The Comparison of the Relationship Between Sleep Duration and the Academic Performance of Teenage Students in China and the United States

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Abstract. The impact of sleep lengths on academic performance has always been discussed in different fields, such as psychology and pedagogy. At present, scholars always select individuals from specific ranges. They usually ignore the differences among individuals. Their habits and culture can both be the reasons that influence sleep duration and quality, further affecting academic performance. In the future, scholars can improve the development of students' studies and provide help with education policy through this kind of research. In this study, students from different cultures and backgrounds are compared, and their impact of sleep on learning is examined. Each individual needs to provide data by filling out the questionnaire. According to the answering variables, the difference in the impact is discussed by the scatter plots. In the last, at the same sleep time, students in the United States are predicted to have a higher academic performance than students in China. Excluding the data error and the difference between the scoring criteria, cross-culture, and the background also become the main factors to influence sleep.

Keywords: sleep duration, academic performance, cross-culture and background, teenage students.

1. Introduction

Sleep is one of the most important daily needs of human beings. According to prior research, people need different sleep lengths at various ages. Members of the American Academy of Sleep Medicine claimed that adolescents from 13 to 18 should have 8 to 10 hours of sleep every day was the best [1]. Less than the recommended time might cause many problems, such as mentality, behavior, and learning. Especially for teenagers, who are in the stage of mental and physical growth. Lack of sleep could let them increase their mental illness and suicide risk. However, inadequate sleep is a common issue among students globally [2].

Sleep deprivation is not only caused by sleep disorders but also by various external factors [3]. For example, students may have too much homework, stay up late watching TV, or consume too much caffeine. Kelly collected data from over 100 volunteers of different ages in the college to find the relationship between sleep duration and Grade Point Average (GPA) among college students. Denied there was a relationship between age and GPA or gender and GPA, his research shows people who have long sleep lengths have a higher GPA than people who sleep less as a result [4].

In general, most of the studies focus on a single country, even just in a state or a school, to find the impact of sleeping on learning. Yet, there might be some differences among different countries according to the correlation of sleep and study. China and the United States have separate and different academic systems. Chinese education believes that all-round development is important. Students prefer to listen to the lecture instead of doing the project. American education is more flexible. Students can choose the courses which they like. Also, they have very different cultures and lifestyles. These all might be the reasons to affect their sleep, further influencing their grades. In this research, the questionnaire is the method to analyze the impact of sleep lengths on GPAs in different countries. This can provide data support for the research on sleep lengths of students and academic performance with cross-culture and cross-region.

2. Method

2.1. Study Design

To find the easiest way to compare their academic levels, the population will be chosen from American international schools in China and the local schools in the United States. This is because all students in these kinds of schools are graded in GPA. This is a significant tool to evaluate students' learning skills and academic performance. It typically ranks from 0 to 4 when it is unweighted. If it is weighted, it can be out of 4 because some students are taking higher-level courses. They have more bonus credits.

2.2. Questionnaire method

There are 181 people between 13 to 18 years old participating in the survey. This data includes junior school students and high school students. 85 of them study in the United States; 92 of them study in China; 1 of them study in the United Kingdom; 2 of them study in Canada; and 1 of them study in Indonesia. The data shows 75 of them are from the United States, and 105 of them are from Asian countries. 1 is from Europe. 120 of them are female; 55 of them are male; 6 of them prefer not to say.

In this survey, they have to answer their sleep lengths and their both unweighted and weighted GPAs. This data is the most important because it can be directly used for analyzing. Secondly, they need to rank their sleep quality. Because of different body conditions, some people sleep less, but they can feel more energetic than other people. At last, they should explain how their sleep duration and cultural affection affect their study.

This survey is published on the internet and welcomes all students who are from 13 to 18 years old to fill it out. The volunteers are compensated after finishing the survey.

2.3. Regression analysis method

After filtering out the particularly anomalous data, two stratified random samples can be found. First, all the individuals who study in the United States are labeled with integers from 1.

Then, a random number generator is used to select 50 unique numbers as the sample from individuals studying in the United States. Next, the same process is applied to individuals studying in China, generating 50 unique random numbers as the sample from China. 100 individuals in these two samples would be randomly selected to do the analysis.

The scatter plots compare the relationship between sleep duration and GPA in this research. Because many of the students responded that they didn’t have weighted GPAs. Sleep duration is set as the explanatory variable, and the unweighted GPA is the response variable.

To analyze a scatter plot, there usually are three regression models, least-square regression line model, quadratic regression model, and exponential regression model. The least-square regression model is the most simple one among these three models. It can show a straight line on the graph which shows the average rate of constant change between two variables. It can quickly help researchers analyze a huge amount of data. In the quadratic regression model, There is a curve. It can show the turning point and the extremes in the data. Exponential regression models usually show the variables increase or decrease exponentially. It also shows a curve on the graph.

