An observational study on the relationship between usage time of electronic devices and the degree of myopia

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Abstract

This report presents the findings of an observational study conducted in the international department of Beijing National Day School (BNDS) to investigate the correlation between the degree of myopia and the usage time of electronic devices. The study collected data from 81 randomly selected students using a questionnaire administered through Wen Juan Xing (WJX). The results showed a statistically significant association between myopia degree and device usage time ($p < 0.1$). A simple linear regression model was initially used to analyze the data, but its correlation coefficient ($r = 0.2$) indicated a weak relationship. To refine the model, a more complex linear model was constructed using the initial degree of myopia as an additional explanatory variable. The refined model showed a moderately strong correlation coefficient ($r = 0.6$), suggesting a more appropriate description of the data. These findings highlight the need to consider multiple factors, including initial degree of myopia, when examining the relationship between device usage and myopia development.

1 Introduction

Myopia is the leading cause of correctable visual impairment and preventable blindness worldwide [1]. According to 2019 statistics, there weas about 22% prevalence of myopia worldwide at the beginning of the 21st century. By 2019, the number had risen to 33%. It was estimated that the prevalence of myopia will rise to 52% in 2050 [2]. There is no doubt that myopia has become a serious health problem in recent years.

We noticed that the majority of students in the international department at Beijing National Day School (BNDS) are wearing glasses. We have also heard many adults tell us to reduce the use of electronic devices to protect our eyes. We wonder what is the correlation between the time usage of electronic devices and the degree of myopia. We performed an observational study in the BNDS international department.

This observational study helps to reveal whether there is a correlation between the degree of myopia and the usage time of electronic devices in the BNDS international department. We will make a chi-square test for independence; The null hypothesis is that there is no correlation between the degree of myopia and the use time of electronic devices. The alternative hypothesis is that there is a correlation between the degree of myopia and the use time of electronic devices. We also construct a Least Square Regression Line (LSRL) for the degree of myopia and the time of electronic device use and construct a confidence interval for the slope of the regression line.

2 Background Research

Association between electronics and eyesight is a heavily studied topic. In 2021, a group led by Joshua Foreman analyzed over 3000 articles about smart devices' effects on children's and young men's eyesight, and the result supported the claim that exposure to electronics is related to increasing risk of myopia. [3] Such association was also observed by another study that tested university students' eyesight and compared the result with their electronic devices using history, in which 40% of the electronics-relied student had eye problems. [4] Symptoms of the use of electronics are summarized to a new syndrome called digital eye strain (DES), also known as computer vision syndrome, which is reported to present in over half of the computer users. [5] Digital eye strain can cause dry eyes, blurred vision, and headache. [6]

3 Methods and Procedures

3.1 Data Collection

We collect our data from the Wen Juan Xing(WJX) link. We first collected the name of all three grade students in the international department. We got 634 available names and labeled them through 1-634. We used a random number generator to generate 90 different numbers. We ignore the numbers that have been chosen and the numbers other than 1-634. The corresponding students will be our samples. We sent the WJX link through Wecom privately. The population and corresponding samples are shown in figure 7.
In the WJX questionnaire, we asked their average time of electronic devices use and their degree of myopia. Data we obtained is shown in figure 6.
Then we put our data into a two-way table (Table 1).

time\degree	5-7 h	8 - 10 h	11+ h
0-300	9	7	6
325-600	6	23	6
600+	4	12	8

Table 1: Classified data.

3.2 Data Analysis

We made a chi-square test for independence to test correlation between the degree of myopia and the usage time of electronic devices:
H_0: the usage time of electronic devices and the degree of myopia are independent.
H_a: the usage time of electronic devices and the degree of myopia are not independent.

Check the conditions:

1. Random: We used a random number generator to generate 90 different numbers from all national department students in BNDS.
2. Large sample size: the expected value chart is shown below, each value is greater than 5. (Table 2)
3. Independent: The samples were randomly collected. Though 81 samples is greater than 10% * 650 population ,12.4% is close to 10%, so we still proceed the test.

5.1604	11.407	5.432
8.2098	18.148	8.6419
5.6296	12.444	5.9259

Table 2: Calculated expected values.

Test statistics:

$$X^2 = \sum_i^n \frac{(O_i - N_i)^2}{N_i^2} = 8.532$$

Calculate p-value:
We put all the observed data into the calculator and set the matrix. The calculator calculated the p-value with df = (3 - 1) $\times$ (3 - 1) = 4 to be 0.07.

Analysis P-value:
For a Chi-square test for independence, if the p-value equals to or less then significance level, the null hypothesis will be rejected, and the alternate hypothesis is true. If not, the null hypothesis will not be rejected. Since we set the significance level $\alpha = 0.1$. The p-value we got from the calculator is 0.07,less than 0.1, so we can reject the null hypothesis. We have enough evidence to conclude that the degree of myopia have association with the usage time of electronic devices.

