Does Weekday Sleep Duration Influence Productivity Level of College Students?

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Introduction

Imagine waking up after only a few hours of sleep, and then dragging your tired body through hours of coursework, assignments, and even exams. Now imagine repeating that for days on end, for months! According to University of Georgia Health Promotion (n.d.) and Wallis (2024), most college students get an average of only 6-6.9 hours of sleep per day, although the recommended amount of nightly sleep for college students is 7-9 hours. In the daily life of a college student, certain deadlines and exams often seem to be more important than a few extra hours of sleep. But if this trade-off is sustained over many consecutive days, such as throughout a semester, it may lead to unexpected consequences and actually impair overall academic performance.

This project aims to investigate the relationship between sleep duration and one of the most crucial aspects of any college student's life: their productivity. Our research question is **"Does the amount of sleep a college student gets during weekdays influence their productivity level?"**. As college students ourselves, our goal is to evaluate college students' sleep duration and whether it significantly impacts their academic and general productivity throughout the week. Understanding this connection can support us and other students in devising our own methods to improve our academic college lives, as well as our personal health.

The data for this study was collected through a Google Form survey. Our target population is college students, and our sample included students from various colleges including Smith College, Amherst College, and UMASS Amherst. We used a convenience sampling method, gathering many of our survey responses from our friends and acquaintances who are also college students. We are investigating whether the amount of sleep a college student gets on weekdays influences their productivity using a **Two-Way Table Test of Independence** with **Chi-square Distribution**.

Exploratory Data Analysis

Main Sample Questions

1. **How long do you sleep during weekdays, on average?**

a. Less than 5 hours
b. 5-7 hours
c. More than 7 hours

2. **How productive are you during weekdays, on average?** *Rate your productivity on the following scales: 1 - not productive, 2-4 - somewhat productive, 5 - very productive*

a. Not productive
b. Somewhat productive
c. Very productive

About the Data

Data Collection

Our target population is college students.

This data is collected through Google Form. We used convenience sampling with responses from our friends and their acquaintances from Smith College, UMASS Amherst, Amherst College, Brown University, and MIT (USA), as well as National Economic University, Diplomatic Academy of Vietnam, Hanoi University of Science and Technology (Vietnam). Our survey did not collect the name of the school currently attended by the participants, so we do not know the number of observations from each school.

In addition to requesting participation in our survey from our friends at Smith, we posted our Google Form on Smith Confession to increase diversity in the observations from Smithies. Evelyn also had her Vietnamese friends post it on Meta posts and stories to seek responses from their network of Vietnamese college students. Our friends at colleges other than Smith in the USA also shared our survey with their acquaintances, which helped widen the scope of our survey's observations to include students from as many colleges as possible.

Dataset Introduction

We collected **90 responses** i.e. observations through our survey for **6 variables** in total, including major division, class year, whether the respondent is an early bird or a night owl, their average amount of sleep during weekdays in hours, their average productivity level during weekdays.

We used **2 variables** - average amount of sleep during weekdays in hours and weekday average productivity level in a 3-point scale (not-somewhat-very productive). Specifically, we consider the weekday average amount of sleep our **explanatory variable** and the weekday average productivity level our **response variable**. In our survey, we simplified the options for amount of sleep during weekdays and weekday productivity level by dividing them into 3 categories. Both variables are **ordinal** and **categorical**.

Data Wrangling

Most of our questions were in multiple-choice format, so we did not have to re-code the variables for consistency. The questions regarding sleep duration, productivity, and stress level required answers in order to submit the form, eliminating the possibility of missing values in our data set. However, since the sheet generated by the Google Form listed the variable names as the questions (in sentence form including spaces and capitalization), we had to clean their names and rename them to be concise and effective. We created 1 subset of the data set - sleep and productivity level with 2 variables regarding sleep duration and productivity level.

