Types of Lamp for Homework and Myopia among Chinese School-Aged Children

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Types of Lamp for Homework and Myopia among Chinese School-Aged Children
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ABSTRACT

Purpose: We aim to determine the association of the types of lamp for homework including incandescent lamp, fluorescent lamp, and light-emitting diode (LED) lamp with the prevalence of myopia in Chinese children.

Methods: 2346 grade 7 students from ten middle schools (93.5% response rate) aged 13 to 14 years in Mojiang, a small county located in Southwestern China, participated in the study. Refractive error was measured with cycloplegia using an autorefractor by optometrists or trained technicians. An IOL Master was used to measure ocular biometric parameters including axial length (AL). Information regarding the types of lamp for homework after schools was collected by questionnaires.

Results: Of all the study participants, 693 (29.5%) were affected by myopia, with the prevalence estimates being higher in girls (36.8%; 95% confidence interval [CI]: 34.0, 39.6) than in boys (22.8%; 95% CI: 20.4, 25.1) (P < 0.001). After adjusting for potential confounders such as gender, height, parental history of myopia, time on computer use, time on watching TV, time outdoors, and time on reading and writing, participants using LED lamps for homework had a more myopic refractive error and a longer AL compared with those using incandescent or fluorescent lamps. There were no significant differences in myopia prevalence between children using incandescent and fluorescent lamps for homework. The population attributable risk percentage for myopia associated with using LED lamps for homework after schools was 11.2%.

Conclusions: Using LED lamps for homework after schools might contribute to the development of myopia among school-aged children.

Introduction

Myopia is the most prevalent vision disorder among children, and the prevalence is increasing rapidly throughout the world. Myopia is considered to be driven by both genetic and environmental factors. Despite genetic influence, multiple evidences have revealed that environmental factors play an essential role in myopia development. Recent evidence regarding environmental risk factors for myopia emphasized on the role of lights as time outdoors has been confirmed to be a major protective factor which could reduce the incidence of myopia in children.

Since 1879, Thomas Edison invented the first commercially practical incandescent lamp, and this invention has greatly changed the world of human beings. Nowadays, with the development of science and technology, many types of lamps were invented and used throughout the world. Different types of lamps may have different impacts on eye and vision due to different frequency flickers and colors of lights produced by different lamps.

High prevalence of myopia has been observed in many Chinese communities such as Shanghai, Guangzhou, Singapore, Hong Kong, and Taiwan. Even in some rural areas in China, high prevalence of myopia was also reported among school-aged children. Thus, Chinese communities are regarded to have a prevailing concept of an “epidemic” of myopia. Schooling system in China is highly competitive and academically oriented and emphasizes on very early educational achievements. Usually, Chinese school students spent much more time doing homework after schools compared with children in western countries. We hypothesized that the types of lamp for homework after schools may contribute to the variations in myopia risks in Chinese children. In this study, we aim to...
determine the association of the types of lamp for homework including incandescent lamp, fluorescent lamp, and light-emitting diode (LED) lamp with the likelihood of myopia in a school-based sample of Chinese children.

**Methods**

**Study population**

The Mojiang Myopia Progression Study is a school-based cohort study aiming to longitudinally observe the onset and progression of myopia as well as other major childhood ocular diseases in school-aged children in rural China. The overall study included two cohorts: elementary school grade 1 students and middle school grade 7 students. The current analysis was performed on the grade 7 cohort with a mean age of 13.8 years as they had been studying in primary schools for several years and using different lamps for homework in primary schools. Grade 1 students had just started to do homework and thus were not chosen for this study. Mojiang, a small county located in Southwestern China with a population of 0.36 million and an area of 5312 km², was chosen as the study site due to its relatively stable demographic structure and similar socioeconomic status to the average of rural China. The compulsory schooling system is well executed in Mojiang with an enrollment rate of 99% for elementary and middle schools in 2014. Thus, school-based samples in Mojiang are highly representative of the local population and could be regarded as population-based samples.

All the grade 7 students from middle schools in Mojiang were invited to participate in this study. For the baseline survey, the students roster was obtained from each school’s principal to ascertain the eligibility of the study participants, that is, he or she should have been living in Mojiang for at least 1 year and planned to live there for at least 4 years. A cell phone message was sent to the parents to explain the nature of the study and invite them to participate in the study. For those who did not agree to participate or did not respond, telephone interview was made to let them better understand the nature of the study and the importance of their children’s vision development. If the parents could not be reached by cell phone message or telephone, home visits were made. In the end of the study, a total of 2346 (93.5%) grade 7 students participated in the baseline survey.

