Background. The aim of our study was to evaluate the prevalence of myopia in elementary school students and to assess the risk factors for myopia. Methods. This school-based cross-sectional study was performed on students from two elementary schools in Jiaojiang, Taizhou City, China. A total of 556 students, whose age ranged from 9 to 12 years, were included. The uncorrected visual acuity and noncycloplegic refractive error tests were performed to determine the myopia. Each student was asked to fulfill the questionnaire about the possible factors associated with myopia. Multivariate logistic analyses of risk factors were conducted. Results. The overall prevalence of myopia among those students was 63.7%, ranged from 53.4% in grade 4 to 72.5% in grade 6. Multivariate logistic analysis showed that adjusting the height of desks and chairs according to the changing height and the presence of myopia in parents were significantly associated with myopia in these students, respectively. Conclusions. Our results showed that myopia among elementary school students was associated with environmental and hereditary factors.

1. Introduction

Myopia, also known as short-sightedness, is one of the leading causes of visual disability that develops primarily during childhood when excessive elongation of the eyes results in blurry distance vision and clear close vision [1]. The increasing prevalence of myopia is a global health and social problem [2]. Researchers have estimated that about 50% of the world’s population will be myopic and about 10% will be high myopic by 2050 [3]. The "myopia boom" is particularly prominent in urban areas of East and Southeast Asia, where 80% to 90% of high school graduates have myopia and about 20% have high myopia [4, 5]. As the most common visual impairment in children, myopia poses an enormous personal and social burden [6]. Additionally, children with high myopia are at high risk of developing irreversible visual impairment or blindness mostly due to retinal detachment, glaucoma, and myopic macular degeneration [7, 8].

Most myopic individuals are associated with excessive axial elongation, and very few occur as a result of disproportionately high corneal power [9]. For adults aged 50 or older, myopia can also be rarely caused by nuclear cataracts [9]. Both environmental and genetic factors impose a significant risk of myopia [10]. The identified genetic variants could explain about 12% of the variance of the refractive error trait [11, 12]. Tideman et al. found that different genetic loci were associated with different ages of axial length (AL) and corneal radius (CR) ratio [13]. Among those younger than 10 years, three loci (GJD2, CHRNG, and ZIC2) were associated with AL/CR. In people aged 10 to 25 years, four loci (BMP2, KCNQ5, A2BP1, and CACNA1D) were associated; and in adults (>25 years of age), 20 loci were associated. Environmental factors such as high levels of education, lack of outdoor exposure, and excessive near-work activities are the most established risk factors for myopia [1, 5]. A Mendelian
randomization study by Mountjoy et al. also showed that more time in education may be a causal risk factor for myopia [14]. Since refractive error correction could not prevent the myopic pathologies, preventing the myopia and particularly high myopia at the early age is of great significance [1, 4]. Each year of delay in the age at onset could substantially reduce the chance of developing high myopia in adulthood [15]. With the aim of discovering potentially effective prevention methods during childhood, in this cross-sectional study, we collected children potentially effective prevention methods during child-

myopia in adulthood [15]. With the aim of discovering significance [1, 4]. Each year of delay in the age at onset and particularly high myopia at the early age is of great prevent the myopic pathologies, preventing the myopia and the prevalence of myopia in primary school students. The frequencies of changing class seats and adjusting the height of desks and chairs were statistically associated with the presence of myopia ($P < 0.05$). Sleeping time more than 8 h and the presence of myopia in parents were also found to be associated with the prevalence of myopia ($P < 0.05$). No other factor showed a univariate association.

After adjusting the age and gender, adjusting the height of desks and chairs according to the changing height and the presence of myopia in parents were still associated with the prevalence of myopia (all $P < 0.05$, Table 3). Comparing with never adjusting the height of desks and chairs, adjusting the height of desks and chairs once a year and once a semester in total (OR = 0.37, 95% CI = 0.21–0.67, $P = 0.001$; OR = 0.60, 95% CI = 0.35–0.74, $P = 0.037$) and adjusting the height of desks and chairs once a year in school B (OR = 0.26, 95% CI = 0.11–0.62, $P = 0.003$) were protective factors. Parents having no myopia was a protective factor for myopia in total (OR = 0.51, 95% CI = 0.35–0.74, $P < 0.001$), school A (OR = 0.56, 95% CI = 0.34–0.93, $P = 0.026$), and school B (OR = 0.45, 95% CI = 0.25–0.83, $P = 0.009$), respectively.

