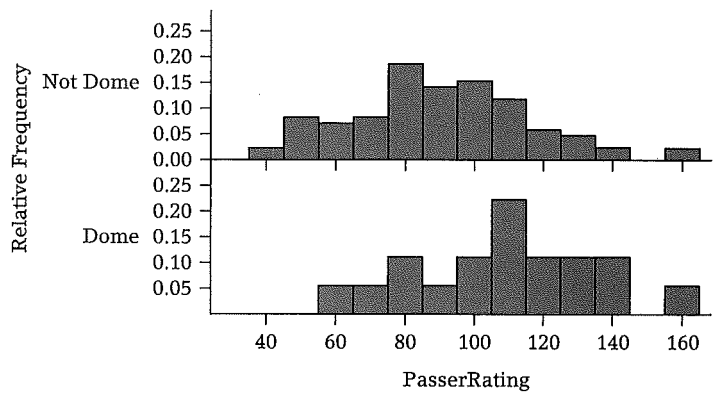
For Practice

1. Does Peyton Manning have a greater passing *ABILITY* in domes? After all, inside a dome the weather is always nice for throwing the ball! The accompanying relative frequency histograms show Manning's 18 career road *PERFORMANCES* inside a dome and his 86 career road *PERFORMANCES* outside (through the 2010 season).[4] In this case, his *PERFORMANCE* is measured with his passer rating, a combination of passing yards, completion percentage, number of touchdowns, and number of interceptions. Only road games are included because Manning plays his home games in a dome and the benefit of playing in a dome would be impossible to separate from the benefit of playing at home.

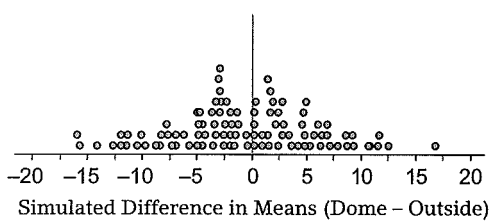


(a) Briefly compare these distributions.

(b) State the hypotheses we are interested in testing.

(c) Manning's mean passer rating in domes was 109.3 and his mean passer rating outside was 89.8, for a difference (dome − outside) of 19.5. Describe how to simulate the distribution of this test statistic, assuming that Manning's *ABILITY* is the same in both locations.

(d) Here are the results of 100 trials of the simulation from part (c). Describe what information is provided by the dotplot.

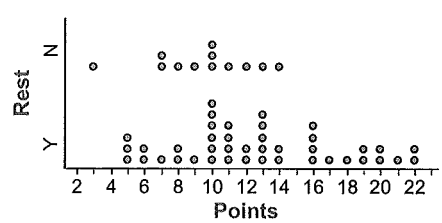


(e) Use the dotplot to estimate and interpret the *p*-value.

(f) Using the *p*-value from part (e), make an appropriate conclusion.

(g) If there is convincing evidence that Manning had a greater *ABILITY* in domes, can we conclude that the dome is the cause? Explain.

2. Do players in the NBA, especially large players like Shaquille O'Neal, have a greater *ABILITY* to score when they are rested? The graph at right shows Shaq's distribution of points scored in his 12 games with no rest (meaning he played in a game the day before) and his 41 games where he had at least 1 day's rest during the 2009–2010 regular season.[5]



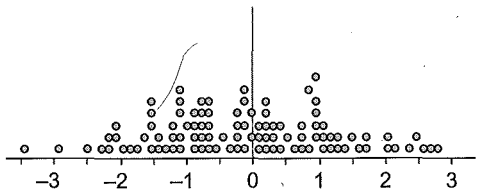
(a) Briefly compare these distributions.

(b) State the hypotheses we are interested in testing.

(c) Shaq's mean points per game with no rest was 9.5 and his mean points per game with rest was 12.7, for a difference (no rest − rest) of −3.2.

Describe how to simulate the distribution of this test statistic, assuming that Shaq's *ABILITY* is the same in both locations.

(d) Here are the results of 100 trials of the simulation from part (c). Describe what information is provided by the dotplot.



Simulated Difference in Means (No Rest – Rest)

(e) Use the dotplot to estimate and interpret the *p*-value.

(f) Using the *p*-value from part (e), make an appropriate conclusion.

