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Relationship between Visual Acuity and Lifestyle: A Cross-Sectional Study in Japanese Children

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ABSTRACT

Purpose: To evaluate poor visual acuity (PVA) prevalence and factors related to PVA, including parental myopia status and lifestyle, in primary school children.

Methods: Of total 220 primary school children from grades 4–6 in Hiroshima, 184 (83.6%) were enrolled in the study. They were divided into non-PVA (both eyes' acuities ≥ 1.0) and PVA (one or both eyes' acuity < 1.0 and/or wearing spectacles) groups. Data on lifestyle activities were obtained using self-reported questionnaires regarding daily lifestyle, including the duration of watching TV, playing games, using a computer, studying, number of books read per month, and outdoor activities.

Results: The total prevalence of PVA was 66.8%: 50.0% for grade 4, 71.4% for grade 5, and 74.6% for grade 6. In binary logistic regression models, children who had at least one parent with myopia showed greater PVA than those with parents without myopia (OR = 1.89; 95% CI, 1.14 to 3.15). In addition, weekend studying was significantly associated with PVA (OR = 1.48; 95% CI, 1.03 to 2.12), and the number of books read per month was associated with PVA (OR = 1.26, 95% CI, 1.05 to 1.51).

Conclusions: This study confirmed a high PVA prevalence in primary school children, and that the rate of PVA increased with advancing grade. Parental myopia was associated with PVA, as were long studying time and a high number of books read per month.

Key words: *Poor Visual Acuity Prevalence*, *Lifestyle*, *Japanese Children*, *Myopia*

INTRODUCTION

Myopia is one of the most common eye diseases among children. A high prevalence of myopia (80%) was reported among adolescents in China[1)] and it was 78% among those in South Korea[2)]; in contrast, low myopia prevalence rates were reported in south Asia, with a maximum rate of 19% in Nepal[3)], and 15% in India[4)]. In Japan, a study has indicated that the prevalence of myopia is 41.8% and that of high myopia is 8.2% among adults of age over 40 years[5)]; additionally, myopia prevalence is increasing dramatically among children and adolescents[6)]. According to the Vision 2020 report[7)], approximately 153 million people exhibit low vision, and blindness as uncorrected refractive errors and visual impairment myopia. Thus, myopia, particularly high myopia, is the chief cause of ophthalmic diseases including myopic glaucoma, myopic retinopathy, and retinal detachments[8–10)]. High myopia (defined as ≤ −6 diopters[11)]) is not acute, but gradually develops from mild myopia, and poor visual acuity (PVA) is a symptom of blurred distance vision. The primary cause of PVA is considered to be the presence of myopia during childhood[12)]. Because most cases of myopia begin in childhood[13,14)], it is necessary to focus on myopia assessment and prevention in children.

Several previous investigations have identified the genetic and environmental factors associated with myopia. Children of parents with myopia tended to have myopia[15)]. The ocular refraction of twins is similar, as reported by Lyhne et al[16)] and Hammon et al[17)]. Additionally, some environmental factors were associated with the incidence and progression of myopia; in particular, these included near work, outdoor activities, urban region, gender, educational level, and school type, as reported by previous studies[18–25)]. Most of these studies were performed in China, Australia, and Singapore; however, the lifestyle and living conditions of children are different in Japan, and prior studies are relatively limited. We performed a study to investigate whether lifestyle and other possible factors including grade and parental myopia were associated with PVA in Japanese children.

METHODS

Over a 2-week period beginning in June 2015, children in grades 4–6 at a single public primary school in Hiroshima, Japan were invited to participate. Of 220 children, a total of 184 children (90 boys and 94 girls, ages 10–12 years) agreed to participate in the study.

