

# Time spent outdoors and myopia: establishing an evidence base

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Submitted Nov 25, 2015. Accepted for publication Nov 26, 2015.

doi: 10.3978/j.issn.1000-4432.2015.11.20

**View this article at:** <http://dx.doi.org/10.3978/j.issn.1000-4432.2015.11.20>

Myopia is a highly prevalent refractive error in Asia (1). Although mild myopia does not have serious ocular ramifications, pathological myopia is associated with the development of various ocular pathologies that can lead to irreversible visual loss or blindness (2). The prevalence of visual impairment attributable to pathologic myopia is 0.2-1.4% in Asian populations (3).

Over the past few generations, the prevalence of myopia has increased significantly (4). In urbanized areas of East and Southeast Asia, the prevalence of myopia amongst children and young adults has reached epidemic proportions. In school-aged children, the prevalence of myopia is 64.9% in Greater Beijing (5), and 73.1% in Guangzhou (6). In high school students prevalence estimates are as high as 80.7% in Beijing (7) and 86.1% in Taiwan (8). Correction, monitoring and treatment of myopia-associated visual impairment brings a substantial cost to the individual and the healthcare system (9), and can adversely impact quality of life (10). There is presently a lack of effective interventions available to prevent the development of myopia and slow its progression. In addition, patients with pathological myopia are at risk of developing sight-threatening ocular pathologies not preventable by refractive correction such as myopic choroidal neovascularization (CNV), myopic retinoschisis and macular hole, retinal detachment, earlier-onset cataract and open-angle glaucoma (2).

Both genetic and environmental factors contribute to myopia development (1). The rising public health burden of myopia has generated significant interest into interventions that may prevent or delay its development and slow its progression in school-age children. Studies thus far have targeted the optical properties of the eye, the use of pharmacological agents and the modification

of environmental factors. Use of corrective lenses has demonstrated a small delay in myopic progression (11), whereas the use of low-dose antimuscarinic eyedrops shows promise (12), but are limited by side-effects and problems with compliance. Evidence from recent observational and interventional studies suggest increased time outdoors is associated with a lower risk of myopic development and progression in children and adolescents (4,13).

He and colleagues (14) recently reported the results of the Guangzhou Outdoor Activity Longitudinal study. This well-designed randomized controlled trial of 1,903 children (mean aged 6.6 years) assessed the efficacy of increasing time spent outdoors in preventing myopia in schoolchildren over a 3-year period. Twelve schools in Guangzhou, China with similar distributions of visual acuity amongst their students were selected to participate. Cluster randomization was used with half of the schools were randomized to the intervention group and half to the control group. In the intervention schools, students were required to participate in an additional compulsory 40-minute outdoor class scheduled at the end of each school day and parents were encouraged to increase participation of their children in outdoor activities outside of school. In the control schools, children and parents did not change their pattern of outdoor activity.

At baseline, the intervention and control groups were well matched in demographic factors and risk factors, apart from a significantly lower rate of parental myopia in the intervention group (53.6%) compared to the control group (59.8%). The baseline prevalence of myopia was less than 2% in both groups. Measurement of the outcomes over all 3 years was completed by 1,579 of the original 1,903 children, owing to dropout and refusal to participate in

cycloplegic auto-refraction. Adherence to the outdoor intervention by schools was achieved 83.5% of the time, as measured by random school visits. At least half of the non-adherence to the program was due to poor weather.

He *et al.* found the addition of a 40-minute outdoor class every day for 3 years cumulative incidence of myopia had a modest but statistically significant effect on the incidence of myopia. The cumulative incidence rate of myopia was 30.4% in children in the intervention group compared to 39.5% in the control group ( $P < 0.001$ ). A post hoc analysis adjusting for parental myopia was consistent, showing a lower risk of myopia development in the intervention group as compared to the control group.

The difference in mean refraction between the groups at 3 years was 0.17 diopters (D;  $-1.42$  D in the intervention group *vs.*  $-1.59$  D in the control group), which does not reflect a clinically meaningful difference. The authors found no significant difference in the axial length of the two groups.

