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Myopigenic activity change and its risk factors in urban students in Beijing: three-year report of Beijing Myopia Progression Study

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ABSTRACT

Purpose: To investigate the myopigenic activity change and its risk factors in urban students in Beijing.

Methods: 241 primary or secondary students aged 6-17 years from the Beijing Myopia Progression Study (BMPS) were re-examined 3 years after their baseline enrollment. A detailed questionnaire was administered to assess myopigenic activities at both baseline and at the three-year follow-up. 217 students (90.0%) with completed data were included in the analysis.

Results: Compared to baseline, primary students (n=123) had significant increases in outdoor sports time (mean ± standard deviation: 3.5 ± 4.3 vs. 2.4 ± 3.0 hours/week, p=0.02), near work time (32.1 ± 13.4 vs. 24.8 ± 9.2 hours/week, p<0.001), diopter hours (128.8 ± 53.3 vs. 97.5 ± 35.9 diopter hours/week, p<0.001), and indoor time (53.8 ± 22.8 vs. 41.4 ± 16.9 hours/week, p<0.001) at the three-year follow-up. At both baseline and follow-up, females spent less time than males on outdoor sports (baseline: 2.4 ± 2.8 vs. 4.0 ± 5.2 hours/week, p=0.006; follow-up: 2.3 ± 3.1 vs. 5.1 ± 5.0 hours/week, p<0.001), and total outdoors (baseline: 11.9 ± 7.9 vs. 14.4 ± 9.5 hours/week, p=0.03; follow-up: 10.5 ± 8.2 vs. 13.9 ± 9.6 hours/week, p=0.005). In the multivariate regression analysis after adjustment by student’s gender, younger students had more increase in both near work time (slope= -0.99 hours/week for age, p=0.009) and indoor time (slope= -2.04 hours/week for age, p=0.001).

Conclusions: During the three-year follow-up, primary students had more myopigenic activities. Female students had more myopigenic activities than males at both baseline and follow-up. Children’s age was a significant risk factor for this myopigenic activity change.

Key words: myopigenic activity; near work; outdoor activity; myopia; risk factors
INTRODUCTION

Myopia is the most common visual disorder affecting children in East Asia.\textsuperscript{1-6} In the baseline report of the Beijing Myopia Progression Study (BMPS), we demonstrated that the generational myopic shift from parents to their children was approximately 2 diopters (D) and 1D in urban and rural Chinese students, respectively.\textsuperscript{7, 8} These data provide support that lifestyle and exposure to environmental factors contribute to the development of myopia. Among the environmental factors, daily activities such as near work and outdoor activities are generally thought to be key factors associated with myopic onset and/or its progression. In a recent school-based study, Wu et al. reported that the prevalence of myopia in 16-18 year old students in Beijing was over 80\%.\textsuperscript{9} Longitudinal studies in students of Beijing also found that close near work, less time on outdoor activities, and more time on indoor activities was significantly associated with more myopia progression.\textsuperscript{10-12}

Although daily activities are important environmental risk factors for myopic onset and its progression,\textsuperscript{13-16} few studies have assessed the change of children’s daily activities over time and their associated risk factors. French et al. reported that children in the Sydney Adolescent and Vascular Eye Study (SAVES) had significant decrease in amount of time on outdoor activities, and also had significant increase in near work time, in both 6 and 12 year-old cohorts, when re-examined 5 years later.\textsuperscript{17} The pattern of activity change in the girls and boys was similar.\textsuperscript{17} However, girls spent somewhat less time on outdoors and more time on performing near work than boys in both age cohorts at both baseline and at follow-up.\textsuperscript{17} To unravel the impact of daily activities on myopia, age-related changes in daily activities, and their risk factors need to be evaluated. This study analyzed data from both baseline and three-year follow-up from BMPS to assess the changes in the school children’s myopigenic activities, as well as their risk factors, in urban Beijing children.

METHODS

Subjects

The study design, procedures, and baseline characteristics of BMPS were reported elsewhere.\textsuperscript{18} Briefly, students (aged 6-17 years) from primary or secondary schools in the inner city of Beijing were recruited from July to September, 2010. The enrolled students were invited to be re-examined at the clinic center at a similar time of the year in 2011, 2012, and 2013. The parents of these
students were also invited to have a similar vision examination and questionnaire as their children at baseline. The study followed the tenets of the Declaration of Helsinki and was approved by the Beijing Tongren Hospital Ethics Committee. All participants (children and their parents) signed written informed assent/consent.