(g) If your conclusion in part (f) is in error, which type of error did you make? Explain.

3. Do the noisy crowds in the Metrodome help the Minnesota Vikings play better defense?[6] Here are the points allowed at home and on the road for the 2008 Vikings:

Points Allowed at Home: 18 10 10 21 27 14 24 19

Points Allowed on Road: 24 30 27 48 19 12 16 14

(a) State the hypotheses we are interested in testing.

(b) Graph these distributions so they can be easily compared. Write a few sentences comparing them.

(c) Find the mean points allowed at home and on the road. How much better does the defense play at home? Use the difference in means as your test statistic.

(d) Describe how to simulate the distribution of the test statistic, assuming that the Vikings have the same *ABILITY* to play defense at home and on the road.

(e) Conduct at least 20 trials of your simulation, display the results in a well-labeled dotplot, and use it to estimate the *p*-value.

(f) Based on your *p*-value, make an appropriate conclusion.

(g) If a student concluded that the Vikings have better *ABILITY* to play defense at home, can we guarantee that the noisy crowd is the cause? Are there other possible causes? Explain.

4. Do the "Cameron Crazies" at Duke home games help the Blue Devils play better defense? Here are the points allowed by the Duke men's basketball team at home and on the road for 2008–2009 conference games.[7]

Points Allowed at Home: 44 56 44 54 75 101 91 81

Points Allowed on Road: 58 56 70 74 80 67 65 79

(a) State the hypotheses we are interested in testing.

(b) Graph these distributions so they can be easily compared. Write a few sentences comparing them.

(c) Find the mean points allowed at home and on the road. How much better does the defense play at home? Use the difference in means as your test statistic.

(d) Describe how to simulate the distribution of the test statistic, assuming that Duke has the same *ABILITY* to play defense at home and on the road.

(e) Conduct at least 20 trials of your simulation, display the results in a well-labeled dotplot, and use it to estimate the p-value.

(f) Based on your p-value, make an appropriate conclusion.

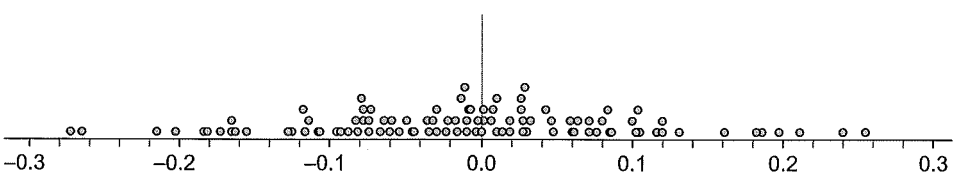
(g) If you made an error, which type could it be, Type I or Type II? Explain. What can you do to reduce the chances of making this type of error?

5. In Chapter 4 (Exercise 25), you compared the distributions of innings per game for 24 starting pitchers in 1958 and 99 starting pitchers in 2008. Do the data provide convincing evidence that pitchers in 1958 had a greater *ABILITY* to stay in games?

(a) State the hypotheses we are interested in testing.

(b) The mean innings per game in 1958 was 6.70 and the mean innings per game in 2008 was 6.05 for a test statistic of $6.70 - 6.05 = 0.65$. Describe how to simulate the distribution of the test statistic, assuming that pitchers in both years have the same *ABILITY* to stay in games.

(c) A simulation was conducted assuming that pitchers both years have the same *ABILITY* to stay in games. In each of the 100 trials, the difference in means was calculated and recorded on the dotplot below. Use the dotplot to estimate and interpret the p-value.



Simulated Difference in Mean Innings/Game (1958 – 2008)

(d) Based on the p-value, make an appropriate conclusion.

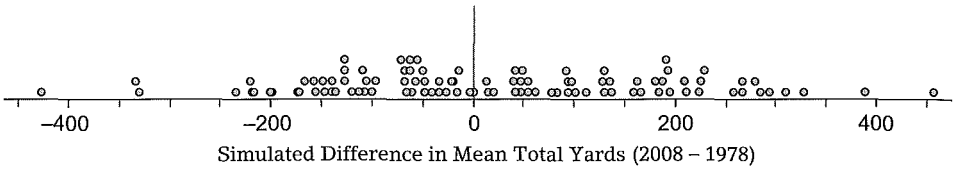
(e) If there is convincing evidence that pitchers in 1958 did have a greater *ABILITY* to stay in games, does that mean today's pitchers are wimpier? What other possible explanations could there be?

