

Tired of Being Tired? Effects of Sugar and Sleep on Energy Levels

Name: Honglang Wang

Abstract

The purpose of this experiment was to find any statistically significant relationships between someone's Average Daily Energy Level and variables such as Presence or Absence of Sugar in Diet, Daily Hours of Sleep, Student Status, Gender, Exercise, and Supplement Consumption. The experiment sample included 47 willing participants who were randomly assigned to either eat a serving of refined sugar at every primary meal for two weeks or abstain from all refined sugars for two weeks. Multiple linear regression models conducted on the data that was collected before and throughout the study revealed Daily Hours of Sleep and Sugar or Non-Sugar Group to be the only variables with a statistically significant effect on Average Daily Energy Level.

Background and Significance

One research report was found that compared the effects of Sugar vs. Exercise on Energy Levels (Thayer RE), but research revealed no interesting studies done on the other variables in our study such as Daily Hours of Sleep, Student Status, Gender, and Supplement Consumption. Our goal in this experiment was to test the combined effects on energy level based on all of these variables.

Methods

In this experiment, Biola University biostatistics students obtained volunteers from amongst their family members and peers to participate in a study testing the affect of sugar consumption, sleep, and other variables on daily energy levels. All volunteers had to consent to being randomly assigned to either a sugar or non-sugar group prior to their participation in the study. The sugar group was required to consume at least one serving of refined sugar at each primary meal for fourteen consecutive days. Conversely, the non-sugar group was instructed to abstain from all refined sugars for a period of fourteen consecutive days (see Appendix for the refined sugar list). The volunteers were randomly assigned using R (www.r-project.org) according to the blocking variables: sleep (hrs/day), sick (times/year), consume dietary supplements (yes/no), exercise (hrs/wk), gender (M/F), and Biola student (yes/no). Following random assignment, the individuals in both groups were required to record daily information about their physical health. Once the subjects had completed their fourteen days, all of the data was compiled for analysis.

During the two weeks of the study, volunteers recorded daily whether or not they felt sick. Volunteers were advised to leave the experiment if they became sick at any point during the study. Volunteers also kept a log of the number of hours they slept per night and scales ranging from 0-10 were used for the volunteers to report information on the their energy levels, sinus, and throat issues experienced that day. RStudio was used to analyze the data.

Descriptive statistics shown in Table 1 for both hours of sleep and energy levels in terms of sugar or non-sugar group were generated based on data returned from participants. Using a multiple linear regression model, hypothesis tests were conducted on the data to determine the change in daily energy levels, as modified by the variables recorded during the study. Our first linear regression model included all tested explanatory variables: group status, average hours of sleep obtained per night, student status, gender, average hours of exercise obtained per week, and supplement consumption. The test was then modified by eliminating the single least significant variable, according to its p-value, from the multiple linear regression model. This procedure was repeated until all statistically insignificant explanatory variables were removed. In this way, a multiple linear regression model was obtained that appropriately represented the collected data as can be seen in Table 2. The R^2 value for the statistical model was then analyzed to determine if any one of the contributing variables had a greater affect on Energy Levels than any other the others, and if so, by how much.

The assumptions for the linear regression model were tested utilizing QQ plots, Residuals vs. Fitted plots, histograms and the Shapiro Wilk test. Plots are shown in the Appendix section for those variables that proved to be statistically significant.

Results

Analysis of the QQ plot revealed that the residuals followed a relatively linear pattern with only a few outliers, demonstrating normalcy. From the Residuals vs. Fitted plot, it was seen that the residuals were relatively evenly spaced above and below a horizontal line, with no general trends in the data. This demonstrated that the residuals had common variance. The assumptions of the linear regression model were confirmed to be true for the data set.

After running the initial multiple linear regression model on all explanatory variables, it was observed, that Sugar Group Status and Daily Hours of Sleep proved to have statistically significant p-values (0.01241 and 0.00029 respectively) at the 5% level of significance. No other factors developed statistical significance throughout the course of the testing, while Sugar

Group and Daily Hours of Sleep only increased in their statistical significance, as can be seen in Table 2.

According to the boxplot comparing energy distributions between the two groups (Graph 1), the 95% confidence intervals showed no overlap. A scatterplot shows the positive relationship between amount of sleep and energy levels (Graph 2).

The R^2 value for the final multiple linear regression model was found to be 0.3817. According to the additive property of the sums of squares, the R^2 value can also be described as the sum of the individual R^2 values for Daily Hours of Sleep (0.2684) and Group (0.1132) as can be seen in Table 3.