### 3. Results

A total of 556 students (310 in school A and 246 in school B) were included in this study. The prevalence of myopia was 63.7%, with 64.8% in school A and 62.2% in school B. There is no statistical difference in the prevalence of myopia between the two schools ($P = 0.520$). The prevalence of myopia showed statistically different among grade 4, grade 5, and grade 6 in school B ($P < 0.001$) and total ($P = 0.001$), respectively. The average age of students with myopia was higher than those of normal students in school B and total (both $P < 0.001$). No statistical difference in the proportion of myopia was found between males and females (Table 1).

Table 2 shows the associations between factors studied and the prevalence of myopia in primary school students. The frequencies of changing class seats and adjusting the height of desks and chairs were statistically associated with the presence of myopia ($P < 0.05$). Sleeping time more than 8 h and the presence of myopia in parents were also found to be associated with the prevalence of myopia ($P < 0.05$). No other factor showed a univariate association.

After adjusting the age and gender, adjusting the height of desks and chairs according to the changing height and the presence of myopia in parents were still associated with the prevalence of myopia (all $P < 0.05$, Table 3). Comparing with never adjusting the height of desks and chairs, adjusting the height of desks and chairs once a year and once a semester in total (OR = 0.37, 95% CI = 0.21–0.67, $P = 0.001$; OR = 0.60, 95% CI = 0.35–0.74, $P = 0.037$) and adjusting the height of desks and chairs once a year in school B (OR = 0.26, 95% CI = 0.11–0.62, $P = 0.003$) were protective factors. Parents having no myopia was a protective factor for myopia in total (OR = 0.51, 95% CI = 0.35–0.74, $P < 0.001$), school A (OR = 0.56, 95% CI = 0.34–0.93, $P = 0.026$), and school B (OR = 0.45, 95% CI = 0.25–0.83, $P = 0.009$), respectively.

### 4. Discussion

In this study, we identified that adjusting the height of desks and chairs according to the changing height and the presence of myopia in parents were associated with myopia in elementary school students.

The prevalence of myopia in our study was 63.7%, which was similar to the myopia prevalence of 66.5% among
Table 2: The associations between factors and the prevalence of myopia.