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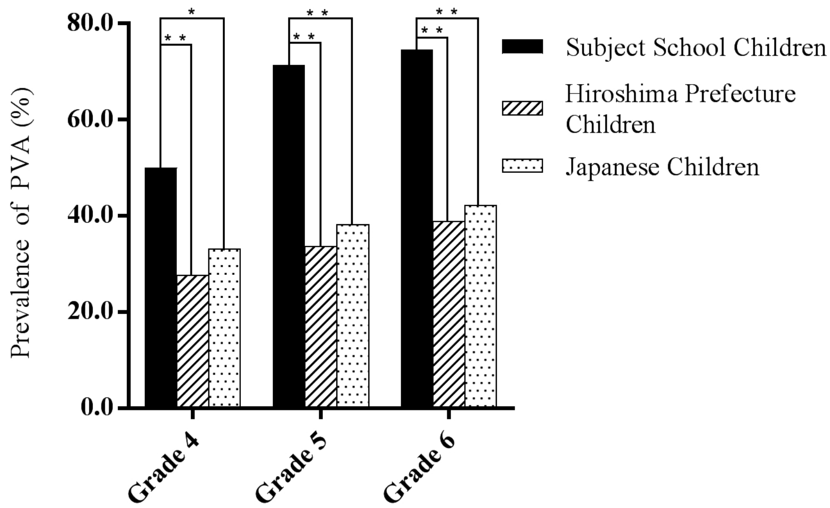

Figure 1 Comparison of PVA prevalence between the subjects of our study and Hiroshima prefecture and Japanese children included in the MEXT using the Run Test. PVA, Poor Visual Acuity; MEXT, Ministry of Education, Culture, Sports, Science and Technology. *p < 0.01, **p < 0.001.

Children with chronic medical conditions or eye diseases were excluded. We included only those children in grades 4–6 who could complete the questionnaire without assistance.

Children were asked to complete an extensive questionnaire selected from the annual National Academic Ability and Learning Situation Survey, published by the National Institute for Educational Policy Research (NIER)[26]. The items included assessments of time spent on a variety of activities, such as watching television, playing games, using a computer, reading books, studying, and sleeping. All activities were performed on both weekdays and weekends, except for book reading, and the number of parents with myopia (none, one, or two) based on use of spectacles or contact lenses for distance vision was assessed[27].

Data of the participants' visual acuity, height, and weight were collected from the records of an annual school health examination survey conducted in April 2015. Visual acuity was measured by the Landolt C chart at 5 meters. The primary schools' president committee granted permission to provide the researchers with health examination data of the students participating in the study, and for all children, written parental permission was obtained. The study protocol was approved by the Human Ethics Committee of Hiroshima University. The children voluntarily completed a self-selected questionnaire of lifestyle activities.

Definitions

According to the definition used by the Japan school health statistics survey per Ministry of Education, Culture, Sports, Science and Technology (MEXT)[28] and in a previous study[29], non-PVA was defined as visual acuity ≥ 1.0 in both eyes, and PVA as use of spectacles/contact lenses or visual acuity < 1.0 in either one or both eyes.

Analysis

Data analysis was performed using the statistical package for social sciences (SPSS, version 22.0, IBM, Chicago, USA). Statistical significance was assumed at $p < 0.05$. Comparison of the PVA prevalence between the subjects of our study and Hiroshima prefecture and Japanese children included in the MEXT survey was conducted using the Run Test. The associations between PVA and factors of lifestyle activities were identified using Student *t* tests for normally distributed variables, Mann-Whitney U tests for variables that were not normally distributed, and chi-squared test for categorical variables. All examined variables were included in the binary logistic regression analysis through the stepwise method to identify independent risk factors. Odds ratios and 95% confidence intervals (CI) were determined.

RESULTS

A total of 184 children in grades 4–6 participated in the study, including 90 boys (48.9%) and 94 girls (51.1%). The response rate was 83.6%. The total prevalence of PVA was 66.8% (n = 123), 61.1% (n = 55) in boys and 72.3% (n = 68) in girls ($\chi^2 = 2.616$, $p = 0.106$).

As shown in Figure 1, the prevalence of PVA increased with advancing grade, with 50% in grade 4, 71.4% in grade 5, and 74.6% in grade 6. In comparison, MEXT data published in March 2016[30], showed that the PVA prevalence in Japanese children was 33.0% in grade 4, 38.3% in grade 5, and 42.3% in grade 6. Thus, the prevalence in the present study was significantly higher at all grades. In addition, the PVA prevalence in the subject school children was significantly higher than that in the Hiroshima Prefecture children[30] (27.7% in grade 4, 33.8% in grade 5, and 38.9% in grade 6).

