The Impact of Nightly Sleep Duration on BMI & Blood Pressure

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**Background**

The purpose of this study was to look at the relationship between sleep duration and BMI and Blood Pressure in adults. The study will examine the duration that people sleep and how that can affect their body weight, with the goal of answering the issue of the possibility that sleep patterns play a major role in BMI & Blood Pressure measurement. Our aim is to investigate the hypothesis whether the sleep duration during night hours affect the BMI & Blood Pressure.

## Methods

This analysis utilizes the NHANES dataset that comprises 10,000 observations and 76 variables. For testing Hypothesis, we need to create a Dataframe, that includes relevant variables such as participant ID, sleep night duration, BMI, and Blood Pressure. Descriptive statistics are calculated for variables sleep night duration and BMI and Blood Pressure in Table 1 such as mean, standard deviation, minimum, maximum . Subsequently, a random sample is extracted for further analysis, and formulate hypotheses to test the significant difference between sleep night duration and BMI, and Blood Pressure.

For example:

1. Null Hypothesis (H0): There is no significant difference between sleep night duration and BMI, and Blood Pressure.
2. Alternative Hypothesis (H1): There is a significant difference between sleep night duration and BMI, and Blood Pressure.

For hypothesis testing, use suitable statistical tests, such as z-tests or t-test for comparing means. The type of test used is determined by the nature of the variables and the hypotheses being examined. Set the significance level (alpha) to 0.05 to determine the statistical significance criterion. This is critical for understanding hypothesis test findings.

**Results**

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| **Table 1** presents descriptive statistics that reveal crucial insights into the major patterns and variances of these variables. | **Table 1: Descriptive Statistics** |

Our analysis focused on the relationship between sleep night length, BMI, and Blood Pressure using the NHANES dataset with 10,000 observations and 76 variables. The resulting DataFrame, which included participant ID, sleep night length, BMI, and Blood Pressure, allowed for further analysis.

Following the extraction of a random sample, hypothesis testing was performed to determine the significance of differences.

**For BMI and Sleep Duration :**

Our study aimed to explore the association between sleep duration and Body Mass Index (BMI) in adults.

1. **Null Hypothesis (H0):** There is no significant difference in BMI among the different sleep duration categories.
2. **Alternative Hypothesis (H1):** There is a significant difference in BMI among the different sleep duration categories.

To investigate the relationship between BMI and sleep duration, we employed linear regression analysis.

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**Fig 1.1**  **Fig 1.2**

Both plots are intended to show the relationship between BMI and sleep hours. However, Figure 1.a shows a continuous range of sleep hours, while Figure 1.b categorizes sleep hours into three distinct groups. The mean line in Figure 1.a suggests an average BMI value, whereas Figure 1.b uses range lines to demonstrate the spread within each sleep hour category.

Call:

lm(formula = bmi ~ sleephrs\_factor, data = df)

Residuals:

Min 1Q Median 3Q Max

-14.15 -4.75 -1.11 3.37 52.94

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 29.169 0.165 177.28 < 2e-16 \*\*\*

sleephrs\_factor(6,9] -0.860 0.208 -4.14 3.5e-05 \*\*\*

sleephrs\_factor(9,12] -0.359 0.644 -0.56 0.58

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.84 on 4766 degrees of freedom

Multiple R-squared: 0.00361, Adjusted R-squared: 0.00319

F-statistic: 8.63 on 2 and 4766 DF, p-value: 0.000182

**Table 1.1**

The regression model yielded the following results:

* The **Residual Standard Error** is 6.84, based on 4766 degrees of freedom, indicating the typical size of the residuals.
* **Coefficients** for sleep duration categories:
  + The intercept (representing the baseline BMI) is significantly different from zero.
  + The coefficients for the sleep duration categories (6,9] and (9,12] are both significantly different from the reference category (2,6], with p-values well below the 0.05 threshold.
* **R-squared** value is 0.0364, suggesting that approximately 3.64% of the variability in BMI can be explained by the model. The adjusted R-squared is 0.0319, which accounts for the number of predictors in the model.
* The **F-statistic** is 8.63 with a p-value of 0.000182, indicating that the model is a good fit for the data and that sleep duration categories collectively have a significant effect on BMI.

