Editorial

The role of outdoor activity in myopia prevention

Li Deng[1], Yi Pang[2]

[1]Department of Vision Science, New England College of Optometry, Boston, MA, USA; [2]Illinois College of Optometry, Chicago, IL, USA
Correspondence to: Li Deng. New England College of Optometry, 424 Beacon St, Boston, MA 02115, USA. Email: DengL@neco.edu.

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Myopia, also known as nearsightedness, is the most common vision disorder among children and young adults. In the last several decades, the prevalence of myopia has surged in East Asia. In some industrialized regions it has already reached an epidemic level (1,2). A smaller increase in the prevalence has also been observed in Western countries (2,3). The cost of visual aids or corrections put a great financial burden on individuals, families and the health care system. Myopia is not just an optical inconvenience. Early onset myopia is often accompanied with fast progression and very likely it will end up with high myopia (higher than 6.00 D myopia). High myopia poses a higher risk for developing glaucoma, retinal detachments and other vision threatening conditions. As our understanding of myopia was and is still poor, the research and development of an effective and safe tool in controlling myopia has been moving forward slowly. The current options for slowing down myopia progression include applying pharmaceutical agents such as atropine, wearing corrections with special optical design including bifocal spectacles, dual-focal contact lenses, and orthokeratology (ortho-K) (4). The most effective treatment up-to-date is 1% atropine, with well-established clinically relevant efficacy. However, the side-effect of long-term use and rebound effect after discontinuation of atropine were major concerns. Recently published results from a study conducted in Singapore clearly showed that atropine at a much lower dosage 0.01% could slow down myopia progression in children though its treatment size was smaller compared to the higher dosage levels: 1.0%, 0.5% and 0.1% (5). In addition, their results indicated that the group with 0.01% atropine had little rebound after cessation of the treatment while the other groups progressed much faster than the control group. More investigations on this promising strategy are still ongoing. Another promising option is ortho-K contact lenses. The benefit of wearing ortho-K in retarding axial elongation has been confirmed by randomized clinical trials (RCTs) (6). Prescribing contact lenses in very young children is still non-conventional due to hygiene and safety concerns. Other optical correction methods include multifocal and bifocal spectacles. Multifocal/bifocal spectacle provides minimal myopia control effect: statistically significant but without clinical significance (4). Finally, none of these intervention methods had been studied for a long period of time (>5 years) and thus their long-term effect is unknown. Unlike studies on retarding myopia progression, publications on myopia prevention methods are rarely seen in literature.

Although the exact mechanism of refractive error development is unclear, most researchers agree that both genetic and environmental factors contribute to myopia development (7). Results from numerous studies based on animal models and human subjects have helped us to better understand the underlying mechanism. The familial aggregation of myopia especially high myopia implies that genetic factors may be at play (8,9). The manipulation of visual environment at an early age using animal models demonstrates the importance of environment factors (10). Furthermore, the fact that the huge jump in the prevalence of myopia in East Asia over the last several decades cannot be explained by changes in genetic factors suggests that environmental factors play a substantial role in myopia development (7).

Early myopia research focused on education and near-work. With conflicting evidences from various studies, the role of near work is still inconclusive. Data from early studies suggested a detrimental role of excessive near-work as people with more years of education and near-work tend to be more myopic (11,12). In contrast, some more recent studies using survey data failed to find an association (13,14). Using questionnaire data, numerous observational studies also examined the associations of myopia with time spent on physical/outdoor activities (13,15). Consistently, most of them found that more time spent outdoors was associated with less myopia (13-15). This convergence of evidence sparked huge interest in studying light and its association with myopia. Messages from recently published animal studies on light intensity are mixing (16). High-intensity light exposure was shown to prevent form-deprivation myopia in chicks, tree shews and monkeys. However, in the negative lens setting a preventive effect was only observed in tree shews, but not in monkeys. In chicks, an initial effect was noted but it diminished at the end of the study period.

A direct and standard approach to test the efficacy outdoor activity is to conduct a RCT. The reality is that RCTs on outdoor activities are in shortage in literature. The main challenges and obstacles include (I) how to define two comparative groups: intervention *vs*. control groups with distinguishable amounts of outdoor activity time; (II) how to select the two groups with comparable characteristics at baseline; (III) how to obtain consent from a large number of parents to modify their children's life schedules and to conduct necessary examination procedures such as cycloplegic refractions; and (IV) how to monitor and maintain a high compliance rate in the intervention group.

In *JAMA* 2015 issue 11, He and his research team published findings on the efficacy of increased outdoor activity in reducing myopia incidence using a RCT (17). First-graders from 12 primary schools in Guangzhou, China were selected for this study. In the six schools randomized assigned to the intervention group, during school days additional 40 minutes class of outdoor activity were added to the end of each day. The study found a statistically significant lower cumulative incidence rate of myopia in the intervention group compared to the control group (30.4% *vs*. 39.5%) after 3 years of follow-up. The Guangzhou study was the first RCT with a large sample size (n~1900), a long follow-up period (~3 years) and a high compliance rate. Previously, there was one trial on myopia prevention conducted in Taiwan by increasing the outdoor activity time during class recess (18). Wu's study had a large sample size (~900) but only lasted for 1 year (18). The results from both studies corroborate the findings of previous cross-sectional studies that more outdoor activities are associated with a lower rate of myopia onset. Other strengths of the Guangzhou study are that they invested great effort in study planning, execution and data analyses to improve the quality of their findings. First they applied clustered randomization to ensure schools in the two comparison groups were comparable in their visual acuity distribution before the study started. Second they closely monitored the implementation of the additional outdoor activity time in the intervention group and achieved an 83.5% compliance rate. Besides the main finding, this study also observed a small but statistically significant difference in the change of refraction between the two groups (–1.42 *vs*. –1.59 D in the intervention and the non-intervention group respectively) and a minimal difference in axial elongation (0.95 *vs*. 0.98 mm).

Some caution should be taken when we interpret these results. First, the daily outdoor activity time during summer and winter breaks was neither measured directed by real-time devices nor surveyed in the questionnaire. They were approximated by the activity time on weekends of school days. As the activity schedules of vacation days could be very different from those in weekends of school days (14), such an approximation may not be valid. To what extent this could alter the conclusion is unclear. Second, several important confounders, such as academic performances, time spent on studying/near-work, or school locations etc., were not reported or analyzed in this paper. The difference in the incidence rate could be driven by the difference in these confounders rather than the extra outdoor activity time in school. Third, the benefit observed in this study may not be applicable to children living in countryside, with different ethnicity background or at older ages since the children under study were first graders in a big city in China.

He and his colleagues demonstrated that increased outdoor activity can reduce the chance of developing myopia in Chinese school children with their well-designed and executed RCT. His team made the first step to study efficacy of a myopia prevention method in a rigorous setup. They should be congratulated on their achievements of overcoming numerous obstacles to successfully conduct a randomized trial, recruit a large number of participants, create a clearly defined intervention group and apply all the rigorous criteria defined in RCT whenever possible. Currently there are several hypotheses, focusing on different aspects of outdoor activity, to explain why more outdoor activity is protective against myopia. The main hypotheses include constricted pupil under sunlight leading to increased depth of focus and decreased blurriness (15), elevated retinal dopamine activity with sunlight exposure (16), different light spectrums in natural light compared to indoor light (19), and a far less diopter variation outdoors (20). Future efforts should also be directed to pinpoint which factor(s) of outdoor activity are the primary cause(s). Only with better understandings of the underlying complex mechanism, we can move faster on the way of developing effective myopia strategies and consequently reduce the financial and health cost of myopia worldwide.

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Footnote

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

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