6. In Chapter 4 (Exercise 27), you compared the distributions of total offensive yards for 28 NFL teams in 1978 and 32 teams in 2008. The mean for 2008 was 5236 yards and the mean for 1978 was 4811 yards, giving a difference of $5236 - 4811 = 425$ yards. Does this difference provide convincing evidence that NFL teams had a greater *ABILITY* to gain yards in 2008 than 1978?

(a) State the hypotheses we are interested in testing.

(b) Describe how to simulate the distribution of the test statistic, assuming that teams in both years have the same *ABILITY* to gain yards.

(c) A simulation was conducted assuming that teams in both years have the same *ABILITY* to gain yards. In each of the 100 trials, the difference in mean total yards was calculated and recorded on the dotplot below. Use the dotplot to estimate and interpret the *p*-value.



(d) Based on the *p*-value, make an appropriate conclusion.

(e) Which type of error, Type I or Type II, is it possible you committed in your conclusion? Explain.

7. In the last chapter (Exercise 31), you compared the San Antonio Spurs' offensive *PERFORMANCES* at home and on the road for the 2009–2010 regular season and discovered that the Spurs' average *PERFORMANCE* was 8.2 points higher at home. Suppose that we tested the null hypothesis that the Spurs have the same offensive *ABILITY* at home and on the road against the alternative hypothesis that the Spurs have a greater *ABILITY* to score at home and that the *p*-value was 0.2%. Explain what is wrong with the following conclusions.

(a) Because the *p*-value is small, we fail to reject the null hypothesis. We do not have convincing evidence that the Spurs have a greater *ABILITY* to score at home.

(b) Because the *p*-value is small, we reject the null hypothesis. We have convincing evidence that the home crowd causes the Spurs to score more points.

8. In the last chapter (Exercise 32), you compared Drew Brees's passing *PERFORMANCES* in 2008 and in 2009 and discovered that his average *PERFORMANCE* was 24.2 yards greater in 2008. Suppose that we tested the null hypothesis that Brees's *ABILITY* was the same in 2008 and 2009 against the alternative hypothesis that Brees's *ABILITY* was greater in 2008 and that the *p*-value was 17%. Explain what is wrong with the following conclusions.

(a) Because the *p*-value is large, we fail to reject the null hypothesis. We have convincing evidence that Brees's *ABILITY* was the same in 2008 and 2009.

(b) Because the *p*-value is large, we reject the null hypothesis that his *ABILITY* was the same both years. We have convincing evidence that he had a greater *ABILITY* in 2008.

9. Does using a fuel additive help cars in NASCAR go farther between fill-ups? Suppose that you can use 20 NASCAR cars and 20 drivers in an experiment to investigate this question.

(a) What are the explanatory and response variables in your experiment?

(b) What are the treatments in your experiment?

(c) How will you incorporate randomization in your experiment?

(d) What variables would be important to control during this experiment?

(e) Can the drivers be blind in this experiment? Explain why this is important.

(f) State the hypotheses you are interested in testing.

(g) If the experiment provides convincing evidence that NASCAR cars with the additive have a greater *ABILITY* to go farther than cars without the additive, can we conclude that the additive was the cause? Explain.

10. Do expensive golf balls travel farther than cheap ones? Suppose that you can use 50 balls of each type in an experiment to investigate this question.

(a) What are the explanatory and response variables in your experiment?

(b) What are the treatments in your experiment?

(c) How will you incorporate randomization in your experiment?

(d) What variables would be important to control during this experiment?

(e) Can the golfer(s) be blind in this experiment? Explain why this is important.

(f) State the hypotheses you are interested in testing.

(g) If the experiment provides convincing evidence that golfers have a greater *ABILITY* to drive the ball when using expensive balls, can we conclude that the type of ball is the cause? Explain.

11. In Exercise 9, you designed an experiment to determine whether using a fuel additive helps NASCAR cars drive farther between fill-ups.

(a) Suppose that you conducted the experiment and the results were statistically significant. Sketch two dotplots to show what the results for each treatment group might look like.

