Impact of Uncorrected Refractive Error on Junior High School Student's Academic Performance

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Abstract: **Background:** Uncorrected refractive error was the primary cause of visual impairments in children and can leading to delays in academic development. **Objective:** This study aimed to investigate the association between uncorrected refractive errors in children and their academic performance. **Methods:** Ninety-one students from three classes selected randomly at a public junior high school in Padang, Indonesia, were included in this study. All students were interviewed and then underwent visual acuity and refractive examination. Student's academic performance was assessed based on student reports from the last two semesters. **Results:** Most students are emmetropic (56.0%); however, one-fourth (25.3%) have uncorrected refractive error. Most students with uncorrected refractive error (69.6%) have no history of wearing eyeglasses. The mean presenting visual acuity of students with the uncorrected refractive error was 0.22±0.13, significantly lower than emmetropic students and students with no significant/corrected refractive error ($p<0.001$). Students with an uncorrected refractive error have no significant difference in mean report marks (89.00±2.07) from students in the other two groups (p:0.379).**Conclusion:** Poor distance visual acuity did not correlate with poor academic performance. Concerning most students with uncorrected refractive error who did not have eyeglasses, the provision of spectacles is essential in providing reasonable distance visual acuity.

1 INTRODUCTION

Uncorrected refractive error is the primary cause of visual impairments in children and adults. Globally, from 338 million people with visual impairment, about 153 million are affected by uncorrected distance refractive error, 8 million are blind, and 145 million have significant distance visual impairment [1, 2]. In children, the prevalence of refractive error varied around the world, from as low as 1,58% in Nepal [3] to as high as 9,84% in Chile [4] and 11,3% in China [5]. About 12.8 million children worldwide aged 5–15 years are estimated to be visually impaired from uncorrected corrected refractive errors [6].

Uncorrected refractive errors can result in immediate and prolonged repercussions for children and adults, including missed educational and employment prospects, diminished economic productivity for individuals, families, and societies, and compromised quality of life [6, 7]. Children's learning and educational advancement heavily rely on vision, so any visual impairment could diminish their motivation to explore the environment, engage in social interactions, or interact with objects. Failure in children's education may ensue if visual impairment remains uncorrected or undetected promptly [8].

Studies in China [9, 10], Nigeria [11], and Lahore [12] showed that the academic performance of students was improved after refractive error correction with eyeglasses. However, studies in Singapore [13], China [14], and Lisbon [15] have shown that students' refractive error status did not correlate significantly with academic performance. These contradictive results warrant further investigation into the role of vision on student's academic performance.

The prevalence of refractive error in Indonesian school-aged children is about 15,9% [16] and 18.39% [17],

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far above the estimated prevalence of refractive error at 4,9% in South East Asia children [18]. The prevalence of uncorrected refractive error in Indonesian children is also relatively high. Studies in Bandung [16] and Yogyakarta City [19] showed the prevalence at 12,1% and 12,3%, respectively, in school-aged children. However, studies about the impact of uncorrected refractive errors on students' academic performance in Indonesia are very limited. Therefore, this study aims to investigate the impact of uncorrected refractive error on academic performance in junior high school students. Another study's aim is to investigate other factors besides vision which can contribute to academic performance.

2 METHODS

This study was an analytic observational study with a cross-sectional design. This study occurred at a Public Junior High School in Padang, Indonesia, in September 2019. The Ethics Committee of the Faculty of Medicine, Andalas University, approved this study with an ethical clearance number of 530/UN.16.2/KEP-FK/2021. The research was carried out following the principles of the Declaration of Helsinki. All students provided written informed consent before participating in the study. We conducted visual acuity and refractive examinations on 91 students from three classes selected randomly. Student's academic performance was assessed based on student reports from the average marks of the last two semesters. Students' marks on various subjects, including mathematics, biology, physics, English language, art, culture, and social sciences, were collected.

All students were interviewed to collect data about family history of refractive error, history of wearing eyeglasses, duration of reading or near work activity in a day, duration of playing gadgets in a day, and duration of outdoor activity in a day. Then, the students had a visual acuity examination using the Snellen chart. Students with eyeglasses did the visual acuity examination while wearing his/her eyeglasses. The results of the visual acuity examination are converted to decimal units for statistical analysis. The objective refractive examination was done using an auto-refractometer without cycloplegy, followed by a subjective refractive examination. The spherical and cylindrical power of the student's refractive error correction was recorded as spherical equivalent power—lens meter examination done to record the spherical and cylindrical power of the student's previous eyeglasses.