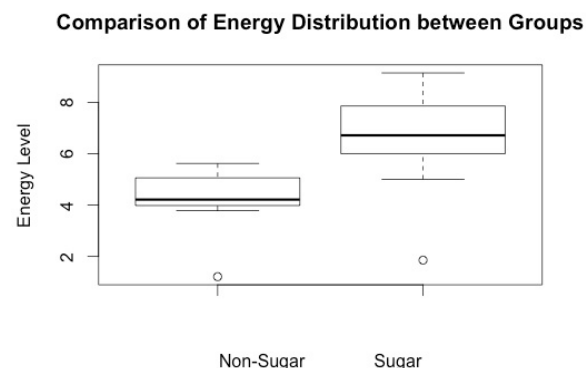
After substantial testing, it was concluded that the following multiple linear regression model best describes the data collected:

$$\text{Energy Level} = 1.5390 + (0.8767)(\text{Group}) + (0.6633)(\text{Sleep})$$

Table 1: Descriptive Statistics for Hours of Sleep and Energy Levels					
Daily Averages	Standard Deviation	Min	Mean	Max	95% Confidence Interval
Sugar Group Sleep (hours)	1.23	7.00	7.10	11.00	$6.60 < \mu < 7.60$
Non-Sugar Group Sleep (hours)	0.78	7.00	7.23	8.50	$6.85 < \mu < 7.61$
Sugar Group Energy Levels	1.44	6.71	6.76	9.14	$6.18 < \mu < 7.34$
Non-Sugar Group Energy Levels	1.00	4.21	4.39	5.62	$3.90 < \mu < 4.87$

Table 2: Affect on Daily Energy Levels According to the Multiple Linear Regression Model					
	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5
EXPLANATORY VARIABLES	p-Value	p-Value	p-Value	p-Value	p-Value
Sugar Group	0.0124	0.0124	0.0118	0.0059	0.0082
Daily Hours of Sleep	0.0003	0.0002	0.0001	0.0001	0.0001
Biola Student	0.3257	0.3954	0.4057	0.3466	Removed
Gender Male	0.5565	0.4399	0.4606	Removed	Removed
Exercise	0.9235	0.7715	Removed	Removed	Removed
No Supplements	0.9816	Removed	Removed	Removed	Removed
Supplements	0.7383	Removed	Removed	Removed	Removed

Graph 1:



Graph 2:

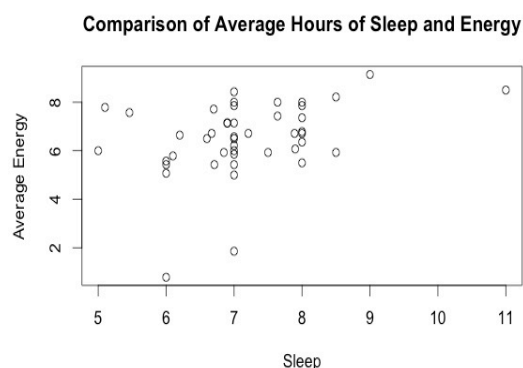


Table 3: R² Values for Variables in Relation to Energy	
Sugar Group + Daily Hours of Sleep	38.17%
Daily Hours of Sleep	26.84%
Sugar Group	11.32%

Discussion

After running the initial multiple linear regression model on all explanatory variables, it was observed that Sugar Group Status and Daily Hours of Sleep proved to have a statistically significant effect on variation in Daily Energy Levels. The series of five modified multiple linear regression models confirmed this initial observation (Table 2). Additionally, the boxplot (Graph 1) comparing the Energy Levels of the two groups confirmed that there is a significant difference in the means between the two groups. The scatterplot (Graph 2) of the data (see Graph 2) also confirmed this positive relationship between these Hours of Sleep and Energy Levels.

Thus, the null hypothesis, that neither Sugar Group, Daily Hours of Sleep, Student Status, Gender, Exercise, nor Supplement Consumption has an effect on Energy Levels, was rejected. The final multiple linear regression model, which showed Energy Levels modeled by Sugar Group Status and Daily Hours of Sleep, was proved to be the strongest model for the collected data. This test revealed that refined sugar intake added 0.876 points to the average daily energy level, while daily hours of sleep added 0.6633 points.

The R² values calculated for the multiple linear regression model revealed that 38.2% of all variation in daily energy levels can be explained by the combination of the presence of refined sugar in one's diet and amount of sleep obtained daily (Table 3).

Following these discoveries, we analyzed the R² value further to see which explanatory variable, Sugar Group or Daily Hours of Sleep, proved to contribute more to changes in daily energy levels. We discovered that Daily Hours of Sleep accounts for 26.84% of the daily changes in energy levels, while Sugar Group only accounts for only 11.32% of the variation. Thus, while both Daily Hours of Sleep and Sugar Group have a statistically significant affect on Daily Energy Levels, Daily Hours of Sleep proves to have a significantly larger affect on Daily energy levels than Sugar Group.