Then, we used the data to construct a LSRL (Figure 1).

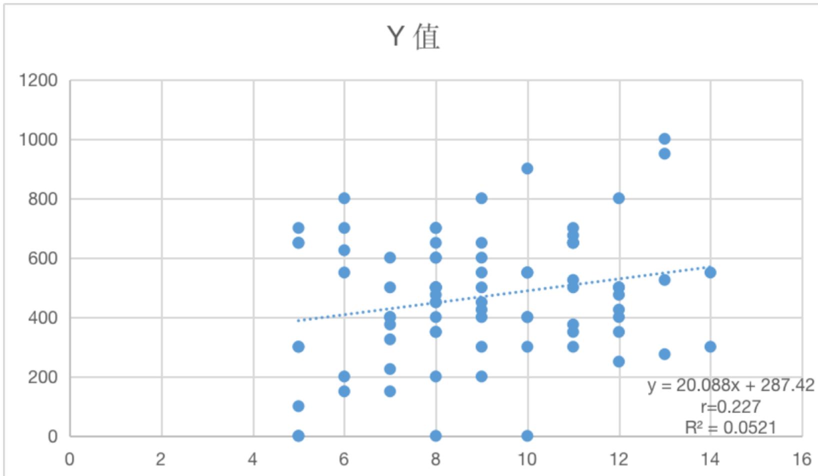

Figure 1: LSRL model we created. X axis: average usage time of participants. Y axis: degree of myopia of participants.

In our model, there is a weak positive, linear relationship between the use time of electronic devices and the degree of myopia in BNDS international department. For every 1 unit increase in the use time of electronic devices, our model predicts an average increase of 20.088 increase in the degree of myopia. 5.21% of the variation in the degree of Myopia can be explained by the linear relationship with the use time of the electronic devices.

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We also performed a t test for the slop.

H_0: $\beta = 0$, there is no linear association between the usage time of electronic devices and the degree of myopia.

H_a: $\beta \neq 0$, there is a linear association between the usage time of electronic devices and the degree of myopia.

Where β is the slope of the population regression line.

Conditions:

1. There is no special pattern in the residual plot, the true relationship is linear.
2. The standard deviation of y does not vary much with x.
3. The samples were randomly collected. Though 81 samples > 10% * 650 population, 12.4% is close to 10%, so we still proceed the test.
4. For a particular number of usage time, the degree of myopia is approximately normally distributed. As shown in the residual plot and following calculation data. (Acceptable values of

skewness fall between -3 and $+\ 3$, and kurtosis is appropriate from a range of -10 to $+\ 10$ when utilizing SEM).[7]

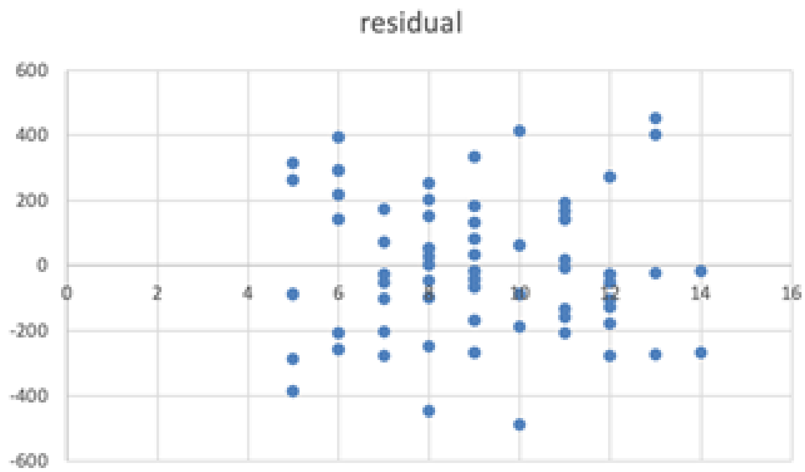

Figure 2: The distribution of residues.

列1	
平均	0.00331
标准误差	22.9474
中位数	-18.212
众数	51.876
标准差	206.527
方差	42653.3
峰度	-0.31115
偏度	-0.01561
区域	939.736
最小值	-488.3
最大值	451.436
求和	0.268
观测数	81
最大(1)	451.436
最小(1)	-488.3
置信度(95.	45.6668

Figure 3: The statistics about residual. Skewness is -0.01561, kurtosis is -0.31115. Both are in acceptable range.

$$Teststatistics = \frac{b - \beta}{SE_b}$$

where

$$SE_b = \frac{s}{S_x\sqrt{n-1}} = \frac{206.53}{2.42\sqrt{80} = 9.58}$$

$$t^* = \frac{20.088 - 0}{9.58} = 2.097$$

Using the t distribution calculator with df = 81 - 2 = 79, we found that p-values is 0.039.

