Hypothesis Testing

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1 Hypothesis Testing

The observed correlations from the data analysis and visualizations suggest several hypotheses that could be explored through further analysis:

1. **Impact of Sleep Disturbances on Quality:** Given the strong negative correlation between sleep disturbances and quality, we can hypothesize that increased sleep disturbances are likely to negatively impact the quality of sleep.
2. **Age in Relation to Sleep Duration:** The negative correlation between age and calculated night sleep duration leads to the hypothesis that sleep duration may decrease with age.
3. **Relationship Between Sleep Onset Time and Quality:** The moderate negative correlation observed between sleep onset time and quality suggests that a longer time to fall asleep might be associated with poorer sleep quality.
4. **Influence of Exercise on Sleep Duration and Quality:** The slight positive correlation between exercise days per week and sleep duration hints at a potential hypothesis that increased physical activity could contribute to longer and possibly better quality sleep.
5. **Nap Duration's Effect on Nighttime Sleep Duration and Quality:** Although the correlation is weak, we could investigate whether the duration of naps has any effect on the duration of nighttime sleep.

For each hypothesis, we aim to perform at least two types of hypothesis testing methods provided by the Scipy libray.

1.1 Hypothesis 1 - Increased sleep disturbances negatively impact the quality of sleep.

Null Hypothesis (H_0): The level of Sleep Disturbances has no impact on Sleep Quality.

Alternative Hypothesis (H_1): The level of Sleep Disturbances has a negative impact on Sleep Quality.

1.1.1 Spearman Correlations Test

We will a 1-tail negative *Spearman correlation test* by setting `alternative='less'` to measure the correlation

[5]:
```
import scipy.stats as stats
```

```
correlation, p_value = stats.spearmanr(df['Sleep Quality'].to_numpy(),␣
↪df['Sleep Disturbances Ordinal'].to_numpy().astype(float),␣
↪alternative='less')

print(f'Correlation: {correlation:.3f}')
print(f'P-value: {p_value}')
```

```
Correlation: -0.453
P-value: 4.198014093688787e-07
```

With the given results of a Spearman correlation coefficient (ρ) of approximately -0.453 and a p-value of approximately 4.2e-07, we can draw the following conclusions about the relationship between sleep disturbances and sleep quality:

- **Strength and Direction of Correlation:** The Spearman correlation coefficient of -0.453 indicates a moderate negative correlation between sleep disturbances and sleep quality. This means that as sleep disturbances increase (become more frequent), sleep quality tends to decrease (gets worse).
- **Statistical Significance:** The p-value is a measure of the probability that the observed correlation occurred by chance if there were no actual relationship in the population. A p-value of 4.2e-07 is extremely small, far below the common alpha level of 0.05 used to determine statistical significance. This means that the negative correlation observed is highly unlikely to be due to random variation in the sample; it's statistically significant.

Conclusion: Based on the Spearman correlation test, we can confidently reject the null hypothesis that there is no correlation between sleep disturbances and sleep quality. The data supports the alternative hypothesis that sleep disturbances do affect sleep quality, with more disturbances associated with worse sleep quality. This result aligns with what might be expected intuitively: that individuals who experience more disturbances during sleep tend to report lower overall sleep quality.

1.1.2 Chi-squared Test

First, construct contigency table between `Sleep Disturbances` and `Sleep Quality`

[6]:
```
contingency_table = pd.crosstab(df['Sleep Disturbances'], df['Sleep Quality'])
contingency_table
```

[6]:

Sleep Quality	2	3	4	5
Sleep Disturbances				
Frequently	5	2	0	0
Never	0	5	6	4
Often	2	1	0	0
Rarely	2	17	24	5
Sometimes	5	16	14	0

After that, the Chi-squared test could be conducted with `scipy` library

[7]:
```
from scipy.stats import chi2_contingency

# Perform the Chi-squared test
chi2_stat, p_val, dof, ex = chi2_contingency(contingency_table)

# Print the results
print(f"Chi2 Stat: {chi2_stat}")
print(f"P Value: {p_val}")
print(f"Degrees of Freedom: {dof}")
```

```
Chi2 Stat: 46.03087922530431
P Value: 6.853850711377629e-06
Degrees of Freedom: 12
```

The results from the Chi-squared test on our data can be interpreted as follows

Chi-Squared Statistic (Chi2 Stat): The value is approximately 46.03, which is notably higher than the critical value of 21.026 for a chi-square distribution with 12 degrees of freedom at significant level of 0.05. As a result, this considerable difference suggests strong evidence to reject the Null hypothesis.