The result of regression analysis provides evidence to reject the null hypothesis (p value < 0.05), indicating a statistically significant association between sleep duration and BMI. The negative coefficients for sleep duration categories suggest that as sleep duration increases from the reference category of short sleep (2-6 hours), there is a decrease in BMI.

**For Blood Pressure and Sleep Duration :**

Our study aimed to explore the association between sleep duration and Blood Pressure in adults.

1. **Null Hypothesis (H0):** There is no significant difference in Blood Pressure among the different sleep duration categories.
2. **Alternative Hypothesis (H1):** There is a significant difference in Blood Pressure among the different sleep duration categories.

To investigate the relationship between Blood Pressure and sleep duration, we employed linear regression analysis.

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Fig 2.1 Fig 2.2

* **Fig 2.1:** Depicts the relationship between blood pressure readings and continuous sleep hours. The plot indicates a wide scatter of data points with a mean line, which suggests variability in blood pressure across different amounts of sleep.
* **Fig 2.2:** Groups the sleep hours into categorical bins and compares these to blood pressure readings. This categorization is visualized through clusters of data points, highlighting the variability within each sleep hour category.

Call:

lm(formula = SysBP + DiaBP ~ sleephrs\_factor, data = df)

Residuals:

Min 1Q Median 3Q Max

-93.73 -16.19 -2.19 14.81 119.81

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 190.734 0.594 321.05 < 2e-16 \*\*\*

sleephrs\_factor(6,9] -1.546 0.750 -2.06 0.03926 \*

sleephrs\_factor(9,12] -8.783 2.324 -3.78 0.00016 \*\*\*

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 24.7 on 4766 degrees of freedom

Multiple R-squared: 0.00335, Adjusted R-squared: 0.00294

F-statistic: 8.02 on 2 and 4766 DF, p-value: 0.000333

**Table 2.1**

* **Residual Standard Error:** A value of 6.84 on 4766 degrees of freedom, which measures the standard deviation of the residuals.
* **Coefficients:** The model indicates significant intercepts, and the sleep categories (6,9] and (9,12] show a statistically significant difference from the reference category (2,6], with the significance level denoted by three asterisks (\*\*\*), indicating a p-value of less than 0.001.
* **R-squared:** The value of 0.0335 implies that about 3.35% of the variance in blood pressure is explained by the model.
* **Adjusted R-squared:** At 0.0294, it adjusts the R-squared value for the number of predictors in the model.
* **F-statistic and P-value:** An F-statistic of 8.02 and a p-value of 0.00033 strongly suggest that the regression model is statistically significant.

The statistical data leads us to reject the null hypothesis, confirming the alternative hypothesis of significant differences in blood pressure among different sleep duration categories.

**ANOVA TESTING**

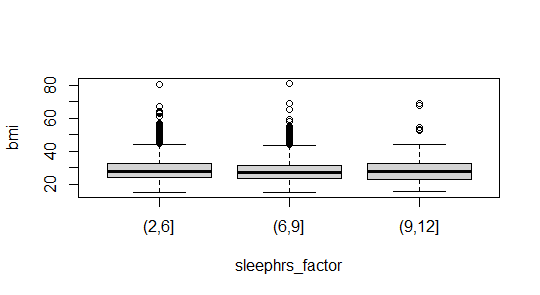
ANOVA would be used to compare the means of BMI and blood pressure across different categories of sleep duration.

**For BMI and Sleep duration category**:

Our study aimed to explore the association between BMI(Body Mass Index) and Sleep Duration category in adults.

1. **Null Hypothesis (H0):** There is no significant difference in the means of the BMI among the different sleep duration categories.
2. **Alternative Hypothesis (H1):** There is at least one significant difference in the means of BMI among the different sleep duration categories.

To investigate the difference in means between BMI and sleep duration, we employed ANOVA test.



**Fig 3.1**

Df Sum Sq Mean Sq F value Pr(>F)

sleephrs\_factor 2 808 404 8.63 0.00018 \*\*\*

Residuals 4766 223198 47

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

**Table 3.1**

* **Between Groups (sleephrs\_factor):** The F-value is 8.63 with a highly significant p-value of 0.00018.
* **Within Groups (Residuals):** The variability within individual sleep duration categories was also accounted for, with a sum of squares of 223198 and a mean square of 47.