Variable Distribution

Weekday Sleep Duration

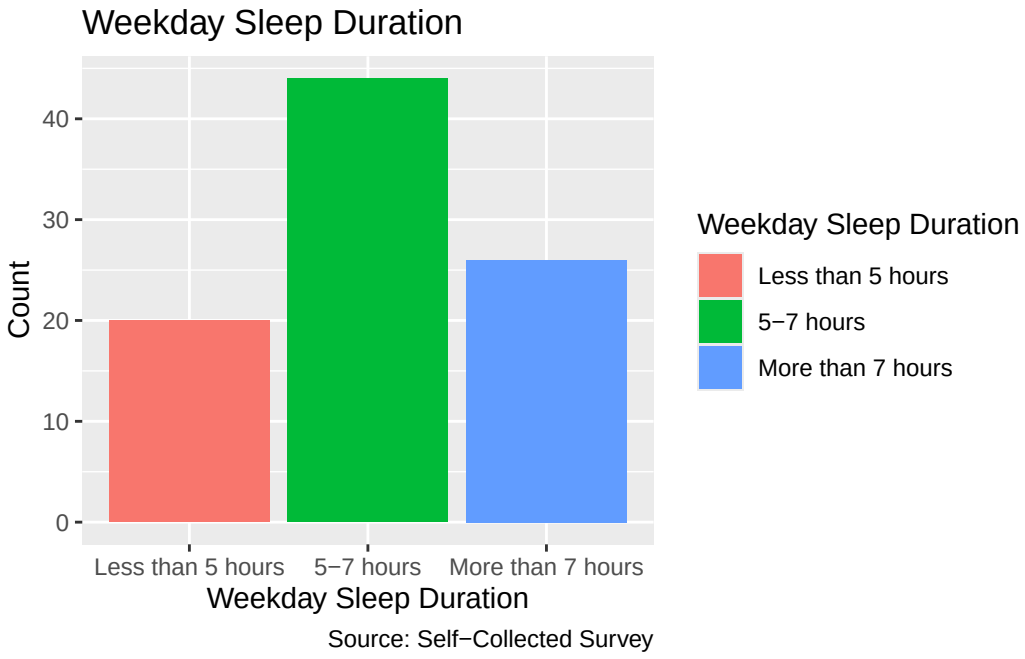

Figure 1: Weekday Sleep Duration of College Students

From Figure 1, it is noticeable that nearly half of the observed college students, 44 out of 90 observations, sleep for 5-7 hours on average during weekdays. About 26 observations sleep for more than 7 hours on average during weekdays, while only 20 observations sleep for less than 5 hours on average during weekdays.

Weekday Productivity Level

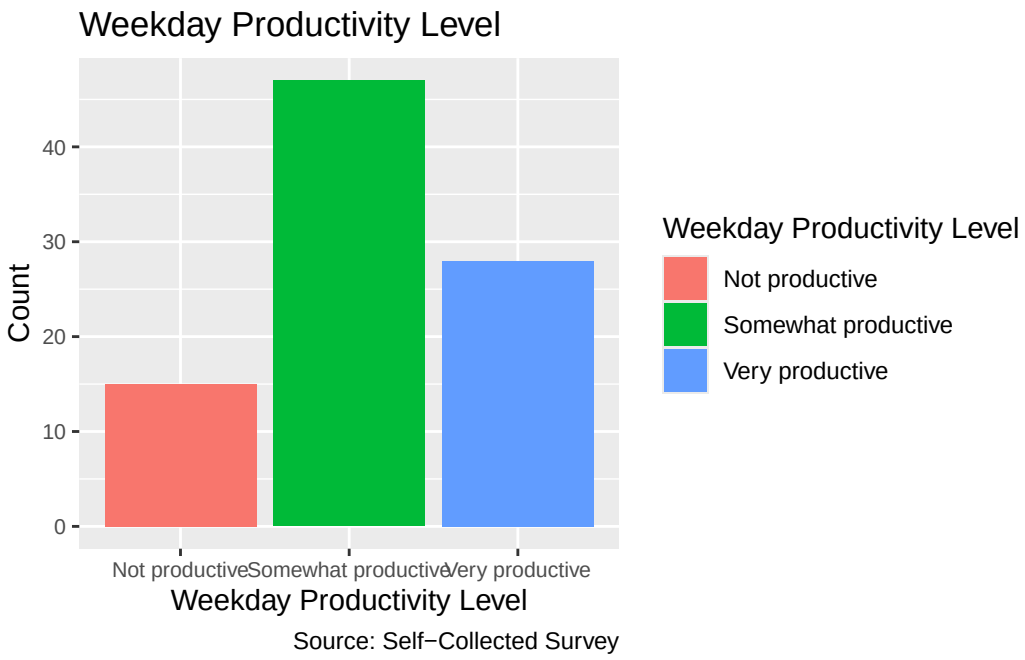

Figure 2: Weekday Productivity Level of College Students

From Figure 2, it can be seen that the majority (47 out of 90) of observed college students feel somewhat productive on average during weekdays. Nearly 1/3 of the observations feel very productive on average during weekdays while only 15 out of 90 observations do not feel productive on average during weekdays.

