Objective: To study the associations between near work, outdoor activity, and myopia among children attending secondary school in rural China.

Methods: Among a random cluster sample of 1892 children in Xichang, China, subjects with an uncorrected acuity of 6/12 or less in either eye (n=984) and a 25% sample of children with normal vision (n=248) underwent measurement of refractive error. Subjects were administered a questionnaire on parental education, time spent outdoors, and weekly time spent engaged in and preferred working distance for a variety of near-work activities.

Results: Among 1232 children with refraction data, 998 (81.0%) completed the near-work survey. Their mean age was 14.6 years (SD, 0.8 years), 55.6% were girls, and 83.1% had myopia of −0.5 diopters or less (more myopia) in both eyes. Time and diopter-hours spent on near activities did not differ between children with and without myopia. In regression models, time spent on near activities and time outdoors were unassociated with myopia, adjusting for age, sex, and parental education.

Conclusions: These and other recent results raise some doubts about the association between near work and myopia. Additional efforts to identify other environmental factors associated with myopia risk and that may be amenable to intervention are warranted.

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Uncorrected refractive error is the leading cause of visual disability among school-aged children of European, South Asian, and East Asian descent. As a result, programs to improve children’s access to glasses have become increasingly popular. Recent reports have demonstrated, however, that rates of spectacles wearing may be low, even among children who have recently been provided free glasses. Accuracy of the prescription in currently worn spectacles also appears to be an important problem in at least some parts of the world.

Because of these and other practical problems with spectacles use and the various pathologic associations with higher degrees of myopia, there has been much interest in pharmacologic and refractive strategies to prevent or slow the progression of myopia in children. Behavioral strategies, often focused on reducing near work or visual activity with a high accommodative demand, are also becoming more popular. Near work has been reported by some studies to increase the risk for myopia development and progression. Other studies have reported no association between myopia and measures of near work, such as time spent reading or doing schoolwork. One factor that leads to uncertainty in this area is the reliance of some studies on surrogates for the amount of near work, such as number of books read per week, which may actually be indicators of educational attainment, which is independently associated with myopia itself. Few large studies have reported on the actual distance subjects use during near-work tasks, an important factor in assessing accommodative demand. Fewer have assessed levels of outdoor activity as a possible mediator of the effects of near work.

The association between sex and prevalence of refractive error appears to vary from population to population. While girls are reported to have a higher prevalence of myopia than boys in urban China, rural India, and Malaysia, studies in South Africa and Chile have found no difference, and reports from urban India and Nepal suggest that girls have more hyperopia. Recent data from rural secondary school students in China, including our own, reflect a consistently
higher prevalence of myopia among female students. Reasons for the higher myopia prevalence among Chinese girls are not well understood, but in view of the worse presenting vision that has been reported for girls compared with boys in this setting, the problem deserves further study.

The Xichang Pediatric Refractive Error Study (X-PRES) is a school-based study of refractive error prevalence, patterns of spectacles wear, and refractive services use among 1900 children in junior middle school years 1 and 2 (ages, 13-17 years) in rural China. Owing to compulsory education in this age range, the sample likely represents the local population. The current article provides data on the potential association between sex, myopia, outdoor activity, and self-reported time spent on and preferred working distance for a variety of common near-work tasks.

**METHODS**

Xichang is a rural town located within a 2 hours' drive of the city of Shantou in eastern Guangdong province, China. Basic refractive services and spectacles are available at an eye center supported by the local government medical clinic and the Li Ka Shing Foundation and at a small number of privately run optical shops in Xichang. The total population of Xichang was 109,673 in 2002, of which 10,780 people were aged between 10 and 14 years, 7540 from 15 to 19 years.

We carried out a school-based survey on a random cluster sample, selected by class (class size was approximately 60 students) among children in junior middle school years 1 and 2 at all 3 middle schools in Xichang. The purpose of the survey was to determine the prevalence and predictors of visual disability, refractive error, spectacles wear, and uptake of refractive services. The protocol was approved by the ethics committee at the Joint Shantou International Eye Center in Shantou. Informed consent was obtained from parents of all participating children, and the Declaration of Helsinki was followed throughout.

The parents of all children in randomly selected junior middle school year 1 and 2 at all 3 middle schools in Xichang were sent invitation letters explaining the purpose and methods of the study. Parents were asked to check a box indicating whether or not they would allow their child to participate in the study and to return the form to school with their child.

