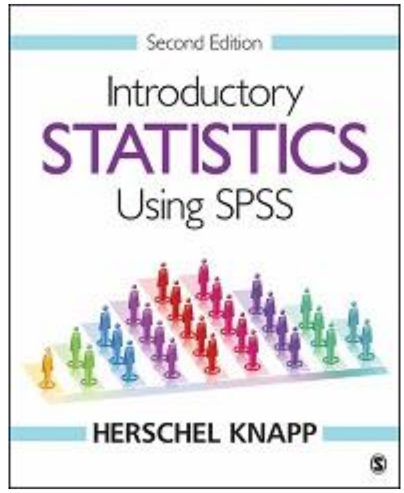



# Chapter 7

## Paired *t* Test and Wilcoxon Test

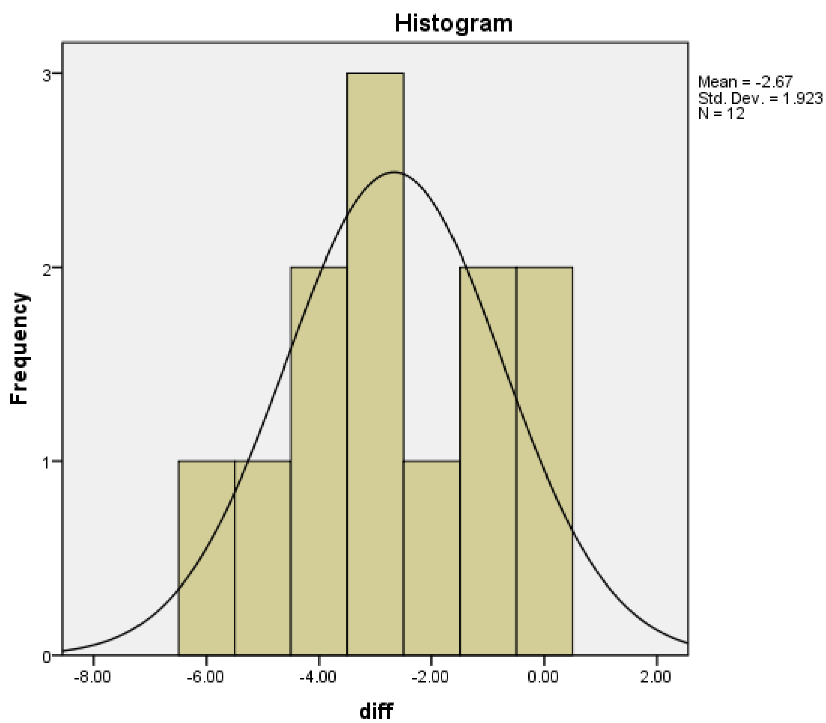
### Solutions to Odd Numbered Exercises

Exercise Page

**Exercise 7.1, Data Set A**

(a)
$H_0$: Acme Monster Spray has no effect on children's monster anxiety.
$H_1$: Acme Monster Spray reduces children's monster anxiety.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 6.75 | 12 | 1.485 | .429 |
| | posttest | 4.08 | 12 | 1.443 | .417 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | pretest - posttest | 2.667 | 1.923 | .555 | 1.445 | 3.888 | 4.804 | 11 | .001 |

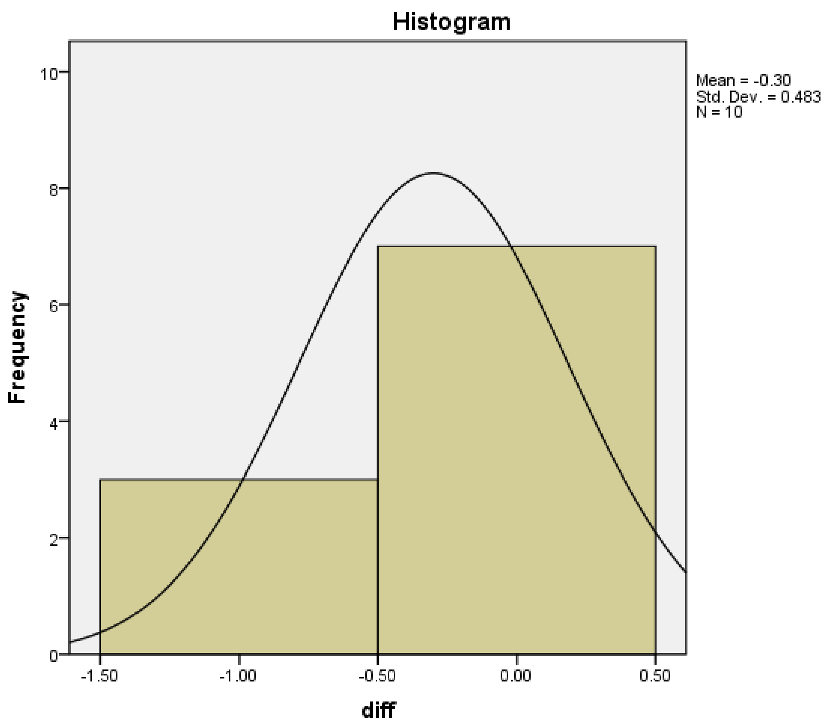
Prior to using the Monster Spray, the children's mean anxiety level was 6.75; after using the spray, that level dropped to 4.08. This 2.67-point reduction in reported anxiety is statistically significant since the *p* value of .001 is less than the specified $\alpha$ level of .05. Based on these findings, we would reject $H_0$, and not reject $H_1$.