The aforementioned study has several important limitations, which are also common to other studies utilizing similar interventions. Follow-up of this population is required to ensure there is no myopic rebound in the intervention group after cessation as has been reported in other interventional studies (15). It is unclear whether the findings of this study, and indeed other trials on outdoor time, are generalizable beyond East Asian populations. The high prevalence of myopia in East Asia may allow the detection of a small protective effect that would not be seen in other populations. The effect and interaction of genetic and environmental factors may differ between populations. Another limitation of this study is that the time spent outdoors outside of school activity was measured by questionnaire rather than an objective measure of light exposure. Additionally, refraction was only measured using auto-refraction techniques.

High myopia has a strong genetic basis, with environmental risk factors less likely to be influential on its progression (16). The small difference (0.17 D) in absolute myopic progression and lack of a difference in axial length reported by He and colleagues (14) are unlikely to have a significant impact on the burden of high myopia. Additional studies with stratification for the high myopia phenotype are required to conclusively determine the impact of interventions on this group which carries a high burden of morbidity.

Implementation of interventions which increase time spent outdoors may pose risks to children including

increased exposure to harmful air pollution (17) and ultraviolet radiation (UVR) (18). Increased UVR exposure to the eye may also result in higher numbers of pterygia, cataract and malignancy of the ocular surface (19).

The study by He and colleagues demonstrates a small effect of increased outdoor time on myopic incidence and progression in the largest randomized trial to date measuring myopia using cycloplegic refraction (14). Other trials with fewer participants have reported effects of similarly small magnitude. A study in Taiwan of 571 students aged 7-11 years reported myopia incidence of 8.41% in the outdoor intervention group compared to 17.65% in the control group at 1 year, and a difference in mean refraction between the groups of 0.13 D (20). A subgroup study in Sujiatun, China of 391 students aged 6-11 years reported an incidence of 3.70% in the intervention group *vs.* 8.50% in the control group at one year, and a difference in mean refraction of 0.2 D (21). Another small study of 80 students aged 7-11 years in Changsha, China reported a difference in mean refraction of 0.14 D at 1 year between the intervention and control groups (22). The fact that the majority of research has come from Asia, is indicative of the significant myopia burden associated with this region.

Critically, the evidence so far points to an effect of smaller magnitude than that of progressive addition and bifocal lenses and antimuscarinic drops (11). Longer follow-up is required to assess the importance of outdoor interventions on long-term myopic development and progression to high myopia.

The mechanism underlying the protective association between increased outdoor time and myopia is unclear (4). Increased light exposure may stimulate the release of retinal dopamine, which inhibits axial elongation of the eye (13). Other potential mechanisms include increased exposure to blue light, increased vitamin D levels, increased depth of focus under high light intensity outdoors, and reduced accommodative demand for distance viewing (4). Further research into the biological mechanisms of this association will enable targeted interventions more likely to slow myopic progression. The content of outdoor activities and duration spent outdoors differs between studies. Standardization or objective measurement of time spent outdoors will help to inform future research and study design.

Future studies should address the impact of longer treatment periods, compare different durations of time spent outdoors, and address the question of whether

there is a dose-dependent effect as suggested by previous observational studies (13).

Increasing time spent outdoors is unlikely to be a panacea for the myopia epidemic. The modest effect on myopic development and progression suggests there are other genetic and environmental factors at play. However, the cost of implementation in schools is low and likely to pose little additional risk in most environments. Further research is required to characterize the mechanism of action, generalizability to other populations, and whether its effect will persist in the long term.

Interventions to increase the time spent by children outdoors should be recommended to parents and schools as a potential low-cost means of delaying myopia development and progression. However, parents and educational institutions must be informed the protective effect is likely small. The potential benefit must be balanced against the potential harms of increased outdoor exposure, particularly in locations with higher risk of harm from UVR and pollution, and locations with a lower prevalence of myopia.

## Acknowledgements

None.

## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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**Cite this article as:** Kocak ED, Sherwin JC. Time spent outdoors and myopia: establishing an evidence base. *Eye Sci* 2015;30(4):143-146. doi: 10.3978/j.issn.1000-4432.2015.11.20