(b) Suppose that you conducted the experiment and there was some evidence that the additive helped, but the evidence wasn't convincing. Sketch two dotplots to show what the results for each treatment group might look like.

12. In Exercise 10, you designed an experiment to determine whether using a more expensive golf ball helps golfers drive the ball farther.

(a) Suppose that you conducted the experiment and there was some evidence that the expensive golf ball helped, but the evidence wasn't convincing. Sketch two boxplots to show what the results for each treatment group might look like.

(b) Suppose that you conducted the experiment and the results were statistically significant. Sketch two boxplots to show what the results for each treatment group might look like.

13. A tennis player looking for an edge suspects that using warmer tennis balls will allow her to serve faster. Is this true? Design an experiment to find out.

(a) What are the explanatory and response variables in your experiment?

(b) What are the treatments in your experiment?

(c) How will you incorporate randomization in your experiment?

(d) What variables would be important to control during this experiment?

(e) Can the tennis player be blind in this experiment? Explain why this is important.

14. Many baseball players believe that "corking" their bats will help them hit the ball farther. To cork their bats, the players hollow out the barrel of a wooden bat and fill it with cork to make it lighter. Does this work?* Design an experiment to find out if this is true for you.

(a) What are the explanatory and response variables in your experiment?

(b) What are the treatments in your experiment?

(c) How will you incorporate randomization in your experiment?

(d) What variables would be important to control during this experiment?

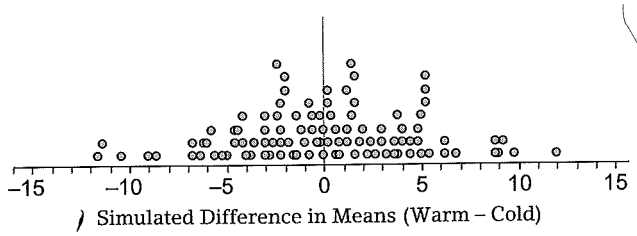
(e) Can you be blind in this experiment? Explain why this is important.

15. In Exercise 13, you designed an experiment to see whether using warmer tennis balls helps a tennis player serve faster.

(a) State the hypotheses you are interested in testing.

(b) Suppose that when she used 10 warm tennis balls, the player's mean serve speed was 79.9 mph, and when she used 10 cold tennis balls, her mean serve speed was 67.9 mph. Calculate the value of the test statistic (difference in means) and describe how to simulate its distribution, assuming the tennis player has the same *ABILITY* to serve with each temperature of tennis ball.

(c) Here are the results of 100 trials of the simulation. Describe what information is provided by the dotplot.



(d) Use the dotplot to estimate the *p*-value and make an appropriate conclusion.

(e) What would be the benefit of increasing the number of serves with each type of ball? What is the name for this principle of experimental design?

16. In Exercise 14, you designed an experiment to see whether using a corked bat helped you hit the ball farther.

(a) State the hypotheses you are interested in testing.

(b) Suppose that you used a corked bat 20 times and a noncorked bat 20 times. When using the corked bat, the mean distance you hit the ball was 225 feet, and when you used the noncorked bat, the mean distance

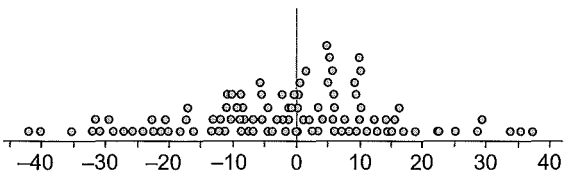
*The show *MythBusters* investigated this claim and found that corked bats are actually worse because the cork absorbs some of the energy rather than transferring it to the baseball. Do an Internet search for "MythBusters Corked Bat" to find out more.

you hit the ball was 221 feet. Calculate the value of the test statistic (difference in means) and describe how to simulate its distribution, assuming you have the same *ABILITY* to hit with each type of bat.

(c) Here are the results of 100 trials of the simulation. Describe what information is provided by the dotplot.