Student's refractive error status was categorized as emmetropic if a student had visual acuity of 20/20 or 20/25 (1 or 0,8 in decimals unit, respectively) in both eyes and spherical equivalent power less than plus or minus half diopter. Student's refractive error status categorized as not significant refractive error or corrected refractive error if a student had visual acuity better than or equal to 20/40 (0,5) in both eyes with no history of wearing eyeglasses or with using his/her previous eyeglasses, respectively. A student's refractive error status is categorized as an uncorrected refractive error if a student has visual acuity worse than 20/40 (0,5) in both eyes with no history of wearing eyeglasses or using his/her previous eyeglasses.

Statistical analysis is computerized with descriptive analysis to present category and continuous variables. Descriptive analysis was presented as figures and tables. The figure shows frequency as the y-axis and continuous variables as the x-axis. Categorical variables are presented as frequency and percentage. Continuous variables are presented as mean ± standard deviation. The mean comparison of continuous variables was analyzed using the Independent sample T-test and one-way ANOVA test, which was followed by Bonferroni adjusted post-hoc. A p-value <0.05 is statistically significant with a 95% confidence interval).

3 RESULTS

Demographic characteristics of students are presented in Table 1. More female students participated in this study, with the youngest age was 12 years old and the oldest age was 15 years old. Many of the students did not have a family history of refractive error. Most students have reading and gadget playing time of less than 3 hours a day. Most students have long outdoor time, which is more than 2 hours a day. Most students' spherical equivalent power was between -3.50 diopters and +1.00 diopters (Fig. 1), and the student's mean report marks were commonly between 83.0 and 95.0 (Fig. 2).

Table 2 shows that most students are emmetropic. However, about one-fourth of the students had uncorrected refractive errors. Moststudents with uncorrected refractive errors have no history of wearing eyeglasses. If they already have eyeglasses, they do not have the correct eyeglasses prescription.

Table 3 shows a significant difference in mean visual acuity between three groups of students, with students with uncorrected refractive error having the worst mean visual acuity. Nevertheless, the difference in mean visual acuity does not affect the student's academic performance regarding report

marks. Students with uncorrected refractive errors have similar mean report marks to students in the other two groups.

Table 1: Demographics characteristic of students.

Variables	
Gender (n)	
Male	38 (41.8%)
Female	53 (58.2%)
Age (Mean ± SD. (95% CI))	13.56 ± 0.54 (13.45-13.67)
Family history of refractive error (n)	
No history	39 (42.9%)
One of the parents	23 (25.3%)
Both of the parents	29 (31.9%)
Reading/Near work activity/day (n)	
Less than 3 hours	46 (50.5%)
Between 3 to 6 hours	31 (34.1%)
More than 6 hours	14 (15.4%)
Gadget/screen time/day (n)	
Less than 3 hours	51 (56.0%)
Between 3 to 6 hours	31 (34.1%)
More than 6 hours	9 (9.9%)
Outdoor activity/day (n)	
Less than 2 hours	32 (35.2%)
More than 2 hours	59 (64.8%)

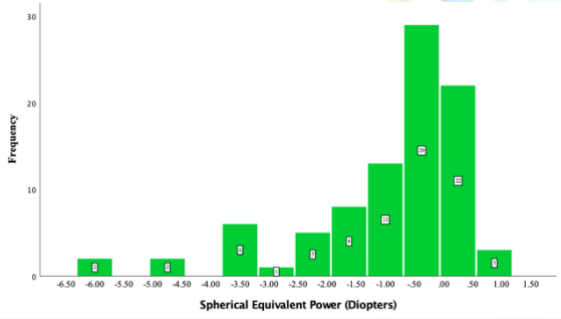

Figure 1: Distribution of spherical equivalent power of student's refractive error correction

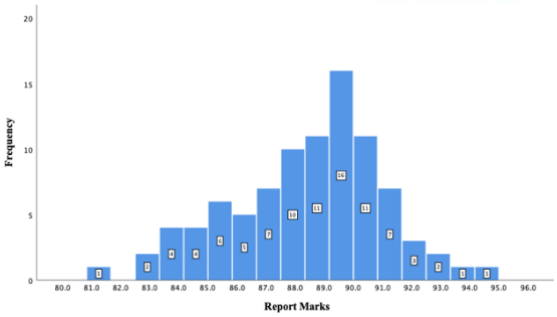

Figure 2: Distribution of student's mean report marks.

Table 4 shows that reading activity affects the student's academic performance more significantly than the refractive error status of the students. Students with a reading time of more than three hours a day have better mean report marks. Student's gadget playing time in a day does not significantly impact mean report marks.