| Parameters                                      | All (n = 556) | School A (n = 310) | School B (n = 246) |
|------------------------------------------------|---------------|-------------------|-------------------|
| Change class seats, n (%)                      |               |                   |                   |
| Never                                          | 0 (0.0%)      | 0 (0.0%)          | 0 (0.0%)          |
| Once a semester                                | 5 (55.6%)     | 2 (50.0%)         | 3 (60.0%)         |
| Once a month                                   | 49 (65.3%)    | 43 (68.3%)        | 6 (50.0%)         |
| Once a fortnight                                | 142 (44.0%)   | 142 (44.0%)       | 111 (45.8%)       |
| Once a week                                    | 44 (66.7%)    | 44 (66.7%)        | 33 (70.2%)        |
| Adjust the height of desks and chairs, n (%)   |               |                   |                   |
| Never                                          | 88 (66.7%)    | 37 (61.7%)        | 51 (70.8%)        |
| Once a year                                    | 44 (48.4%)    | 19 (70.4%)        | 25 (39.1%)        |
| Once a semester                                | 176 (65.9%)   | 104 (63.0%)       | 72 (70.6%)        |
| Once every 2 to 3 months                       | 46 (70.8%)    | 41 (70.7%)        | 5 (71.4%)         |
| Activity place during recess, n (%)           |               |                   |                   |
| Teaching building                              | 264 (63.9%)   | 153 (66.5%)       | 111 (60.7%)       |
| Outside teaching building                      | 90 (63.4%)    | 48 (60.0%)        | 42 (67.7%)        |
| Time for homework per day, n (%)               |               |                   |                   |
| <1 h                                           | 52 (65.0%)    | 48 (69.6%)        | 4 (36.4%)         |
| 1–1.99 h                                       | 157 (63.1%)   | 88 (66.2%)        | 69 (59.3%)        |
| 2–2.99 h                                       | 106 (65.4%)   | 47 (63.5%)        | 59 (67.0%)        |
| ≥3 h                                           | 37 (62.7%)    | 18 (56.3%)        | 19 (70.4%)        |
| Uncertain                                      | 2 (40.0%)     | 0 (0.0%)          | 2 (66.7%)         |
| Time for interest classes per week, n (%)      |               |                   |                   |
| 0 h                                            | 57 (60.0%)    | 33 (67.3%)        | 24 (52.2%)        |
| <1 h                                           | 17 (60.7%)    | 14 (58.3%)        | 3 (75.0%)         |
| 1–1.99 h                                       | 66 (64.7%)    | 43 (67.2%)        | 23 (60.5%)        |
| 2–2.99 h                                       | 81 (62.3%)    | 37 (59.7%)        | 44 (64.7%)        |
| ≥3 h                                           | 129 (66.2%)   | 73 (66.4%)        | 56 (65.9%)        |
| Uncertain                                      | 4 (80.0%)     | 1 (100.0%)        | 3 (75.0%)         |
| Parents limit sports time for study, n (%)     |               |                   |                   |
| Often                                          | 28 (60.9%)    | 17 (65.4%)        | 11 (55.0%)        |
| Sometimes                                      | 111 (65.7%)   | 60 (64.5%)        | 51 (61.7%)        |
| Never                                          | 215 (63.2%)   | 124 (64.9%)       | 91 (61.1%)        |
| Parents limit electronic products, n (%)       |               |                   |                   |
| Yes                                            | 323 (64.3%)   | 182 (66.2%)       | 141 (62.1%)       |
| No                                             | 31 (58.5%)    | 19 (54.3%)        | 12 (66.7%)        |
| Sit more than one punch-distance from the edge of the table when reading and writing, n (%) |               |                   |                   |
| Never                                          | 23 (59.0%)    | 15 (57.7%)        | 8 (61.5%)         |
| Sometimes                                      | 108 (62.1%)   | 57 (62.6%)        | 51 (61.4%)        |
| Often                                          | 129 (62.9%)   | 56 (63.6%)        | 73 (62.4%)        |
| Always                                         | 94 (68.6%)    | 73 (69.5%)        | 21 (65.6%)        |
| The distance between eyes and books is more than 33 cm when reading and writing, n (%) |               |                   |                   |