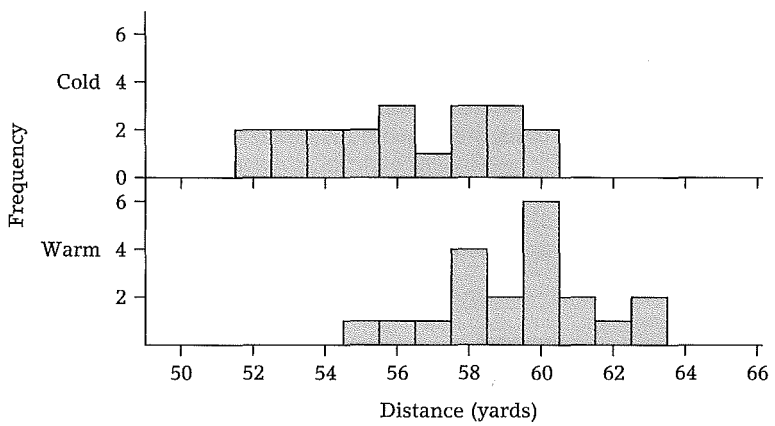
(d) Use the dotplot to estimate the *p*-value and make an appropriate conclusion.

(e) If your conclusion was in error, which type of error did you make? Explain. What can you do to reduce the chances of making this type of error?

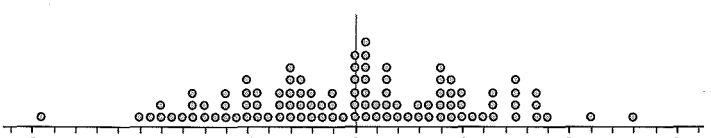


17. Earlier in this chapter, we analyzed the results of an experiment that compared kicking distances with warm footballs to kicking distances with cold footballs. The difference in means (test statistic) was 3.2 yards, but because the *p*-value was approximately 0.10, we did not have convincing evidence that the kicker has a greater *ABILITY* to kick with a warm football. To continue the investigation, he kept repeating the experiment until he had kicked each type of ball 20 times.

(a) Here are two histograms showing the results. Compare these distributions.

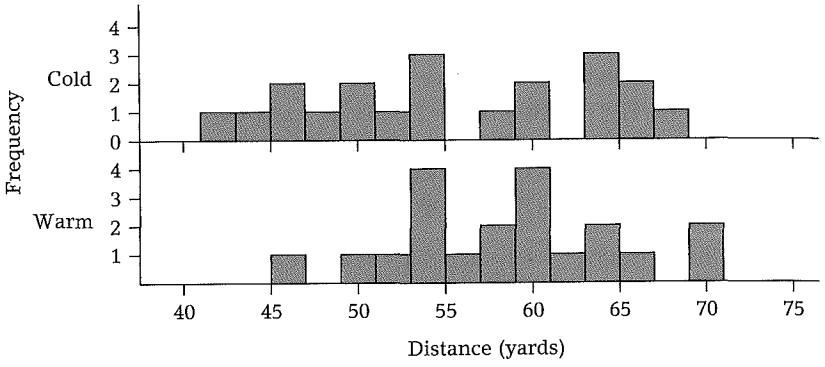


(b) Coincidentally, the mean for the cold footballs was still 56.2 yards and the mean for the warm footballs was still 59.4 yards, giving the same value for the test statistic (3.2 yards). A simulation was conducted to estimate the distribution of the difference in means, assuming that the kicker's *ABILITY* is the same with both types of footballs. Use the results at right to estimate the *p*-value.



(c) Based on your *p*-value, make an appropriate conclusion. Is your conclusion different than the one from the example? Why do you think this is?

18. Another kicker decided to try the hot football experiment and repeated the procedure from Exercise 17. The new kicker obtained the results shown in the histograms below.

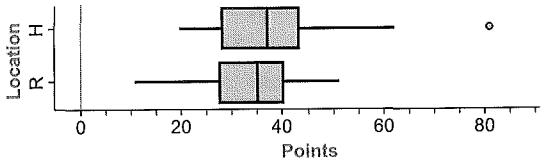


(a) How do the spreads of these distributions compare to the distributions for the kicker in Exercise 17?

(b) The *p*-value for a test comparing the mean distance kicked with warm footballs and cold footballs was 0.18. Interpret this value and make an appropriate conclusion.