(d)
In order to help children rest easier at night, 12 children were asked to rate their bedtime anxiety due to fear of nighttime monsters on a 1 to 10 scale (1 = not afraid at all, 10 = very afraid), then Acme Monster Spray, an inert sweet-smelling mist was administered by their parents, after which children were asked to rate their anxiety level. Upon spraying, children reported a 2.67-point average drop in anxiety (6.75 before spraying, down to 4.08 after spraying). Paired *t* test analysis revealed this change to be statistically significant ($p$ = .001) using a .05 $\alpha$ level, suggesting that the (placebo) effect of this spray may help children rest more comfortably.

**Exercise 7.1, Data Set B**

(a)
$H_0$: Acme Monster Spray has no effect on children's monster anxiety.
$H_1$: Acme Monster Spray reduces children's monster anxiety.

(b) After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 5.70 | 10 | 1.947 | .616 |
| | posttest | 5.40 | 10 | 2.066 | .653 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | pretest - posttest | .300 | .483 | .153 | -.046 | .646 | 1.964 | 9 | .081 |

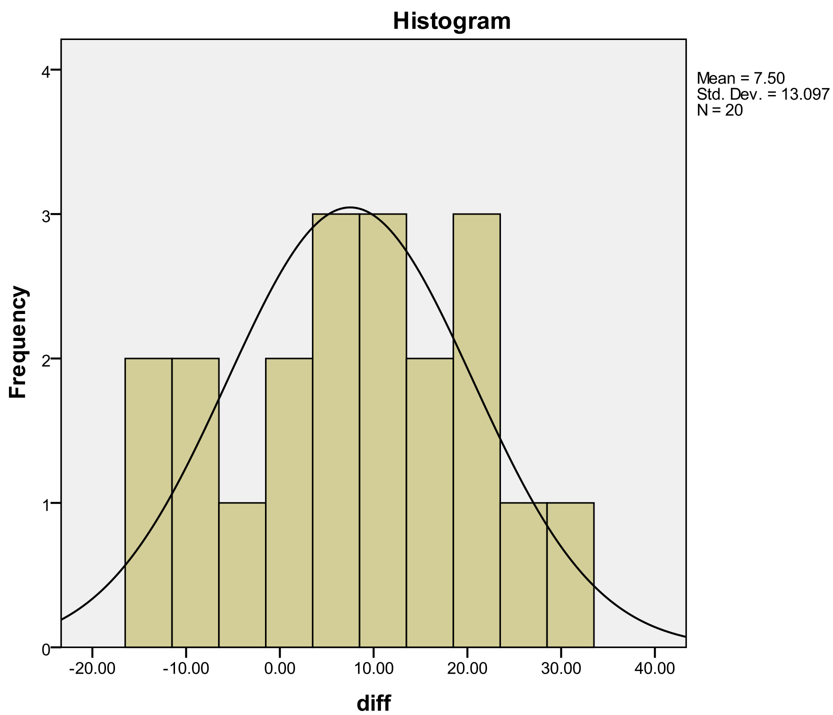
Prior to using the Monster Spray, the children's mean anxiety level was 5.70; after using the spray, that level dropped to 5.40. This .30-point reduction in reported anxiety is not statistically significant since the *p* value of .081 is greater than the specified $\alpha$ level of .05. Based on these findings, we would not reject $H_0$, and reject $H_1$.

