In the previous chapter we used the *z*, *t*, and χ2 tests to compare a sample mean, variance or proportion to a specific population mean, variance, or proportion to decide whether or not to reject the null hypothesis.

Now we will use the same basic steps for hypothesis testing to compare two sample means, proportions or variances. When comparing two means, we may be able to use the *z* test, but when the *t* test is used we must decide if the samples are \_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

The *z* test is used to compare two proportions. We will learn to use a new test, called the *F* test, to compare two variances.

# 9 - 1. Testing the Difference Between Two Means: Using the *z* Test

## Objective 1. Test the Difference Between Two Means, Using the z Test.

Suppose a researcher wanted to study whether there is a difference in the manual dexterity of athletes and band members. In this case, the research question is “Does the mean score on a manual dexterity test given to athletes differ from the mean score for the same test when given to band members.” The researcher is interested in comparing the means of the two groups, not in knowing if the mean of all the athletes and band members together differs from a specific value.

Thus, each group’s mean is considered separately:

*μ*1 = mean score on a manual dexterity test of athletes

*μ*2 = mean score on a manual dexterity test of band members

The hypotheses are

*H*0:

*H*1:

If there is no difference between the means, the difference between them will be \_\_\_\_\_\_\_\_. If they are not different, subtracting one from the other will not yield zero. Then the hypotheses become

*H*0: \_\_\_\_\_\_

*H*1: \_\_\_\_\_\_

Either method of stating the hypotheses is correct. We will use the first method.

The hypotheses testing whether there is difference between the means of two populations or not may also be one-tailed:

| **Right-Tailed** | | | **Left-Tailed** | | |
| --- | --- | --- | --- | --- | --- |
|  | or |  |  | or |  |
|  |  |  |  |

Two samples can be collected such that they are *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_* or *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.*

### Definition: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Samples

Two samples are *independent* when the subjects selected for the first sample in no way \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ how the subjects are selected for the second sample.

For example, a researcher might select a group of 100 people and randomly assign them to two groups of 50 people each in order to test the effectiveness of a new drug. One group is given the new drug and the other group is given a placebo. The two samples are independent.

### Definition: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Samples

Two samples are *dependent* when the selection or subjects for the first sample in some way does \_\_\_\_\_\_\_\_\_\_\_\_\_\_ the selection of subjects for the second sample.

For example, suppose researchers wanted to determine if the average temperature of persons’ right foot was different from the average temperature of one’s left foot. The temperature of the right foot of each person in a randomly selected group of 25 people would be measured. Then the temperature of the left foot of each of the same people would be measured. The sample for the right foot temperature influences the selection of subjects included in the second sample, so the samples are dependent.

### Assumptions for the *z* Test to Determine the Difference Between Two Means

1. Both samples are \_\_\_\_\_\_\_\_\_\_\_\_ samples.
2. The samples are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of each other.
3. The standard deviation of both samples must be \_\_\_\_\_\_\_\_\_\_\_\_\_.
4. If the either of the samples sizes is less than 30, the populations must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_ or approximately \_\_\_\_\_\_\_\_\_\_\_\_\_\_ distributed.

The theory behind testing the difference between two means is based on selecting pairs of samples and comparing the means of the pairs. It is not necessary to know the population mean for either population. For this test, all possible pairs of samples are taken from populations. The means for each pair of samples are computed, subtracted, and the differences are plotted. If both populations have the same mean, then most of the differences will be \_\_\_\_\_\_\_\_\_\_ or close to \_\_\_\_\_\_\_\_\_\_\_, with occasional large, negative and positive, differences due to \_\_\_\_\_\_\_\_\_\_\_\_\_\_. The plotted differences will be shaped like a normal distribution and have a mean of zero.

The variance of the difference is equal to the sum of the individual variances of and . Thus, where and .

That is, . Therefore, the standard deviation of is .

### Formula for the *z* Test for Comparing Two Means from Independent Populations

As before, the basic format of hypothesis testing using the traditional method is:

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Find the critical value(s).

**Step 3 –** Compute the test statistic.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

### Example 9-1. Home Prices

A real estate agent compares the selling prices of randomly selected homes in two municipalities in southwestern Pennsylvania to see if there is a difference. The results of the sampling is

| **Scott** | **Ligonier** |
| --- | --- |
|  |  |
|  |  |
|  |  |

Is there enough evidence to reject the claim that the average cost of a home of a home in both locations is the same? Use

*Solution:*

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Find the critical value(s).