When choosing the regression model, it is usually sufficient to select the most suitable one for analyzing in general. When the coefficient of determination R^2 (read ‘R squared’) of the model is the biggest, it means this model is the most suitable one. 0 is the lowest, which means they have no relation between the two quantitative variables. 1 is the highest, which means 100% of the response variables are accounted for by the explanatory variables. Usually, when R squared is over 0.5, it can be justified that there is a great relationship.

Correlation (r) can show the direction and strength of a relationship between two variables. When it is negative, there is a negative linear relationship; when it is positive, there is a positive linear relationship; when it is equal to 0, there is no linear relationship.

Each model has an equation ŷ (called 'y hat'). Both the line and the curve shown on the graph are calculated by the equation. They provide all the predicted values in the range. This equation can be used for predicting both the interpolation and extrapolation value of the response variable for a given value of the explanatory variable.

The original formula for least-square regression line

$$\hat{y} = a + bx. \tag{1}$$

The exponential regression model

$$\hat{y} = ab\hat{}x. \tag{2}$$

The quadratic regression model

$$\hat{y} = a + bx - cx\hat{}2. \tag{3}$$

In this study, the best sleep lengths for teenagers will be plugged into this equation, and comparing the values between the China model and the United States model. The interpolation is the prediction value inside of the interval of values of the explanatory variables. Conversely, the extrapolation is a predicted value out of the interval of values of the explanatory variables. Because the best sleep duration—8 to 10 hours—for teenagers is concluded in the data, the interpolation should be calculated [1].

3. Result

3.1. Regression analysis results

Based on the data from the individuals who study in the United States, the quadratic regression model is the best fit (see Fig. 1). The explanatory variables on the horizontal axis are the sleep duration of the students in the United States. All the data is the whole number. On the contrary, the response variables on the vertical axis are close to one decimal place, which represents students' academic performance. There are some obvious influential data. Its R^2 is equal to 0.064. The R^2 values of the exponential regression model and the least-square regression line model are 0.032 and 0.038. They are both lower than the R^2 value of the quadratic regression model. It displays a huge downcurve on the graph. First, the GPA increases until sleeping around 6 hours. After that, the more hours that people sleep, the less GPA they get. In general, it appears that there is a negative association between the sleep duration and the GPA in the United States. This result opposes the prior research which claims that the GPA should be higher when a student sleeps more [4].

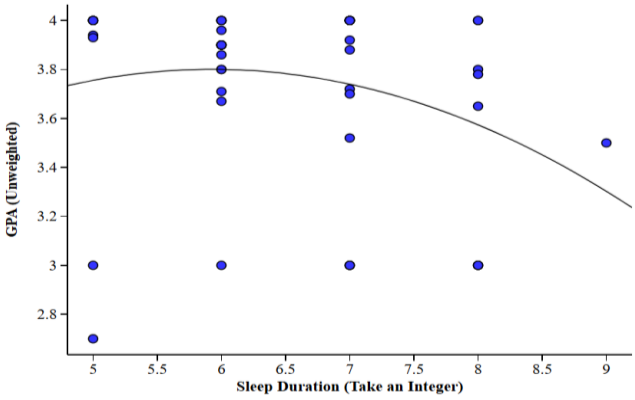

Fig. 1 Scatter plot of unweighted GPA by integral sleep duration in the United States (Photo/Picture credit: Original).

Based on the data from the individuals who study in China, the exponential regression model is more suitable for two variables (see Fig. 2). The explanatory variables on the horizontal axis are the sleep duration of the students in China. Just like the sample in the United States, all the data from China also is the whole number. Besides, the response variables on the vertical axis are close to one

decimal place, which represents students' academic performance. There are some obvious influential data. The R^2 value is equal to 0.031, which is the highest value among the three models. The R^2 values of the quadratic regression model and the least-square regression line model are 0.09 and 0.028. It is a curve but looks like a straight line. Also, it reflects the result that the more hours students sleep, the less GPA they get. It still does not match with the result which is given from the prior research [4].