(c) Coincidentally, the difference in mean distance kicked for this kicker was 3.2 yards, the same as the kicker in Exercise 17. However, the results for this kicker weren't significant, whereas the results for the kicker in Exercise 17 were. Why do you think the conclusions differ?

19. Does Los Angeles Lakers player Kobe Bryant have a greater *ABILITY* to score at home than on the road? Here are boxplots summarizing his 40 *PERFORMANCES* at home and his 40 *PERFORMANCES* on the road during the 2005–2006 regular season.

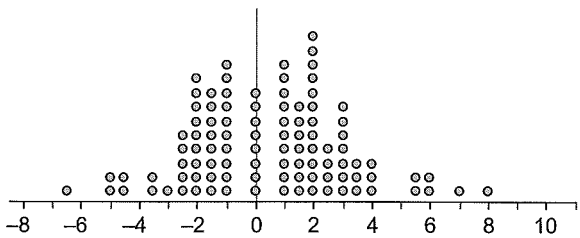


(a) Briefly compare these distributions.

(b) State the hypotheses we are interested in testing.

(c) On January 22, 2006, Kobe scored 81 points at home against the Toronto Raptors. Because this outlier will affect his mean points scored at home, we will use the difference in his *median* points per game as our test statistic. The observed value of the test statistic (home − road) is $37 - 35 = 2$. Describe how to simulate the distribution of this test statistic, assuming that Kobe's *ABILITY* to score is the same in both locations.

(d) Here are the results of 100 trials of the simulation from part (c). Describe what information is provided by the dotplot.

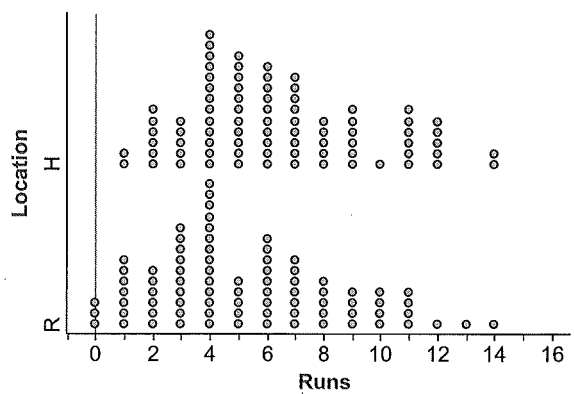


(e) Use the dotplot to estimate and interpret the *p*-value.

(f) Using the *p*-value from part (e), make an appropriate conclusion.

(g) If your conclusion in part (f) was in error, what type of error did you make? Explain.

20. Did the 2004 Boston Red Sox have a greater *ABILITY* to score runs at home? Here are dotplots summarizing their 81 *PERFORMANCES* at home and their 81 *PERFORMANCES* on the road during the 2004 regular season.



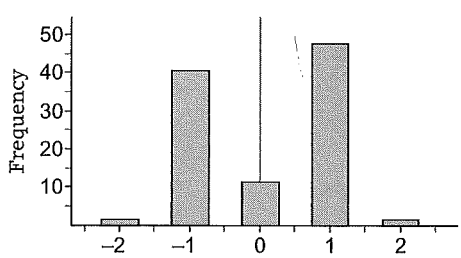
(a) Briefly compare these distributions.

(b) State the hypotheses we are interested in testing.

(c) Because the distributions are both skewed, we will use the difference in the *median* runs per game as our test statistic. Calculate the value of the test statistic (home − road).

(d) Describe how to simulate the distribution of this test statistic, assuming that Boston's *ABILITY* to score runs is the same in both locations.

(e) Here are the results of 100 trials of the simulation from part (d). Describe what information is provided by the histogram.



(f) Use the histogram to estimate and interpret the *p*-value.

(g) Using the *p*-value from part (f), make an appropriate conclusion.

(h) The Red Sox play their home games in Fenway Park, which is generally known as a "hitter-friendly" park. If there is convincing evidence that the Red Sox have a greater *ABILITY* to score at home, can we conclude that Fenway Park is the cause?

21. Did the Washington Redskins have a greater *ABILITY* to play defense at home in the 2010 regular season? The following table shows the number of points they allowed in each game at home and on the road.

Home	7	30	13	27	59	17	17	17
Road	30	12	14	37	16	31	33	17

(a) Justify that 59 is an outlier in the home distribution.