**Step 3 –** Compute the test statistic.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

The *P*-value method for hypothesis test follows the same process as in Chapter 8. The steps for hypothesis testing for the *P*-value method are:

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Compute the test statistic.

**Step 3 –** Find the *P*-value.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

### Example 9-2. Ages of College Students

The dean of students wants to see whether there is a significant difference in ages of resident students and commuting students. She selects a random sample of 32 students from each group. The ages are listed below. At , decide if there is enough evidence to reject the claim that there is a difference in the ages of the two groups. Use the *P*-value method. Assume and . (Use the formulas, or technology, to calculate the *z* value and the *P-* value.)

*Resident Students.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 22 | 25 | 18 | 19 | 26 | 22 | 19 | 27 |
| 26 | 26 | 18 | 19 | 19 | 28 | 26 | 19 |
| 22 | 18 | 20 | 18 | 24 | 19 | 23 | 22 |
| 18 | 20 | 25 | 20 | 30 | 21 | 23 | 29 |

*Commuter Students*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 18 | 23 | 26 | 19 | 29 | 20 | 20 | 19 |
| 23 | 22 | 35 | 21 | 18 | 22 | 28 | 22 |
| 19 | 36 | 23 | 24 | 20 | 18 | 19 | 27 |
| 19 | 18 | 22 | 22 | 19 | 19 | 19 | 25 |

*Solution:*

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Compute the test statistic.

**Step 3 –** Find the *P-*value.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

When the researcher wants to test whether a specific difference in the means other than zero, the hypotheses are written as the difference between the population means is different from that specific number. For instance, if the claim is that the mean age of nursing students at a community college, , are 3.2 years older than those at a university, , the hypotheses would be and . The formula for the test statistic remains the same, but the hypothesized difference is .

### Formula for the *z* Confidence Interval for the Difference Between Two Means

### Example 9-3. Ages of College Students

Using the data, and summary statistics, for the previous example, find the 95% confidence interval for the difference between the means of ages of resident and commuting college students.

*Solution:*

By the formula –

Using technology, the result is

The confidence interval (contains / does not contain) zero, so the decision is to (reject / not reject) the null hypothesis. This result (agrees / does not agree) with the previous result.

# 9 – 2. Testing the Difference between Two Means of Independent Samples: Using the *t* Test

## Objective 2. Test the Difference Between Two Means for Independent Samples, Using the *t* Test.

The *t* test is used to test the difference between means when two samples are independent and when the samples are taken from two normally, or approximately normal, distributed populations. Samples are independent samples when they are not related. We will assume the variances, and, therefore, the standard deviations, are not equal. The formula for the *t* test uses the standard deviations of the samples to find the standard error of the difference between two means since the population standard deviations are not known.

### Assumptions for the *t* Test for Two Independent Means When and Are Unknown

1. The samples are \_\_\_\_\_\_\_\_\_\_\_\_ samples.
2. The sample data are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of one another.
3. When the sample sizes are less than 30, the populations must be \_\_\_\_\_\_\_\_\_\_\_\_\_ or approximately \_\_\_\_\_\_\_\_\_\_\_\_\_\_ distributed.

### Formula for the *t* Test for Testing the Difference between Two Means, Independent Samples

Variances are assumed to be unequal.

Degrees of freedom are equal to the smaller of or

We assume that the assumptions are met.

### Example 9-4. Weights of Vacuum Cleaners

Upright vacuum cleaners have either a hard body type or a soft body type. Shown are the weights in pounds of a random sample of each type. At , can it be concluded that the means of the weights are different?

| **Hard Body Types** | **Soft Body Types** |
| --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | 21 | 17 | 17 | 29 | | 16 | 17 | 15 | 20 | | 23 | 16 | 17 | 17 | | 13 | 15 | 16 | 18 | | 18 |  |  |  | | |  |  |  |  | | --- | --- | --- | --- | | 24 | 13 | 11 | 13 | | 12 | 15 |  |  | |

*Solution:*

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Find the critical value(s).

**Step 3 –** Compute the test statistic.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

Confidence intervals can be calculated for the difference of two means using the *t* distribution when the population standard deviations are unknown.