P-Value: The p-value is about 6.85e-06, which is significantly less than the common alpha level of 0.05. This low p-value indicates that the observed association between sleep disturbances and sleep quality is highly unlikely to have occurred by random chance.

Conclusion: Given the very low p-value and the high Chi-squared statistic, we can reject the null hypothesis of independence. This means there is a statistically significant association between sleep disturbances and sleep quality in our dataset. In other words, the level of sleep disturbances appears to be related to the reported sleep quality of the individuals in our study.

1.2 Hypothesis 3 - The longer it takes to fall as sleep, the worse Sleep Quality becomes

1.2.1 Spearman Correlation Test

Null Hypothesis (H_0): The increase of Sleep onset time has no impact on Sleep Quality.

Alternative Hypothesis (H_1): The increase of Sleep onset time leads to the decline on Sleep Quality.

[9]:
```
import scipy.stats as stats

# Perform Spearman correlation test
correlation, p_value = stats.spearmanr(df['Sleep Quality'].to_numpy(),␣
↪df['Sleep Onset Time Ordinal'].to_numpy().astype(float), alternative='less')

print(f'Correlation: {correlation}')
print(f'P-value: {p_value}')
```

```
Correlation: -0.37764117513828727
P-value: 2.7990152273389178e-05
```

- **Correlation Coefficient:** The negative correlation coefficient indicates an inverse relationship between sleep onset time and sleep quality. This suggests that longer times to fall asleep (indicating difficulty initiating sleep) are associated with lower sleep quality ratings.
- **Statistical Significance:** The p-value measures the probability that the observed correlation is due to random chance. A p-value of 2.80e-05 is very small and well below the conventional alpha level of 0.05, which is commonly used to assess statistical significance. This indicates that the observed correlation is highly unlikely to have occurred by chance.

Conclusion:

Based on the Spearman correlation test, we can reject the null hypothesis (H_0) that sleep onset time has no impact on sleep quality. Instead, we accept the alternative hypothesis (H_1) that there is a statistically significant negative relationship between sleep onset time and sleep quality. In practical terms, this result suggests that interventions aimed at reducing sleep onset time might be beneficial for improving overall sleep quality.

1.2.2 Chi-squared Test

First, construct contigency table between `Sleep Onset Time` and `Sleep Quality`

[10]:
```python
contingency_table = pd.crosstab(df['Sleep Onset Time'], df['Sleep Quality'])
contingency_table
```

[10]:
```
Sleep Quality     2   3   4  5
Sleep Onset Time
15-30 Minutes     5  22  24  4
30-60 Minutes     5  12   4  0
<15 Minutes       2   5  14  5
>60 Minutes       2   2   2  0
```

After that, the Chi-squared test could be conducted with `scipy` library

[11]:
```python
from scipy.stats import chi2_contingency

# Perform the Chi-squared test
chi2_stat, p_val, dof, ex = chi2_contingency(contingency_table)

# Print the results
print(f"Chi2 Stat: {chi2_stat}")
print(f"Degrees of Freedom: {dof}")
print(f"P Value: {p_val}")
```

```
Chi2 Stat: 19.297119225405574
Degrees of Freedom: 9
P Value: 0.022781787964876524
```

The results from the Chi-squared test related to Hypothesis 3, which concerns the relationship between sleep onset time and sleep quality, can be interpreted as follows:

1. **Chi-Squared Statistic (Chi2 Stat):** The value is approximately 19.30. This statistic measures how much the observed frequencies in the data deviate from the frequencies that

would be expected if there were no association between sleep onset time and sleep quality. A higher value typically indicates a stronger departure from the null hypothesis.