Analysis p-value: Since our p-value 0.039 is smaller than our significance level 0.1, we reject the null hypothesis. We do have enough evidence to conclude that $\beta \neq 0$ and there is a linear association between the usage time of electronic devices and the degree of myopia.

However, after discussion, we concluded that a linear regression model might not be appropriate to describe the relationship between the screen usage time and degree of myopia, since students' initial degree when they came to high school could also influence their current eyesight. So we resent the WJX questionnaire and added a question about their degree of myopia when they were in grade 9. Due to the time limitation, 41 sets of data were collected in total. The data is shown in figure 8.

Considering that time might not support a non-linear model, we decided to construct a complex linear model which set the initial myopia degree as a linear variable. The coefficient of initial myopia degree may not be 1, since it is able to indicate complex behavior patterns of a specific person. We also decided to replace the current degree of myopia by the change of degree of myopia.

SSPS was used to analyze the new data. A more complex linear model with two explanatory variables, students' average usage time per day and their initial degree of myopia before entering high school, was constructed.

New linear model:
$D = -91.663 + 33.087t + 0.023D_0$

D = present degree of myopia
D_0 = initial degree of myopia
t = average daily screen using time

$r = 0.66 > 5$, making the new linear relation moderately strong.

系数[a]

模型		未标准化系数		标准化系数		
		B	标准错误	Beta	t	显著性
1	(常量)	-91.663	60.427		-1.517	.138
	日均屏幕使用时间	33.078	6.080	.663	5.440	<.001
	初三度数	.023	.071	.040	.330	.743

a. 因变量：度数变化量

Figure 4: Some parameters of the new complex linear model.

模型摘要

模型	R	R 方	调整后 R 方	标准估算的错误
1	.662[a]	.438	.408	98.97395

a. 预测变量：(常量), 初三度数, 日均屏幕使用时间

Figure 5: r and R^2 of new model.

4 Results

The statistic analysis above suggests that BNDS international department students' degree of myopia is associated to their average screen using time. However, a simple linear regression model with one variable of screen using time is not appropriate for describing such relationship, for the correlation coefficient r = 0.2 is so weak. The refined model, adding students' initial degree of myopia as another explanatory variable, has correlation coefficient r = 0.6 which is greater than 0.2. We conclude that the new model is more appropriate to describe the data.

5 Discussion and Further Suggestions

In this observation, we followed the standard procedure and constructed a promising model, but there are still some limitations. Because of the confidentiality of students' information, we coudn't get the official list of students from grade teachers, so there might be people who are not on the list or have changed schools on the list. A voluntary bias might exist since some of the sent questionnaires didn't receive answers. Getting the complete student's name list and all questionnaires back is needed to increase result's accuracy. In addition, some students might not have provided us with true electronic device usage times, and some of the data provided by students might contain overlapping time of different electronic devices. To get more precise data, we need to make the students provide data that is as precise as possible. For the new model, we failed to collect all 81 students' data but only collected 41 students' due to the time limitation. That may weaken our model. Plus, other variables may contribute to the change of myopia degree.

6 Conclusions

From the observational study and data analysis, we found an association between the use time of electronic devices and the degree of myopia; however, a complex linear model including students' initial myopia degree is expected to be more accurate than a simple linear model relating the two.

7 References

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[5] Sheppard, A.; Wolffsohn, J. BMJ Open Ophthalmol. 2018, 10.1136/bmjophth-2018-000146

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use time	degree of myopia	use time	degree	use time	degree	use time	degree	use time	degree	use time	degree	use time	degree
9	650	10	300	5	650	11	500	11	0	8	450	11	650
5	300	4	50	8	0	7	650	8	150	7	150	11	700
7	400	4	600	14	550	5	0	12	250	12	400	11	375
6	550	6	200	11	650	7	425	11	650	9	550	10	400
11	700	6	150	8	700	7	350	10	550	9	200		
10	100	8	400	7	400	8	650	5	0	12	500		
8	500	12	800	10	300	10	0	6	700	7	325		
7	600	10	250	12	350	11	700	5	300	13	950		
9	400	11	525	8	500	13	650	6	800	12	500		
5	200	9	500	10	400	8	500	9	300	8	200		
4	150	8	600	6	325	5	100	13	900	8	0		

Figure 6: Collected data.