Sleep Duration vs. Productivity Level

Since college students' weekday average sleep duration and their weekday average productivity level are both **categorical variables**, we are using a **contingency table** as well as a **stacked bar plot** to visualize their distribution and potential association.

Table 1: Sleep Duration vs. Productivity Level of College Students

	Not productive	Somewhat productive	Very productive
Less than 5 hours	1	7	12
5-7 hours	7	29	8
More than 7 hours	7	11	8

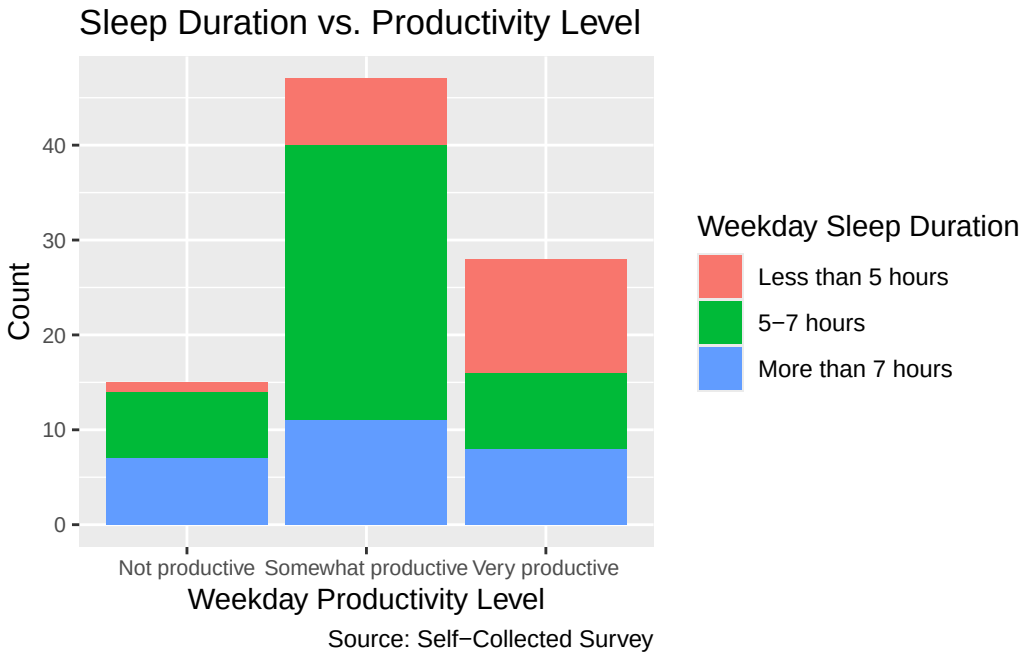

Figure 3: Sleep Duration vs. Productivity Level of College Students

Table 1 and the corresponding Figure 3 show the distribution of the observed values of productivity levels across different sleep duration. It is noticeable that college students who sleep 5-7 hours on average make up the majority of "somewhat productive" group with 29 students, while those who sleep less than 5 hours on average have the highest number of individuals in the "very productive" group with 12 students For both the "not productive" and "very productive" group, the number of college students sleeping 5-7 hours and more than 7 hours on average is the same. Surprisingly, in the "not productive" category, 7 students each reported sleeping 5-7 hours and more than 7 hours on average, both are significantly higher than the number of students sleeping less than 5 hours on average, which was only 1.

Results

Type of Test

Since college students' weekday sleep duration and their productivity level are both **categorical variables** of 3 categories each, we use inference of two-way tables. Therefore we are using the **Two-Way Table Test of Independence** with **Chi-square Distribution** using a **Mathematical Model**.

Hypotheses

To investigate whether the amount of sleep a college student gets during weekdays influences their productivity level, our null hypothesis H_0 is that college students' weekday sleep duration and productivity level are independent. Our alternative hypothesis H_A is that college students' weekday sleep duration and productivity level are dependent.

Conditions

The Conditions for Two-Way Table Test of Independence include **Independence**, in which the data values were collected were from a random sample, and **Large Sample**, in which $e_{i,j} \geq 5$ for each cell.

For the **Independence** condition, the use of convenience sampling method may introduce certain dependence among observations by overrepresenting students from certain social circles or colleges with similar traits, behaviors, or habits, potentially skewing the results. Thus, the Independence condition for Two-Way Table Test of Independence is not met.