As shown in Table 1, having parents with myopia was strongly related with the presence of PVA in children in the study ($\chi^2 = 6.55$, $p = 0.038$). A total of 75.8% of children who had two parents with myopia had PVA, compared with those who only had one parent with myopia (58.1%), or no parents with myopia (57.9%).

The average height in the non-PVA group was 139.17 ± 8.16 cm; in the PVA group, it was 141.14 ± 8.37 cm (*t*

Table 1 Parental Myopia among Children with Non-PVA and PVA.

Parental Myopia (n = 184)	Non-PVA % (n)	PVA % (n)	χ^2	p
None (n = 19)	42.1 (8)	57.9 (11)		
One parent (n = 74)	41.9 (31)	58.1 (43)	6.55	0.038
Two parents (n = 91)	24.2 (22)	75.8 (69)		

Non-PVA, Non Poor Visual Acuity; PVA, Poor Visual Acuity.

Table 2 Lifestyles of Children with and without PVA.

Parameter	Non-PVA Mean (SD)	PVA Mean (SD)	p
Reading books, No./month	2.97 (1.99)	3.98 (1.80)	0.001
Weekday, hours/day			
Watching TV	1.52 (1.23)	1.15 (0.99)	0.096
Playing games	0.38 (0.73)	0.24 (0.53)	0.314
Using a computer	0.25 (0.44)	0.22 (0.53)	0.263
Sleeping	7.34 (0.86)	7.09 (0.79)	0.06
Studying	2.12 (1.05)	2.59 (0.93)	0.004
Outdoor activity	0.57 (0.68)	0.52 (0.70)	0.054
Weekend, hours/day			
Watching TV	2.05 (1.12)	1.85 (0.97)	0.225
Playing games	0.64 (0.99)	0.49 (0.86)	0.512
Using a computer	0.47 (0.64)	0.35 (0.71)	0.086
Sleeping	7.84 (0.77)	7.74 (0.78)	0.359
Studying	2.35 (1.15)	2.90 (0.89)	0.001
Outdoor activity	1.14 (0.90)	1.00 (0.81)	0.209

Mann-Whitney U tests were performed.
Non-PVA, Non Poor Visual Acuity; PVA, Poor Visual Acuity; SD, Standard Deviation

Table 3 Factors associated with PVA based on binary logistic regression.

Parameter	Odds Ratio	95% CI	p
Sex	1.03	0.51–2.08	0.944
Grade	1.43	0.91–2.24	0.119
Parental myopia	1.89	1.14–3.15	0.014
Weekend studying (hours/day)	1.48	1.03–2.12	0.033
Reading books (No./month)	1.26	1.05–1.51	0.014

PVA, Poor Visual Acuity; CI, Confidence Interval.

= −1.107, p = 0.27). Body weights were 33.55 ± 6.98 kg and 34.84 ± 7.68 kg in the non-PVA and PVA groups, respectively (t = −1.514, p = 0.132).

As shown in Table 2, our study showed absence of associations between PVA and watching TV/playing games. On average, the non-PVA group spent more time involving TV and games on weekdays than the PVA group, with similar results obtained on weekends, indicating that the non-PVA group spent more time involved with TV and games. Comparisons of the time spent using a computer were similar, but the differences did not achieve statistical significance.

The average time spent studying, including homework and remediation, was 2.12 ± 1.05 hours in the non-PVA group and 2.59 ± 0.93 hours in the PVA group on weekdays (p = 0.004). The same trend was observed on weekends (non-PVA, 2.35 ± 1.15 hours vs. PVA, 2.90 ± 0.89 hours; p = 0.001). Regarding the number of books read per month, the PVA group reported significantly higher number of books than the non-PVA group (3.98 ± 1.80 vs. 2.97 ± 1.99; p = 0.001).