2. **P-Value:**

The p-value is approximately 0.0228, which is lower the common alpha level of 0.05. This indicates that there is a statistically significant association between sleep onset time and sleep quality, although the strength of this association is not as strong as it might be for a much lower p-value.

Conclusion: Given the p-value of 0.0228, which is less than the alpha level of 0.05, we can reject the null hypothesis. This suggests that there is a statistically significant association between sleep onset time and sleep quality in our dataset. The relationship, as indicated by the Chi-squared statistic, is present but not extremely strong.

1.3 Hypothesis 4a - Weekly exercise frequency improves sleep quality

1.3.1 Spearman Correlation Test

Null Hypothesis (H_0): The increase of Weekly exercise frequency has no impact on Sleep Quality.

Alternative Hypothesis (H_1): The increase of Weekly exercise frequency improves on Sleep Quality.

Since we are testing the positive correlation, `alternative='greater'` is used

[13]:
```
import scipy.stats as stats

# Perform Spearman correlation test
correlation, p_value = stats.spearmanr(df['Exercise Days/Week Ordinal'],␣
↪df['Sleep Quality'], alternative='greater')

print(f'Correlation: {correlation}')
print(f'P-value: {p_value}')
```

```
Correlation: -0.0577165101075317
P-value: 0.7235175030385403
```

1. **Correlation Coefficient:** The negative correlation coefficient of -0.0577 is very close to zero, indicating a very weak inverse relationship between exercise frequency and sleep quality. This suggests that as exercise frequency increases, there is a very slight tendency for sleep quality to decrease, but the effect is so small that it might not be meaningful in practical terms.

2. **Statistical Significance:** The p-value of 0.724 is much higher than the common alpha level of 0.05. A high p-value indicates that the correlation observed in the sample is very likely to have occurred by random chance and is not statistically significant.

Conclusion: Based on this analysis, there is no evidence to support a significant relationship between exercise frequency and sleep quality in the dataset. The correlation is very weak and not statistically significant. This means that, within the data collected, changes in exercise frequency do not appear to have a notable impact on sleep quality. These findings suggest that other factors not captured in this analysis might play a more substantial role in determining sleep quality.

1.3.2 Chi-squared Test

First, construct contigency table between `Exercise Days/Week` and `Sleep Quality`

After that, the Chi-squared test could be conducted with `scipy` library

[15]:
```
from scipy.stats import chi2_contingency

# Perform the Chi-squared test
chi2_stat, p_val, dof, ex = chi2_contingency(contingency_table)

# Print the results
print(f"Chi2 Stat: {chi2_stat}")
print(f"P Value: {p_val}")
print(f"Degrees of Freedom: {dof}")
```

```
Chi2 Stat: 13.219870509579255
P Value: 0.1529071255382214
Degrees of Freedom: 9
```

1. **Chi-Squared Statistic (Chi2 Stat):** With a critical value of approximately 16.92 for a chi-square distribution with 9 degrees of freedom at a significance level (α) of 0.05, it's important to note that the calculated chi-square statistic (13.2199) falls below this critical value. Consequently, this indicates insufficient evidence to reject the null hypothesis.
2. **P-Value:** Given a p-value of 0.1529, which exceeds the common significance level of 0.05 (or 5%), we are unable to reject the null hypothesis (H_0). In essence, this implies that there isn't enough compelling evidence to support a significant association or difference between the variables under examination (Weekly Exercise Frequency and Sleep Quality). In simpler terms, the observed data does not significantly differ from what would be expected assuming no association or difference.

Conclusion: In summary, the results of the chi-squared test indicate that we lack the requisite evidence to reject the null hypothesis. Therefore, at a 5% significance level, it is not possible to conclude that Weekly Exercise Frequency has a significant impact on Sleep Quality.

1.4 Hypothesis 4b - Weekly exercise frequency improves Sleep Duration

1.4.1 Spearman Correlation Test

Null Hypothesis (H_0): The increase of Weekly exercise frequency has no impact on Sleep Quality.

Alternative Hypothesis (H_1): The increase of Weekly exercise frequency improves on Sleep Quality.