**ASSESSMENT OF VISUAL ACUITY**

Visual acuity with and without habitual refraction (if available) was measured by trained study personnel in well-lighted areas during daylight hours at a distance of 6 m separately for each eye of each child. Children who did not have their spectacles at school were asked to bring them for vision assessment on a separate day, and visual acuity was recorded both with and without glasses. An illuminated Snellen tumbling E visual acuity chart (Shantou City Medical Equipment Ltd, Shantou, China) was used for all testing. The subject covered his or her untested eye using a handheld occluder, with proper occlusion and neutral head position monitored by the examiner. The right eye was tested first. A single optotype of each size was presented first, starting at 6/30. If the subject could not read a letter, testing began 2 lines above that line, with the subject being asked to read sequentially all optotypes on the line. A subject had to correctly identify more than half of the letters on a given line (eg, 3 of 5, 4 of 6) to be considered to have achieved that level of acuity.

**BASIC QUESTIONNAIRES**

All subjects (n = 1892) (Figure) were given a self-administered basic questionnaire by study personnel prior to being told the results of their vision assessment. The basic questionnaire included questions on age, sex, parental education, and history of glasses wear. The basic questionnaire included a Chinese translation of an instrument originally developed by Fletcher et al33 to assess self-reported visual function in rural Asia. This instrument has previously been validated for use in Chinese34,35 and is described elsewhere in detail.33 The questionnaire could be administered in 5 to 10 minutes. The overall scale score ranged from 0 (worst) to 100 (best).

**REFRACTION**

All subjects with uncorrected vision of 6/12 or worse in either eye (n = 985) and a 25% random sample of subjects with vision better than 6/12 in both eyes (n = 248) underwent cycloplegia with 2 drops of cyclopentolate, 1%, in each eye. Eye drops were administered 3 minutes apart and followed by autorefration (Canon RK-F1 Refractometer/Keratometer; Canon Inc, Tochigi, Japan) no less than 30 minutes later, with subjective refinement by an ophthalmologist in each eye (Figure).
NEAR-WORK SURVEY

Three months later, children who participated in the original survey and had undergone refraction measurement were administered a questionnaire asking them to report the number of hours spent during the previous week in each of the following 6 activities: schoolwork (at home and in school), personal reading, watching television, video games and computer use, any tasks performed in a family business involving focusing at closer than a meter (eg, running a cash register), and outdoor activities of all kinds. Subjects were also asked to indicate their preferred working distance in meters) for each task, which was multiplied by the number of hours spent to give weekly task-specific diopter-hours. The near-work survey was readministered to a random sample of approximately half the participants again on a separate occasion 3 months later to assess the test-retest variability of the instrument (Figure).

STATISTICAL ANALYSIS

Presenting vision of the better-seeing eye (the decimal equivalent of the Snellen fraction) was transformed by taking the log of the inverse (that is, logMAR) to correct its skewness before statistical analyses, but the untransformed value is presented in this table for clarity. All other statistical analyses were performed using StatXact 4.01 (Cytel Software Corporation; Cambridge, Massachusetts). All other statistical analyses were performed using SPSS, version 14.0 (SPSS Inc, Chicago, Illinois). All statistical tests were 2-sided, and \( P < .05 \) was considered statistically significant.

Except for a 25% random sample, children with normal vision did not undergo refraction. Although only children who actually underwent refraction are included in our analyses of the association of refraction and near work, in giving figures for myopia prevalence (defined by a cutoff of \( \leq -2.0 \) D in both eyes), we assumed that children with normal vision who did not undergo refraction were not myopic. Among 248 children with normal vision who were selected at random for refraction, only 2 (0.86%) had myopia of less than \( -2.0 \) D (more myopia) in both eyes.

RESULTS

Among 2235 subjects in the sample, parental consent was obtained for 1945 (87.0%). A total of 1892 subjects (97.3% of consenting children and 84.7% of the total sample) received a vision examination and basic questionnaire. Of these, 1232 children underwent a detailed examination, including refraction measurement: 984 (79.9%) with uncorrected vision of 6/12 or less in either eye, and 248 (20.1%) with normal vision selected as part of a 25% random sample. A total of 998 children (81.0% of those with refractive data) subsequently completed the near-work questionnaire (Figure). The 998 children with both refractive and near-work data were slightly younger, more likely to be female and wear glasses, and had worse uncorrected and presenting visual acuity and worse self-reported visual function than children without these data (Table 1).