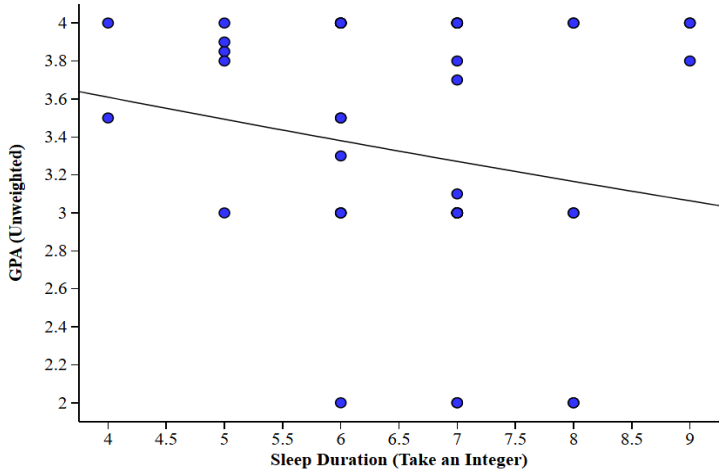

Fig. 2 Scatter plot of unweighted GPA by integral sleep duration in China (Photo/Picture credit: Original).

Both of the coefficients of determination values from these two models are small. They show a weak relationship between the sleep duration and GPA of students in the two countries. Yet, the value of the students who study in the United States is double higher than the value of the students who study in China. It indicates the US students are more likely to be affected by their sleep duration during their study than the Chinese Students.

3.2. Predictive Analysis

Both of the correlations between two variables are negative. The value of the United States is $r = -0.194$; the value of China is $r = -0.168$. It shows that the students in the United States have more sleep lengths affection on their study again. The correlation of the US students is closer to -1.

The equation of predicted GPA by the given sleep duration in the United States is

$$\hat{y} = 1.9504 + 0.6245x - 0.0527x\text{^}2. \quad (4)$$

Plugging $x = 8$ and $x = 10$ into the equation. The predicted GPAs for the students who have the best sleep duration in the United States are from 3.576 to 2.925. Both of the answers are close to the three decimal places.

The equation of predicted GPA by the given sleep duration in China is

$$\hat{y} = 4.1151 * 0.9677\text{^}x. \quad (5)$$

Plugging $x = 8$ and $x = 10$ into the equation. The predicted GPAs for the students who have the best sleep duration in China are from 3.165 to 2.963. Both of the answers are close to the three decimal places.

If all students have the best sleep lengths, students in the United States will have higher GPAs than students in China in prediction.

4. Discussion

In this study, the difference in the impact of sleep duration on academic performance between students in the United States and in China is found. There are several ways that might cause this result.

First, some people are not willing to answer their real GPAs or only answer the whole numbers instead of answering with exact two decimal places. In addition, in this study, only unweighted GPAs

are used. It can not show the difficulties that every student has in their courses. They both can cause errors and bias. Also, there might be different methods to calculate the GPA. For example, some schools focus on letting students fill out the academic competencies, some schools would like to let students take exams. In the future, scholars can make improvements based on the reasons above.

Secondly, according to self-reports and the Pittsburgh Sleep Quality Index, there is research that female teenagers easily have poorer sleep qualities than male teenagers [5]. Also, there is even a survey that shows females need more sleep than males on average [6]. In the data, both female students in the United States and China have an average of 6.5 hours of sleep every day; Male students in the United States have 6.7 hours of sleep on average; Male students in China have 6.9 hours of sleep on average. Based on the data, students in China should have higher GPAs. Yet, the data can not show the consistency with the prior study. It might be caused by the sample size being too small. There are some biases in the sample. Although their sleep qualities are collected, there is no significant correlation with sleep lengths. It is not necessary to be discussed.

Thirdly, the prior scholar used a case-control Critical Appraisal Skills Programme (CASP) tool to analyze people coming from 40 countries with their impact of cross-culture on sleep. Students in China usually sleep less and have more sleep disorders than students in the United States [7]. It is mismatched with this study. It is still caused by the sample size being insufficient.

In this study, culture does not really help in seeing the relationship between sleep and GPAs because of the limitations. The data is collected from students who study in China and the United States, they have multiple nationalities and diverse cultures. This study only focuses on the location where the students study, but does not show how the different cultures and heritages affect the sleep duration and other habits where the students come from. In the future, expanding the individuals of this study based on their backgrounds is good for understanding how different cultures affect the study directly.

5. Conclusion

The data used in this study is from the internet where people fill out the questionnaires. Scatter plots are used to compare the impact of sleep on the academic performance of teenage students in the United States and in China. As a result, the best sleep lengths, predict that students in the United States have higher academic performance than students in China. Based on the limitations in the questionnaire, data error possibly is one of the main reasons for the difference. Biological factors due to gender do not cause any change in this study. This research involves diversity and cross-culture. Although the data comes from different backgrounds students, they only study in the United States or in China. Cross-culture and the background become one of the most important reasons for forming sleep differences. Then sleep further affects performance. The data and the result provide a valid example for scholars. They can analyze the impact of culture and background in not only sleep or study but even in different fields, they can expand individuals.

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