(d)
In order to help children rest easier at night, 10 children were asked to rate their bedtime anxiety due to fear of nighttime monsters on a 1 to 10 scale (1 = not afraid at all, 10 = very afraid), then Acme Monster Spray, an inert sweet-smelling mist was administered by their parents, after which children were asked to rate their anxiety level. Upon spraying, children reported a .30-point average drop in anxiety (5.70 before spraying, down to 5.40 after spraying). Paired *t* test analysis revealed a *p* level of .081; using a .05 $\alpha$ level, this suggests that this difference in scores is not statistically significant, hence, parents will need to find a different way to console their children at nighttime.

**Exercise 7.3, Data Set A**

(a)
$H_0$: Students do not significantly improve their spelling skills over the course of a month.
$H_1$: Students improve their spelling skills over the course of a month.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 62.05 | 20 | 9.041 | 2.022 |
| | posttest | 69.55 | 20 | 9.478 | 2.119 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | pretest - posttest | -7.500 | 13.097 | 2.929 | -13.629 | -1.371 | -2.561 | 19 | .019 |

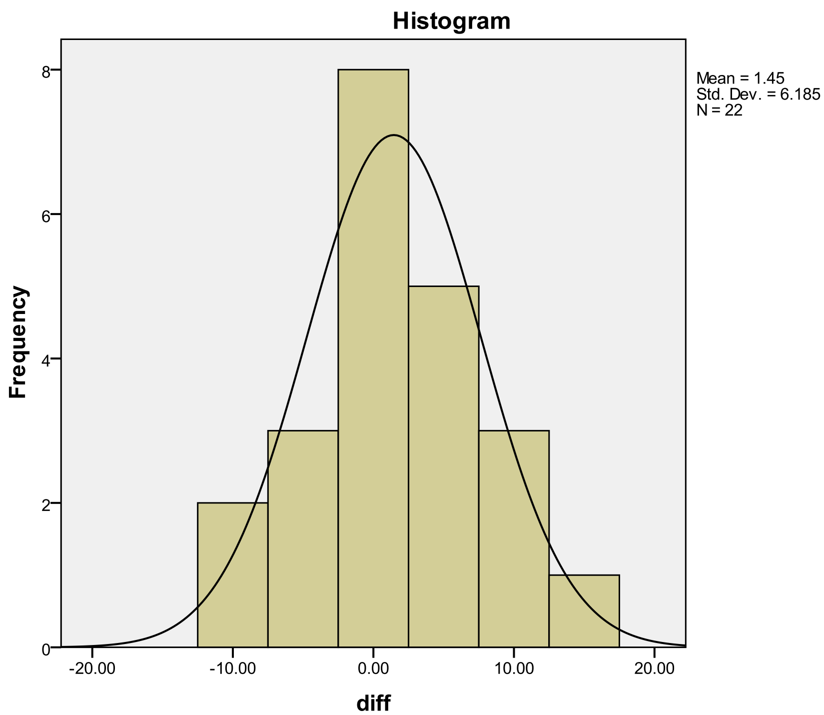
At the start of the month, students were administered a 100-word spelling test to find out how many words on the prescribed spelling list for that month students could already spell correctly. Students spelled an average of 62.05 words correctly on this pretest. At the end of the month, students were readministered this 100-word test, and spelled an average of 69.55 words correctly. The 7.5 increase in score constitutes a statistically significant improvement since the *p* level is .019, which is less than the specified $\alpha$ level of .05. Based on these findings, we would reject $H_0$, and not reject $H_1$.

(d)
In order to assess if students substantially advance their spelling proficiency on a monthly basis, students were given a 100-word spelling test at the beginning of the month; after studying 25 words per week from the list, students took the same 100-word test 30 days later. At the end of the month, students spelled an average of 69.55 of the words correctly, compared to 62.05 at the beginning of the month. Using an $\alpha$ level of .05, this 7.5-point improvement in score was found to be statistically significant ($p$ = .019).