Ethics committee approval was obtained from the Institutional Review Board of Kunming Medical University. We carried out the study according to the tenets of the Declaration of Helsinki involving human participants and the approved guidelines. Additionally, we obtained written informed consents from at least one parent or legal guardian of each participant.

**Refractive error and ocular biometry measurement**

Each participant’s refractive status was measured before and after cycloplegia using an autorefractor (RM-8000; Topcon Corp., Tokyo, Japan) by optometrists or trained technicians. For cycloplegia, each participant was first administered two drops of 1% cyclopentolate (Alcon) after a 5-min interval. Thirty minutes later, a third drop was administered if pupillary light reflex was still present or the pupil size was less than 6.0 mm. The first five valid readings of autorefraction were used and averaged using vector methods to generate a single estimate of refractive error. All five readings should be at most 0.50D apart in both the spherical and cylinder components. Myopia was defined as spherical equivalent (SE) at three different levels, less than −0.50D, −0.75D, or −1.00D, for statistical analysis. An IOL Master (Carl Zeiss Meditec AG, Jena, Germany) was used to measure ocular biometric parameters including axial length (AL). Three repeated reading were obtained and averaged before cycloplegia.

**Questionnaires**

The questionnaires used in this study were similar to several previous epidemiologic studies of myopia on Chinese children. The questionnaires were filled up by the parents or legal guardians of the children. We collected detailed information regarding socioeconomic status, parental education, parental history of myopia, medical history, time spent on near work, time on outdoor activities, and so on. Information regarding the types of lamp for homework after schools was also collected by questionnaires by asking “Which kinds of lamps do you usually use for homework after schools?”. The options for this question were “incandescent lamp,” “fluorescent lamp,” “LED lamp,” “Others,” and “unknown.”

**Statistical analysis**

As the correlation of SEs \( r = 0.90 \) and ALs \( r = 0.98 \) between both eyes was high \( r = 0.90 \) and the results of analysis in both eyes were similar, only data for the right eye were presented in this article. We compared the baseline characteristics of the participants using different types of lamp for homework, using the chi-square test or analysis of variance, as appropriate. We performed the following prespecified analyses to
examine the association between lamps for homework and myopia. We calculated the odds ratio (OR) and 95% confidence interval (CI) associated with different kinds of lamp for homework for three myopia-related outcomes: (1) the presence of myopia; (2) per D increase in SEs, and (3) per mm increase in ALs in multivariable regression models. For each outcome, we only adjusted for gender in the first model. In the second model, we additionally adjusted for covariates known to be associated with myopia, such as parental history of myopia, height, time spent on nearwork activities, and time outdoors. We also performed subgroup analyses to test whether our results were consistent across categories of possible confounders. In addition, the population attributable risk percentage of myopia associated with using LED lamps for homework after schools was estimated. All statistical analyses were performed using a commercial statistical software (Statistical Package for Social Science, SPSS V16.0; SPSS Inc., Chicago, IL).

**Results**

The study cohort consisted of 1213 (51.7%) boys and 1133 (48.3%) girls with a mean age of 13.8 ± 0.8 years (mean ± standard deviation). Of all the study participants, 693 [29.5% (95% CI: 27.7, 31.4)] were affected by myopia (SE<−0.50), with the prevalence estimates being significantly higher in girls (36.8%; 95% CI: 34.0, 39.6) compared with boys (22.8%; 95% CI: 20.4, 25.1) (*P* < 0.001). In this study, 315, 771, and 1196 individuals used LED, incandescent, and fluorescent lamps for homework after school, respectively. Participants who indicated that they used other types of lamps (*n* = 24) or did not know which types of lamps they were using (*n* = 40) were excluded from the current analysis. Thus, the final data analysis included 2282 children.

The distributions of SEs and ALs associated with types of lamps for homework are shown in **Figure 1** and **Figure 2**. More myopic refractive error was found in children using LED lamps for homework (mean SE: −0.49D, 95% CI: −0.68D, −0.30D) compared with those using incandescent (mean SE: −0.26D, 95% CI: −0.36D, −0.15D) or fluorescent lamps (mean SE: −0.23D, 95% CI: −0.31D, −0.15D) (*P* < 0.001). Similarly, the longest AL was also found in children who used LED lamps for homework among the three groups (LED lamps: 23.8 mm; incandescent lamps: 23.5 mm; fluorescent lamps: 23.5 mm).

**Table 1** shows the distributions of myopia-related variables among students using different types of lamps for homework after schools. There were no significant differences in terms of gender, height, parental history of myopia, and time outdoors among participants using different lamps for homework (all *P* > 0.05). Although there was statistically significant difference in time on watching TV, playing computers, and reading and writing per day, the magnitude of difference was extremely small.

