JMP INTRO® Lab Activities

Lab Activity – Hypothesis Testing – Two-Sample *t*-test

Data Sets: HTWT12.jmp and HTWT15.jmp

It is well known that mean height for adult males is greater than for females. You are going to examine if the mean heights for 12-year-old and 15-year-old adolescent males is greater than the mean heights for similarly aged females. You will be given data for the heights of a random sample of 12-year-old males and females from a middle school. You will also be given data for the heights of a random sample of 15-year-old males and females from a high school.

Open JMP INTRO, and from the **JMP Starter** menu, select **Open Data Table**. Open the HTWT12.jmp file. Choose **Analyze** ® **Distribution** using **Height** as the **Y,Columns** variable **By Gender**. Look at the displays of the data to see if the conditions for using the two-sample *t* test are reasonable.

To compare means, choose **Analyze** ® **Fit Y by X** with **Height** as the **Y,Response** variable and **Gender** as the **X,Factor**. Because **Gender** is categorical, this produces side-by-side vertical dotplots for the two gender groups. To continue with the analysis, select **UnEqual Variances** from the pop-up red triangle menu from **Oneway Analysis of Height By Gender**. This causes a test to be done for whether the variances are equal, but it also displays the output necessary for the two-sample *t*-test. Although you don't need to worry about the variance test analysis, if you want to find out more information about this analysis, click on the question mark icon,  , and when the cursor changes to a question mark, click somewhere in the **Tests that the Variances are Equal** area. For the two-sample *t*-test, the test statistic is the last line of the display of this test. The p-value is in the line of output above this, **Prob > F**. JMP INTRO provides a p-value for a two-sided test.

Repeat this analysis, using the second data set HTWT15.jmp, a sample of 15-year-olds.

Using your results from JMP INTRO, carry out a complete hypothesis test for each age using one of the commonly used significance levels. Include assumptions, hypotheses, sample statistic values, test statistic and p-values, and conclusions in the context of the problem. Be sure to include a graphical display of the data and hypothesis test results from JMP INTRO into your word processing document.

JMP INTRO® Lab Activities
Teacher Notes

Lab Activity – Hypothesis Testing – Two-Sample *t*-test

Objectives:
- Gain familiarity with some of the basic operational tools of JMP INTRO.
- Use JMP INTRO to conduct a hypothesis test for a comparison of two means.
- Create a word processing document, incorporating displays from JMP INTRO.

Time Required: 45 minutes

Materials:
- Hypothesis Testing – Two-Sample *t*-test student activity directions
- HTWT12.jmp and HTWT15.jmp data sets

  Note: HTWT12.jmp and HTWT15.jmp are data sets that are not included in the Sample Data folder for JMP INTRO. These data sets can, however, be downloaded from SAS (the parent company of JMP) free of charge. To do so, go to the www.jmpdiscovery.com website. Go to **Support & Services** on the left-hand side, and click on **Documentation**. At the top of the next screen, click on **JMP IN Doc**. You may need to scroll down on this screen until you reach a link labeled **sample data used in the examples**. Click here. You again may need to scroll down a bit, until you reach the download area. Choose the correct format, and click on the **Request Download** box. When you do so, you will be asked to complete a profile form before downloading.

Prerequisites:
- Students should have basic knowledge of how to use JMP INTRO.
- Students should have experience conducting tests of hypothesis for a comparison of two means by hand and/or with graphing calculators.
- Students should have experience writing conclusions for hypothesis tests in the context of the problem.

JMP INTRO Notes:
- JMP INTRO includes an extensive online help system. It contains a table of contents and/or can be used to search for a specific topic. In addition, JMP INTRO has context sensitive help. You can access it by selecting the help tool (?) from the tools toolbar and clicking inside a data table or report. JMP INTRO opens help specific to the clicked-on item.
- Students should have a good conceptual understanding of p-values.
- When conducting the significance test, students may wonder why they choose the test with unequal variances rather than conducting the **Means/Anova/*t* Test**. Conducting a two-sample *t*-test for means assuming unequal variances is a more

conservative approach. The **Means/Anova/*t* Test** assumes equal variances and pools the data. Many statisticians suggest using the unequal variance approach with an introductory statistics class.