**Exercise 7.3, Data Set B**

(a)
$H_0$: Students do not significantly improve their spelling skills over the course of a month.
$H_1$: Students improve their spelling skills over the course of a month.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 86.14 | 22 | 4.201 | .896 |
| | posttest | 87.59 | 22 | 4.469 | .953 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair 1 | pretest - posttest | -1.455 | 6.185 | 1.319 | -4.197 | 1.288 | -1.103 | 21 | .283 |

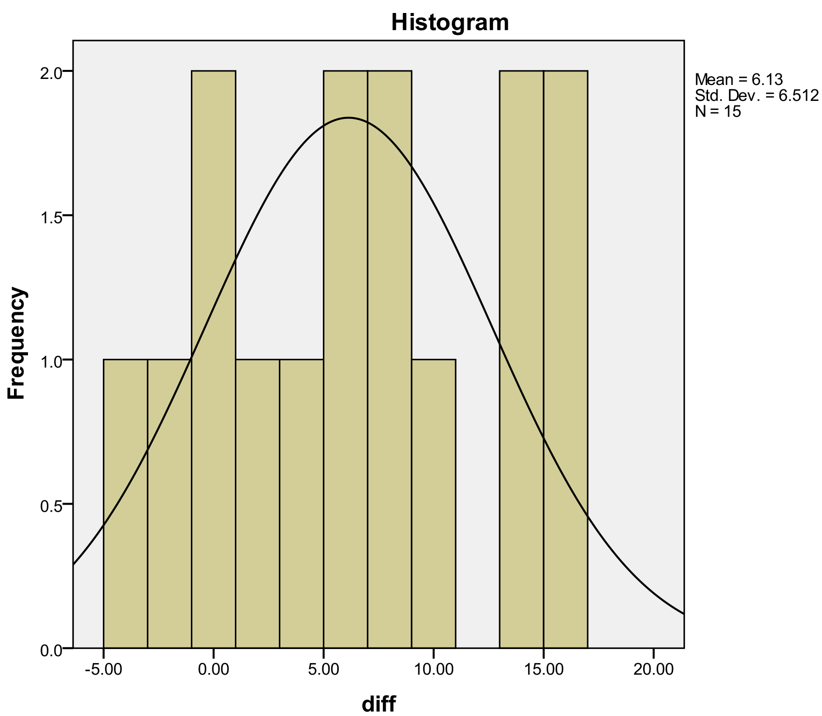
At the start of the month, students were administered a 100-word spelling test to find out how many words on the prescribed spelling list for that month students could already spell correctly. Students spelled an average of 86.14 words correctly on this pretest. At the end of the month, students were readministered this 100-word test, and spelled an average of 87.59 words correctly. The 1.45-point increase in score is not a statistically significant improvement since the *p* level is .283, which is greater than the specified $\alpha$ level of .05. Based on these findings, we would not reject $H_0$, and reject $H_1$.

(d)
In order to find out if students substantially advance their spelling proficiency on a monthly basis, students were given a 100-word spelling test at the beginning of the month; after studying 25 words per week from the list, students took the same 100-word test 30 days later. At the end of the month, students spelled an average of 87.59 of the words correctly, compared to 86.14 at the beginning of the month. Using an $\alpha$ level of .05, this 1.45-point improvement in score is not statistically significant ($p$ = 283).

**Exercise 7.5, Data Set A**

(a)
$H_0$: A 15-minute individual session with a bowling coach has no effect on bowling scores.
$H_1$: A 15-minute individual session with a bowling coach enhances bowling scores.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 151.60 | 15 | 15.459 | 3.991 |
| | posttest | 157.73 | 15 | 13.936 | 3.598 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | pretest - posttest | -6.133 | 6.512 | 1.681 | -9.740 | -2.527 | -3.648 | 14 | .003 |