| Never                                          | 21 (53.8%)    | 15 (57.7%)        | 7 (50.0%)         |
| Sometimes                                      | 114 (62.3%)   | 57 (62.6%)        | 52 (66.7%)        |
| Often                                          | 137 (63.4%)   | 56 (63.6%)        | 79 (61.2%)        |
| Always                                         | 82 (70.1%)    | 73 (69.5%)        | 15 (62.5%)        |
| The distance between fingers and nib is about 3.3 cm when reading and writing, n (%) |               |                   |                   |
| Never                                          | 31 (53.4%)    | 15 (53.6%)        | 16 (53.3%)        |
| Sometimes                                      | 65 (61.9%)    | 38 (61.3%)        | 27 (62.8%)        |
| Often                                          | 125 (61.3%)   | 44 (57.9%)        | 81 (63.3%)        |
| Always                                         | 133 (70.7%)   | 73 (69.5%)        | 29 (65.9%)        |
| Teachers remind the gestures of reading and writing, n (%) |               |                   |                   |
| Never                                          | 28 (65.1%)    | 18 (66.7%)        | 10 (62.5%)        |
| Sometimes                                      | 75 (56.4%)    | 46 (61.3%)        | 29 (50.0%)        |
| Often                                          | 90 (64.7%)    | 47 (65.3%)        | 43 (64.2%)        |
| Always                                         | 161 (67.1%)   | 90 (66.2%)        | 71 (68.3%)        |
| Parameters | All (n = 556) | School A (n = 310) | School B (n = 246) | P value |
|-----------|--------------|------------------|------------------|---------|
| **Parents remind the gestures of reading and writing, n (%)** | | | | |
| Never | 13 (48.1%) | 9 (50.0%) | 4 (44.4%) | 0.145 |
| Sometimes | 60 (65.3%) | 37 (67.3%) | 33 (60.5%) | 0.079 |
| Often | 108 (60.3%) | 55 (61.1%) | 53 (59.6%) | 0.462 |
| Always | 173 (67.6%) | 100 (68.0%) | 73 (67.0%) | 0.379 |
| **Watching TV per day, n (%)** | | | | |
| Never | 51 (66.2%) | 33 (66.8%) | 18 (62.1%) | 0.145 |
| Sometimes | 86 (69.4%) | 56 (69.1%) | 30 (69.8%) | 0.379 |
| Often | 21 (72.4%) | 14 (87.5%) | 7 (53.8%) | 0.051 |
| Always | 6 (35.3%) | 1 (50.0%) | 2 (100.0%) | 0.051 |
| **Using computers per day, n (%)** | | | | |
| Never | 190 (64.0%) | 122 (66.7%) | 68 (59.6%) | 0.085 |
| Sometimes | 79 (68.7%) | 57 (65.5%) | 46 (65.3%) | 0.051 |
| Often | 4 (50.0%) | 3 (50.0%) | 1 (50.0%) | 0.051 |
| Always | 7 (75.0%) | 6 (50.0%) | 2 (100.0%) | 0.051 |
| **Using mobile devices more than 1 hour per day, n (%)** | | | | |
| Yes | 278 (63.3%) | 153 (65.4%) | 125 (61.0%) | 0.744 |
| No | 76 (60.5%) | 48 (63.2%) | 80 (39.0%) | 0.724 |
| **Reading books or electronic screens in direct sunlight, n (%)** | | | | |
| Never | 264 (62.3%) | 159 (64.9%) | 105 (58.7%) | 0.205 |
| Sometimes | 79 (68.7%) | 53 (63.5%) | 46 (73.0%) | 0.543 |
| Often | 4 (50.0%) | 3 (50.0%) | 1 (50.0%) | 0.051 |
| Always | 7 (87.5%) | 6 (85.5%) | 1 (100.0%) | 0.051 |
| **Turn off the light when looking at the electronic screen after dark, n (%)** | | | | |
| Never | 282 (63.5%) | 171 (65.0%) | 111 (61.3%) | 0.989 |
| Sometimes | 61 (66.3%) | 44 (66.7%) | 40 (67.8%) | 0.997 |
| Often | 5 (55.6%) | 4 (66.7%) | 1 (33.3%) | 0.597 |
| Always | 6 (60.0%) | 5 (62.3%) | 1 (50.0%) | 0.597 |
| **Reading or looking at electronic screens when walking or taking a bus, n (%)** | | | | |
| Never | 278 (63.2%) | 165 (65.5%) | 113 (60.1%) | 0.732 |
| Sometimes | 71 (65.7%) | 64 (64.0%) | 65 (61.9%) | 0.256 |
| Often | 5 (71.4%) | 1 (16.7%) | 5 (50.0%) | 0.051 |
| Always | 0 | 0 | 0 | 0.051 |
| **The lamp used when reading after dark, n (%)** | | | | |
| Both desk lamp and roof lamp | 230 (65.2%) | 123 (34.8%) | 105 (65.6%) | 0.354 |
| Only desk lamp | 24 (53.3%) | 14 (50.0%) | 10 (58.8%) | 0.237 |
| Only roof lamp | 99 (63.5%) | 61 (69.3%) | 38 (55.9%) | 0.376 |
| Others | 1 (100.0%) | 1 (100.0%) | 0 (0.0%) | 0.051 |
| **The distance between eyes and screens more than 66 cm when using computers, n (%)** | | | | |
| Never using computers | 115 (68.9%) | 77 (73.3%) | 38 (61.3%) | 0.884 |
| Never | 34 (59.6%) | 12 (54.5%) | 22 (62.9%) | 0.238 |
| Sometimes | 72 (62.6%) | 23 (63.4%) | 46 (62.2%) | 0.844 |
| Often | 57 (64.8%) | 23 (60.5%) | 34 (68.0%) | 0.238 |
| Always | 76 (59.4%) | 63 (60.6%) | 13 (54.2%) | 0.238 |
**Table 2:** Continued.