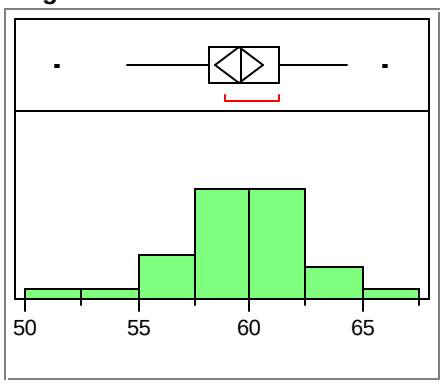
- There will probably be a great deal of confusion in the calculation of the p-value for the twelve-year-old comparison. JMP INTRO automatically assumes a two-sided test for comparison of means. The alternate hypothesis in this case is one-sided, and the data does not support this one-sided alternate. As a result, to correctly calculate the p-value, students must split the given p-value in half for a one-sided test, but in this case, that value needs to be subtracted from one. Because the observed difference in means is not in the direction of the alternative hypothesis, you should get a resulting p-value greater than 0.05. Students may question why a hypothesis test was even necessary, and in reality, a test was not required to conclude insufficient evidence to show twelve-year-old males taller than twelve-year-old females.

JMP INTRO® Lab Activities
Answer Key

The following are suggested answers for Hypothesis Testing – Two-sample *t*-test.

Graphical displays of data for 12-year-olds:

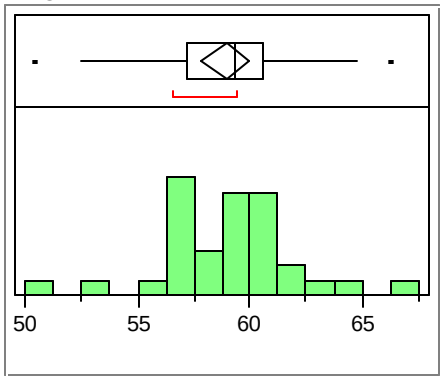
Gender=f
Distributions
Height



Moments

Mean	59.51
Std Dev	2.9878316
Std Err Mean	0.5455009
upper 95% Mean	60.625675
lower 95% Mean	58.394325
N	30

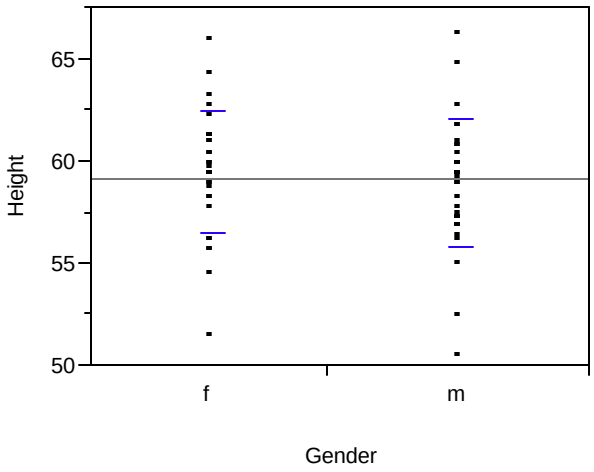
Gender=m
Distributions
Height



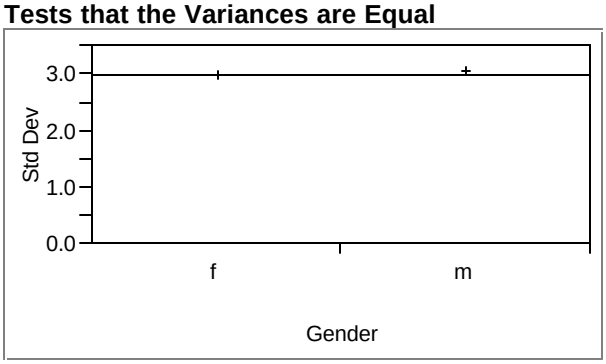
Moments

Mean	58.884848
Std Dev	3.0736909
Std Err Mean	0.5350609
upper 95% Mean	59.974732
lower 95% Mean	57.794965
N	33