### Confidence Intervals for the Difference of Two Means (*σ*1*, σ*2 are unknown):

### Independent Samples

Variances are assumed to be unequal.

d.f. = smaller value of or

### Example 9-5. Ages of Homes

Whiting, Indiana, leads the “Top 100 Cities with the Oldest Houses” list with the average age of houses being 66.4 years. Farther down the list resides Franklin, Pennsylvania, with an average house age of 59.4 years. Researchers selected a random sample of 20 houses in each city and obtained the following sample data:

|  | **Whiting** | **Franklin** |
| --- | --- | --- |
| Sample Mean age | 62.1 years | 55.6 years |
| Sample Standard deviation | 5.4 years | 3.9 years |

At , can it be concluded that the houses in Whiting are older? Use the *P*-value method. Also, construct the 95% confidence interval for the difference between two means using the sample data given.

*Solution:*

**Step 1 –** State the null and alternative hypotheses and identify the claim.

**Step 2 –** Compute the test statistic.

**Step 3 –** Find the *P*-value.

**Step 4 –** Make the decision: Reject or do not reject the null hypothesis.

**Step 5 –** Summarize the results.

The confidence interval is:

The confidence interval (contains / does not contain) zero, so the decision is to (reject / not reject) the null hypothesis. This result (agrees / does not agree) with the previous result.

# 9 – 3. Testing the Difference Between Two Means: Dependent Samples

## Objective 3. Test the Difference Between Two Means for Dependent Samples.

Dependent samples are those where the subjects are paired or \_\_\_\_\_\_\_\_\_\_\_\_ in some way, so they are also called \_\_\_\_\_\_\_\_\_\_\_\_-\_\_\_\_\_\_\_ samples.

Examples of matched-pair samples include:

* \_\_\_\_\_\_\_\_\_\_\_-and-\_\_\_\_\_\_\_\_\_\_ samples where the value of a variable for each subject is measured before a treatment and again after the treatment;
* Duplicate measurements on the \_\_\_\_\_\_\_\_\_\_ sample;
* Twins or siblings randomly assigned to different treatments, controlling for genetics and environment, with the same variable measured after the treatments have been applied;
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ samples, where individuals are matched based on personal \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ such as age, gender, and ethnicity.

Cautions:

When subjects are matched according to one variable, the matching process does not eliminate the influence of other variables.

When the same subjects are used for a before/after study, it is possible that knowledge they are participating in a study can influence the results.

A special *t-*test for dependent means is used, based on the differences between values for each of the matched pairs.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mean of the difference of the matched pairs:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the values of the pairs of data:

Mean of the differences of the matched pairs of data where n is the number of \_\_\_\_\_\_\_\_\_\_\_\_ of data:

Standard deviation of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_:

, where

Estimated standard \_\_\_\_\_\_\_\_\_\_ of the differences:

### Formula for the *t-*Test Value for Dependent Samples.

, with .

### Assumptions for the *t* Test for Two Means When the Samples Are Dependent

1. The sample or samples are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. The sample data are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
3. When the sample size or sample sizes are less than 30, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ must be normally or approximately normally distributed.

### Procedure for Testing the Difference Between Means for Dependent Samples

**Step 1** State the hypotheses and identify the claim.

**Step 2** Find the critical value.

**Step 3** Compute the test value.

|  |  | **A** | **B** |
| --- | --- | --- | --- |
| **.**  **.**  **.** | **.**  **.**  **.** | **.**  **.**  **.** | **.**  **.**  **.** |
|  |  | \_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_ |

1. Make a table.
2. Find the difference and place the results in Column A.
3. Find the mean of differences.
4. \_\_\_\_\_\_\_\_\_\_\_\_\_ the differences and place the results in column B. Complete the table.
5. Find the standard deviation of the differences.
6. Find the test value.

, with .

**Step 4** Make the decision.

**Step 5** Summarize the results.

### Example 9-6. Obstacle Course Times

An obstacle course was set up on a campus, and 8 randomly selected volunteers were given a chance to complete it while they were being timed. They then sampled a new energy drink and were given the opportunity to run the course again. The “before” and “after” times in seconds are shown:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Student** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Before** | 67 | 72 | 80 | 70 | 78 | 82 | 69 | 75 |
| **After** | 68 | 70 | 76 | 65 | 75 | 78 | 65 | 68 |

Is there sufficient evidence at to conclude that the students did better the second time?

*Solution.*

**Step 1** State the hypotheses and identify the claim.

Students times completing the obstacle course were \_\_\_\_\_\_\_\_\_ before and after the energy drink.

Students times completing the obstacle course was \_\_\_\_\_\_\_\_\_\_ before than after consuming the energy drink.