The non-PVA group tended to sleep longer on weekdays than the PVA group (7.34 ± 0.86 hours vs. 7.09 ± 0.79 hours; p = 0.06); the results were nearly identical for weekends, although in both groups, the durations of sleep were longer than those on weekdays (7.74 ± 0.78 hours vs. 7.84 ± 0.77 hours; p = 0.359). In addition, there was no significant difference in the time spent on outdoor activities per day at either weekdays or weekend.

All examined variables were included in the binary logistic regression model (Table 3). After adjusting for sex and grade, children who had at least one parent with myopia showed greater PVA than those with parents without myopia (OR = 1.89; 95% CI, 1.14 to 3.15). Weekend study duration was significantly associated with PVA (OR = 1.48; 95% CI, 1.03 to 2.12). In addition, the number of books read per month was associated with PVA (OR = 1.26; 95% CI, 1.05 to 1.51).

DISCUSSION

The present study explored the relationships between Japanese children's current lifestyle habits and PVA. As a result, parental myopia, reading books, and studying were associated with PVA. However, there was no relation between PVA and watching TV, playing games, using a computer, sleeping, and outdoor activity.

In the present study, we confirmed the higher prevalence of PVA with increases at increasing grade level. The prevalence of PVA in our subjects was significantly higher, compared with that at same grade in Hiroshima Prefecture children and Japanese children. The high prevalence of PVA may be due to location of the school in urban region, and category of principal/key school in the city. Guo et al[22] suggested that children in urban regions had greater ocular axial length and higher prevalence of myopia than children in rural areas surrounding Beijing. Urbanization is considered to be associated with increased myopia prevalence because of fewer green spaces, less outdoor activity, and reduced variation in lifestyle in urban districts[23,24]. The findings in the present study are consistent with those published by You et al[25] indicating that children in a key school showed higher prevalence of myopia and higher myopic refractive error than children in a non-key school. In Singapore, a cross-sectional study showed that children with higher Intelligence Quotient (IQ) scores tended to have myopia[31]. Mutti and colleagues reported that high school achievement scores were a risk factor for myopia in children[32]. The previous studies reported that, for better achievements and passing entrance examinations for key junior and senior high schools, as well as universities, children experienced a high burden of continuous near work and minimal time for outdoor activities[1].

In our study, the results indicated that parental myopia was associated with PVA in children, which corroborates results from previous studies. Sydney Myopia Study (SMS) suggested that the children who had at least one parent with myopia were more likely to have myopia than children whose parents did not exhibit myopia (OR = 7.9; 95% CI, 5.0 to 12.4)[15]. Likewise, Singapore Cohort Study of the Risk Factors for Myopia (SCORM) reported that the presence of two parents with myopia was associated with an increased incidence of myopia in children[14]. In a population-based study including 20–45-year-old twins, Lyhne et al showed that ocular refraction was similar in twins[16]. These studies suggest that one or more genetic factors are strong influencing factors for PVA. However, the habits or lifestyle of the parents also affect the children. For instance, parents who spend more time on reading or outdoor activities may engage their children in similar activities.

Our study determined that weight or height were not significantly associated with PVA, similar to previous studies including schoolchildren of age 6–7 years (SMS)[33] and Singaporean Chinese adults of age 40–82 years (Tanjong Paper Survey)[23]. However, a study including Singaporean Chinese preschool children of age 6–72 months showed that a 1-cm increase in height was associated with the increased spherical equivalent refraction of 0.01 diopters in the myopic direction[14]. In the present study, the subjects were children in grades 4–6 (age, 10–12 years), suggesting that the association between height and PVA may substantially differ between preschool children and older school children or adults.

The behaviors of using digital devices such as watching TV, playing games, and using a computer were not significantly different between the PVA and non-PVA groups in our study. In contrast, a large population-based longitudinal investigation in young adults in Spain reported that computer use at longer duration was associated with the progression or development of myopia[34]. A study including junior high school female students showed that the distance of watching TV was a more significant factor than time spent on watching TV for reduced visual acuity[35]. Unlike using a computer or watching TV, studying and reading books are performed under lower light conditions and involve small-sized print; in addition, the distance of studying and reading is lower. Further study is required to clarify the effects of digital device usage or the distance of usage on visual acuity.