| Parameters | All (n = 556) | School A (n = 310) | School B (n = 246) |
|------------|---------------|--------------------|--------------------|
|            | Myopia (n = 354) | Normal (n = 202) | P value | Myopia (n = 201) | Normal (n = 109) | P value | Myopia (n = 153) | Normal (n = 93) | P value |
| **The distance between eyes and TV more than 3 m when watching TV, n (%)** | | | | | | | | | |
| Never watching TV | 28 (65.1%) | 15 (34.9%) | 17 (70.8%) | 7 (29.2%) | 11 (57.9%) | 8 (42.1%) | | | |
| Never | 27 (62.8%) | 16 (37.2%) | 13 (52.0%) | 12 (48.0%) | 14 (77.8%) | 4 (22.2%) | | | |
| Sometimes | 101 (70.6%) | 42 (29.4%) | 0.319 | 39 (70.9%) | 16 (29.1%) | 0.318 | | | |
| Often | 72 (63.2%) | 42 (36.8%) | 45 (70.3%) | 19 (29.7%) | 27 (54.0%) | 23 (46.0%) | | | |
| Always | 126 (59.4%) | 86 (40.6%) | 87 (61.3%) | 55 (38.7%) | 39 (55.7%) | 31 (44.3%) | | | |
| **Time on outdoor activities at daytime per day, n (%)** | | | | | | | | | |
| <1 h | 60 (59.4%) | 41 (40.6%) | 39 (62.9%) | 23 (37.1%) | 21 (53.8%) | 18 (46.2%) | | | |
| 1–1.99 h | 184 (68.9%) | 83 (31.1%) | 110 (69.2%) | 49 (30.8%) | 74 (68.5%) | 34 (31.5%) | | | |
| 2–2.99 h | 61 (62.2%) | 37 (37.8%) | 0.130 | 23 (67.6%) | 11 (32.4%) | 0.276 | | | |
| ≥3 h | 40 (54.1%) | 34 (45.9%) | 24 (53.3%) | 21 (46.7%) | 16 (55.2%) | 13 (44.8%) | | | |
| Uncertain | 9 (60.0%) | 6 (40.0%) | 5 (50.0%) | 5 (50.0%) | 4 (80.0%) | 1 (20.0%) | | | |
| **Sleeping time more than 8 h, n (%)** | | | | | | | | | |
| Yes | 346 (64.6%) | 190 (35.4%) | 0.025 | 197 (66.1%) | 101 (33.9%) | 0.043 | 149 (86.2%) | 89 (13.8%) | 0.724 |
| No | 8 (40.0%) | 12 (60.0%) | 4 (33.3%) | 8 (66.7%) | 4 (50.0%) | 4 (50.0%) | | | |
| **Father or mother has myopia, n (%)** | | | | | | | | | |
| Yes | 222 (69.4%) | 98 (30.6%) | 0.001 | 120 (70.6%) | 50 (29.4%) | 0.019 | 102 (68.0%) | 48 (32.0%) | 0.024 |
| No | 132 (56.2%) | 103 (43.8%) | 81 (57.9%) | 59 (42.1%) | 51 (53.7%) | 44 (46.3%) | | | |
| **Performed the examination of myopia in the past year, n (%)** | | | | | | | | | |
| Yes | 336 (64.2%) | 187 (35.8%) | 0.361 | 189 (65.4%) | 100 (34.6%) | 0.444 | 147 (62.8%) | 87 (37.2%) | 0.814 |
| No | 18 (56.3%) | 14 (43.8%) | 12 (57.1%) | 9 (42.9%) | 6 (54.5%) | 5 (45.5%) | | | |

