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ORIGINAL ARTICLE

Effects of Outdoor Activities on Myopia Among Rural School Children in Taiwan

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ABSTRACT

Purpose: The aim was to identify the prevalence and risk factors of myopia among elementary school students in a rural area of Taiwan.

Methods: A cross-sectional study was conducted. Elementary school students aged 7–12 years were recruited from the two schools located on Chimei Island. Data were obtained by means of a parent questionnaire and ocular evaluations that included axial length and cycloplegic autorefraction.

Results: One hundred and forty five students were recruited for this study. Myopia prevalence was 31%. In univariate analysis, myopia was significantly associated with school year, myopic parent, and watching television (TV) ($P < .0001$, $= 0.007$ and $= 0.029$, respectively). Multiple logistic regression analysis revealed that myopia was significantly associated with school year and myopic parent. However, the effect of watching TV was not statistically significant ($P = 0.059$). Outdoor activity showed significance and was inversely associated with myopia (Odds Ratio [OR] = 0.3, 95% Confidence Interval [CI] = 0.1–0.9, $P = 0.025$).

Conclusion: This study suggests that outdoor activities might be an important protecting factor for myopia in rural school children.

KEYWORDS: epidemiology; myopia; outdoor activity; prevalence; watching TV

INTRODUCTION

In recent years, myopia has become a public health issue worldwide.[1–5] The prevalence of myopia in East Asia, especially in countries such as Singapore,[3,4,6] Japan,[7] and Taiwan,[8–10] is very high. Studies have shown that myopia progresses faster when children present with myopia at a younger age.[11,12] Onset of myopia varies from site to site. In East Asia, the onset of myopia in lower grade primary school years is common.[10,13] In Europe, it is common in lower secondary schooling.[14,15] Once myopia occurs, myopia progresses fast until early adulthood.[16–18] Early onset of myopia is associated with high myopia in adult life.[19–21] High myopia is a significant public health problem because of its association with increased risk of several ocular diseases including cataract, glaucoma, retinal detachment, myopic retinal degeneration, visual impairment, and blindness.[22–24] Therefore, it is important to investigate the reasons for the increase in the prevalence of myopia and to identify the possible risk factors. This would point to possible directions to take for preventing myopia in the future.

Chimei is an isolated rural island located southwest of Taiwan and has an area of 7 kilometers^2 (km^2). The population is composed mostly of Chinese (95%). This study investigated the prevalence of myopia in elementary school children in rural Taiwan and identified the possible risk factors associated with myopia.

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METHODS

School children aged 7–12 years, residing on Chimei Island, Taiwan, were invited to participate in this

study. Parents and children were provided with an explanation of the study, and the parents gave consent for their children's participation. This study was approved by the Institutional Review Board at the Chang Gung Memorial Hospital and adhered to the Declaration of Helsinki. The children included in this analysis were in elementary school (1st–6th grades) and were examined in 2007. Myopia was defined as at least -0.75 D of spherical equivalent refraction (SER) on cycloplegic autorefraction performed using an autorefractometer (Retinomax K-plus, Nikon, Japan). Corneal anesthesia was used to minimize the discomfort from the cycloplegic drops. For cycloplegia, 1 drop of 0.5% proparacaine was followed by 1 drop of 1% tropicamide and 1% cyclogel administered 5 minutes apart. Measurements were made 30 minutes after initial drop instillation. Five to eight consecutive readings were obtained for each child. The measurement of axial length (AXL) was taken using an ultrasound biometer A-scan (Ocuscan RXP, Alcon, USA). Before screening in Chimei, the SER values of the hand-held autorefractometer (Retinomax K-plus, Nikon, Japan) versus the table-mounted autorefractor (KR-7000/8100; Topcon; Tokyo, Japan) used on 10 children were studied. It showed that the Retinomax values were significantly "minus" (-0.23 ± 0.41diopters [D]) compared to the table-mounted autorefractor values. This is similar to others' results (-0.22 D).[25] Therefore, myopia was defined as at least -0.75 D of SER on cycloplegic autorefraction performed using a hand-held autorefractometer. This value is similar and comparable to the commonly used criteria of ≤-0.5D using a table-mounted autorefractor. Children with best corrected visual acuity (BCVA) not achieving 20/25 were excluded from this study.

Parents provided information on parental myopia through a survey. Parents completed a survey form that asked the following question: "During each week of the school year, what is the estimated frequency your child performed the following activities outside of regular school hours (please check the appropriate box; often is defined as greater than 3 times and over 1 hour each time, seldom or none)? The activities listed were: "reads books; other near work activities (eg, plays piano/violin, calligraphy and painting); plays computer/handheld video games; watches television (TV)/TV games; and engages in outdoor and/or sports activities."