Table 5 shows that students with more prolonged reading and gadget playing time in a day have higher mean spherical equivalent than the shorter one, although not statistically significant. The reading activity showed a greater effect on the severity of refractive error than the gadget-playing activity. Otherwise, students with more prolonged exposure to sunlight outside time have a lower mean spherical equivalent than the shorter one.

4 DISCUSSION

The degree of refractive error that affected the child in this study was mostly mild refractive error, with the most common form being myopia. Previous studies [19-24] also found that myopia was the most common refractive error in children in Southeast Asia. About 25.3% of children suffered visual impairment due to uncorrected refractive error. Studies in South Africa [25] and Yogyakarta, Indonesia [19] found a higher prevalence of visual impairment at 36.3% and 45.7% in school children due to uncorrected refractive error, respectively. However, studies in India [26], Nigeria [27], and Bhutan [28] found a lower prevalence of visual impairment at 2.7%, 3.4%, and 12.8% in school children due to uncorrected refractive error, respectively. In the Asia Pacific region, uncorrected refractive error contributed to 49.38% (47.39%–51.11%) of the eye conditions that caused moderate-to-severe visual impairment in 2020 [29].

Table 2: Refractive error and eyeglasses prescription status.

Refractive Error Status	Eyeglasses Prescription				Total
	No refractive error	Had a refractive error with the correct eyeglasses prescription	Had a refractive error with incorrect eyeglasses prescription	Had a refractive error and no eyeglasses prescription	
Emmetropic child	51 (100%)	-	-	-	51 (56.0%)
Child with no significant/corrected refractive error	-	12 (70.6%)	-	5 (29.4%)	17 (18.7%)
Child with uncorrected refractive error	-	-	7 (30.4%)	16 (69.6%)	23 (25.3%)
Total	51 (56.0%)	12 (13.2%)	7 (7.7%)	21 (23.1%)	91 (100%)

Table 3: Mean visual acuity and report marks based on the refractive error status of the students.

Refractive Error Status	Mean Presenting Visual Acuity + SD (95% CI)	p	Mean Report Marks + SD (95% CI)	p
Emmetropic child	0.97 ± 0.06 (0.95 - 0.99)	<0.001	88.33 ± 2.82 (87.53 - 89.12)	0.379
Child with no significant/corrected refractive error	0.68 ± 0.20 (0.58 - 0.79)		87.89 ± 2.49 (86.60 - 89.17)	
Child with uncorrected refractive error	0.22 ± 0.13 (0.17 - 0.28)		89.00 ± 2.07 (88.11 - 89.90)	

Table 4: Mean report marks based on student's activity.

Activity	Mean Report Marks + SD (95% CI)	P
Reading/Near work activity/day		
Less than 3 hours	87.64 ± 2.55 (86.88 - 88.39)	0.014
Between 3 to 6 hours	89.19 ± 2.50 (88.28 - 90.11)	
More than 6 hours	89.24 ± 2.24 (87.94 - 90.53)	
Gadget/screen time/day		
Less than 3 hours	88.56 ± 2.52 (87.85 - 89.27)	0.605
Between 3 to 6 hours	88.40 ± 2.64 (87.44 - 89.37)	
More than 6 hours	87.62 + 2.94 (85.35 - 89.88)	

Table 5: Mean spherical equivalent based on student's activity.

Activity	Mean Spherical Equivalent + SD (95% CI)	p
Reading/Near work activity/day		
Less than 3 hours	-0.47 ± 1.12 (-0.80 - -0.13)	0.057
Between 3 to 6 hours	-0.89 ± 1.48 (-1.44 - -0.35)	
More than 6 hours	-1.43 ± 1.69 (-2.40 - -0.46)	
Gadget/screen time/day		
Less than 3 hours	-0.89 ± 1.33 (-1.27 - -0.52)	0.937
Between 3 to 6 hours	-0.98 ± 1.50 (-1.54 - -0.43)	
More than 6 hours	-1.04 ± 1.49 (-2.19 - 0.11)	
Outdoor activity/day (n)		
Less than 2 hours	-1.03 ± 1.63 (-1.62 - -0.44)	0.094
More than 2 hours	-0.55 ± 1.09 (-0.83 - -0.26)	

Although refractive error can be cost-effectively managed by spectacles correction, a high prevalence of uncorrected refractive error still exists, especially in low-middle-income countries. This problem is attributed mainly to the expenses and limited availability of refraction and spectacles dispensing services, typically accessible only at secondary and tertiary eye care facilities. [30]. We found a high rate of children (69.6%) who did not have spectacles as a primary cause of uncorrected refractive error. Studies in China [31], Bhutan [28], and India [26] also reported a high percentage of school children with uncorrected refractive error (53,5%, 80,92%, and 90,8%, respectively) who did not wear spectacles. Cost and affordability are the primary barriers that hinder people from getting refractive services and spectacles in low-middle-income countries [32-34]. Other factors, such as breakage/loss/forgetfulness of spectacles, cosmetic factors (unattractive frames/poor appearance), and parent's disapproval or perception that using spectacles would cause their child's vision to deteriorate, also play an essential role in poor spectacles compliance [34, 35].