### Table 1. Comparison of Chinese Children by Sex and Participation in Near-Work Survey and Refraction

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All Participants (n=1892)</th>
<th>Boys (n=923)</th>
<th>Girls (n=969)</th>
<th>( P ) Value</th>
<th>Boys (n=443)</th>
<th>Girls (n=555)</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>14.7 (0.8)</td>
<td>14.7 (0.8)</td>
<td>14.6 (0.8)</td>
<td>.08</td>
<td>14.7 (0.8)</td>
<td>14.6 (0.8)</td>
<td>.02</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>923 (48.8)</td>
<td>480 (53.7)</td>
<td>443 (44.4)</td>
<td>(&lt; .001)</td>
<td>295 (66.6)</td>
<td>293 (52.8)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>F</td>
<td>969 (51.2)</td>
<td>414 (46.3)</td>
<td>555 (55.6)</td>
<td>(&lt; .001)</td>
<td>259 (34.4)</td>
<td>262 (47.2)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Wearing glasses</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No</td>
<td>1392 (73.6)</td>
<td>747 (80.9)</td>
<td>645 (66.6)</td>
<td>(&lt; .001)</td>
<td>804 (89.9)</td>
<td>588 (58.9)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Yes</td>
<td>500 (26.4)</td>
<td>176 (19.1)</td>
<td>324 (33.4)</td>
<td>(&lt; .001)</td>
<td>10 (10.1)</td>
<td>410 (41.1)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Parents’ highest education</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Primary school</td>
<td>413 (21.8)</td>
<td>193 (20.9)</td>
<td>220 (22.7)</td>
<td>(&lt; .001)</td>
<td>187 (20.9)</td>
<td>226 (22.6)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Junior high school</td>
<td>880 (46.5)</td>
<td>436 (47.2)</td>
<td>444 (45.8)</td>
<td>(&lt; .001)</td>
<td>444 (49.7)</td>
<td>436 (43.7)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>High school</td>
<td>576 (30.4)</td>
<td>282 (30.6)</td>
<td>294 (30.3)</td>
<td>(&lt; .001)</td>
<td>252 (28.2)</td>
<td>324 (32.5)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>College</td>
<td>23 (1.2)</td>
<td>12 (1.3)</td>
<td>11 (1.1)</td>
<td>(&lt; .001)</td>
<td>11 (1.2)</td>
<td>12 (1.2)</td>
<td>(&lt; .001)</td>
</tr>
<tr>
<td>Uncorrected vision in the better eye, median (IQR), Snellen decimal fraction</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Myopia of ≤-0.5 D in both eyes</td>
<td>829 (83.1)</td>
<td>364 (82.2)</td>
<td>465 (83.8)</td>
<td>.499</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual function score, mean (SD)</td>
<td>75.8 (16.3)</td>
<td>77.2 (16.0)</td>
<td>74.4 (16.5)</td>
<td>(&lt; .001)</td>
<td>81.8 (13.7)</td>
<td>70.7 (16.5)</td>
<td>(&lt; .001)</td>
</tr>
</tbody>
</table>

Abbreviations: D, diopters; IQR, interquartile range.

- The logarithm of the inverse of this value (logMAR) is used for statistical calculations, but the untransformed value is presented in this table for clarity.
- On the basis of 1232 subjects with refraction data.
Girls had significantly ($P < .001$) worse uncorrected vision than boys in the sample of 1892 children (Table 1). As we have reported elsewhere, the prevalence of myopia of less than $-2.0$ D in both eyes was also higher among girls (36.1%) than boys (25.9%, $P < .001$).

Among the various near-work and leisure activities, girls spent significantly more time and diopter-hours on homework and other reading ($P < .001$ for both) and were significantly more likely than boys to report any time spent during the last week doing homework or reading ($P < .001$). Boys reported more time spent on outdoor activities ($P < .001$) and more time and diopter-hours on video games ($P < .001$) than girls (Table 2).

There was no difference between 829 (83.1%) examined children with myopia of $-0.5$ D or less (more myopia) in both eyes and examined nonmyopic children with regard to time spent on homework, other reading, watching television, or outdoor activities, while time spent on video games ($P = .02$) and family-business activities ($P = .01$) was significantly less in myopic children (Table 3). Myopic children reported a significantly closer working distance for all surveyed near-work activities than did nonmyopes, though their calculated diopter-hours per week did not differ significantly from those of nonmyopic children for any near-work activities (Table 3).

Among 578 children who underwent retesting on the near-work survey, the weighted $k$ values were as follows: time spent on homework, 0.47; time spent on personal reading, 0.47; time spent watching television, 0.48; time spent on computer/video games, 0.60; time spent outdoors, 0.43; and reading distance (for both homework and personal reading), 0.33. The proportion of exact agreement for these values ranged from 35% to 60%. All of the values indicate moderate agreement, except for the reading distance, which is consistent with fair agreement.