For homogenous comparison of eye refraction data, analyses were conducted on the right eye only because refractive error was highly correlated between the right and left eyes ($r = 0.93$). The extracted data were obtained from the right eye of subjects and used only once. The relationship between the possible variables and myopia was assessed by Chi-square tests for univariate analysis. Correlation coefficient analysis was used to analyze the relationship between the AXL and SER. Multiple logistic regression analysis was conducted for comparing risk factors that were used as independent variables. All data analyses were performed with commercially available software (SAS V 9.1.3; SAS, Inc., Cary, NC, USA).

RESULTS

A total of 150 children, aged 6–12 years (participation rate 76.1%), from two elementary schools were enrolled. Five children with BCVA less than 20/25 were excluded. Thus, 145 school children (52% boys and 48% girls) were included in the study. The prevalence of myopia was 31%. The axial nature of the refractive errors can be seen by the correlation between AXL and spherical equivalent ($r = -0.56$, $P < 0.0001$). In school year 1 (7 years old), school year 2 (8 years old), school year 3 (9 years old), school year 4 (10 years old), school year 5 (11 years old), and school year 6 (12 years old), the prevalence of myopia was 8%, 21%, 21%, 27% 44%, and 65%, respectively (Table 1). The prevalence of myopia was higher in more advanced school years. The mean (± standard deviation [SD]) SER in school year 1 was 0.02 (± 0.78), and the myopic pattern shifted to SER -1.58 (± 1.46) in school year 6 ($P < 0.001$).

Results of the univariate analysis were shown in Table 1. Myopia was found to be significantly associated with more advanced school year ($P < 0.001$), having myopic parents ($P = 0.007$), and watching more TV ($P = 0.029$). Myopia was not significantly associated with gender, reading and writing, computer use and other near work activities, and outdoor activity.

Multivariate analysis (Table 2) showed that the factors of advanced school year and a myopic parent were significantly associated with an increased risk of higher myopia prevalence (adjusted odds ratio [OR] = 1.9 and 4.3; 95% confidence interval [CI] = 1.4–2.5 and 1.6–11.3, $P < 0.001$ and $P = 0.003$). Watching TV was not significantly associated with myopia (adjusted OR = 3.0, 95% CI = 1.0–9.2, $P = 0.059$). Outdoor activity was significantly associated with decreased risk of myopia (adjusted OR = 0.3, 95% CI = 0.1–0.9, $P = 0.025$).

Outdoor activity was not significant in chi-square tests, but was significant in multivariate logistic regression analysis. There was interaction between outdoor activity and TV ($P = 0.004$). Because of the interaction between these two variables, there were non-significant chi-square test values and significant multivariate logistic regression analysis values. The reference was defined as TV = 0 and outdoor = 1, and the risk of myopia as TV = 1 and outdoor = 0 (0 as seldom or none, 1 as often). There were four cross-tables for further analysis

TABLE 1 Univariate analysis of factors associated with schoolchild myopia status

Factor	Definition	Non-myopia Number (%)	Myopia Number (%)	*P*-value
School year	1	23 (92.0)	2 (8.0)	<.001*
	2	23 (79.3)	6 (20.7)	
	3	15 (79.0)	4 (21.0)	
	4	16 (72.7)	6 (27.3)	
	5	15 (55.6)	12 (44.4)	
	6	8 (34.8)	15 (65.2)	
Gender	Boy	49 (64.5)	27 (35.5)	0.219
	Girl	51 (73.9)	18 (26.1)	
Myopic parent	None	74 (76.3)	23 (23.7)	0.007*
	One or both	26 (54.2)	22 (45.8)	
Reading/writing	often	32 (72.7)	12 (27.3)	0.518
	seldom or none	68 (67.3)	33 (32.7)	
Computer	often	28 (60.9)	18 (39.1)	0.150
	seldom or none	72 (72.7)	27 (27.3)	
Other near works	often	13 (72.2)	5 (27.8)	0.749
	seldom or none	87 (68.5)	40 (31.5)	
Television	often	67 (63.8)	38 (36.2)	0.029*
	seldom or none	33 (82.5)	7 (17.5)	
Outdoor activity	often	66 (70.2)	28 (29.8)	0.659
	seldom or none	34 (66.7)	17 (33.3)	

The chi-square test was used to estimate *P*-values; * indicates statistical significance.

(Table 3). In the analysis of controlling for TV = 0, outdoor activity had a significant protective effect for myopia ($P = 0.006$). In the analysis of controlling for TV = 1, outdoor activity had no significant effect on myopia ($P = 0.472$). In the analysis of controlling for outdoor = 0, TV had no significant association with myopia ($P = 0.669$). In the analysis of controlling for outdoor = 1, TV showed a significant risk associated with myopia ($P = 0.002$).

DISCUSSION

This study found the prevalence of myopia to be 31% in 7- to 12-year-old school children in rural Taiwan. Previous report also showed a high prevalence of myopia (22~28%) in rural Taiwan.[10] Several factors including parental myopia, age, and outdoor activity showed an association with myopia. Outdoor activity was found to be a strong protective factor in comparison to the risk factors of near to mid-distance activities.

