One-Way ANOVA

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2023-04-08

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Learning Objectives

1 Sample data

This dataset consists of 45 participants divided into three exercise programs (A, B, and C). Each participant's flexibility was measured at three time points (Time1, Time2, and Time3). Additionally, the dataset includes information about each participant's gender (Male or Female).

Download the dataset:

2 Intro to one-way ANOVA

One-way Analysis of Variance (ANOVA) is a statistical technique used to compare the means of three or more groups. It is an extension of the t-test, which can only compare the means of two groups. The main purpose of one-way ANOVA is to determine if there are any significant differences among the group means.

One-way ANOVA tests the null hypothesis (H0) that all group means are equal against the alternative hypothesis (H1) that at least one group mean is different. It does not tell us which specific group means are different, but rather whether there is sufficient evidence to conclude that there is a significant difference among the groups. If the null hypothesis is rejected, post-hoc tests can be conducted to identify the specific group differences.

3 Equation

The one-way ANOVA equation can be broken down into two parts: the calculation of the sum of squares (SS) and the F-ratio. The F-ratio is the test statistic used to determine whether there is a significant difference among the group means.

3.1 Calculate the sum of squares:

Sum of squares is calculated using the following components:

Sum of squares between groups (SSB): It measures the variability among group means.

$$SSB = \Sigma k(i. - ..)^2/ni$$

where k is the number of groups, Ŷi. is the mean of group i, Ŷ.. is the grand mean, and ni is the number of observations in group i.

Sum of squares within groups (SSW): It measures the variability within each group.

$$SSW = \Sigma\Sigma(Yij - i.)^2$$

where Yij is the observation j in group i, and Ŷi. is the mean of group i.

Total sum of squares (SST): It measures the total variability in the data.

$$SST = \Sigma\Sigma(Yij - ..)^2$$

3.2 Calculate the F-ratio

The F-ratio is calculated using the mean squares, which are obtained by dividing the sum of squares by their respective degrees of freedom.

Mean squares between groups (MSB):

$$MSB = SSB/(k-1)$$

where k is the number of groups.

Mean squares within groups (MSW):

$$MSW = SSW/(N-k)$$

where N is the total number of observations.

F-ratio:

$$F = MSB/MSW$$

The F-ratio follows an F-distribution with (k - 1) and (N - k) degrees of freedom. The F-ratio is then compared to the critical value from the F-distribution table at a given significance level (usually   = 0.05) to determine if the null hypothesis can be rejected.

4 One-Way ANOVA Example

Using the sample dataset provided earlier, we will now perform a one-way ANOVA to determine if there is a significant difference in flexibility among the three exercise programs.

4.1 Research question

Is there a significant difference in flexibility among participants in the three different exercise programs (A, B, and C)?

4.2 Hypothesis Statements

Null Hypothesis (H0): $\mu_A = \mu_B = \mu_C$

There is no significant difference in flexibility among the three exercise programs.

Alternative Hypothesis (H1): $\mu_A \neq \mu_B$ or $\mu_A \neq \mu_C$ or $\mu_B \neq \mu_C$

There is a significant difference in flexibility among at least two of the exercise programs.

4.3 Hand calculation

1. Calculate the group means, grand mean, and the number of observations in each group:
   - Group A mean (ŶA.) = (20 + 25 + 28 + 22 + 27) / 5 = 24.4
   - Group B mean (ŶB.) = (30 + 35 + 29 + 32 + 37) / 5 = 32.6
   - Group C mean (ŶC.) = (26 + 24 + 21 + 27 + 22) / 5 = 24
   - Grand mean (Ŷ..) = (24.4 + 32.6 + 24) / 3 = 27
   - Number of observations: nA = nB = nC = 5
2. Calculate the sum of squares:
   - SSB = Σk(Ŷi. - Ŷ..)^2 / ni = [(24.4 - 27)^2 + (32.6 - 27)^2 + (24 - 27)^2] / 5 = 52.88
   - SSW = ΣΣ(Yij - Ŷi.)^2 = [(20 - 24.4)^2 + ... + (22 - 24)^2] = 342.8
   - SST = ΣΣ(Yij - Ŷ..)^2 = [(20 - 27)^2 + ... + (22 - 27)^2] = 395.68
3. Calculate the F-ratio:
   - MSB = SSB / (k - 1) = 52.88 / (3 - 1) = 26.44
   - MSW = SSW / (N - k) = 342.8 / (15 - 3) = 28.57
   - F = MSB / MSW = 26.44 / 28.57 = 0.925
4. Determine the critical value:
   - For = 0.05 and degrees of freedom (2, 12), the critical value from the F-distribution table is approximately 3.89.
5. Compare the F-ratio to the critical value:

- Since the calculated F-ratio (0.925) is less than the critical value (3.89), we fail to reject the null hypothesis. This means that there is not enough evidence to conclude that there is a significant difference in flexibility among the three exercise programs.

In summary, one-way ANOVA is a powerful statistical technique for comparing the means of three or more groups. By understanding the underlying concepts and equations, kinesiology professionals can apply this method to their research and draw meaningful conclusions about the effects of various interventions on human movement and health.

4.4 Analyze with jamovi

Here are the steps to analyze the provided dataset using jamovi:

1. **Import the dataset:**
   - First, open jamovi and click on the 'open' button in the top-left corner.
   - Browse your computer to find the CSV file containing the dataset, select it, and click 'Open.'
   - The dataset should now be displayed in the jamovi data editor.
2. **Conduct the one-way ANOVA:**
   - Click on the 'Analyses' tab in the top-left corner of the jamovi window.
   - In the 'Analyses' panel on the left side, click on the 'ANOVA' section, and then select 'One-Way ANOVA.'
   - In the 'One-Way ANOVA' options panel, drag and drop the 'Flexibility' variable into the 'Dependent Variable' box and the 'Group' variable into the 'Fixed Factors' box.
3. **Select additional options (if desired):**
   - Under the 'Assumption Checks' section, you can select 'Homogeneity tests' to check for the homogeneity of variances assumption (Levene's test).
   - Under the 'Post Hoc Tests' section, you can select a post hoc test (e.g., Tukey, Bonferroni, or Scheffé) to perform pairwise comparisons between the groups if you find a significant overall effect.
4. **Interpret the results:**
   - After completing the steps above, jamovi will display the results of the one-way ANOVA in the right panel.
   - Look for the 'ANOVA' table, which includes the F-ratio, degrees of freedom, p-value, and other relevant information.

- Compare the calculated p-value with your chosen significance level (usually = 0.05). If the p-value is less than , you can reject the null hypothesis and conclude that there is a significant difference in flexibility among the exercise programs.

5. **Interpret post hoc tests (if applicable):**

    - If you selected a post hoc test and found a significant overall effect, examine the post hoc test results to determine which specific group means are significantly different from each other.

By following these steps, you can analyze the provided dataset using one-way ANOVA in jamovi and draw meaningful conclusions about the differences in flexibility among the three exercise programs.