Three years after their baseline enrollment, 241 students (62.4%, 241/386) aged 6-17 years from the BMPS were re-examined from July to September in 2013. All students were required to complete a comprehensive vision examination, including visual acuity, A-scan ultrasound, and cycloplegic autorefraction (Canon, RK-F1). The students were also required to complete a detailed activities-related questionnaire.

Questionnaire

The myopia questionnaire used in the Sydney Myopia Study was translated into Chinese with minor modifications. Details of the myopia questionnaire on daily activities and their baseline results were reported elsewhere. For very young students who could not read or understand the questionnaire very well (e.g., primary students in grade one), help was sought from their respective parent(s) to complete the questionnaire. Estimates of the time children spent performing the various specified activities outside of school hours were recorded for weekdays and weekends during the school term. The daily activities were grouped into near work, diopter hours, outdoors (including outdoor leisure and outdoor sports), and indoors.

Data analysis

The average hours spent on near work activities were calculated from the time spent reading for pleasure, playing hand-held computer games, drawing or writing, and doing homework. Diopter hours were calculated using a modification of the Ip et al report: $3 \times (\text{hours of reading/drawing/writing + performing homework}) + 2 \times (\text{hours of computer usage + playing videogames/toys/musical instruments + doing crafts}) + \text{hours of television watching}$. Outdoor leisure activities were based on questions regarding playing outdoors, family picnics and barbeques, bicycle riding, and hiking. Time engaged in indoor sports activities was also estimated and incorporated into these findings. Total time spent outdoors was calculated as the sum of time spent in outdoor leisure activities and outdoor sports. Total time indoors was the sum of time spent on near work, cooking and fabricating things, doing crafts, playing a musical instrument, and computer and television hours per week. Time of activity change was defined as activity time at follow-up minus activity time at
The normally-distributed activity hours were presented as the mean ± one standard deviation. Activity hours between baseline and follow-up were compared with paired t-tests, while activity hours between males and females were compared using the Student t-tests. Univariate and multivariate linear regression models that adjusted by age and gender were conducted to assess their putative risk factors. All analyses were performed using Statistical Analysis System for Windows version 9.1.3 (SAS Inc., Cary, NC).

RESULTS

Of the 241 (62.4%, 241/386) students examined at both baseline and the three-year follow-up of BMPS, a total of 217 (90.0%, 217/241) with complete questionnaire data were included in this study. The baseline characteristics of these included students were shown in Table 1. The study included 106 (48.8%) boys and 111 (51.2%) girls, 123 (56.7%) primary students and 94 (43.3%) secondary students, respectively. The mean (± standard deviation) age at baseline was 8.4 ± 1.1 years and 14.2 ± 1.7 years for the primary and secondary students, respectively (Table 1). The mean follow-up time was 35.3 ± 2.5 months for both primary and secondary students. No significant difference was found at baseline between those children included versus those excluded from the study in gender (p=0.86), near work time (27.9 vs. 29.1 hours/week, p=0.34), total time indoors (46.0 vs. 46.8 hours/week, p=0.72), total time outdoors (13.1 vs. 12.9 hours/week, p=0.78), outdoor leisure time (10.0 vs. 10.1 hours/week, p=0.79), outdoor sports (3.2 vs. 2.8 hours/week, p=0.26), and indoor sports time (1.5 vs. 1.1 hours/week, p=0.13). There was also no significant difference found for paternal refraction (-2.11 ± 2.55 vs. -1.83 ± 2.29 D, p=0.27), maternal refraction (-2.39 ± 2.54 vs. -1.99 ± 2.36 D, p=0.12), paternal educational years (14.6 vs. 14.4 years, p=0.49) and maternal educational years (14.3 vs. 14.1 years, p=0.42), and the study pressure and motivation score (16.8 vs. 16.7 points, p=0.82). However, the included children were younger (10.9 vs. 11.6 years, p=0.02), and less myopic (-1.51 ± 2.46 vs. -2.09 ± 2.33 D, p=0.02).

