)	890 (8.18%) -0.59 ($\pm$ 1.37)	737 (12.14%) -0.92 ($\pm$ 1.42)
10	268 (6.50%) -0.07 ($\pm$ 1.57)	767 (7.30%) 0.06 ($\pm$ 1.56)	785 (9.06%) -0.08 ($\pm$ 1.54)	1023 (9.15%) -0.37 ($\pm$ 1.74)	945 (8.69%) -0.77 ($\pm$ 1.81)	870 (14.34%) -1.11 ($\pm$ 1.53)
11	263 (6.38%) -0.27 ($\pm$ 1.72)	751 (7.15%) -0.15 ($\pm$ 1.70)	765 (8.83%) -0.33 ($\pm$ 1.68)	1017 (9.10%) -0.72 ($\pm$ 1.81)	944 (8.68%) -1.20 ($\pm$ 1.93)	979 (16.13%) -1.39 ($\pm$ 1.78)
12	266 (6.45%) -0.48 ($\pm$ 1.83)	750 (7.14%) -0.30 ($\pm$ 1.81)	613 (7.07%) -0.58 ($\pm$ 1.83)	1082 (9.68%) -1.04 ($\pm$ 1.95)	920 (8.46%) -1.45 ($\pm$ 2.21)	887 (14.62%) -1.77 ($\pm$ 1.86)
13	265 (6.42%) -0.68 ($\pm$ 1.90)	813 (7.74%) -0.75 ($\pm$ 1.93)	648 (7.48%) -0.94 ($\pm$ 1.96)	1016 (9.09%) -1.45 ($\pm$ 2.20)	969 (8.91%) -2.11 ($\pm$ 2.35)	369 (6.08%) -1.89 ($\pm$ 1.80)
14	264 (6.40%) -1.25 ($\pm$ 1.98)	788 (7.50%) -1.29 ($\pm$ 2.21)	677 (7.81%) -1.53 ($\pm$ 2.18)	1000 (8.95%) -1.73 ($\pm$ 2.31)	960 (8.83%) -2.44 ($\pm$ 2.64)	403 (6.64%) -2.12 ($\pm$ 2.01)
15	257 (6.23%) -1.49 ($\pm$ 2.20)	775 (7.38%) -1.50 ($\pm$ 2.36)	648 (7.48%) -1.84 ($\pm$ 2.35)	1001 (8.96%) -2.27 ($\pm$ 2.55)	937 (8.61%) -2.89 ($\pm$ 2.70)	394 (6.49%) -2.31 ($\pm$ 2.03)
16	576 (13.96%) -2.11 ($\pm$ 2.35)	1285 (12.24%) -2.16 ($\pm$ 2.55)	760 (8.77%) -2.25 ($\pm$ 2.56)	816 (7.30%) -2.94 ($\pm$ 2.64)	816 (7.30%) -2.94 ($\pm$ 2.64)	-
17	604 (14.64%) -2.22 ($\pm$ 2.39)	1255 (11.95%) -2.40 ($\pm$ 2.57)	826 (9.53%) -2.64 ($\pm$ 2.66)	745 (6.67%) -3.07 ($\pm$ 2.70)	745 (6.67%) -3.07 ($\pm$ 2.70)	-
18	574 (13.92%) -2.55 ($\pm$ 2.55)	1053 (10.03%) -2.68 ($\pm$ 2.62)	666 (7.69%) -2.93 ($\pm$ 2.71)	649 (5.81%) -3.32 ($\pm$ 2.75)	649 (5.81%) -3.32 ($\pm$ 2.75)	-
Total	4125	10,500	8667	11,175	10,878	6069

Table 2. Mean Refractive Index (D) of Schoolchildren in Different Areas in 1995 and 2000, and in Chiayi in 2013-2015 (Right Eyes Only)

	Boys				Girls			
	Elementary School		Junior High School		Elementary School		Junior High School	
	1995	2000	1995	2000	1995	2000	1995	2000
Taipei	-0.58	-0.88	-2.04	-2.48	-0.87	-1.03	-2.70	-3.12
Kaohsiung	-0.60	-0.66	-2.26	-2.92	-0.53	-0.92	-2.43	-2.81
Provincial cities	-0.14	-0.76	-1.82	-2.83	-0.39	-0.85	-2.60	-3.23
Developing area	-0.02	-0.52	-1.14	-2.44	-0.04	-0.62	-1.53	-2.53
Industrial area	-0.40	-0.64	-1.72	-2.13	-0.57	-0.76	-2.01	-2.29
Service business area	-0.42	-0.59	-1.66	-1.75	-0.61	-0.74	-2.22	-2.30
Combination area	0.1	-0.30	-1.72	-1.65	0.1	-0.48	-1.84	-2.16
Remote area	-0.01	0.09	-1.24	-1.83	-0.12	-0.47	-1.58	-2.28
Hilly area	0.19	-0.75	-0.40	-1.11	0.17	-0.38	-1.23	-2.31
Aboriginal area	0.16	0.02	-0.30	-0.22	0.12	-0.41	-0.69	-1.36
Chiayi	-1.10		-2.10		-1.01		-2.13	