**Step 2** Find the critical value.

**Step 3** Compute the test value.

|  |  | **A** | **B** |
| --- | --- | --- | --- |
| 67  72  80  70  78  82  69  75 | 68  70  76  65  75  78  65  68 | **.**  **.**  **.** | **.**  **.**  **.** |
|  |  | \_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_ |

1. Make a table.  
   Find the difference and place the results in Column A.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **A** | **B** |
| 67  72  80  70  78  82  69  75 | 68  70  76  65  75  78  65  68 | -1  2  4  5  3  4  4  7 | **.**  **.**  **.** |
|  |  | 28 | \_\_\_\_\_\_\_\_\_\_ |

1. Find the mean of differences.
2. Square the differences and place the results in column B. Complete the table.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **A** | **B** |
| 67  72  80  70  78  82  60  75 | 68  70  76  65  75  78  65  68 | -1  2  4  5  3  4  4  7 | 1  4  16  25  9  16  16  49 |
|  |  | 28 | 136 |

1. Find the standard deviation of the differences.
2. Find the test value.

**Step 4** Make the decision.

The critical value of *t* is 1.895 for a right-tailed test and The critical value of *t* is to the left of the test value. The test value is greater than the critical value. Therefore, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the null hypothesis.

Using Table F, the range for the *P-*value for t = 1.778 is , indicating that the null hypothesis is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (Using technology,

**Step 5** Summarize the results.

There (is / is not) sufficient evidence to conclude that the students did better after drinking the energy drink.

### Confidence Interval for the Mean Difference

### Example 9-7. Find the Confidence Interval for the Mean Obstacle Course Times

(one-tailed: : two-tailed )

Zero is not included in the confidence interval which indicates that the null hypothesis is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Example 9-8. Automobile Part Production

In an effort to increase production of an automobile part, the factory manager decides to play music in the manufacturing area. Eight workers are selected, and the number of items each produced for a specific day is recorded. After one week of music, the same workers are monitored again. The data are given:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Worker** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Before** | 6 | 8 | 10 | 9 | 5 | 12 | 9 | 7 |
| **After** | 10 | 12 | 9 | 12 | 8 | 13 | 8 | 10 |

At , can the manager conclude that the music has increased production?

*Solution:*

**Step 1** State the hypotheses and identify the claim.

**Step 2** Find the critical value.

**Step 3** Compute the test value.

(Or use technology to compute the test value and the *P-*value.)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **A** | **B** |
| **.**  **.**  **.** | **.**  **.**  **.** | **.**  **.**  **.** | **.**  **.**  **.** |
|  |  | \_\_\_\_\_\_\_\_\_\_ | \_\_\_\_\_\_\_\_\_\_ |

1. Make a table.
2. Find the difference and place the results in Column A.
3. Find the mean of differences.
4. Square the differences and place the results in column B. Complete the table.
5. Find the standard deviation of the differences.
6. Find the test value.

, with .

The *P*-value is \_\_\_\_\_\_\_\_\_\_\_.

**Step 4** Make the decision.

**Step 5** Summarize the results.

# 9 – 4.Testing the Difference between Proportions

## Objective 4. Test the Difference between Two Proportions

The *z* test with some modifications can be used to test the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ of two proportions. A researcher might ask, is there a difference between the proportions of customers who order salad with their meal and those who order soup with their meal or is there a difference in the proportion of local community college students who commute more than five miles to school and the proportion of local university students who commute more than five miles to school?

When testing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between two population proportions, and , the hypotheses can be stated as

|  |  |  |
| --- | --- | --- |
|  | *or* |  |
| Two-tailed:  Left-tailed:  Right-tailed: | Two-tailed:  Left-tailed:  Right-tailed: |

For two proportions, and , where

and number of units from respective samples that possess the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of interest, and

and respective sample \_\_\_\_\_\_\_\_\_\_

and estimate the population proportions, and .

and .

The weighted estimate *p,* based on the hypothesis that , is .

So,

The standard error of the difference is .

### Formula for the *z* Test Value for Comparing Two Proportions

### Assumptions for the *z* Test for Two Proportions

1. The samples must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_ samples.
2. The sample data are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of one another.
3. For both samples \_\_\_\_\_\_\_ and \_\_\_\_\_\_\_.

Be sure to check assumptions in situations when the assumptions have been met before proceeding.

Follow the same five-step hypothesis-testing procedure used before except that , , , and must be computed.