The overall myopigenic activities at baseline and the three-year follow-up

Table 2 showed the comparison of various activity times between baseline and the three-year follow-up for primary students, secondary students separately and combined. Among all students combined, there was a significant increase from baseline in near work time (33.2 ± 14.0 vs. 27.9 ±
11.5 hours/week, p<0.001), diopter hours (129.6 ± 53.6 vs. 109.6 ± 46.8 diopter hours/week, p<0.001), time on doing crafts (2.9 ± 4.0 vs. 2.1 ± 3.2 hours/week, p=0.02), time on playing a musical instrument (3.3 ± 5.2 vs. 2.1 ± 3.5 hours/week, p=0.001), and indoor time (53.5 ± 22.8 vs. 46.0 ± 21.1 hours/week, p<0.001) at the follow-up. There was a decrease in the outdoor leisure time (8.5 ± 7.7 vs. 9.9 ± 7.0 hours/week, p=0.02).

For the primary students, there was a significant increase from baseline in the time on outdoor sports (3.5 ± 4.3 vs. 2.4 ± 3.0 hours/week, p=0.02), near work time (32.1 ± 13.4 vs. 24.8 ± 9.2 hours/week, p<0.001), diopter hours (128.8 ± 53.3 vs. 97.5 ± 35.9 diopter hours/week, p<0.001), time on doing crafts (4.2 ± 4.4 vs. 2.5 ± 2.9 hours/week, p<0.001), time on playing a musical instrument (4.3 ± 5.4 vs. 2.1 ± 3.3 hours/week, p<0.001), and indoor time (53.8 ± 22.8 vs. 41.4 ± 16.9 hours/week, p<0.001) at the follow-up.

For secondary students, although there was a decrease in the total outdoor time (10.9± 8.8 vs. 12.7 ± 9.8 hours/week, p=0.09) and an increase in the near work time (34.6 ± 14.8 vs. 32.00 ± 12.9 hours/week, p=0.19) at the follow-up, these changes were not statistically significant.

Both primary and secondary students had a significant decrease from baseline in the number of books read for leisure per week (1.00 ± 0.2 vs. 2.1 ± 2.4, p<0.001; secondary: 0.8 ± 0.4 vs. 1.9 ± 1.5, p<0.001) (Table 2).

**The myopigenic activities between male and female students**

Table 3 presented a comparison of activity time at baseline and follow-up between the male and female students. At both baseline and at follow-up, females spent significantly less time than males on outdoors (baseline: 11.9 ± 7.9 vs. 14.4 ± 9.5 hours/week, p=0.03; follow-up: 10.5 ± 8.2 vs. 13.9 ± 9.6 hours/week, p=0.005) and outdoor sports (baseline: 2.4 ± 2.8 vs. 4.0 ± 5.2 hours/week, p=0.006; follow-up: 2.3 ± 3.1 vs. 5.1 ± 5.0 hours/week, p<0.001), while spending more time on playing a musical instrument at follow-up (4.4 ± 5.9 vs.2.2 ± 4.1 hours/week, p=0.001).

**The risk factors for activities change**

Table 4 presents the risk factors for the changes of time spent on near work, outdoors, and indoors among all students. The univariate analysis showed that the younger the student, the more increase in near work time (linear slope= -0.93, p=0.01) and indoor time (linear slope= -1.95, p=0.002). After adjusting for gender, these associations remain significant for near work (adjusted slope= -0.99, p=0.009) and indoor time (adjusted slope= -2.04, p=0.001). No significant association
was found between the risk factors and change of daily activities.

**DISCUSSION**

The results of the present investigation reveal considerable activity changes in Chinese students over a three-year period. There were several important findings.

First, near work time increased in both primary and secondary students, particularly in the primary students (approximately 7.3 and 2.5 hours/week in primary and secondary students, respectively). The increase was much higher in the students of Beijing than reported by French et al in the Sydney Adolescent and Vascular Eye Study (SAVES), which was approximately 4 and 1 hours/week in the younger (mean 6.7 years old) and older (mean 12.7 years old) cohort of children, respectively. This may be related to the higher academic demands and pressure in the Chinese students. Furthermore, secondary students had a decrease in outdoor time, did not reach statistical significance (approximately 1.8 hours/week). This finding was comparable with what French et al. reported in an older cohort of children in SAVES (approximately 2.2 hours/week). However, it should be mentioned that the near work time was apparently more in our study than SAVES (e.g., Beijing: approximately 30 hours/week in secondary students vs. Sydney: approximately 20 hours/week in the older cohort of children), while the time outdoors was less than SAVES (e.g., Beijing: approximately 10 hours/week in secondary students vs. Sydney: approximately 16 hours/week in the older cohort of children).