(b) Make boxplots to compare these distributions. Briefly describe what you see.

(c) State the hypotheses we are interested in testing.

(d) Calculate the difference of medians and use this as your test statistic.

(e) Describe how to simulate the distribution of the test statistic, assuming the Redskins have the same *ABILITY* to play defense at home and on the road.

(f) Conduct at least 20 trials of your simulation and display the results on a well-labeled dotplot.

(g) Based on the results of the simulation, estimate the *p*-value and make an appropriate conclusion.

22. In Chapter 4, we looked at Tom Brady's distribution of passer ratings in 2001 and noticed that there were a few high outliers. Did Brady have a greater passing *ABILITY* at home in the 2001 regular season? The table below shows his passer rating in each game at home and on the road.

Home	62.9	79.6	93.4	78.9	70.8	143.9	61.3	91.6
Road	58.7	148.3	57.1	124.4	93.3	63.6	62.1	

(a) Justify that 143.9 is an outlier in the home distribution.

(b) Make boxplots to compare these distributions. Briefly describe what you see.

(c) State the hypotheses we are interested in testing.

(d) Calculate the difference of medians and use this as your test statistic.

(e) Describe how to simulate the distribution of the test statistic, assuming that Tom Brady's passing *ABILITY* is the same at home and on the road.

(f) Conduct at least 20 trials of your simulation and display the results on a well-labeled dotplot.

(g) Based on the results of the simulation, estimate the *p*-value and make an appropriate conclusion.

CHAPTER REVIEW EXERCISES

23. In Chapter 4 (Exercise 26), you compared the number of three-point attempts taken by the 25 NBA teams in 1989 and the 30 NBA teams in 2009 to see if there was evidence that teams took more three-point shots in 2009. Here are the actual data:

1989:	481	676	1147	629	667	645	774	646	397	309	567	474	523
	243	615	400	530	234	293	824	380	430	568	681	298	
2009:	1145	1475	1516	2284	1725	1477	1122	1293	1632	2147			
	1355	1594	1670	1555	1408	1289	1656	1631	1735	1633			
	1539	1072	949	1620	1198	1526	1513	1079	1106	1339			

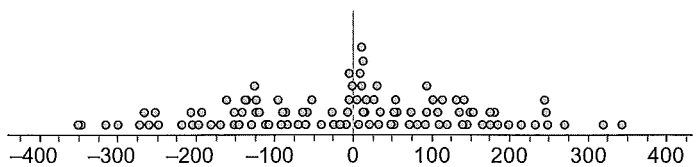
(a) Graph these distributions with dotplots and briefly compare them.

(b) State the hypotheses we are interested in testing.

(c) Calculate the difference in means (2009 − 1989) and use this as our test statistic.

(d) Describe how to simulate the distribution of the test statistic, assuming that the *ABILITY* of teams to take three-pointers is the same in 1989 and 2009.

(e) Here are the results of 100 trials of the simulation. Describe what information is provided by the dotplot.



Simulated Difference (2009 − 1989) in Mean Number of Three-Point Attempts

(f) Estimate and interpret the p-value based on the simulation.

(g) Based on your p-value, make an appropriate conclusion.

(h) If you made an error, which type could it be, Type I or Type II? Explain.

(i) Why might it be a good idea to use the difference in medians as the test statistic instead of the difference in means?

24. Does resting between sets help athletes who are weight training lift more weight? An experiment was conducted where the 50 members of the varsity football team were randomly assigned to one of two treatments. In both treatments, subjects were asked to bench press 75% of their maximum bench press weight. The first treatment was sets of 10 reps with a 5-minute rest in between sets. The second treatment was sets of 10 reps with a 2-minute rest in between. Each athlete continued to do sets until exhaustion and then the total number of reps was recorded.

(a) What were the explanatory and response variables in this experiment?

(b) How was randomization incorporated in this experiment? Why is this important?

(c) What variables were important to control during this experiment?

(d) Could the players be blind in this experiment? Explain why this is important.

(e) State the hypotheses we are interested in testing.

(f) If the experiment provides convincing evidence that players with longer rest periods have a greater *ABILITY* to lift weights, can we conclude that the rest was the cause? Explain.