Multiple logistic/linear regression analyses were performed to determine the associations of using different types of lamp for homework with the presence of myopia,
Table 1. Distribution of myopia-related variables among children using different types of lamp for homework.

<table>
<thead>
<tr>
<th>Variables</th>
<th>LED lamp (n = 315)</th>
<th>Incandescent lamp (n = 771)</th>
<th>Fluorescent lamp (n = 1196)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls (%)</td>
<td>147 (46.7)</td>
<td>364 (47.2)</td>
<td>598 (50.0)</td>
<td>0.37</td>
</tr>
<tr>
<td>Height, cm</td>
<td>153.6 (8.0)</td>
<td>152.7 (7.6)</td>
<td>152.9 (7.8)</td>
<td>0.07</td>
</tr>
<tr>
<td>Having myopic father (%)</td>
<td>16 (5.1)</td>
<td>25 (3.3)</td>
<td>33 (2.8)</td>
<td>0.12</td>
</tr>
<tr>
<td>Having myopic mother (%)</td>
<td>16 (5.1)</td>
<td>24 (3.1)</td>
<td>25 (2.1)</td>
<td>0.45</td>
</tr>
<tr>
<td>Time on computer per day, hours</td>
<td>1.1 (1.0)</td>
<td>0.9 (0.9)</td>
<td>0.8 (0.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time on watching TV per day, hours</td>
<td>1.4 (0.9)</td>
<td>1.5 (0.9)</td>
<td>1.3 (0.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time on reading and writing, hours</td>
<td>1.3 (0.7)</td>
<td>1.4 (0.6)</td>
<td>1.3 (0.7)</td>
<td>0.03</td>
</tr>
<tr>
<td>Time outdoors per day, hours</td>
<td>0.9 (0.3)</td>
<td>0.9 (0.3)</td>
<td>0.8 (0.3)</td>
<td>0.53</td>
</tr>
<tr>
<td>Family income less than 5000 yuan per year (%)</td>
<td>30 (9.4)</td>
<td>82 (10.6)</td>
<td>114 (9.5)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Bold type indicates statistical significance (p<0.05).
Data presented are means (standard deviations) or n (%), as appropriate.

The prevalence of myopia in this population was 29.5%, while it was 26.2% among individuals who did not use LED lamps for homework. Thus, the population attributable risk percentage of myopia associated with using LED lamps for homework was 11.2%.

Discussion

In this study, we observed an association of the types of lamp used for homework with myopia and ALs among grade 7 school students in rural China. After controlling for the effect of gender and myopia-related variables including height, parental history of myopia, time on computer use, time on watching TV, time outdoors, and time on reading and writing, children who used LED lamps for homework were more likely to have myopia and longer ALs compared with those who used incandescent or fluorescent lamps. Our study provided initial clues to the role of lamps in myopia prevention among school-aged children.

The first practically useful visible LED lamp was invented by Nick Holonyak Jr. in 1962. Nowadays, although LED lamps are becoming more and more popular throughout the world as they can save power and energy, the health-related effects of LED lamps have not been well understood. It has been well established that lights are important in vision-related conditions and can result in damage to the eyes through photothermal, photomechanical, and photochemical mechanisms. The components of lights produced by LED lamps may be different from those from incandescent or fluorescent lamps, resulting in disparities in myopia risks. One hypothesis regarding our observation may be related to flickering-light stimulation. Compared with incandescent or fluorescent lamps, LED lamps may contain more lights with low-frequency visible flicker and high-frequency invisible flicker. A study on mice found myopia can be induced by low-frequency flickering-light stimulation. Another study found that low-frequency temporal modulation of light promotes a myopic shift in refraction among chicks. However, no evidence from human were available in this area.

In addition to flickering-light stimulation, the spectral composition of the lights from LED lamps may also be different from that produced by incandescent or fluorescent lamps. LED lamps produce strong red, green, or blue lights that might be harmful to human eyes. An animal experiment found that...
### Table 2. Associations of using different lamps for homework with myopia prevalence.