Second, similar to that reported in SAVES, female students generally had more myopigenic activities, i.e., less time on total outdoors and outdoor sports than male students at both baseline and follow-up. Given the possible link between myopia and time spent outdoors, rather than sports per se, the time outdoors in the female students was found to be less (approximately 2.5 and 3.5 hours/week for baseline and follow-up, respectively) than their male counterparts. However, different from the French et al.’s report, the male and female students spent similar time on total near work at both baseline and follow-up in this study.

Third, for students who were younger, their time spent on near work and indoors was more likely to be increased, i.e., become myopigenic. The primary student’s near work time and indoor time increased in the follow-up as compared to their secondary counterparts (near work time: approximately 7.3 vs. 2.6 hours/week; indoor time: approximately 8.4 vs. 1.1 hours/week). In addition, the secondary student’s near work time was more than children at a similar age as reported...
in Sydney (near work time 32.0 vs. 21.76 hours/week). Thus, it is understandable that students who were younger or at a lower school grade had more years to increase their near work time and indoor time.

Our study has some potential limitations. First, the Beijing Myopia Progression Study was hospital-based rather than population-based. As a result, the study participants were more likely to have myopia as compared to the other population-based studies (myopia proportion: 66.8% vs. 55.0% for 15-year-old girls in a suburb of Beijing). This selection bias would probably lead to overestimate the myopigenic activity changes, i.e., overestimation of the increase in near work time and decrease in outdoor time. Second, a relatively large proportion of our study participants, especially the secondary students, were lost in the three-year follow-up. This could introduce the bias from missing data and reduce statistical power from smaller sample size. Since more primary school students were enrolled, this sample tended to be younger and less myopic. However, the mean difference in age between students completed the follow-up and students uncompleted the follow-up was small (only approximately 0.7 years). Third, similar to previously reported studies, the myopigenic activities were self-reported by the students (or with the help of parents for very young students). Estimation of activity time could be subject to recall bias. As a result, the extrapolation/generalization of the present study’s conclusion may be limited to some extent. School-based or population-based longitudinal studies with a larger sample size are warranted to validate our study finding.

In summary, in this urban sample, the primary students’ activities became more myopigenic, with female students having a more myopigenic activity pattern than males. Children’s age was an important risk factor for this myopigenic activity change.
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References


<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Primary students (n=123)</th>
<th>Secondary students (n=94)</th>
<th>Overall (n=217)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline age (years, mean ± SD)</td>
<td>8.4 ± 1.1</td>
<td>14.2 ± 1.7</td>
<td>10.9 ± 3.2</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>65/58</td>
<td>41/53</td>
<td>106/111</td>
</tr>
<tr>
<td>Baseline refraction (D, mean ± SD)</td>
<td>-0.46 ± 2.29</td>
<td>-2.86 ± 1.96</td>
<td>-1.51 ± 2.46</td>
</tr>
<tr>
<td>Paternal refraction (D, mean ± SD)</td>
<td>-2.40 ± 2.39</td>
<td>-1.69 ± 2.73</td>
<td>-2.11 ± 2.55</td>
</tr>
<tr>
<td>Maternal refraction (D, mean ± SD)</td>
<td>-2.57 ± 2.48</td>
<td>-2.14 ± 2.61</td>
<td>-2.4 ± 2.5</td>
</tr>
<tr>
<td>Paternal education year (mean ± SD)</td>
<td>14.5 ± 3.1</td>
<td>14.8 ± 2.7</td>
<td>14.6 ± 2.9</td>
</tr>
<tr>
<td>Maternal education year (mean ± SD)</td>
<td>14.2 ± 3.1</td>
<td>14.6 ± 2.7</td>
<td>14.4 ± 2.9</td>
</tr>
<tr>
<td>Study pressure and motivation (mean ± SD)</td>
<td>16.2 ± 3.5</td>
<td>17.6 ± 4.7</td>
<td>16.8 ± 4.1</td>
</tr>
<tr>
<td>Buildings in front of home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>19</td>
<td>17</td>
<td>36</td>
</tr>
<tr>
<td>&lt;5</td>
<td>46</td>
<td>44</td>
<td>90</td>
</tr>
<tr>
<td>≥5</td>
<td>58</td>
<td>33</td>
<td>91</td>
</tr>
<tr>
<td>Higher buildings in front of home (no/yes)</td>
<td>64/59</td>
<td>48/46</td>
<td>112/105</td>
</tr>
</tbody>
</table>

SD: standard deviation.