JMP INTRO significance test output for 12-year-olds:



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
f	30	2.987832	2.183333	2.183333
m	33	3.073691	2.247750	2.227273

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	0.0160	1	61	0.8998
Brown-Forsythe	0.0071	1	61	0.9331
Levene	0.0158	1	61	0.9003
Bartlett	0.0240	1	.	0.8769

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
0.6694	1	60.714	0.4165

t-Test
0.8181

Assumptions: We need to assume the data represents independent samples of twelve-year-old males and twelve-year-old females. Because the two sample sizes are 30 and 33, we should be safe in using the two-sample *t* procedures.

Hypotheses:

$H_o: m_M = m_F$ The average twelve-year-old male is the same height as the average twelve-year-old female.

$H_a: m_M > m_F$ The average twelve-year-old male is taller than the average twelve-year-old female.

Test mechanics: $$t = \frac{\bar{x}_M - \bar{x}_F}{\sqrt{\frac{s_M^2}{n_M} + \frac{s_F^2}{n_F}}} = \frac{58.8848 - 59.5100}{\sqrt{\frac{3.073691^2}{33} + \frac{2.987832^2}{30}}} = -0.818$$

Note: JMP INTRO reports the p-value as a two-sided value and reports the test statistic as positive.

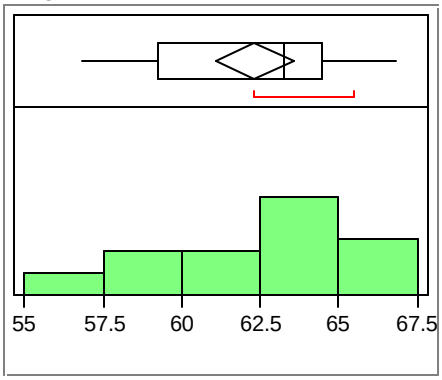
p = 0.79

Note: JMP INTRO reports the two-sided p-value. Because the observed difference in means is not in the direction of the alternative hypthesis, to find the actual p-value of this test, we need to take 1 – (0.4165/2) = 0.79.

Conclusion: At the $\alpha = 0.05$ level, because $p = 0.79 > 0.05$, we fail to reject the null hypothesis. We have insufficient evidence to show that the average male 12-year-old tends to be taller than the average female 12-year-old.

Graphical displays of data for 15-year-olds:

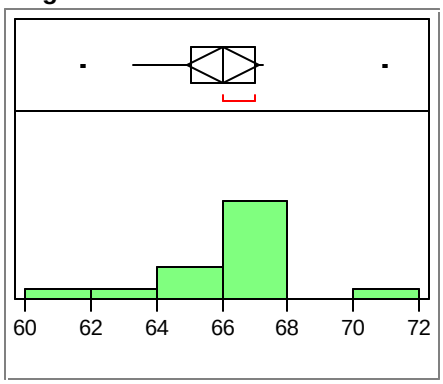
Gender=f
Distributions
Height



Moments

Mean	62.329167
Std Dev	3.0149597
Std Err Mean	0.6154261
upper 95% Mean	63.602272
lower 95% Mean	61.056061
N	24