comparison, the same table also showed the mean refractive index obtained in this study. Based on the figures shown in Table 2, we found, in general, that girls had higher mean refractive index (D) than boys and the severity worsened

with years of investigation. Furthermore, boys in elementary schools of Chiayi County in 2013-2015 had the highest myopia (-1.10D). Girls in elementary schools of Chiayi County in 2013-2015 also had similar mild myopia in

second place (-1.01D), slightly trailing behind the Taipei area (-1.03D) in 2000. Boys in junior high schools in Chiayi County were in second place (-2.10D), with the first place being the Kaohsiung area (-2.26D) in 1995. Girls in junior high schools of Chiayi County were better than 4 areas (Taipei, Kaohsiung, provincial cities, and service business) in 1995, while they were better than most areas except the aboriginal area in 2000.

Table 3 and Figure 1 show the prevalence of myopia with respect to age group. There were no cases of moderate or high myopia at the age of 6. At age 7, there were only 1.13% with moderate myopia and 0.16% with high myopia. However, the trend for moderate and high myopia continuously climbed to 28.43% and 5.58%, respectively at the age of 15. The trend of mild myopia increased until 12 years old before the participants entered junior high schools. In 2001, Lin et al reported that the mean refractive index reached myopic status at the age of 8 and increased to -3.15D for boys and -4.12D for girls at the age of 18.² In our study, we found that the mean refractive index reached myopic status at the age of 6. Among the 6069 subjects, 870 reached moderate (-6D < SE = -3D) and high (SE = -6D) myopia at the age of 7 for boys and at the age of 8 for girls. Refractive index of -4.65D was reached at the age of 15 for both boys and girls (as shown in Table 4). This observation indicates that if we combined students with either moderate or high myopia into a single variable, then there would not have been much difference in mean refractive index (D) between boys and girls in Chiayi County in 2013-2015. Furthermore, the mean refractive index fell in the vicinity of the moderate myopia category.

Bonferroni test is a type of multiple comparison test used in statistical analysis. To compare any statistical significance among the different age levels, the *P* values of Bonferroni tests are shown in Table 5. The results revealed that there

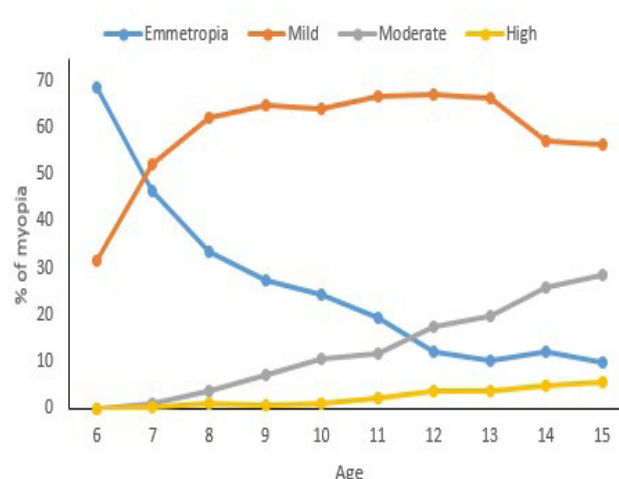


Fig. 1. Distribution of emmetropia, mild, moderate and high myopia with respect to ages.

were significant differences in the Bonferroni tests on mean refractive index when a schoolchild grew 1 or 2 years older. This deterioration was observed for schoolchildren aged 7 to 10 years old. Starting from 11 years old, there was no statistical significance.