### Example 9-9. Seat Belt Use

In a random sample of 200 mean, 130 said they used seat belts. In a random sample of 300 women, 63 said they used seatbelts. Test the claim that men are more safety-conscious than women, at the . Show the traditional and the *P*-value methods.

*Solution*:

**Step 1** State the hypotheses and identify the claim.

**Step 2** Find the critical value of *z*, using Table E.

**Step 3** Compute the test value. Then find the *P*-value for the test value.

**Step 4** Make the decision.

**Step 5** Summarize the results

### Confidence Interval for the Difference Between Two Proportions

### Example 9-10. Seat Belt Use

For the situation in Example 9-9, find the 99% confidence interval for the difference of proportions.

*Solution*:

# 9 – 5. Testing the Difference Between Two Variances

## Objective 5. Test the Difference Between Two Variances or Standard Deviations.

Statisticians are also interested in comparing two variances or standard deviations. For this, an *F* test is used. The *F* test is not a chi-square test, although there are similarities.

### Characteristics of the *F* Distribution

1. The values of *F* cannot be \_\_\_\_\_\_\_\_\_\_\_\_, because variances are always positive or zero.
2. The distribution is \_\_\_\_\_\_\_\_\_\_\_\_\_ skewed.
3. The mean value of *F* is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
4. The *F* distribution is a family of curves based on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_of the \_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_of the \_\_\_\_\_\_\_\_\_\_\_\_\_.

Graph of the first quadrant showing three different shapes of the F distribution, for three different pairs of degrees of freedom.

### Formula for the *F* Test

where the \_\_\_\_\_\_\_\_\_\_\_\_ of the two variances is placed in the numerator, regardless of subscripts.

The *F* test has two values for the \_\_\_\_\_\_\_\_\_ \_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_

that of the numerator, , and

that of the denominator, , where is the sample size from which the \_\_\_\_\_\_\_\_\_\_\_\_\_\_ variance was obtained.

Use Table H to find the critical value. The following figure shows the critical value for , with 21 degrees of freedom for the denominator and 15 degrees of freedom for the numerator.

To find the critical value of F, use Table H, find the correct value of alpha, in the left column locate the degrees of freedom of the denominator, and in the uppermost row locate the degrees of freedom of the numerator.

When the degrees of freedom values cannot be found in the table, the closest value on the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ side should be used. For example, 14 degrees of freedom of the numerator falls between the values of 12 and 15 on the Table. Thus, 12 should be used.

### Assumptions for Testing the Difference Between Two Variances

1. The samples must be \_\_\_\_\_\_\_\_\_\_\_\_ samples.
2. The populations from which the samples were obtained must be \_\_\_\_\_\_\_\_\_\_\_\_\_ distributed.   
   (*Note*: The test should not be used when the distributions depart from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Minor departures from \_\_\_\_\_\_\_\_\_\_\_\_ will affect the results of the test because the standard deviation is not resistant to outliers or extreme values.)
3. The samples must be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of one another.

### Example 9-11. Heart Rates of Smokers

A medical researcher wishes to see whether the variance of the heart rates (in beats per minute) of smokers is different from the variance of heart rates of people who do not smoke. Two samples are selected.

| **Smokers** | **Non-smokers** |
| --- | --- |
|  |  |
|  |  |

Using , is there enough evidence to support the claim? Assume the variable is normally distributed.

*Solution*:

**Step 1** State the hypotheses and identify the claim.

and (claim)

**Step 2** Find the critical value.

This is a two-tailed test, so there is an area of on the left and the right. Use in Table H, with and . The critical value is 2.56 ( was used.)

**Step 3** Compute the test statistic.

Using technology, we find the *P*-value is 0.0084.

**Step 4** Make the decision.

\_\_\_\_\_\_\_\_\_\_\_ the null hypothesis, since . (Also, 0.0084 < 0.05)

**Step 5** Summarize the results.

There (is / is not) sufficient evidence to support the claim that the variance of the heart rates of smokers and non-smokers is different.

### Example 9-12. Heights of Basketball Players

A researcher wants to compare the variances of the heights (in inches) of four-year college basketball players with those of players in junior colleges. A sample of 30 players from each type of school is selected and the standard deviations of the heights for each type are 2.43 and 3.15, respectively. At , is there a significant difference between the variances of the heights in the two types of schools?

*Solution*:

**Step 1** State the hypotheses and identify the claim.

**Step 2** Find the critical value.

**Step 3** Compute the test statistic. (Also, find the *P*-value.)

**Step 4** Make the decision.

**Step 5** Summarize the results.