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**Table 3:** The associations between factors and myopia using multivariate logistic regression.

| Parameters | All (n = 556) | School A (n = 310) | School B (n = 246) |
|------------|---------------|--------------------|--------------------|
|            | OR (95% CI) | P value | OR (95% CI) | P value | OR (95% CI) | P value |
| **Age** | 1.57 (0.87, 2.80) | 0.131 | 1.47 (0.55, 3.92) | 0.437 | 1.75 (0.82, 3.75) | 0.149 |
| **Grade** | | | | | | |
| 4 | 0.94 (0.26, 3.37) | 0.919 | 1.20 (0.15, 9.91) | 0.866 | 0.97 (0.16, 6.08) | 0.976 |
| 5 | 1.03 (0.48, 2.21) | 0.936 | 0.88 (0.27, 2.91) | 0.837 | 1.28 (0.39, 4.16) | 0.686 |
| 6 | Reference | Reference | Reference | Reference | | |
| **Gender** | | | | | | |
| Male | 0.98 (0.68, 1.42) | 0.914 | 0.87 (0.53, 1.44) | 0.596 | 1.08 (0.60, 1.95) | 0.795 |
| Female | Reference | Reference | Reference | Reference | | |
| **Change class seats** | | | | | | |
| Never | | | | | | |
| Once a semester | 1.09 (0.25, 4.82) | 0.907 | 0.83 (0.09, 7.82) | 0.867 | 1.07 (0.13, 8.73) | 0.950 |
| Once a month | 1.08 (0.52, 2.26) | 0.829 | 1.17 (0.38, 3.64) | 0.781 | 0.58 (0.12, 2.75) | 0.497 |
| Once a fortnight | 1.10 (0.61, 2.01) | 0.748 | 1.23 (0.43, 3.52) | 0.694 | 1.15 (0.50, 2.64) | 0.749 |
| **Adjust the height of desks and chairs** | | | | | | |
| Never | | | | | | |
| Once a year | 0.37 (0.21, 0.67) | 0.001 | 1.07 (0.36, 3.13) | 0.908 | 0.26 (0.11, 0.62) | 0.003 |
| Once a semester | 0.60 (0.35, 0.97) | 0.037 | 0.74 (0.34, 1.60) | 0.450 | 0.55 (0.22, 1.34) | 0.188 |
| Once every 2 to 3 months | 0.76 (0.37, 1.56) | 0.452 | 0.98 (0.38, 2.52) | 0.973 | 0.82 (0.13, 5.13) | 0.827 |
| **Sleeping time more than 8 h** | | | | | | |
| Yes | Reference | Reference | Reference | Reference | | |
| No | 0.45 (0.17, 1.18) | 0.103 | 0.29 (0.08, 1.03) | 0.055 | 1.15 (0.21, 6.18) | 0.870 |
| **Father or mother has myopia** | | | | | | |
| Yes | Reference | Reference | Reference | | | |
| No | 0.51 (0.35, 0.74) | <0.001 | 0.56 (0.34, 0.93) | 0.026 | 0.45 (0.25, 0.83) | 0.009 |
students of grades 4 to 6 in Yiwu, a county-level city of Zhejiang Province, China [16]. The prevalence of myopia was found to be positively associated with grade and age. For the intervention of myopia, spectacles and contact lenses are considered as the mainstay to improve distance vision [9]. Pharmacological intervention includes nonselective muscarinic antagonist atropine and the M1 receptor-specific antagonist pirenzepine, which are also used to control myopia [17, 18], whereas refractive surgeries including keratorefractive procedures and intraocular procedures are used to correct refractive error [19–21]. Although the symptoms of myopia can be alleviated with those management practices, the risk of complications from potentially blinding conditions such as retinal detachments increase with the longer AL associated with high myopia [7, 22]. The prevention or delay of myopia by controlling environmental and genetic risk factors at the early age should be the priority for myopia control.

Parents having no myopia were identified to be a protective factor for myopia, suggesting hereditary factors may play an important role in myopia. Verhoeven et al. had identified multiple susceptibility loci for refractive error and myopia [11]. Multiple studies have suggested the family history of myopia was significantly associated with myopia [23, 24]. In our study, adjusting the height of desks and chairs according to the changing height was also shown to be a protective factor, possibly due to the rapid change of stature in students of this age. The prevalence and the associations should be interpreted with caution because of the several limitations in this study. First, because of the relatively small sample size, some variates may not show a significant difference between myopic students and normal students, such as outdoor activities. Second, recall bias could exist in this cross-sectional study; hence, a longitudinal cohort trial was needed to further confirm the associations. Third, only two primary schools were included in this study, which led to a selection bias.

5. Conclusions

Our results showed that the prevalence of myopia among elementary school students was associated with environmental and hereditary factors.

Abbreviations

AL: Axial length
CR: Corneal radius
UCVA: Uncorrected visual acuity
OR: Odds ratio
CIs: Confidence intervals.

Data Availability

The data used to support the findings of this study are presented in the tables.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors’ Contributions

Xin Lu and Congcong Guo contributed equally to this work.

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