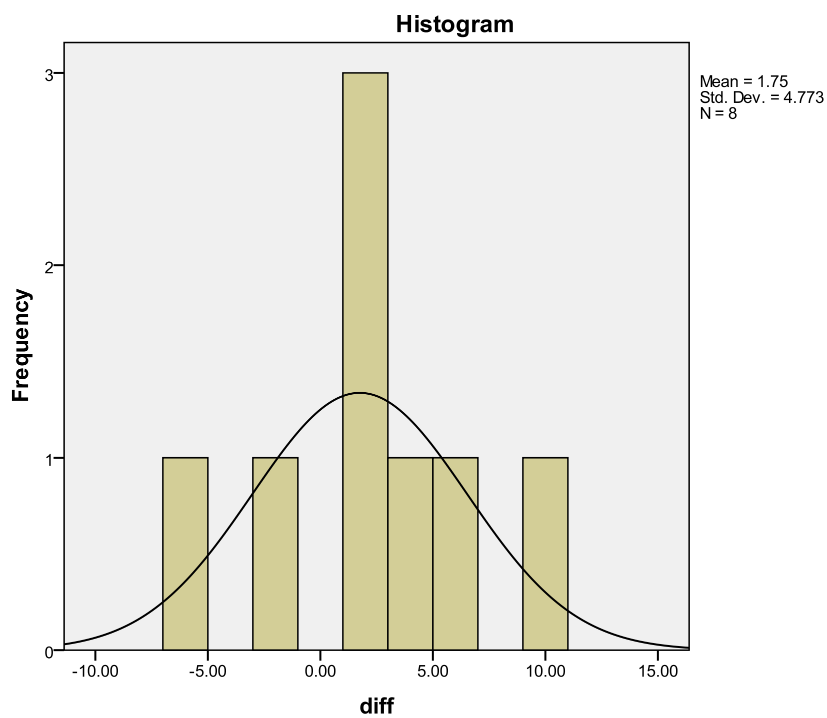
Fifteen students bowled an initial game and scored a average of 151.60, then a coach provided 15 minutes of instructions based on observations made during the student's first game. Student's average score in the second game was 157.73. This 6.13-point increase produced a *p* level of .003; since this is less than the $\alpha$ level of .05, this is considered to be a statistically significant difference. Based on these findings, we would reject $H_0$, and not reject $H_1$.

(d)
To assess the effectiveness of short-term coaching, 15 students bowled one game with a coach observing unobtrusively. Next, the coach provided 15 minutes of individual coaching, after which, each student bowled a second game. On the average, scores were 6.13 points higher in the second game (157.73, up from 151.60 in their first game). This finding is considered to be statistically significant ($p$ = .003, $\alpha$ = .05). Based on these findings, we will continue to use this coaching method for bowling, and we will be evaluating the utility of providing this style of coaching for other sports.

**Exercise 7.5, Data Set B**

(a)
$H_0$: A 15-minute individual session with a bowling coach has no effect on bowling scores.
$H_1$: A 15-minute individual session with a bowling coach enhances bowling scores.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 72.50 | 8 | 3.742 | 1.323 |
| | posttest | 74.25 | 8 | 3.919 | 1.386 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | pretest - posttest | -1.750 | 4.773 | 1.688 | -5.741 | 2.241 | -1.037 | 7 | .334 |

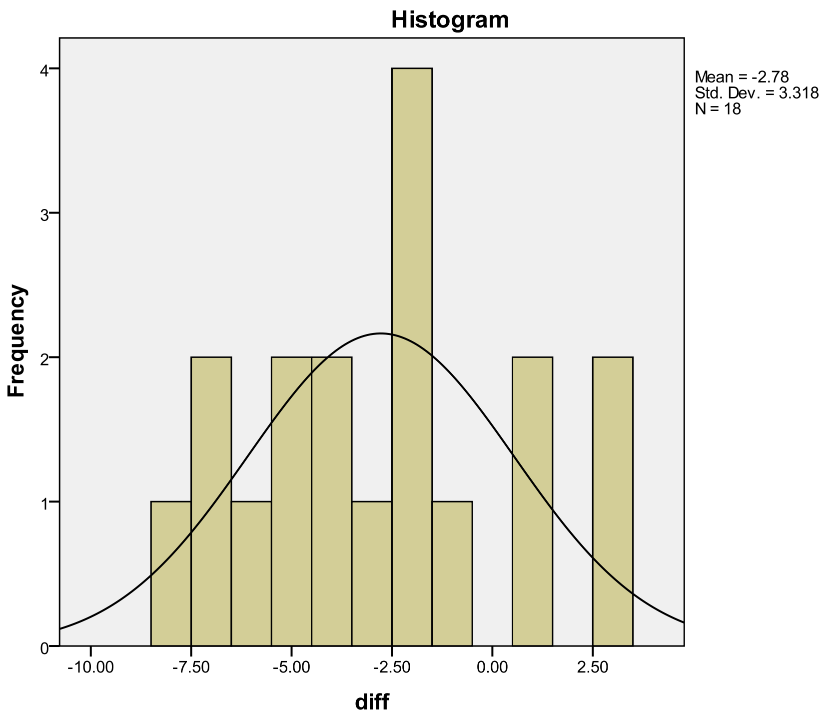
Eight students bowled an initial game and scored a average of 72.50, then a coach provided 15 minutes of instructions based on observations made during the student's first game. Student's average score in the second game was 74.25. This 1.75-point increase produced a *p* level of .334; since this is greater than the $\alpha$ level of .05, this is not considered to be a statistically significant difference. Based on these findings, we would not reject $H_0$, and reject $H_1$.

