Prevalence and risk factors of myopia among schoolchildren in Chimi, Taiwan

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Myopia is the leading cause of blindness in East Asia

Myopia has become a public health issue worldwide recently [1-5]. In East Asia, such as Singapore [3, 4, 6], Japan [7], and Taiwan [8, 9, 10], the prevalence of myopia is very high. In Taiwan, the prevalence of myopia in children aged 6-7 years was 4% in 1986 and increased to 20% in 2000. The prevalence of myopia in 12-year-old children was 74% in 1986 and increased to 84% in 1995 and 2000. Among the myopia population, around 24% is high myopia [10, 11, 12]. High myopia, defined as refraction greater than -6 diopters, recently has become the leading cause of blindness in Taiwan, Japan and China [13, 14, 15]. 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 [16, 17, 18]. Studies have shown that myopia progresses more rapidly when children exhibit myopia at younger age [19]. 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.

Chimi study

Chimi is an isolated rural island located southwest of Taiwan and has an area of 7 km2. The population is composed mostly of Chinese (95%). It has been reported that myopia prevalence is lower in a rural lifestyle [20, 21, 22]. The environment might play an important role in the prevalence of myopia in a rural lifestyle context. We expected that the myopia prevalence might be low in schoolchildren. We conducted the study investigated the prevalence of myopia in elementary school children in rural Taiwan, Chimi island, and identified the possible risk factors associated with myopia.

This is a cross-sectional study. All elementary school children aged 7-12 years, residing on Chimi Island, Taiwan, were invited to participate in this study. Myopia was defined as at least -0.75 D of spherical equivalent refraction (SER) on cycloplegic autorefractometry performed using an autorefractometer. Before screening in Chimi, the SER values of the hand-held autorefractometer (Retinomax) versus the tablemounted autorefractor (KR-7000/8100; Topcon; Tokyo, Japan) used on 10 children were studied. It showed that the Retinomax values were significantly ‘minus’ (- 0.23 +
0.41D) compared to the tablemounted autorefractor values. This is similar to others’ results (-0.22 D) [23]. 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 tablemounted autorefractor. Children with best corrected visual acuity (BCVA) not achieving 20/25 were excluded from this study. Parents completed a questionnaire about parent myopia and the frequency of their child activities outside of regular school.

A total of 145 children (52% boys and 48% girls, 71% of total children in Chimi) 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).

Univariate analysis showed myopia 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 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 myopia prevalence is high in higher grade students

In this study, the prevalence of myopia is 31% in 7- to 12-year-old school children in rural Taiwan, Chimi. The prevalence is higher than previous report of myopia prevalence 22~28% in rural Taiwan [10]. The myopia prevalence in Chimi is higher than expected. Lower myopia prevalence has been reported in a rural lifestyle [20, 21, 22]. The environment might play an important role in the prevalence of myopia in a rural lifestyle context [20, 21]. Although Chimi is a rural area, the rate of myopia is still high, esp. in higher grade schoolchildren. 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. In comparison to a national wide survey of Taiwan in 2000, the prevalence of myopia is 21% among 7 year olds and 61% in 12 year olds. In Chimi, the prevalence of myopia is lower in 1st grade. However, it becomes similarly high in 6th grade. One possible reason that the prevalence of myopia is high in rural as well as urban areas in Taiwan is that there are shared same cultural patterns and educational system 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, 24, 25, 26, 27]. 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 [28]. In addition, it is also reported that less outdoor/sports activity before myopia onset may exert a stronger influence on development of myopia [29]. In the educational system of Taiwan,
there are only 2 hours of outdoor physical education class during the week. In contrast, there are encouraged outdoor activities in the afternoon everyday in the Western society. No wander higher myopia prevalence in Taiwan and East Asia.

**Fig. 1:** Outdoor activity is a protective factor for myopia

### Postpone myopia onset is important

In East Asia, the onset of myopia in lower grade primary school years is common [10, 28]. In Europe, it is common in lower secondary schooling [30, 31]. Once myopia occurs, myopia progresses fast until early adulthood [32, 33, 34]. The myopia progression in Asian children is very fast (nearly -1D/yr), and approximately 1/4 of the population become high myopes as adults [10, 11, 12]. Early onset of myopia has been reported associated with high myopia in adult life [35, 36, 37]. After onset of myopia in children, its progression is difficult to control and only atropine eye drops are effective [38, 39]. However, photophobia, blurred near-vision and fear of long-term ocular or systemic side-effects resulted in a high rate of noncompliance from patients [11]. Recently, orthokeratoplasty seems have some effect on controlling myopia progression [40]. However, due to fear of corneal infection and the high cost, it is not widely used. Nevertheless, it is important to make efforts to decrease the myopia prevalence in schoolchildren by keeping children in a premyopia state to prevent or postpone myopia onset.

### Outdoor activity against myopia

In this study, multivariate analysis showed that outdoor activity was still a significant independent protective factor against myopia. Recently, several studies showed that the more time children spend in outdoor activities, the less likely they were to be myopic [41-46]. Outdoor activity is considered a protective factor against myopia, even though the exact mechanism is still under investigation. There are several possible hypotheses to explain that outdoor activity could protect against myopia. First, the viewing distance is far in an outdoor area and the accommodation, tension from ciliary body or tension in the extraocular muscle of convergence would be relaxed. Second, an emmetropic eye viewing a distant object would reduce the hyperopic blur when viewing a nearby object. Animal models suggest that hyperopic blur promotes eye growth [47]. Thus outdoor activities would be expected to inhibit myopia. Third, the sunlight in the outdoor area would induce pupil constriction resulting in a greater depth of field and less image blur. Fourth, strong light intensity would induce dopamine release from the retina and would act as an inhibitor of eye growth [48, 49, 50]. 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 [51]. It seems possible that the site they chose might lack enough variation in exposure to outdoors for an effect to show through.

### Further study with intervention

This study has shown that the myopia prevalence is high in rural Taiwan. Parent history and age were independent risk factors for myopia. Outdoor activity was an independent protective factor against 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. Further study with intervention and longitudinal followup analyses will be needed to clarify the relative roles of outdoor activity in the prevention of onset of myopia. In addition, the basic study for the

mechanism why outdoor activities could protect against myopia should be further identified.

References