If college students' weekday sleep duration and productivity levels are truly independent under the null hypothesis H_0 of independence, our expected count - the frequency that would be expected in a cell - for all cells would be as follows:

Table 2: Sleep Duration vs. Productivity Level of College Students Expected Counts

	Not productive	Somewhat productive	Very productive
Less than 5 hours	3.33	10.44	6.22
5-7 hours	7.33	22.98	13.69
More than 7 hours	4.33	13.58	8.09

For the **Large Sample** condition, there are 2 expected counts that do not meet the criteria of $e_{i,j} \geq 5$ - $e_{2,1}$ and $e_{3,1}$ - as shown in Table 2. Thus, Large Sample condition for Two-Way Table Test of Independence is not met.

Note: Because both conditions are not met, the test statistics χ^2 may not have a Chi-square Distribution. However, we will still run the Two-Way Table Inference of Independence.

Chi-Square Testing

Test Statistics & Null Distribution

Assuming that conditions for the Mathematical Model of the Two-Way Table Test of Independence are met and H_0 is true, our test statistic $\chi^2 = 14.223$, which is a ratio of how the observed counts vary from the expected counts as compared to the expected counts, has a **Chi-square Distribution** with the parameter **degrees of freedom** having the value of $df = (R-1)(C-1) = (3-1)(3-1) = 4$ in which R represents the number of rows and C represents the number of columns.

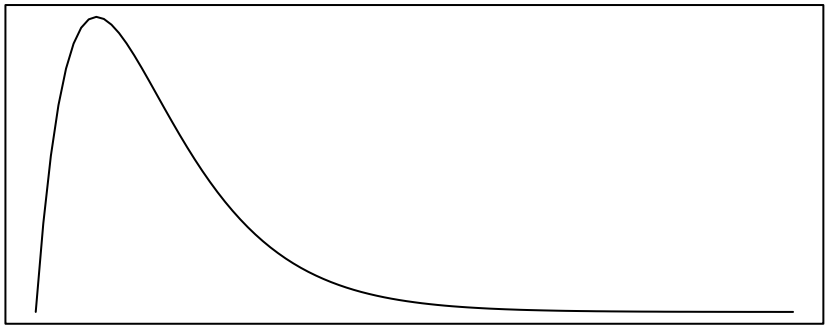

Figure 4: Chi-square Distribution of df = 4

Our null distribution, as shown in Figure 4, is a **Chi-square Distribution** which is always right-skewed, only has positive values, and has a parameter of $df = 4$. The degree of freedom dictates the shape of the Chi-square distribution.

p-value Mathematical Model Plot

Given that we only take the shaded right tail area, as shown in Figure 5, to calculate our p-value, our $p - value = .006615$. This means that the probability that we observe our χ^2 as large as 14.223 or larger is .006615.

We choose our significance level $\alpha = .01$ to control the Type 1 error rate. A Type 1 error in this context would mean that we had concluded that that college students' weekday sleep duration and productivity levels are dependent when they are in fact independent.

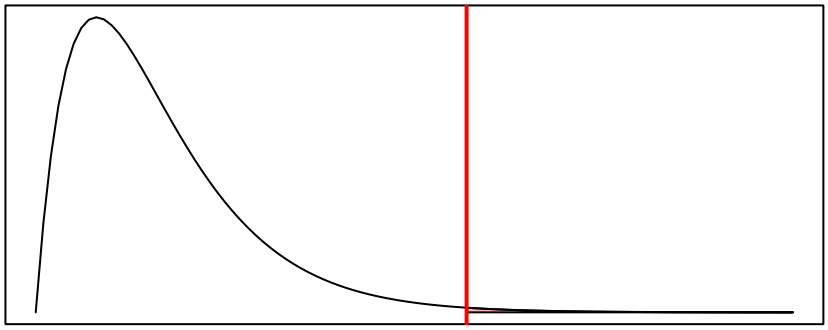

Figure 5: Chi-square Distribution of df = 4 and p-value (shaded right-tail area)

Conclusion & Interpretation

Our $p - value = .006615$ is smaller than $\alpha = .01$, therefore we reject the null hypothesis to conclude that college students' weekday sleep duration and productivity levels are significantly dependent. The data provides statistically significant evidence to support the claim that college students' productivity levels are dependent on the duration of sleep at they get on weekdays, at the $\alpha = .01$ significance level. Therefore, it is reasonable to believe that the amount of sleep a college student gets during weekdays influences their productivity level.