(d) To assess the effectiveness of short-term coaching, eight students bowled one game with a coach observing unobtrusively. Next, the coach provided 15 minutes of individual coaching, after which, the student bowled a second game. On the average, students' scores were 1.75 points higher in their second game (74.25, up from 72.50 in their first game). This finding is not considered to be statistically significant ($p$ = .334, $\alpha$ = .05). Based on these findings, we are considering evaluating if this form of coaching may provide more promising results for different individual sports (e.g., golf, archery, weight training).

**Exercise 7.7, Data Set A**

(a)
$H_0$: Acme allergy medicine has no effect on sneezing.
$H_1$: Acme allergy medicine reduces sneezing.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 15.39 | 18 | 3.274 | .772 |
| | posttest | 12.61 | 18 | 3.165 | .746 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | pretest - posttest | 2.778 | 3.318 | .782 | 1.128 | 4.428 | 3.552 | 17 | .002 |

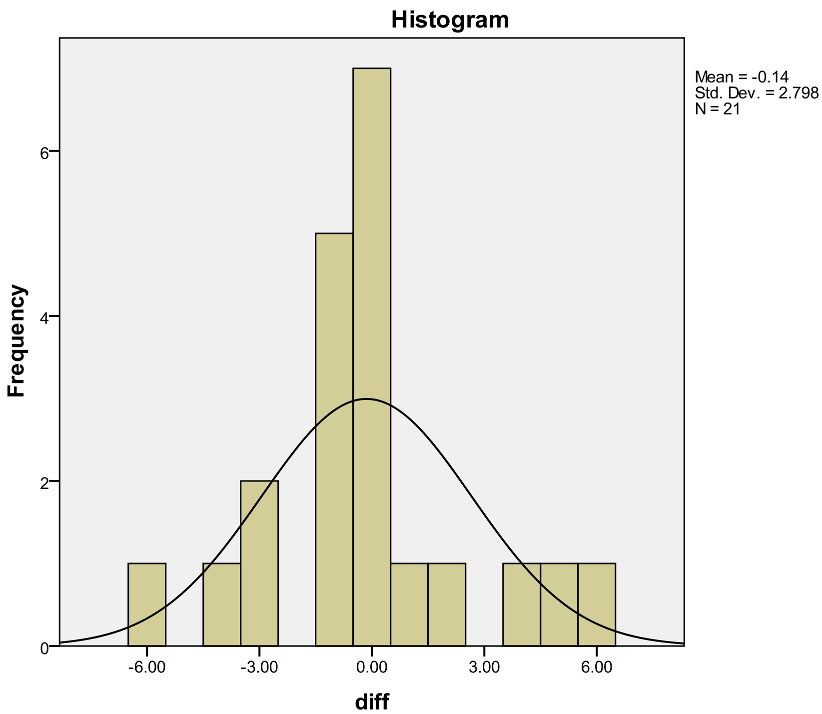
Eighteen people who were experiencing allergy symptoms were recruited and asked to count their total number of sneezes for a day. The next day, they took the Acme allergy medicine as directed, and counted their total number of sneezes for that (second) day. This resulted in an average of 2.77 fewer sneezes (an average of 15.39 on the first day, and 12.61 on the second day). Using a .05 $\alpha$ level, this difference is considered to be statistically significant. As such, we would reject $H_0$, and not reject $H_1$.

(d)
To determine if Acme allergy medicine helps reduce sneezing among those experiencing allergy symptoms, 18 participants were recruited and instructed to count their total number of sneezes for 1 day. The next morning, each took the Acme allergy medicine as directed, and counted their total sneezes for that day. On average, participants sneezed a total of 15.39 times the day before taking the medication, and 12.61 times after taking the medication; an average of 2.77 fewer sneezes. This difference is considered to be statistically significant ($p$ = .002, $\alpha$ = .05), suggesting that the medicine provided some allergy symptom relief.