Buildings in front of house: was defined as the number of buildings which can be seen in front of children’s house on the ground; higher buildings in front of house: was defined as if there was higher buildings than children’s house within 30 meters from the window of children’s house.
Table 2 Time spent in various activities (mean and standard deviation, hours/week) between baseline and the three-year follow-up for primary and secondary students

<table>
<thead>
<tr>
<th>Activity</th>
<th>Primary students (n=123)</th>
<th>Secondary students (n=94)</th>
<th>Overall (n=217)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>p value</td>
</tr>
<tr>
<td>Time indoor</td>
<td>41.4 (16.8)</td>
<td>53.8 (22.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Near work</td>
<td>24.8 (9.2)</td>
<td>32.1 (13.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Television</td>
<td>6.3 (5.0)</td>
<td>6.5 (5.2)</td>
<td>0.80</td>
</tr>
<tr>
<td>Computer</td>
<td>3.7 (5.6)</td>
<td>4.5 (6.2)</td>
<td>0.26</td>
</tr>
<tr>
<td>Doing crafts</td>
<td>2.5 (2.9)</td>
<td>4.2 (4.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Playing musical</td>
<td>2.1 (3.3)</td>
<td>4.3 (5.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>instrument</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cook</td>
<td>1.9 (3.1)</td>
<td>2.2 (3.4)</td>
<td>0.39</td>
</tr>
<tr>
<td>Time outdoors</td>
<td>13.5 (8.0)</td>
<td>13.2 (9.2)</td>
<td>0.74</td>
</tr>
<tr>
<td>Outdoor leisure</td>
<td>11.1 (6.6)</td>
<td>9.7 (8.0)</td>
<td>0.11</td>
</tr>
<tr>
<td>Outdoor sport</td>
<td>2.4 (3.0)</td>
<td>3.5 (4.3)</td>
<td>0.02</td>
</tr>
<tr>
<td>Indoor sport</td>
<td>1.7 (2.3)</td>
<td>1.5 (2.0)</td>
<td>0.42</td>
</tr>
<tr>
<td>Diopter hours</td>
<td>97.5 (35.9)</td>
<td>128.8 (53.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Number of books read</td>
<td>2.1 (2.4)</td>
<td>1.0 (0.2)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Bold values are statistically significant.
### Table 3 Differences in time spent in the various activities (mean and standard deviation, hours/week) between male and female students at baseline and the three-year follow-up

<table>
<thead>
<tr>
<th>Activity</th>
<th>Baseline</th>
<th>P value</th>
<th>Baseline</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (n=106)</td>
<td>Female (n=111)</td>
<td></td>
<td>Male (n=106)</td>
</tr>
<tr>
<td>Time indoor</td>
<td>45.2 (17.8)</td>
<td>46.9 (23.9)</td>
<td>0.56</td>
<td>51.1 (18.7)</td>
</tr>
<tr>
<td>Near work</td>
<td>28.0 (10.8)</td>
<td>27.9 (12.2)</td>
<td>0.98</td>
<td>32.0 (12.3)</td>
</tr>
<tr>
<td>Television</td>
<td>7.0 (5.2)</td>
<td>6.9 (5.4)</td>
<td>0.90</td>
<td>6.7 (5.1)</td>
</tr>
<tr>
<td>Computer</td>
<td>5.4 (6.9)</td>
<td>5.0 (6.1)</td>
<td>0.65</td>
<td>5.3 (5.9)</td>
</tr>
<tr>
<td>Doing crafts</td>
<td>1.8 (2.8)</td>
<td>2.5 (3.5)</td>
<td>0.09</td>
<td>3.0 (4.0)</td>
</tr>
<tr>
<td>Playing musical instrument</td>
<td>1.7 (3.2)</td>
<td>2.5 (3.8)</td>
<td>0.09</td>
<td>2.2 (4.1)</td>
</tr>
<tr>
<td>Cook</td>
<td>1.4 (2.9)</td>
<td>2.1 (3.0)</td>
<td>0.09</td>
<td>2.0 (3.2)</td>
</tr>
<tr>
<td>Time outdoors</td>
<td>14.4 (9.5)</td>
<td>11.9 (7.9)</td>
<td><strong>0.03</strong></td>
<td>13.9 (9.6)</td>
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<tr>
<td>Outdoor leisure</td>
<td>10.4 (7.0)</td>
<td>9.5 (6.9)</td>
<td>0.31</td>
<td>8.9 (7.8)</td>
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<tr>
<td>Outdoor sport</td>
<td>4.0 (5.2)</td>
<td>2.4 (2.8)</td>
<td><strong>0.006</strong></td>
<td>5.1 (5.0)</td>
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<tr>
<td>Indoor sport</td>
<td>1.6 (2.6)</td>
<td>1.4 (2.1)</td>
<td>0.57</td>
<td>1.2 (1.8)</td>
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<tr>
<td>Diopter hours</td>
<td>108.6 (40.2)</td>
<td>110.6 (52.5)</td>
<td>0.75</td>
<td>123.6 (44.3)</td>
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<tr>
<td>Number of books read</td>
<td>2.0 (1.7)</td>
<td>2.0 (2.4)</td>
<td>0.96</td>
<td>0.9 (0.4)</td>
</tr>
</tbody>
</table>