Student academic performance is a central aspect and a significant objective in education. It encompasses the knowledge acquired by students, evaluated through teacher grading, and educational objectives established by both students and teachers to be accomplished within a specific timeframe. Academic performance gauges students' success and pertains to achieving their educational objectives [36-38]. Vision is essential to a child's education process because 75% of the learning process depends on vision. Therefore, a visual impairment that diminishes the effectiveness of the visual system can potentially hinder children's ability to excel academically at school. Reduction in visual acuity because of uncorrected refractive error is supposed to have a negative impact on a child's academic performance. [39-41].

However, we found no significant correlation between academic performance and uncorrected refractive error in this study. Students with uncorrected refractive error have similar mean report marks with students in the other two groups despite having the worst distance visual acuity. Other studies in Singapore [13], Portugal [15], and Los Angeles [42] showed that presenting visual acuity, spherical equivalent power, and corrective lenses had no significant effect on academic school performance. This suggests that distance visual acuity did not play a significant role in a student's learning process and, did not impact academic performance [13]. Studies on Australian students [40, 43] show that learning activities in the classroom are more demanding for extensive near work than distance work. Those studies show that student's learning activities mainly involved near tasks, which occupied 54%-56% of the time, followed by distant tasks for 25%-29% of the time. So, having adequate near vision is more crucial than distance vision for achieving optimal performance in the majority of academic tasks that students are required to undertake. Therefore, hyperopic students who have poor vision in near and distance vision are considered to have poorer academic performance than myopic students, who still have good near vision. This statement is proven by a study in California by Castellanos et al. [44], which showed that only 38% of hyperopic students performed above the basic levels in the English Language Arts test, while 62% of students in the myopic group surpassed the basic levels.

This study found that academic performance was significantly correlated with the reading activity period of the students. This study shows that students with more than 3 hours of reading activity daily have higher mean report marks than those with less than 3 hours a day. Several studies [45-49] have shown a strong relationship between reading habits and academic achievement. Reading habits significantly assist students in their learning process and enhance their academic outcomes. Children with uncorrected myopia have been reported to be associated with higher intelligence scores and improvements in reading ability and other academic-related outcome measures because those with uncorrected myopia require less accommodative effort, so they are better suited for sustained near activities than those with uncorrected hyperopia. Children with uncorrected myopia are also less inclined to take part in tasks necessitating clear distance vision and tend to devote more time to near activities, such as reading. Consequently, this may improve reading skills and academic capabilities [41, 50, 51]. This can explain why children with reduced distance vision due to uncorrected refractive error can have similar academic performance to children with normal vision in this study.

This study also found that children with prolonged reading or near-work time in a day have more minus power of myopia. On the contrary, children with prolonged outdoor activities have less minus power of myopia. These results followed other studies [50, 52-55] that reported that children with myopia were more likely to spend significantly more time studying, more time reading, less time playing sports, and less

outdoor activity. In addition, gadget playing time in a day did not significantly impact myopia. Other studies [56] also showed no significant correlation between the child's posture while using the gadget and the duration of gadget playing time in a day with myopia. Gadget addiction is also not a risk factor for myopia based on multivariate analysis after adjusting the model with sex, age, parenteral myopic history, and interval of rest of the eyes for five minutes [57].

This study has limitations in small sample sizes, which may limit its generalizability. The study could reveal better results if the children with the uncorrected refractive error were given intervention such as free eyeglasses so the study can assess the impact of improved vision on student's academic performance. This study also did not use a standardized test to assess student's academic performance. A national final examination can be used to get uniform data on student's academic performance in our district, and analytic comparison between schools can be done.

5 CONCLUSIONS

Poor distance visual acuity due to uncorrected refractive error did not correlate with poor academic performance. However, increased reading activity can improve student's academic performance, although it can also increase the risk of refractive error. Concerning most students with uncorrected refractive error who did not have eyeglasses, the provision of spectacles is essential in providing good distance visual acuity.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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