The experiment could be improved if further data collection were to take place. Clarification of a "serving size" of refined sugars could be made more specific. This way, all participants in the sugar group would be consuming a fixed amount of sugar, providing a better comparison to the non-sugar group. One of the original 48 participants did not return any data, so only the data from the remaining 47 were used. There were an additional two participants who dropped out midway during the experiment after becoming sick, however we included the data from the days of the experiment that they were able to participate in. Error could have also been introduced due to the subjective nature of how the volunteers rated their energy levels and other variables.

The statistical results from this study reveal the important influence that lifestyle habits, such as sleep and diet, have on one's ability to remain energized throughout the day. Because high sugar diets have been known to be detrimental to overall health, it would be interesting to focus additional testing on the sinus and throat issue ratings provided by volunteers and test for a significant relationship between these issues and the sugar diet. Ultimately, a good night's rest seems to be a good choice according to this study and is consistent with previous conceptions.

References

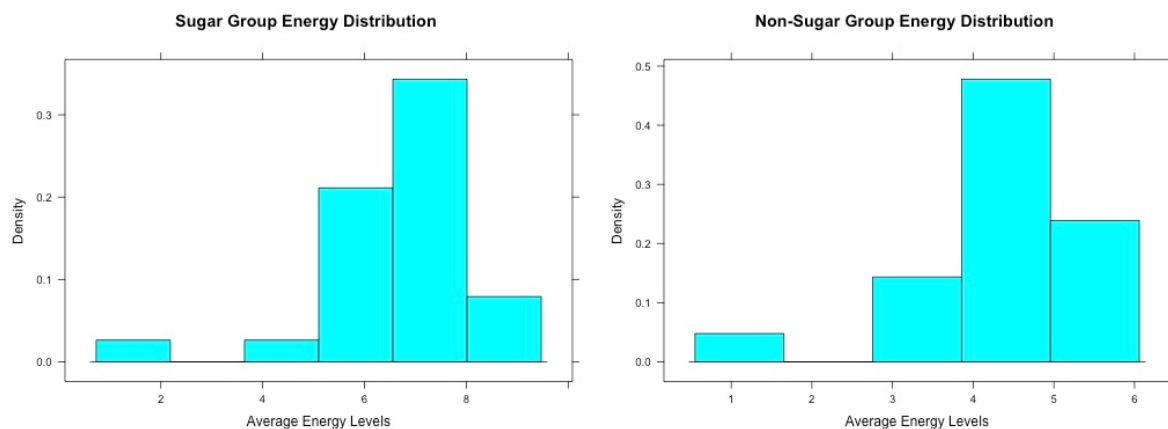
Thayer RE. "Energy, Tiredness, and Tension Effects of a Sugar Snack Versus Moderate Exercise." Journal of Personality and Social Psychology. 52.1 (1987): 119-25.

Appendix

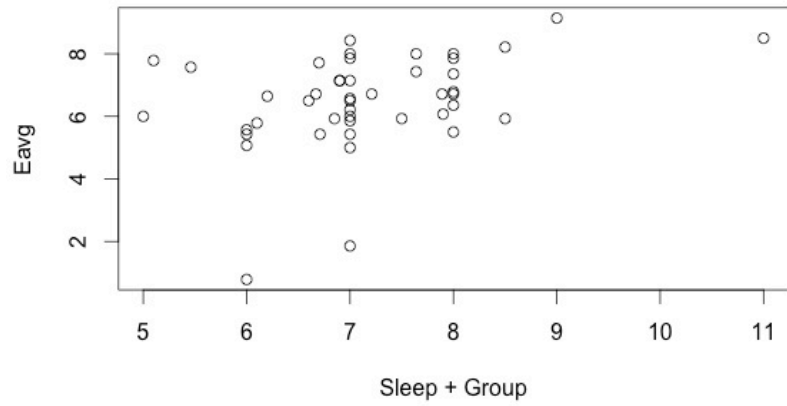
Instructions given to the volunteers:

- **NON SUGAR GROUP:** You will agree not to consume processed sugar for the duration of the experiment (2 weeks). Here are some common sources of processed sugar, which will need to be avoided: corn syrup, candy, sodas, juices, desserts (cookies, cake, etc.), honey. Also, many sauces and breads include sugar. When there is a question, please read the package labels. Plan on consuming your normal diet to the extent that you can. Some non-sugar replacements include chips (read label because some chips have sugar), popcorn, water, milk, coffee, unsweetened tea, fruit, or products with artificial sweetener (diet soda, sugar-free chocolate, etc.).
- **SUGAR GROUP:** You will agree to consume at least one serving of processed sugar at each meal for the duration of the experiment (2 weeks). If you eat a varying number of meals per day, including fasting, this is fine. You are only committing to processed sugar at each meal. One serving consists of, e.g. one cookie or one glass of juice (not 100% juice) or one helping of a dish which has a sugared sauce on it, etc. Some processed sugar products include: corn syrup, candy, sodas, juices, desserts (cookies, cake, etc.), honey, and packaged snacks.

