

## Speed Skating



Athletes from The Netherlands have fared rather well in speed skating events. In fact, Dutch competitors in the Winter Olympics have won 130 medals, 121 in speed skating events. But are the Dutch speed skaters that much better than those from the United States?

Using data from the *SpeedskatingResults.com* database, the times for 15 of the top 100 performances in the Ladies 3000 meter event in 2017 were randomly sampled from each country. You will use these data to answer the following research question:

Do female athletes from The Netherlands have lower average times in the 3000m events than female athletes from the United States?

Discuss the following questions.

1. Based on the research question, identify each of the groups/conditions for the treatment variable.

2. Based on the research question, identify the response variable.

**Observed Data:** The data in *speed-skating.tp* contains a random sample of 30 times (in seconds) for the Ladies 3000m event. Fifteen of these times were recorded by Dutch athletes and 15 from athletes from the United States.

3. Identify whether the response variable is categorical or quantitative in nature.

#### Examine the Observed Data

- Plot the observed times for both groups of skaters in the same plot. Also compute and display the average time for both groups.
4. Sketch the plot of the observed data.

5. Calculate the difference in the mean times for the observed data (i.e., report the observed result). What does the sample result suggest about the answer to the research question.

### Modeling the Sampling Variation

You will now use TinkerPlots™ to conduct a **bootstrap test** in order to account for sampling variation (variation in the difference of means just because of random sampling) *under the assumption that there is no difference in mean times between Dutch and U.S. speed skaters.*

- Set up a sampling device that includes all 30 **observed responses**. You can copy-and-paste the responses from the observed data into a **Mixer**, but don't forget to first remove the default elements so that you paste the results into an empty **Mixer**. Set the **Mixer** to sample *with replacement*.
- Add a linked **Stacks** device that includes the **group/condition labels**.
- Run the model.

### Plotting and Collecting the Results

- Use TinkerPlots™ to plot the results for the trial.
- Collect the results (difference in means) from the trial.

### Simulate and Evaluate the Results

- Carry out 500 bootstrap trials of the simulation in TinkerPlots™.
- Plot the differences in means for the 500 bootstrap trials.

6. Sketch the plot of the distribution of simulated differences.

### Quantifying the Likelihood of the Observed Result Given the Model: $p$ -Value

7. Compute and report the  $p$ -value for the observed difference.

8. Interpret the  $p$ -value you computed.

The  $p$ -value of \_\_\_\_ is the probability of ...

9. Based on the  $p$ -value you computed, how compatible is the observed difference in means with the results produced by the model specified in the null hypothesis? What does this suggest about the answer to the research question? Explain.

### Design and Inference

10. How would you rate the level of internal validity evidence based on the study design? Explain.
  
11. Based on your response to the previous question, are you willing to draw a causal association that the faster times posted by Dutch skaters is due to them being from The Netherlands? If not, offer at least two other possible explanations for the difference in performance.