Labs 8 and 9: Hypothesis Testing

Data

Today we look at data from a paper\textsuperscript{1} studying the effect that light at night has on weight gain and other variables in mice. According to the paper, “The global increase in the prevalence of obesity and metabolic disorders coincides with the increase of exposure to light at night and shift work”. This study is determining whether light at night plays a causal role in the obesity epidemic. The paper is available \textsuperscript{here}.

The study took \( n = 30 \) mice and randomized them to three different treatment groups. All mice spent 16 hours in light, and the explanatory variable was the level of light during the remaining 8 hours. Some of the mice were randomized to darkness during those 8 hours (as is typical for regular mice), some were randomized to a dim light (equivalent to a TV on in the room for humans), and the remaining mice were exposed to bright light for all 24 hours. Mice are nocturnal, and typically most of their activity and eating happen at night. The hypothesis of this study was that having a light on at night may alter mouse eating habits and/or metabolism, and so increase body mass.

The data can be downloaded \textsuperscript{here}. There are some missing values because one mouse died, and one mouse did not receive the full glucose injection for it’s glucose tolerance test. Here is a description of the variables:

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Variable Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>Treatment group (dark, dim, bright)</td>
</tr>
<tr>
<td>BodyMass0</td>
<td>Body mass at the beginning of the experiment (week 0)</td>
</tr>
<tr>
<td>BodyMass8</td>
<td>Body mass after 8 weeks of the experiment</td>
</tr>
<tr>
<td>BMChange</td>
<td>Change in body mass (BodyMass8 - BodyMass0)</td>
</tr>
<tr>
<td>Corticosterone</td>
<td>Blood corticosterene level (a measure of stress)</td>
</tr>
<tr>
<td>DayPct</td>
<td>Percentage of calories consumed during the day</td>
</tr>
<tr>
<td>Consumption</td>
<td>Average daily consumption (in grams)</td>
</tr>
<tr>
<td>GlucoseInt</td>
<td>Glucose intolerant at end of study? (Yes or No)</td>
</tr>
<tr>
<td>GTT15</td>
<td>Glucose level in the blood 15 minutes after a glucose injection</td>
</tr>
<tr>
<td>GTT120</td>
<td>Glucose level in the blood 120 minutes after a glucose injection</td>
</tr>
<tr>
<td>Activity</td>
<td>A measure of physical activity level</td>
</tr>
</tbody>
</table>

So far we’ve only learned how to compare two groups, so for this lab we will just compare the mice exposed to darkness to the mice exposed to bright light overnight. (So when you copy and paste the data, ignore the dim light mice.) The paper uses all three groups, so you may get different results from what is published.

Does being exposed to light at night increase body mass in mice?

Exercise 1: Exploring the data:

(a) What is the explanatory variable?

(b) What should the response variable be?

(c) Plot the response variable by the explanatory variable. (You can use Minitab or the Descriptive Statistics column in StatKey).

(d) Does being exposed to light at night appear to increase body mass in mice? (The goal of this lab is to formalize the answer to this question).

Exercise 2: Hypotheses and statistic:

(a) Define the relevant parameters.

(b) State the null and alternative hypotheses.

(c) Calculate the relevant observed statistic.

Exercise 3: We want to see what kinds of statistics we would see, just by random chance, if the null hypotheses were true. Use the handout to generate one such statistic.

(a) Wrip the sheet in half to break the association between the explanatory variable (light condition) and the response variable (change in body mass). Ensuring no association between the two ensures the null hypothesis is true.

(b) Break up the different values of body mass chance and shuffle them.

(c) Randomly deal them out into two piles, one pile representing the bright light group (how many mice?) and one pile representing the dark group. This mimics the random assignment used in the actual experiment, so allows us to see what would happen just by random chance.

(d) Calculate the difference in means for your simulated sample.

(e) Why did you keep the response values fixed? Why did you deal the values randomly into two piles?

Exercise 4: Go to “Randomization Test for Difference in Means,” copy and paste in your data, and click “Generate one sample”. Explain in detail what StatKey is doing when it generates one sample. HINT: StatKey is doing the same thing you just did!

Exercise 5: Generate a randomization distribution by clicking “Generate 1000 samples,” (you can click this several times, if you like).

(a) Explain what each dot in the randomization distribution represents.

(b) Does your actual statistic look very extreme?

(c) Calculate the p-value and interpret it in context.

(d) Using $\alpha = 0.05$, make a generic conclusion regarding the hypotheses.

(e) Make a conclusion in context.
Exercise 6: Create a 95% confidence interval for the amount that having light on at night increases body mass in mice.

Exercise 7: The researchers were also interested in whether having a light on at night can cause diabetes, so gave the mice a glucose tolerance test (GTT). Test whether light at night causes glucose intolerance in mice (use the categorical outcome).

(a) State the hypotheses.
(b) Calculate the observed sample statistic.
(c) Calculate the p-value.
(d) Make a conclusion in context.

Exercise 8: Does BodyMass0 differ significantly between the two treatment groups?

(a) Should BodyMass0 be significantly different on average between the two treatment groups? Why or why not?

(b) Test to see whether BodyMass0 differs significantly between the two groups. State the hypotheses, calculate the p-value, and make a conclusion in context, using a significance level of $\alpha = 0.05$.

(c) Did you make either a Type I or a Type II error? If so, which kind?

Exercise 9: The paper is titled “Light at night increases body mass by shifting the time of food intake.” Their explanation for the increase in body weight under exposure to light at night is that a higher percentage of calories are consumed during the day, while mice are typically sleeping. Test whether the percentage of calories consumed during the day is significantly higher on average in mice exposed to bright light at night, as opposed to darkness. State hypotheses, calculate a p-value, and make a conclusion in context.

Exercise 10: This difference only really matters if the percentage of calories consumed during the day is correlated with change in body mass. Test whether the association between DayPct and body mass change is significant. State hypotheses, calculate a p-value, and make a conclusion in context.

Exercise 11: Might the fact that mice exposed to light at night gain significantly more weight be caused by a shift in when calories are consumed? Based on the data we have, can we establish with certainty whether this is true? Why or why not? (The researchers conducted additional studies involving limiting when the mice had access to food, in order to further address this question. If you are interested, read the paper!)

Exercise 12: The paper claims “Mice housed in either bright or dim light at night have significantly increased body mass and reduced glucose tolerance compared with mice in a standard light/dark cycle, despite equivalent levels of caloric intake and total daily activity output”. Do you agree with this claim (at least for bright light)? Why or why not? (Address all four parts of the claim; you’ve already done the work for the first half of the claim, the second half requires a bit more testing.)