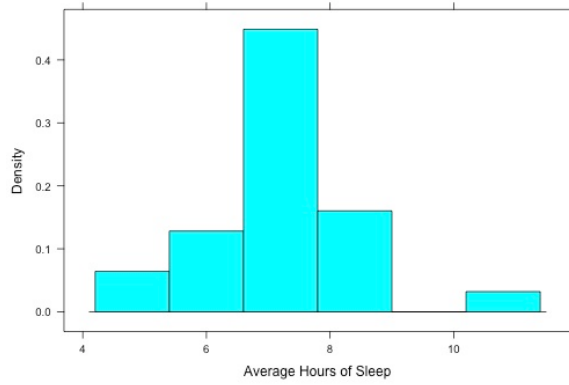
Additional graphs



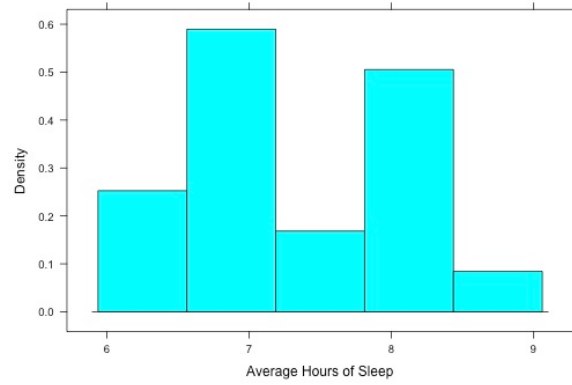
Residuals vs. Fitted Plot



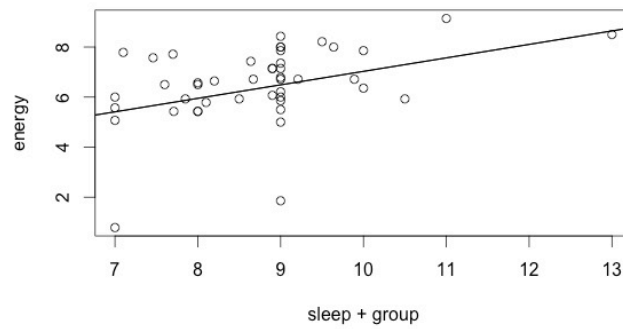
Sugar Group Sleep Distribution

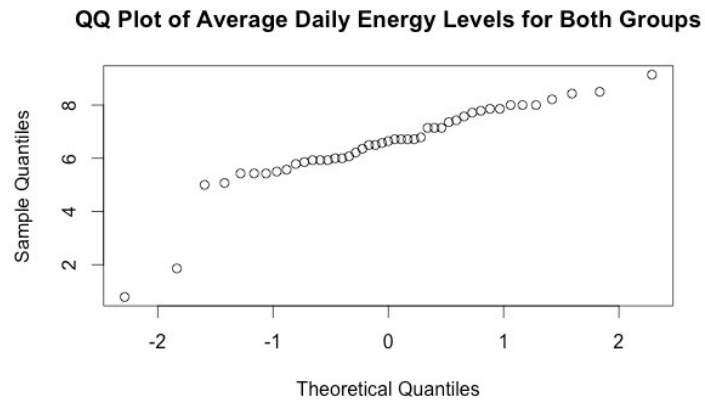
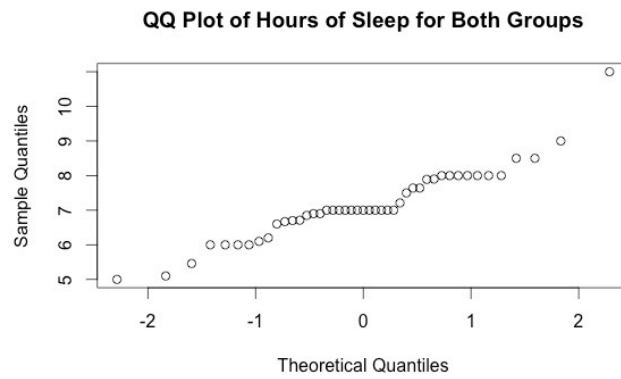


Non-Sugar Group Sleep Distribution



Variation in Energy Levels Due to Sleep and Group





RStudio Output

```
> shapiro.test(fixed.data$Eavg)
```

Shapiro-Wilk normality test

data: fixed.data\$Eavg
W = 0.8659, p-value = 9.672e-05

```
> shapiro.test(fixed.data$Sleep)
```

Shapiro-Wilk normality test

data: fixed.data\$Sleep
W = 0.9246, p-value = 0.006079