<table>
<thead>
<tr>
<th></th>
<th>Myopia &lt; −0.5D</th>
<th></th>
<th>Myopia &lt; −0.75D</th>
<th></th>
<th>Myopia &lt; −1.0D</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gender adjusted</td>
<td>Multivariate adjusted*</td>
<td>Gender adjusted</td>
<td>Multivariate adjusted*</td>
<td>Gender adjusted</td>
<td>Multivariate adjusted*</td>
</tr>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>P</td>
<td>OR (95% CI)</td>
<td>P</td>
<td>OR (95% CI)</td>
<td>P</td>
</tr>
<tr>
<td>LED versus incandescent</td>
<td>1.44 (1.08, 1.90)</td>
<td>0.01</td>
<td>1.30 (0.97, 1.74)</td>
<td>0.08</td>
<td>1.52 (1.14, 2.03)</td>
<td>0.004</td>
</tr>
<tr>
<td>LED versus fluorescent</td>
<td>1.43 (1.09, 1.87)</td>
<td>0.01</td>
<td>1.30 (0.99, 1.72)</td>
<td>0.06</td>
<td>1.53 (1.16, 2.01)</td>
<td>0.003</td>
</tr>
<tr>
<td>Incandescent versus fluorescent</td>
<td>1.01 (0.82, 1.24)</td>
<td>0.94</td>
<td>1.01 (0.82, 1.23)</td>
<td>0.93</td>
<td>1.02 (0.83, 1.27)</td>
<td>0.83</td>
</tr>
</tbody>
</table>

Bold type indicates statistical significance (p<0.05).
*Multivariate models adjusted for gender, parental myopia, time on watching TV, time on reading and reading, time on computers, and time outdoors.
D, Diopter; OR, odds ratios; CI, confidence interval.

### Table 3. Associations of using different lamps for homework with spherical equivalent and axial length.

<table>
<thead>
<tr>
<th></th>
<th>Spherical equivalent (Diopter, D)</th>
<th>Axial length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gender adjusted</td>
<td>Multivariate adjusted*</td>
</tr>
<tr>
<td></td>
<td>β (95% CI)</td>
<td>P</td>
</tr>
<tr>
<td>LED versus incandescent</td>
<td>−0.24 (−0.44, −0.04)</td>
<td>0.02</td>
</tr>
<tr>
<td>LED versus fluorescent</td>
<td>−0.26 (−0.44, −0.08)</td>
<td>0.005</td>
</tr>
<tr>
<td>Incandescent versus fluorescent</td>
<td>−0.04 (−0.16, 0.09)</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Bold type indicates statistical significance (p<0.05).
*Multivariate models adjusted for gender, parental myopia, time on watching TV, time on reading and reading, time on computers, and time outdoors.
D, Diopter; OR, odds ratios; CI, confidence interval.
guinea pigs raised in long-wavelength light illumination developed a significant myopia compared with those raised in mixed-light illumination after 4 weeks. Compared with the guinea pigs raised in normal conditions, those raised in long-wavelength and mixed lights were more myopic and also showed longer vitreous chamber depth at 2, 4, and 6 weeks, suggesting that monochromatic long-wavelength light may lead to myopia and to an abnormal visual experience. Another guinea pig study found that green light with a wavelength of 530 nm is involved in the development of myopia. Blue lights were also reported to cause retinal injuries in animal models. Blue lights might increase the risk of oxidative damage to the retina by interfering the visual phototransduction which converts light into electrical signals. This process may be involved in myopia onset and progression. However, whether oxidative damage to the retina from blue lights could lead to myopia at a population-based level remains unclear. Some LED lamps also produce ultraviolet but the effect of ultraviolet on myopia remains unclear. Some LED lamps might increase the risk of oxidative damage to the retina by interfering the visual phototransduction which converts light into electrical signals. This process may be involved in myopia onset and progression. However, whether oxidative damage to the retina from blue lights could lead to myopia at a population-based level remains unclear. Some LED lamps also produce ultraviolet but the effect of ultraviolet on myopia remains unclear.

The public health implications of the findings warrant clarifications. Nowadays, LED lamps have been gradually replacing traditional incandescent or fluorescent lamps in lighting throughout the world. For example, Chinese governments have called for an end to the production of incandescent lamps in recent years. However, there have been a paucity of data investigating the health benefits of LED lamps in human beings, especially vision-related health. Our study indicated that LED lamps may not be a good choice for myopia prevention in children, though more efforts in this area are needed to confirm our findings and elucidate the mechanisms. Considering that lights are so important to vision-related health, how to balance energy conservation and health promotion is a great challenge for the governments in China as well as in other countries. The strengths of this study included its large sample size and detailed information on a wide range of potential confounders. However, it has a few limitations. First, information regarding the types of lamp used for homework was self-reported and therefore might be subject to information bias on exposures. Furthermore, our analysis was based on cross-sectional data and causal relationship cannot be determined. Last but not least, our study participants were in a narrow age range, and the generalizability of our findings to school children with different ages may be limited.

In conclusion, our study proposed that using LED lamps for homework after schools might contribute to the development of myopia among school-aged children. Further effects are warranted to confirm this finding and elucidate the biological mechanisms underlying this observation.

Competing interests
None.

References


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