Based on the examination data measured from the schoolchildren, we were also interested in analysing if other ocular indices, such as IOP, pupil distance, ocular alignments, or ocular height, affected myopia. ROC curves were calculated to assess the correlation between myopia and each ocular index. The area under the curve (AUC)—an index of discriminant validity—was the primary result of the ROC analyses. An AUC of 0.50 corresponding to test scores of ocular index cannot be discriminated, whereas an AUC of 1.00 indicates a perfect discrimination. Analytical results from ROC curves indicated that AUCs of IOP (0.444), pupil distance (0.418), ocular height (0.361) or ocular alignments (0.189) were smaller than the baseline

Table 3. Prevalence of Myopia in Each Age Group with Different Spherical Equivalent

Age (Years)	Total No. (6069, %)	Emmetropia (SE ≥ 0D) (1421, %)	Mild Myopia (-3D < SE < 0D) (3778, %)	Moderate Myopia (-6D < SE ≤ -3D) (738, %)	High Myopia (SE ≤ -6D) (132, %)
6	79 (1.30)	54 (68.35)	25 (31.65)	-	-
7	621 (10.23)	289 (46.54)	324 (52.17)	7 (1.13)	1 (0.16)
8	730 (12.03)	244 (33.42)	452 (61.92)	26 (3.56)	8 (1.10)
9	737 (12.14)	201 (27.27)	478 (64.86)	53 (7.19)	5 (0.68)
10	870 (14.34)	212 (24.37)	558 (64.14)	92 (10.57)	8 (0.92)
11	979 (16.13)	190 (19.41)	651 (66.50)	116 (11.85)	22 (2.25)
12	887 (14.62)	107 (12.06)	593 (66.85)	155 (17.47)	32 (3.61)
13	369 (6.08)	37 (10.03)	245 (66.40)	73 (19.78)	14 (3.79)
14	403 (6.64)	49 (12.16)	230 (57.07)	104 (25.81)	20 (4.96)
15	394 (6.49)	38 (9.64)	222 (56.35)	112 (28.43)	22 (5.58)

SE: Spherical equivalent

Table 4. Mean Refractive Index (D) for Moderate and High Myopia from 870 Subjects

Age (Years)	No. (%)	Boys (460)			Girls (410)		
		Moderate and High (460)	Moderate (392)	High (68)	Moderate and High (410)	Moderate (346)	High (64)
7	8 (0.92)	-3.42 (8)	-3.29 (7)	-10.30 (1)	-	0	0
8	34 (3.91)	-5.31 (20)	-3.87 (16)	-9.85 (4)	-5.49 (14)	-4.20 (10)	-10.29 (4)
9	58 (6.67)	-4.25 (31)	-4.18 (28)	-6.04 (3)	-4.27 (27)	-3.93 (25)	-6.25 (2)
10	100 (11.49)	-4.36 (53)	-4.04 (49)	-6.88 (4)	-4.29 (47)	-4.02 (43)	-7.59 (4)
11	138 (15.86)	-4.77 (65)	-4.22 (53)	-7.03 (12)	-4.77 (73)	-4.42 (63)	-7.01 (10)
12	187 (21.49)	-4.65 (86)	-4.08 (78)	-6.83 (8)	-4.63 (101)	-4.18 (77)	-7.24 (24)
13	87 (10.00)	-4.50 (50)	-4.10 (40)	-7.19 (10)	-4.50 (37)	-3.90 (33)	-6.78 (4)
14	124 (14.25)	-4.65 (71)	-4.06 (58)	-7.30 (13)	-4.63 (53)	-4.24 (46)	-7.00 (7)
15	134 (15.40)	-4.68 (76)	-4.16 (63)	-7.35 (13)	-4.65 (58)	-4.13 (49)	-6.99 (9)

Table 5. Bonferroni Tests of *P* Values between Ages

Age (Years)	6	7	8	9	10	11	12	13	14	15
6		1	1	0.634	0.598	0.001	<0.001	<0.001	<0.001	<0.001
7	1		1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
8	1	1		0.028	0.017	<0.001	<0.001	<0.001	<0.001	<0.001
9	0.634	<0.001	0.028		1	0.003	<0.001	<0.001	<0.001	<0.001
10	0.598	<0.001	0.017	1		0.001	<0.001	<0.001	<0.001	<0.001
11	0.001	<0.001	<0.001	0.003	0.001		0.117	1	0.046	0.002
12	<0.001	<0.001	<0.001	<0.001	<0.001	0.117		1	1	1
13	<0.001	<0.001	<0.001	<0.001	<0.001	1	1		1	0.968
14	<0.001	<0.001	<0.001	<0.001	<0.001	0.046	1	1		1
15	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	1	0.968	1	

of 0.50, except for BCVA, as shown in Figure 2. These results indicated that their relevance to myopia were less significant compared to BCVA. Among the calculated ROC values, BCVA had the highest AUC of 0.676 with myopia. This confirmed that myopia had effects on BCVA in schoolchildren. BCVA deteriorated with increasing myopia gradually.