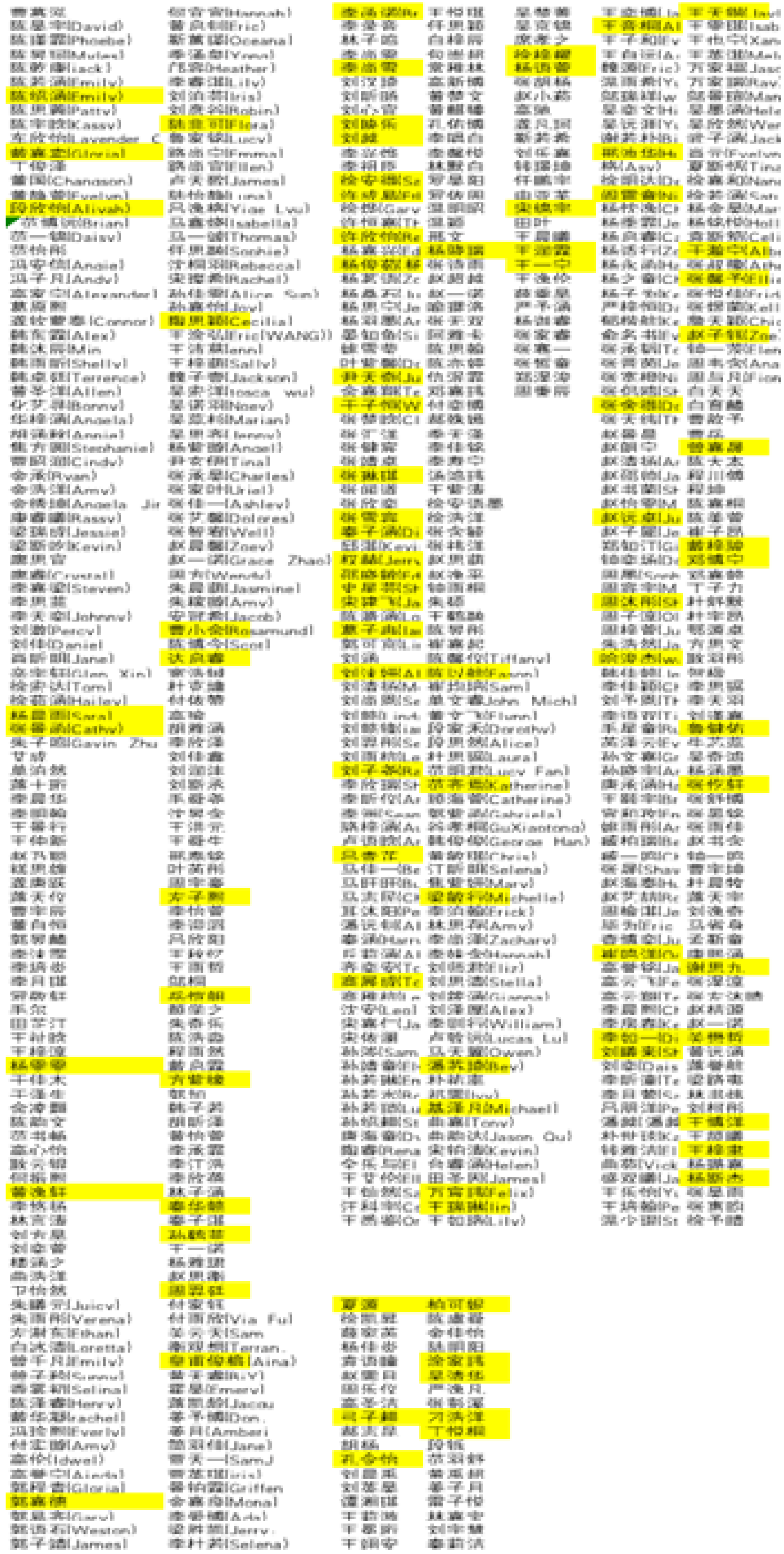

Figure 7: List of students sampled.

	日均屏幕使用时间	初三度数	度数变化量
1	14.00	200.00	400.00
2	13.00	525.00	425.00
3	13.00	600.00	400.00
4	13.00	.00	275.00
5	12.00	500.00	300.00
6	12.00	150.00	200.00
7	12.00	.00	425.00
8	12.00	.00	250.00
9	11.00	450.00	250.00
10	11.00	325.00	325.00
11	11.00	200.00	300.00
12	10.00	.00	300.00
13	10.00	500.00	400.00
14	10.00	400.00	150.00
15	10.00	100.00	300.00
16	10.00	.00	.00
17	9.00	500.00	300.00
18	9.00	400.00	200.00
19	9.00	175.00	25.00
20	9.00	.00	250.00
21	8.00	550.00	150.00
22	8.00	600.00	100.00
23	8.00	300.00	350.00
24	8.00	250.00	225.00
25	8.00	300.00	100.00

Figure 8: Part of the data after including initial degree.