25. Suppose that the difference in the median number of reps (5-minute rest − 2-minute rest) for the experiment in Exercise 24 was 8 reps.

(a) Describe how to simulate the difference in medians, assuming that the players' *ABILITY* to lift is the same with 5-minute rest periods and with 2-minute rest periods.

(b) Suppose that the results of the experiment were not statistically significant. Draw two boxplots that could represent these data, where the 5-minute median is 8 reps greater than the 2-minute median.

(c) If longer rest periods really do increase an athlete's *ABILITY* to lift weights, what type of error was made? How can you modify the experiment to make it more likely to get statistically significant results?

OTHER APPLICATIONS

26. Do name-brand trash bags hold more weight than store-brand trash bags? Two statistics students, Janelle and Brittany, decided to find out. To do so, they randomly selected 15 Glad trash bags and 15 Walmart trash bags and loaded them with oranges until they broke. Why oranges? One of the students had a bumper crop from the orange tree in her yard. Here are the results:

Glad	147	145	143	148	147	156	147	150	139	148	146	149	151	150	145
Walmart	132	138	140	139	133	133	141	131	135	139	145	132	150	139	135

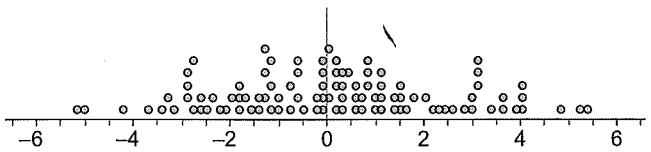
(a) Use dotplots to graph these distributions and briefly compare them.

(b) State the hypotheses we are interested in testing.

(c) Calculate the difference in means (Glad − Walmart) and use this as the test statistic.

(d) Describe how to simulate the distribution of the test statistic, assuming that both brands of trash bags have the same *ABILITY* to hold oranges.

(e) Here are the results of 100 trials of the simulation. Describe what information is provided by the dotplot.



Simulated Difference in Means (Glad – Walmart)

(f) Estimate and interpret the p-value based on the simulation.

(g) Based on your p-value, make an appropriate conclusion.

(h) If you made an error, which type could it be, Type I or Type II? Explain.

27. Does caffeine increase pulse rates? A statistics class with 20 students designed an experiment to find out. Half of the students were randomly assigned to drink cola with caffeine and the other half were assigned to drink caffeine-free cola. Before the students consumed their beverage, they measured their initial pulse rates. Then, 10 minutes after finishing their beverage, they measured their pulse rates again, with each calculating the change in pulse rate (after − before).

(a) What were the explanatory and response variables in this experiment?

(b) How was randomization incorporated in this experiment? Why is this important?

(c) What variables were important to control during this experiment?

(d) Could the students be blind in this experiment? Explain why this is important.

(e) State the hypotheses we are interested in testing.

(f) If the experiment provides convincing evidence that the students in the caffeine group had a greater increase in pulse rates, can we conclude that the caffeine was the cause? Explain.

28. Here were the results of the caffeine experiment:

Caffeine	14	3	−1	0	2	3	4	−1	2	0
Caffeine-free	6	−1	0	2	1	−2	−3	4	1	2

(a) Graph these distributions using boxplots and briefly compare them.

(b) Calculate the difference in medians and use this as the test statistic.

(c) Describe how to simulate the distribution of the test statistic, assuming that caffeine has no effect on pulse rates.

(d) Conduct at least 20 trials of your simulation and record the results on a dotplot.

(e) Using the results of your simulation, estimate the p-value and make an appropriate conclusion.

(f) If you were to test the difference in means instead of the difference in medians, do you think the p-value would be bigger or smaller? Explain.

FOR INVESTIGATION

1. Research an athlete or team of your choice and use the methods of this chapter to investigate whether they have a greater *ABILITY* in a particular context (e.g., home vs. away, day vs. night, dark uniform vs. white uniform, early in game vs. late in game, in domes vs. outside stadiums). Make sure to include graphs of both distributions and compare them in detail before you begin the hypothesis test.
2. Design and conduct an experiment to determine if athletes have a greater *ABILITY* in one context compared to another. Then do the proper analysis based on the methods of this chapter. Make sure to include graphs of both distributions and compare them in detail before you begin the hypothesis test.