Bold values are statistically significant.
Table 4 Linear regression analysis of risk factors (slope and p value) for the near work and outdoor activity change

| Variables | Change of near work time | | Change of time outdoors | | Change of time indoor | |
|-----------|--------------------------|----------------------|--------------------------|----------------------|--------------------------|
|           | Univariate               | Multivariate         | Univariate               | Multivariate         | Univariate               |
| Baseline age (years) | -0.93 (0.01) | -0.99 (0.009) | -0.20 (0.38) | -0.19 (0.42) | -1.95 (0.002) | -2.04 (0.001) |
| Gender |  |  |  |  |  | |
| Male | Ref | Ref | Ref | Ref | Ref | Ref |
| Female | 2.31 (0.34) | 3.10 (0.19) | -0.87 (0.55) | -0.72 (0.62) | 3.11 (0.43) | 4.73 (0.22) |
| School level |  |  |  |  |  | |
| Primary | Ref | Ref | Ref | Ref | Ref | Ref |
| Secondary | -4.69 (0.05) | 4.19 (0.45) | -1.45 (0.32) | -1.62 (0.63) | -11.22 (0.00) | 0.96 (0.92) |
| Baseline refraction (D) | 0.49 (0.32) | -0.16 (0.77) | 0.12 (0.68) | 0.03 (0.93) | 1.03 (0.20) | -0.29 (0.75) |
| Paternal refraction (D) | 0.46 (0.34) | 0.59 (0.22) | 0.45 (0.12) | 0.51 (0.08) | 0.31 (0.70) | 0.61 (0.44) |
| Maternal refraction (D) | 0.16 (0.74) | 0.36 (0.45) | 0.26 (0.37) | 0.30 (0.30) | 0.89 (0.26) | 1.32 (0.09) |
| Paternal education year | -0.13 (0.76) | -0.04 (0.92) | -0.33 (0.22) | -0.32 (0.22) | 0.26 (0.71) | 0.44 (0.53) |
| Maternal education year | -0.18 (0.69) | -0.09 (0.84) | -0.21 (0.42) | -0.21 (0.44) | -0.36 (0.62) | -0.19 (0.78) |
| Study pressure and motivation | 0.23 (0.42) | 0.32 (0.27) | 0.07 (0.72) | 0.10 (0.58) | 0.10 (0.83) | 0.28 (0.53) |
| Buildings in front of house |  |  |  |  |  | |
| No | Ref | Ref | Ref | Ref | Ref | Ref |
| <5 | 0.20 (0.96) | 0.43 (0.91) | 2.92 (0.21) | 3.03 (0.19) | -1.10 (0.85) | -0.49 (0.93) |
| ≥5 | 3.90 (0.29) | 3.79 (0.30) | 1.47 (0.52) | 1.36 (0.56) | 3.14 (0.60) | 2.68 (0.65) |
| Higher buildings in front of house |  |  |  |  |  | |
| No | Ref | Ref | Ref | Ref | Ref | Ref |
| Yes | -2.00 (0.42) | -2.08 (0.39) | -0.27 (0.86) | -0.29 (0.85) | -4.96 (0.22) | -5.13 (0.20) |

Ref: reference group. Bold values are statistically significant.

Activity change was defined as activity time at follow-up minus activity time at baseline.

Buildings in front of house: was defined as the number of buildings which can be seen in front of children’s house on the ground; higher buildings in front of house: was defined as if there was higher buildings than children’s house within 30 meters from the window of children’s house.

Multivariate*: adjusted for children’s age and gender. For baseline age and gender row, only gender and age was adjusted, respectively.