In the present study, studying and reading books was associated with PVA, in accordance with previous studies. SMS showed that among 2,339 children of age 11.1–14.4 years, controlling for sex, age, ethnicity, and parental myopia, near work was associated with myopia; continuous reading for up to 30 minutes and reading distance of < 30 cm were factors of increased risk of myopia[36]. Among 1,005 children of age 7–9 years, Saw et al[37] reported that those who read two books per week had three-fold greater risk for development of myopia as compared to the other children; moreover, the mean diopter and axial length of children whose parents had myopia and who read more than two books per week were −1.33 D and 23.78 mm, respectively; the corresponding measurements for children whose parents did not have myopia and who read fewer than two books per week were −0.19 D and 23.2 mm, respectively. Mutti et al[32] conducted a study on 366 American children (mean age, 13.7 years) and reported that the multivariate OR of myopia for each diopter-hour per week was 1.02 (95% CI, 1.008 to 1.032). In a Greek study, intensive daily study was found to be more frequent among children with myopia than in those who did not exhibit myopia[38].

In recent years, several studies have indicated that outdoor activity is a potential environmental factor to strongly affect decreased myopia prevalence or protect against the onset of myopia. In Orinda longitudinal study on myopia including 514 children in grades 3–8, the time spent on outdoor activities in grade 8 children with myopia (≤ −0.75) was significantly different compared with that in the non-myopia children (mean 11.65 hours vs. 7.98 hours)[39]. The SMS study showed that children of age 11–14 years (adjusted for sex, age, parental myopia, near work, and education), who spent more time outdoors were protected against myopia progression[20]. SCORM including 1,249 Singaporean children of age

11–20 years, showed that among those who spent 1 hour per day outdoors, the diopter was increased by 0.17D and the axial length was decreased by 0.06 mm[21]. However, we did not find any association between outdoor activity and PVA in our study. It is possible that these children daily spend a large amount of time studying with minimal time for outdoor activities resulting in lost balance in daily activities.

In our study, the questionnaires were selected from NIER and completed independently by the children themselves, which increases the reliability of results. However, our study has potential limitations. Children from grades 4–6 were enrolled and the response rate was high, but the study was limited by a small sample size, which might cause selection bias. Because this school was the key type in Hiroshima, the durations of studying, and outdoor activities were different from those of children in non-key schools. Moreover, it may not be representative of Japanese children and cause misclassification bias. Further, cycloplegia was not evaluated with regard to visual acuity in the annual school health examination, and this may cause inaccurate classification because of active accommodation, although the same standard of classification was applied to the PVA and non-PVA groups as that in the MEXT[28] and previous study[29]. Moreover, very few children with hyperopia, amblyopia, or astigmatism may have been included in the PVA group, although published school health trends indicate that the presence of myopia during childhood may be one of the main reasons for the development of PVA[12]. Lifestyle data were collected using self-reported questionnaires, which may cause recall bias. However, these participants were thorough and the self-reported data may be considered reliable. The result of PVA assessment affected daily life; in addition, the lifestyles of children may have changed at post survey. Future studies evaluating changes in lifestyle are required. For instance, in order to reduce recall bias, the steps, sleep duration, outdoor activity and even reading distance may be measured through objective wearable devices, instead of recall questionnaires. Data from devices are likely to be more objective and accurate.

In conclusion, our study confirmed that both genetic and environmental factors were associated with PVA. The identification of potential factors for PVA including reading books, studying, and parental myopia in our study may have important school health significance. In the society that emphasizes the importance of study in childhood, healthy eye care promotion should encourage children to study at proper distance and take breaks during continuous reading. Eye care education programs, including lectures on healthy eye behaviors, as well as promoting awareness on prevention, and treatment of myopia, and eye health development, are needed. Parents should be invited to participate in the eye care education program, as the success of any measures requires parental awareness of the condition and acceptance of recommended healthy eye behaviors. The present findings can increase the understanding of the significance of the child's and parental roles in healthy eye behaviors and contribute to future eye health policy.

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