Since we are testing the positive correlation, `alternative='greater'` is used

[16]:
```
import scipy.stats as stats

# Perform Spearman correlation test
da = df.dropna(subset=['Calculated Night Sleep Duration','Calculated Night␣
↪Sleep Duration'], axis='index')
```

```
correlation, p_value = stats.spearmanr(da['Exercise Days/Week Ordinal'],␣
↪da['Calculated Night Sleep Duration'], alternative='greater')

print(f'Correlation: {correlation}')
print(f'P-value: {p_value}')
```

```
Correlation: 0.18054562562558002
P-value: 0.032659161103946364
```

1. **Correlation Coefficient:** The correlation coefficient, denoted as r, is approximately 0.1805. This value represents a positive, albeit relatively weak, linear relationship between "Weekly Exercise Frequency" and "Night Sleep Duration." In practical terms, it implies that as weekly exercise frequency increases, there is a tendency for night sleep duration to increase slightly, but the strength of this relationship is not very robust.

2. **Statistical Significance:** The p-value associated with the correlation coefficient is approximately 0.0327. This p-value is less than the conventional significance level of 0.05. Consequently, it indicates that the observed correlation between weekly exercise frequency and night sleep duration is statistically significant. This suggests that the observed relationship is unlikely to be a random occurrence.

Conclusion: In summary, the data reveals a statistically significant, yet relatively weak, positive linear relationship between weekly exercise frequency and night sleep duration. This means that as weekly exercise frequency increases, there is evidence to suggest a slight increase in night sleep duration, but it's important to note that other factors may also play a role in determining sleep duration.

1.4.2 ANOVA Test

[17]:
```
import scipy.stats as stats

# Create a DataFrame
da = df.dropna(subset=['Calculated Night Sleep Duration','Calculated Night␣
↪Sleep Duration'], axis='index')

# Perform one-way ANOVA
groups = da["Exercise Days/Week"].unique()
anova_results = []

for group in groups:
    group_data = da[da["Exercise Days/Week"] == group]["Calculated Night Sleep␣
↪Duration"]
    anova_results.append(group_data)


# Perform the ANOVA
f_statistic, p_value = stats.f_oneway(*anova_results)
print(f"F-statistic: {f_statistic}")
print(f"P-value: {p_value}")
```

```
F-statistic: 2.9423229179890527
P-value: 0.03667055489715219
```

1. **F-statistic:** The F-statistic of approximately 2.9423 indicates that there exists some variation between the group means, specifically in the context of sleep duration across exercise frequency groups.
2. **P-value:** With a p-value of approximately 0.0367, which falls below the commonly selected significance level of 0.05, we find evidence to conclude that the one-way ANOVA is statistically significant.

Conclusion: We can infer that there are statistically significant differences in sleep duration among the exercise frequency groups. In practical terms, this suggests that exercise frequency does indeed have a statistically significant impact on sleep duration. However, it's worth noting that the ANOVA itself doesn't elucidate the magnitude or direction of these differences. Further post-hoc tests or in-depth analysis may be necessary to explore the specific nature and extent of these variations.

2 Conclusion

At a significance level of 0.05, our analysis reveals the following noteworthy associations between various factors and sleep quality:

- **Sleep Disturbance:** We find that an increase in sleep disturbances is linked to a notable deterioration in sleep quality. This suggests that individuals experiencing more sleep disruptions tend to report lower sleep quality, indicating the detrimental impact of such disturbances on overall restorative sleep.
- **Sleep Onset Time:** Our analysis indicates that the speed at which an individual falls asleep plays a significant role in determining sleep quality. Specifically, a quicker onset of sleep is associated with a substantial improvement in sleep quality. This implies that individuals who are able to fall asleep more rapidly tend to enjoy a better overall sleep experience in terms of quality.
- **Exercise Weekly Frequency:** Interestingly, our findings do not provide sufficient statistical evidence to support the notion that increasing exercise frequency significantly enhances sleep quality. However, it is worth noting that a correlation exists between higher exercise frequency and extended sleep duration. This suggests that individuals who engage in more frequent exercise routines tend to sleep for longer durations, although the improvement in sleep quality itself remains inconclusive.