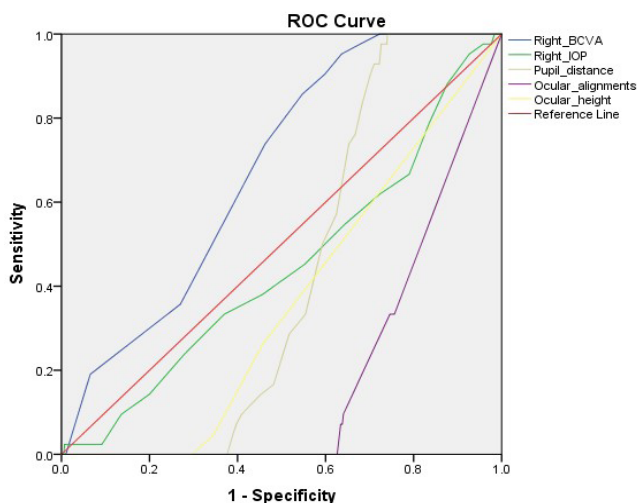


Fig. 2. ROC curves for different ocular conditions of the right eyes.

Furthermore, correlation coefficient was calculated to be 0.637 which indicated a positive correlation between BCVA and myopia. Also, Chi-squared (χ^2) tests were used to determine that myopia had significant associations with BCVA and age levels—both with 95% confidence intervals (CI) 2.553, 2.713 and -0.284, -0.248, respectively, under $P < 0.05$. Table 6 shows the deteriorating BCVA with

Table 6. Effect of BCVA and IOP with Progressive Myopia of the Right Eyes

Ages (Years)	Myopia	BCVA	IOP
6	0.19 ($\pm$ 0.95)	0.96 ($\pm$ 0.21)	15.58 ($\pm$ 4.36)
7	-0.22 ($\pm$ 1.04)	0.95 ($\pm$ 0.26)	15.76 ($\pm$ 4.17)
8	-0.62 ($\pm$ 1.50)	0.91 ($\pm$ 0.32)	17.24 ($\pm$ 4.51)
9	-0.92 ($\pm$ 1.42)	0.83 ($\pm$ 0.39)	16.85 ($\pm$ 4.85)
10	-1.11 ($\pm$ 1.53)	0.83 ($\pm$ 0.42)	16.97 ($\pm$ 4.68)
11	-1.39 ($\pm$ 1.78)	0.75 ($\pm$ 0.44)	17.38 ($\pm$ 4.45)
12	-1.77 ($\pm$ 1.86)	0.69 ($\pm$ 0.43)	17.15 ($\pm$ 4.29)
13	-1.89 ($\pm$ 1.80)	0.72 ($\pm$ 0.53)	18.12 ($\pm$ 4.83)
14	-2.12 ($\pm$ 2.01)	0.67 ($\pm$ 0.50)	17.77 ($\pm$ 5.72)
15	-2.31 ($\pm$ 2.03)	0.65 ($\pm$ 0.53)	17.29 ($\pm$ 4.18)

BCVA: Best corrected visual acuity; IOP: Intraocular pressure

progressive myopia in ages. At the age of 6, there was no myopia and the BCVA was close to 1 (BCVA = 20/20). Myopia started at the age of 7 and progressed with age, whereas BCVA deteriorated sharply with growing age (from 0.95 at age 7, down to 0.65 at age 15, a 31.57% drop). When the IOPs were considered for different age levels, they all fell within the range of 8 mmHg and 20 mmHg. A jump of IOP = 17.15 at age 12 to 18.12 at age 13 was potentially due to the fact that as schoolchildren transitioned from elementary school (sixth grade) to junior high school (seventh grade), more time was spent indoors studying. ROC curve from IOP in this study did not show impact on progressive myopia.