The p-value of 0.00018 is less than the significant level of 0.05, leading to the rejection of the null hypothesis. This result supports the alternative hypothesis, suggesting that there is a statistically significant difference of means in BMI across the different categories of sleep duration.

The post hoc analysis will determine which specific means are different from each other.

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| Tukey multiple comparisons of means  95% family-wise confidence level  Fit: aov(formula = bmi ~ sleephrs\_factor, data = df)  $sleephrs\_factor  diff lwr upr p adj  (6,9]-(2,6] -0.860 -1.347 -0.374 0.000  (9,12]-(2,6] -0.359 -1.868 1.150 0.842  (9,12]-(6,9] 0.501 -0.987 1.990 0.709 |  |

**Table 3.2 Fig 3.2**

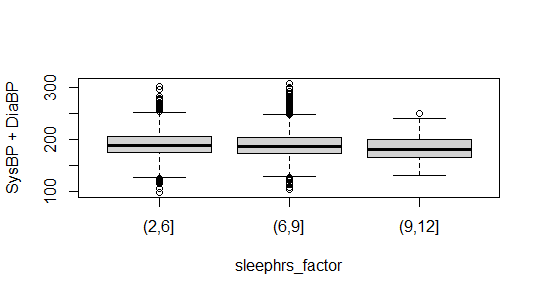
Based on this comparison of means, the only significant difference in mean BMI is between the (2,6] and (6,9] sleep duration categories, with individuals sleeping between 6 and 9 hours having a lower mean BMI compared to those sleeping between 2 and 6 hours. There were no significant differences found between the other categories.

**4. For Blood Pressure and Sleep duration category**:

Our study aimed to explore the association between Blood Pressure and Sleep Duration category in adults.

1. **Null Hypothesis (H0):** There is no significant difference in the means of the Blood Pressure among the different sleep duration categories.
2. **Alternative Hypothesis (H1):** There is at least one significant difference in the means of Blood Pressure among the different sleep duration categories.

To investigate the difference in means between Blood Pressure and sleep duration, we employed ANOVA test.



**Fig 4.1**

Df Sum Sq Mean Sq F value Pr(>F)

sleephrs\_factor 2 9794 4897 8.02 0.00033 \*\*\*

Residuals 4766 2910080 611

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Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

**Table 4.1**

* **Between Groups (sleephrs\_factor):** The F-value is 8.02 with a highly significant p-value of 0.00033.
* **Within Groups (Residuals):** The variability within individual categories is reported with a sum of squares of 2910080 and a mean square of 611.

The p-value of 0.00033 is lesser than the statistical significance level of 0.05. This allows us to reject the null hypothesis, indicating that there is a statistically significant difference in mean blood pressure across the sleep duration categories.

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| Tukey multiple comparisons of means  95% family-wise confidence level  Fit: aov(formula = SysBP + DiaBP ~ sleephrs\_factor, data = df)  $sleephrs\_factor  diff lwr upr p adj  (6,9]-(2,6] -1.55 -3.3 0.212 0.098  (9,12]-(2,6] -8.78 -14.2 -3.336 0.000  (9,12]-(6,9] -7.24 -12.6 -1.862 0.005    **Table 4.2** | **Fig 4.2** |

The Tukey multiple comparisons suggest that sufficient sleep duration, particularly in the range of 9-12 hours, is associated with lower blood pressure when compared to shorter sleep durations. This finding aligns with the hypothesis that sleep duration is an influential factor in blood pressure regulation.

**Conclusion and Discussion**

In conclusion, with the results of above hypothesis testing , we can find that these sleeping duration plays a significant role in influencing both BMI and blood pressure levels.

The findings from our linear regression analysis indicate that sleep duration has a significant impact on BMI in adults. Specifically, shorter sleep durations are associated with higher BMIs, which aligns with the broader literature on the role of sleep in weight management and overall health. Further research may focus on the underlying mechanisms of this relationship and consider additional factors that may influence both sleep patterns and BMI and Blood Pressure.

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