Discussion

The statistical analysis above set out to test the relationship between average hours of sleep gotten on weekdays and productivity level of college students. Our analysis showed that there is statistically significant evidence that the amount of sleep a college student gets on weekdays influences their productivity level, which answered our original research question. However, our population of interest was all college students, and our sample is not accurately representative of this population of interest. Although our data included observations from students at multiple colleges, the colleges we received data from was based on convenience, instead of any sort of randomized process. Thus, our results cannot be generalized to the entire population of interest.

Data was self-reported and was collected from college students using convenience sampling with a Google Form. We reached out to our peers who are also in college, and received responses from Smithies, as well as many individuals who attend colleges other than Smith. To assure consistency and ease of data analysis, the questions on the Google Form were answerable only by multiple choice options. There were three options for average amount of sleep on weekdays, dividing observations into: less than 5 hours, 5-7 hours, and more than 7 hours. This converted the data for hours, which are typically continuous numerical values, into an ordinal categorical variable. Survey participants indicated their self-evaluated productivity as "not productive", "somewhat productive", or "very productive". This resulted in another ordinal categorical variable for the data regarding productivity. Figure 1 and Figure 2 show the proportions of survey respondents that indicated themselves as falling within these three divisions of hours of sleep and productivity, respectively. Table 1 and Figure 3 summarize the distribution of both of our variables, displaying the counts of observations grouped by both hours of sleep and productivity. We determined that the appropriate statistical analysis to use in this context given that both of our variables are categorical was the Two-Way Table Test of Independence using a mathematical model.

A major limitation of our analysis is that it was conducted despite the data meeting neither the Independence nor the Large Sample conditions for our chosen hypothesis test. The Independence condition can not be met given that we did not collect data using a random sample. The Large Sample condition requires that the expected counts - the frequency that would be expected in a cell - for all cells in our contingency table are greater than or equal to 5. As indicated in Table 2, two out of nine cells do not meet the Large Sample condition; the expected counts for these two cells is less than 5. This means that our test statistics χ^2 may be inaccurate, making our calculated p-value inaccurate as well. If the p-value is smaller than it should be, we may be more likely to reject the null hypothesis when it is actually true, resulting in a Type 1 error. If the p-value is larger than it should be, we may be more likely to fail to reject the null hypothesis when the alternative hypothesis is actually true, which would be a Type 2 error. We conducted our hypothesis test under the assumption that the conditions described above were met. The hypothesis test concluded that the self-reported average productivity level of college students is dependent on the average amount of sleep they get during weekdays at the $\alpha = .01$ significance level.

Although our results can not be generalized to the population of interest, they are congruent with published research on similar topics. For example, Okano et al. (2019) is a study performed on student volunteers enrolled in the Massachusetts Institute of Technology's Introduction to Solid State Chemistry course. The study explored the relationship between academic performance as measured by scores in the Chemistry course and sleep duration, as measured by a Fitbit wearable activity tracker. The tracker uses health statistics such as heart rate and motion sensing to collect the data used in this study, including sleep duration. Okano et al. (2019) found that longer duration of sleep is strongly associated with improved college academic performance.

This is reaffirmed by the results of another thematically related study. Preetha et al. (2020)

is an analysis of levels of awareness among dental students that getting insufficient sleep is detrimental to productivity. Similarly to our study, the data were collected by distributing online surveys. The study found that 74% of surveyed individuals are aware that inadequate sleep causes stress, and the same percentage responded that they were aware that insufficient sleep causes degeneration of cognitive functions. 77% of participants claimed to be aware that insufficient sleep can trigger irritability. The study's results include further analyses of dental student's knowledge of the negative effects of sleep deprivation; only the ones most pertinent to the research we conducted are included here. Once again, the published literature reaffirms our finding that getting less sleep diminishes a student's ability to perform productively. Based on the results of both of these studies, it seems probable that our result reflects a real correlation between shorter sleep duration and lower overall productivity level in college students.

Many other analyses could be conducted with the data we gathered using this form. These other variables dictate the most feasible and convenient possible future extensions to this research project. Our Google Form collected a total of six variables, only two of which were used for the statistical analysis conducted above. The variables we did not use include class year, major division, whether the respondent considers themselves an early bird or a night owl, and stress level (as a categorical variable formulated similarly to those used in the we conducted). Based on these variables, we could consider examining whether stress (or productivity) levels vary based on major division or class year. We could also evaluate whether being an early bird or a night owl is correlated with higher or lower stress or productivity levels. Beyond the scope of the dataset we have collected, we could consider using random sampling to select colleges throughout the world from which to collect data, and then randomly sample students enrolled there in order to compile a larger and more robust data set. Statistical analyses of such a dataset would yield results generalizable to the entire target population of college students.

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