Discussion

This study investigated the prevalence and severity of myopia in Chiayi County, Taiwan based on examined data from elementary and junior high schools in 2013-2015. It is generally believed that myopia is more of a problem in urban areas where academically rigorous classes and higher demand for education are present.² In the past 15 years, there was hardly any survey or study done on myopia in Taiwan. In 2000, Lin et al studied about myopia and reported that the prevalence of high myopia (SE = -6D) at the age of 18 was 24%.^{21,22} This study found that at the age of 7, the prevalence of myopia with a refractive index (D) was -0.22D, which increased to -1.77D at the age of 12, and then to -2.31D at the age of 15. Lin et al have studied myopia and revealed that in 1983, myopia started at the age of 10, in 1995 it was 9, and in 2000 it became 8. In contrast, this study during 2013-2015 found that myopia started at the early age of 7. Furthermore, this study found that the prevalence and severity of myopia in elementary schools in Chiayi County was higher than what was reported in the previous study by Lin et al in 2000.² In addition, girls had higher mean refractive index (D) than boys and the severity worsened with years of investigation. Furthermore, boys in elementary schools of Chiayi County in 2013-2015 had the highest myopia (-1.10D), as compared to the previous study. Girls in elementary schools also had similar mild myopia in second place (-1.01D), slightly trailing behind the Taipei area (-1.03D) in 2000. Boys in junior high schools in Chiayi County were in second place (-2.10D), with the first place being the Kaohsiung area (-2.26D) in 1995. Girls in junior high schools of Chiayi County were better than 4 areas (Taipei, Kaohsiung, provincial cities, and service business) in 1995 while they were better than most areas except the aboriginal area in 2000. This could be attributed to the fact that schoolchildren in the mountainous or aboriginal areas had more outdoor activities to touch green trees and grasses; therefore, milder myopia was expected as compared to most schoolchildren in other areas.

When studying the prevalence of myopia with respect to age group, we found there were 31.65% with mild myopia but there were no cases for moderate or high myopia at the age of 6. At age 7, the percentage of mild myopia increased to 52.17% and there were only 1.13% of moderate myopia and 0.16% of high myopia. The trend of mild myopia increased until 12 years old before they entered junior high school. The percentages of moderate and high myopia jumped to 17.47% and 3.61%, respectively at sixth grade (the final year of elementary school), then increased to 19.78% and 3.79% in the first year of junior high school, and this trend increased to 28.43% and 5.58%, respectively until the age of 15.

In general, girls had higher prevalence of myopia than boys at the elementary school level but the severity was overturned by boys in junior high schools. The role played by the environment in the development of myopia remained unclear.²³ The utilisation of computers or electronic devices in daily life has been a significant factor in the prevalence of myopia among children.^{20,24} Dr Luke Lin, a retired professor at the National Taiwan University's College of Ophthalmology, said factors such as heavy workload at school, the stringent system of university entrance examinations, the possession and obsession of electronic devices all contributed to the epidemic of myopia.¹⁵ In this study, we found that the onset of myopia started earlier and progressively worsened over the years among suburban schoolchildren. Specifically, this study found that the prevalence and severity of myopia in elementary schools was higher than the previous study. While we only mentioned computers and electronic devices as likely contributing factors to this trend, we realise that there are other potential risk factors. In fact, some scientific publications revealed that near-work activities might increase the prevalence of myopia as well. Hsu et al revealed that prevalence of myopia in second grade children in metropolitan Taipei was significantly associated with time spent on near-work activities every day. Further analysis on their study found that 6.2% of participants who spent more than 2 hours daily using cellphone, computer or tablet products tended to have a 41% higher risk of myopia than those who spent less than 2 hours on them.²⁴ Systematic review from Huang et al showed that near-work activities were associated with myopia and more diopter-hours of near-work might increase myopia prevalence. Specifically, they found that children with more near-work activities had an 80% higher risk of having myopia. Furthermore, myopic children spent more time reading, but not studying, using a computer, or watching television (TV) than non-myopic children.²⁵ Deng et al studied 147 children aged 6-18 years and found that during the school year, myopes spent less time on sports/outdoor activity than non-myopes. For non-myopes, the average

weekly TV hours (8.91 ± 5.95 hours/week) was significantly lower than in myopes (12.78 ± 9.28 hours/week).²⁶ Sherwin et al's findings from observational epidemiologic studies suggested that increasing time outdoors may be associated with a reduced risk of myopia and myopic progression.²⁷

The risk is less for adult eyes which have a natural defense. As children's eyes are still developing, blue light is able to penetrate much easier and directly into the retina. One reason for the high prevalence of myopia in Taiwan is increasing workload from formal education and excessive usage of smartphones at a young age. Furthermore, with constant surfing on the Internet, watching TV, using computers and playing games on smartphones, the prevalence of myopia may exacerbate in schoolchildren. This study contributes to the investigation of prevalence of myopia in schoolchildren in an agriculture-based county in Taiwan and discusses how severe myopia was, as compared to the previous study in 2000.

Conclusion

In conclusion, this study finds that myopia can occur at an age, as early as 7 years old and progressively worsens as a child ages. The prevalence and severity of myopia in schoolchildren has increased in the last 15 years.

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