Lower myopia prevalence has been reported in a rural lifestyle. [26–28] The environment might play an important role in the prevalence of myopia in a rural lifestyle context.[26,27] Although Chimei is a rural area, the rate of myopia is still high. The lower prevalence (8%) in 1st grade (7 years old) and the high prevalence (65%) in 6th grade (12 years old) found in this study should be noted. One possible reason that the prevalence of myopia is high in rural as well as urban areas in Taiwan is that there are shared cultural patterns of high engagement in near work activities and low engagement in outdoor activities.[10] Near work activity for young children has been reported as an important risk factor for myopia.[10,29–32] However, there was no significant effect of near work activity in this study. Early educational pressures with less time outdoors may be associated with higher myopia prevalence.[13]

In this study, univariate analysis showed that outdoor activity was not significantly associated with myopia. However, multivariate analysis showed that outdoor activity was still a significant independent protective

TABLE 2 Multivariate logistic regression analysis of factors associated with myopia status

	OR (95% CI)	*P*-value
School year	1.9 (1.4–2.5)	<.001*
Gender	1.9 (0.8–4.5)	0.115
Myopic parent	4.3(1.6–11.3)	0.003*
Reading/writing	0.9(0.4–2.2)	0.805
Computer	1.0(0.4–2.5)	0.970
Other near work activities (eg, plays piano/violin, calligraphy and painting)	0.7(0.2–2.6)	0.593
Television	3.0(1.0–9.2)	0.059
Outdoor activity	0.3(0.1–0.9)	0.025*

School year indicates 1–6. For gender, for myopic parent, 0 indicates none; and 1, one or both. For reading/writing, computer, other near work activities, TV, and outdoor activity, 0 indicates none or seldom; and 1, often. Value in parentheses is 95% confidence interval. * indicates statistical significance. OR = Odds Ratio; CI = Confidence Interval.

TABLE 3 Stratified analysis of factors of TV and outdoor activities associated with schoolchild myopia status

Factors		Myopia	
Controlling		Number (%)	P-value
TV seldom or none	Outdoor activity seldom or none	6/16 (37.5)	0.007*
	Outdoor activity often	1/24 (4.17)	
TV often	Outdoor activity seldom or none	11/35 (31.4)	0.473
	Outdoor activity often	27/70 (38.5)	
Outdoor activity seldom or none	TV seldom or none	6/16 (37.5)	0.699
	TV often	11/35 (31.4)	
Outdoor activity often	TV seldom or none	1/24 (4.17)	0.002*
	TV often	27/70 (38.5)	

The chi-square test was used to estimate *P*-values; * indicates statistical significance

factor against myopia. Recently, several studies showed that the more time children spend in outdoor activities, the less likely they were to be myopic.[33–38] Outdoor activity is considered a protective factor against myopia, even though the exact mechanism is still under investigation. A recent study supports the light-induced dopamine hypothesis in chicks.[39] However, one study by Lu et al. failed to find a protective effect of outdoor activity on a rural Chinese population with high myopic prevalence.[40] It seems possible that the site they chose might lack enough variation in exposure to outdoors for an effect to show through.

In this study, univariate analysis showed TV as a risk factor of myopia. However, TV was not a statistically significant factor in multivariate analysis, although it was close to achieving statistical significance (OR 1.0–9.2, $P = 0.059$). This might be due to and limited by the small sample of this study. We stratified the data by outdoor activity and time spent watching TV. When children were watching little TV, then a protective effect of outdoor activity was observed, but if the children were watching a lot of TV, then no protective effect was observed. There are some previous reports that showed viewing TV from a close distance before the age of 12 for 1 to 3 years has been associated with myopia in Asia.[41,42] Recently, there has been some evidence to show that watching TV is a risk factor in Caucasians.[43] However, another study showed that time spent watching TV was not significantly associated with myopia.[34] There is some controversy over whether or not watching TV is associated with myopia. Further large sample size studies are warranted to verify the influence of watching TV on myopia.

As this study collected participants from a remote island of Taiwan, it has the benefit of evaluating participants from a similar social economic status and lifestyle within the same community. Even though all of the school children aged 7–12 years on this island were invited for this study, the small population led to a major limitation of this study—a small sample size. Although a multi-areas study would be preferable as it would provide larger sample sizes, the variability of the different communities may confound the relationship of activities and myopia. The results were cross-sectional rather than longitudinal, modeling the odds ratios associated with being a myope rather than with becoming a myope. Longitudinal follow-up analyses will be needed to clarify the relative roles of factors in the onset of myopia. A potential weakness of this study was that the activities were reported by the parents; therefore, the results may be subject to recall bias.

In conclusion, this study has shown that the myopia prevalence is high in rural Taiwan. Parent history and age were independent risk factors for myopia and outdoor activity was an independent protective factor against myopia.

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