Gender=m
Distributions
Height

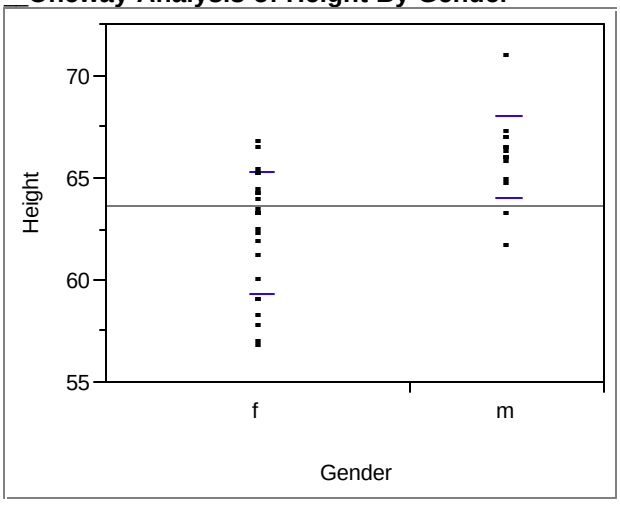


Moments

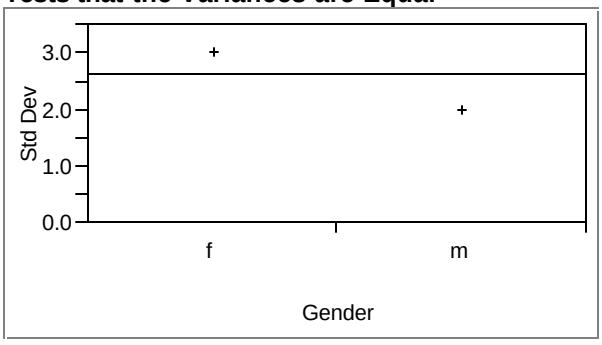
Mean	66.02
Std Dev	2.0121772
Std Err Mean	0.5195419
upper 95% Mean	67.134307
lower 95% Mean	64.905693
N	15

JMP INTRO significance test output for 15-year-olds:

Oneway Analysis of Height By Gender



Tests that the Variances are Equal



Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
f	24	3.014960	2.482639	2.387500
m	15	2.012177	1.261333	1.260000

Test	F Ratio	DFNum	DFDen	Prob > F
O'Brien[.5]	2.7684	1	37	0.1046
Brown-Forsythe	3.3984	1	37	0.0733
Levene	5.4215	1	37	0.0255
Bartlett	2.5338	1	.	0.1114

Welch Anova testing Means Equal, allowing Std Devs Not Equal

F Ratio	DFNum	DFDen	Prob > F
21.0002	1	36.777	<.0001

t-Test
4.5826

Assumptions: We need to assume the data represents independent random samples of fifteen-year-old males and fifteen-year-old females. Because the fifteen-year-old males have a sample of size 15 with outliers, we cannot safely use the two-sample *t* procedures. However, the following results are what we would get if we continued with the analysis.

Hypotheses:

$H_o: \mu_M = \mu_F$ The average fifteen-year-old male is the same height as the average fifteen-year-old female.

$H_a: \mu_M > \mu_F$ The average fifteen-year-old male is taller than the average fifteen-year-old female.

Test mechanics:

$$t = \frac{\bar{x}_M - \bar{x}_F}{\sqrt{\frac{s_M^2}{n_M} + \frac{s_F^2}{n_F}}} = \frac{66.02 - 62.329}{\sqrt{\frac{2.0122^2}{15} + \frac{3.015^2}{24}}} = 4.583$$

Note: JMP INTRO reports the p-value as a two-sided value . $p < 0.0001$

Note: JMP INTRO reports the two-sided p-value; however, because the observed difference in the means is in the direction of the alternate hypothesis, we divide the given p-value in half, still resulting in $p < 0.0001$.

Conclusion: At the $\alpha = 0.05$ level, because $p < 0.0001 < 0.05$, we reject the null hypothesis. We have sufficient evidence to show that male 15-year-olds tend to be taller than female 15-year-olds. Because our assumptions were not met, however, we need to be careful about drawing any meaningful conclusions from this analysis.