**Exercise 7.7, Data Set B**

(a)
$H_0$: Acme allergy medicine has no effect on sneezing.
$H_1$: Acme allergy medicine reduces sneezing.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 4.10 | 21 | 1.640 | .358 |
| | posttest | 3.95 | 21 | 1.830 | .399 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | pretest - posttest | .143 | 2.798 | .611 | -1.131 | 1.416 | .234 | 20 | .817 |

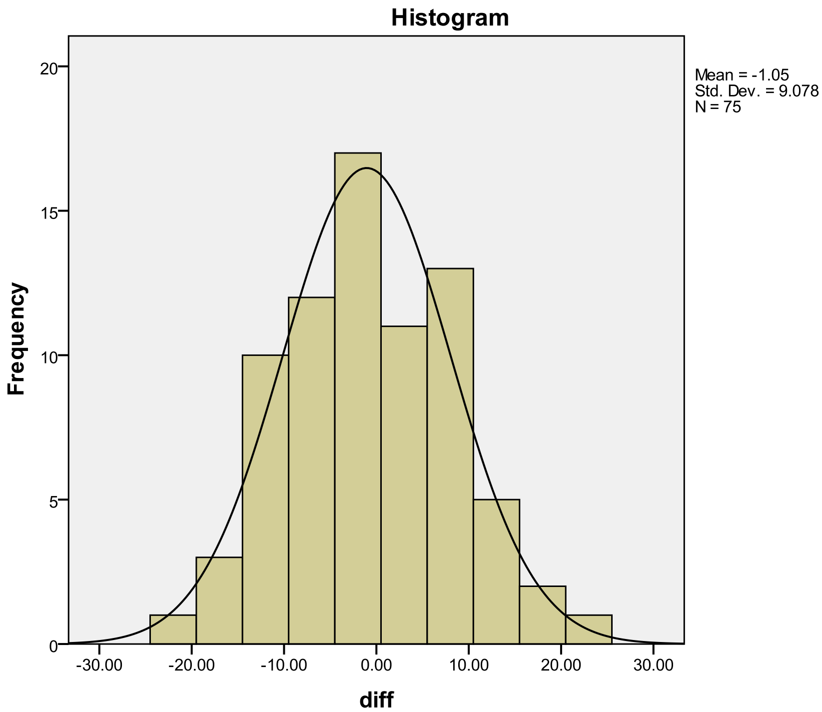
Twenty-one people who were experiencing allergy symptoms were recruited and asked to count their total number of sneezes for a day. The next day, they took the Acme allergy medicine as directed, and counted their total number of sneezes for that (second) day. This resulted in an average of .15 fewer sneezes (an average of 4.10 on the first day, and 3.95 on the second day). This rendered a *p* of .817; since the *p* value is greater than the designated .05 $\alpha$ level, this difference is not considered to be statistically significant. As such, we would not reject $H_0$, and reject $H_1$.

(d)
To determine if Acme allergy medicine helps reduce sneezing among those experiencing allergy symptoms, 21 participants were recruited and instructed to count their total number of sneezes for 1 day. The next morning, they took the Acme allergy medicine as directed, and counted their total sneezes for that day. On average, participants sneezed a total of 4.10 times the day before taking the medication, and 3.95 times after taking the medication, amounting to an average of .15 fewer sneezes. This reduction is not considered to be statistically significant ($p$ = .817, $\alpha$ = .05), suggesting that this medicine was not particularly helpful for these individuals.

**Exercise 7.9, Data Set A**

(a)
$H_0$: Chocolate has no effect on attitude.
$H_1$: Chocolate enhances attitude.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c)
The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 81.91 | 75 | 5.707 | .659 |
| | posttest | 80.85 | 75 | 5.897 | .681 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | pretest - posttest | 1.053 | 9.078 | 1.048 | -1.035 | 3.142 | 1.005 | 74 | .318 |