In logistic regression models of factors potentially predictive of refractive error of $-0.5$ D or less (more myopia) in both eyes, sex, diopter-hours of near work, and outdoor activity were not significantly associated with myopia (Table 4). Playing video games and time spent in near work on the family business were not included in the model, as only two-thirds of respondents reported participating in these activities. No significant associations between near work and myopia were observed in linear regression models with refractive error in the better-seeing eye as the outcome (data not shown).

One factor that is hypothesized to explain the high and possibly rising prevalence of myopia among Chinese children is the accommodative demand associated with near-work tasks such as schoolwork. However, studies of this potential association have had mixed results. We found no evidence of greater time spent on near-work activities among children with myopia in this cohort. Although myopic children reported a closer working distance for all surveyed near-work activities, their diopter-hours spent on near work did not differ from nonmyopic children in univariate or multivariate analyses (Table 4).

It is possible that our failure to find an association between near work and myopia in this cohort is due to inaccuracy in the self-assessment of time spent on near work and preferred working distance. Retesting of more than half the subjects showed moderate agreement for the large majority of relevant self-reported measures. Given that children were instructed to report near work for the previous week, some variability in these values is to be expected. We reanalyzed our data using only hours spent on near-work tasks, excluding estimates of reading distance, which showed less robust test-retest agreement. We still failed to find an association between near work and myopia risk in univariate analyses or in any of our models (data not shown).

It is possible that the use of diaries, pager contact, or other methods less susceptible to recall bias might have yielded different results. However, it has been reported that cross-sectional estimates of near work correlate well with more time-intensive methods. Our assumption that accommodative response remained constant during the various near-work tasks and could be estimated using the accommodative stimulus as denoted by subjects’ self-
reported working distance is obviously an oversimplification and a potential source of error. Unfortunately, it was not practical to measure the actual accommodative response of our subjects over time. Finally, it is to be expected that the impact of near work or any environmental risk factor for myopia is cumulative over time. By focusing on a single week of activity, our questionnaire may have failed to accurately capture children’s long-term experience. In particular, patterns of near work may have been very different at younger ages when myopia first became manifest. We felt, however, that attempting to measure self-reported behavior during a longer period without recourse to written records would have led to questionable accuracy.

We did observe consistently closer self-reported working distances among myopic subjects across a variety of activities (Table 3). This finding of closer working distances among myopes is consistent with the limited published literature. An association between closer reading distances and more rapid progression of myopia has been reported by the Correction of Myopia Evaluation Trial.41 Cross-sectional studies such as the present article cannot draw inferences of causality with regard to closer working distances and myopia. The association could be interpreted either as evidence that near work causes myopia or that myopic persons prefer a closer reading distance owing to the shorter focal length of their eyes’ optical system when uncorrected with spectacles.
Few other articles have attempted to quantify nonreading near-work tasks, such as playing video games, in assessing myopia risk. Our data suggest that such tasks are of importance in measuring overall accommodative effort. Among boys, both television and video games consumed more reported time on a weekly basis than did homework. It is unlikely that including such activities in our models accounted for the lack of an association with myopia, as univariate analyses of reading alone similarly indicated no significant association with refractive error.

We also failed to find evidence of an association between outdoor activity and myopia. Increasing levels of outdoor activity have been reported to be inversely associated with myopia risk among American and Australian children, though not to the best of our knowledge among Chinese cohorts. The mechanism for this potential protective effect is not well understood, though a relaxation of accommodative effort may be involved.

We found a higher prevalence of myopia among girls than boys, as others have observed in subjects from rural China. This difference was associated with a lower median visual acuity among girls in our cohort (Table 1). Although girls did report spending significantly more time and diopter-hours on homework and other reading, the lack of an association between near work and myopia indicates that additional near work is unlikely to explain excess myopia among girls in this setting. Further study of this problem is needed.

Although reliable longitudinal data are scarce, it is widely believed that the prevalence of myopia is increasing in East Asia, particularly in ethnically Chinese urban centers. Increasing near-work demands resulting from mounting educational pressures have frequently been blamed for this “epidemic” of myopia. Data from our article and other studies in Chinese children raise questions about this putative association. Further work is warranted to better understand which aspects of the rapidly changing East Asian environment may explain the apparent increase in myopia prevalence, the ultimate goal being to find practical strategies to reduce the myopia burden.

The results of X-PRES must be interpreted within the context of its limitations. We have reviewed potential limitations of our near-work survey. Our sample was school-based rather than population-based, and consent could not be obtained for 13% of subjects in our sampling frame. School attendance is compulsory for middle–school-aged children in China, and secondary school enrollment rates of greater than 91% have been reported for nearby areas of rural Guangdong. Still, our results can only be applied to find practical strategies to reduce the myopia burden.

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