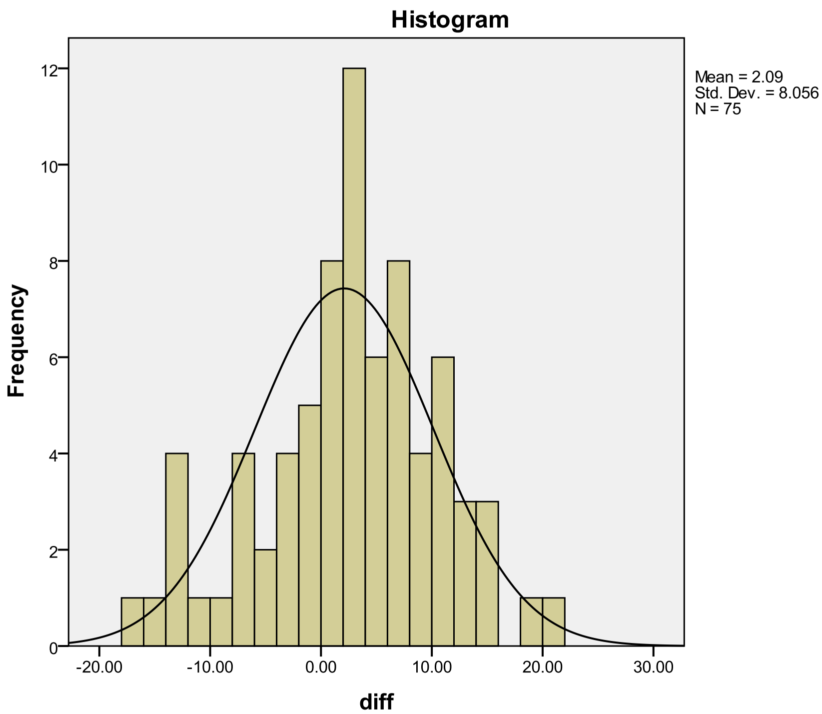
Seventy-five people were recruited to determine if chocolate helps enhance attitude. We began by administering the Acme Attitude Survey (AAS) (0 = very bad attitude, 100 = very good attitude) resulting in an average score of 81.91. After eating a piece of chocolate fudge cake, participants answered the AAS again; on average, the results dropped by .96 points to 80.85. This change in the AAS score produced a *p* level of .318, which using a .05 $\alpha$ level is not statistically significant. This suggests that the chocolate cake did not make a statistically significant impact on attitude, hence, we would not reject $H_0$, and reject $H_1$.

(d)
To better comprehend the effects that chocolate might have on attitude, 75 participants were recruited; we began by administering the Acme Attitude Survey (AAS) which renders a score ranging from 0 to 100 (0 = very bad attitude, 100 = very good attitude). Next, each participant was served a generous slice of chocolate fudge cake. After the cake, participants were asked to complete a second AAS. The pretest revealed a mean attitude score of 81.91; contrary to our expectations, the post-chocolate AAS score dropped an average of .96 points, to 80.85, however, this rendered a *p* value of .318. Using a .05 $\alpha$ level, this drop in the AAS is not considered to be statistically significant.

**Exercise 7.9, Data Set B**

(a)
$H_0$: Chocolate has no effect on attitude.
$H_1$: Chocolate enhances attitude.

(b)
After computing the difference between the pretest score and posttest score (*diff* = *posttest* - *pretest*), a histogram with normal curve was plotted for this difference (*diff*). The graph below presents a symmetrical (bell-shaped) normal curve for *diff*, thus satisfying this criterion.



(c) The paired *t* test revealed the following:

**Paired Samples Statistics**

| | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Pair 1 | pretest | 81.17 | 75 | 5.869 | .678 |
| | posttest | 83.27 | 75 | 6.267 | .724 |

**Paired Samples Test**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | pretest - posttest | -2.093 | 8.056 | .930 | -3.947 | -.240 | -2.250 | 74 | .027 |

Seventy-five people were recruited to determine if chocolate helps enhance attitude. We began by administering the Acme Attitude Survey (AAS) (0 = very bad attitude, 100 = very good attitude) resulting in an average score of 81.17. After eating a piece of chocolate fudge cake, participants answered the AAS again; on average, the results rose by 2.10 points to 83.27. This change in the AAS score produced a *p* level of .027, which, using a .05 $\alpha$ level, is considered to be statistically significant. This suggests that the chocolate cake made a statistically significant impact on attitude; hence, we would reject $H_0$, and not reject $H_1$.

(d)

To better comprehend the effects that chocolate might have on attitude, 75 participants were recruited. We began by administering the Acme Attitude Survey (AAS) which renders a score ranging from 0 to 100 (0 = very bad attitude, 100 = very good attitude). After collecting the AAS forms, each participant was served a generous slice of chocolate fudge cake. After the cake, participants were asked to complete a second AAS. The pretest revealed a mean attitude score of 81.17, and after dining on the chocolate cake, the mean AAS score went up an average of 2.10 points, to 83.27. These figures rendered a *p* value of .027. Using a .05 $\alpha$ level, this increase in the AAS score suggests that chocolate may help enhance attitude.