WHERE DO THE DIFFERENCES LIE? – AN ANALYSIS OF DISTANCE ROAD RUNNING POPULATIONS

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By

Jennifer Elizabeth Johnson

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DOCTOR OF PHILOSOPHY

SUPERVISORY COMMITTEE:

Dr. Rhonda Magel
Chair

Dr. Megan Orr

Dr. Ronald Degges

Dr. Susan Ray-Degges

Approved:

10/30/2015
Date

Dr. Rhonda Magel
Department Chair

ABSTRACT

Recently, much research has been focused on the gap in performance between male and female runners. Our research is focused on examining the gap between these two running populations in depth to determine where the specific differences are located. We will investigate three marathons which require some form of qualification before one can participate along with thirty-two races which do not require qualification.

For the qualifying marathons, we will examine if the proportion of male and female finishers are equal at predetermined levels of performance. We will also examine the overall descriptive statistics and the age group patterns for each marathon.

The non-qualifying races are equally divided among the four popular running distances – marathon, half marathon, ten kilometer (10k) and five kilometer (5k). The proportions of the male and female race finishers were tested to be equal for each individual race at three different levels of performance. To further inspect the population differences, we tested the equality of the distributions through the comparisons of the means, medians, and variances between the two populations. We also examined whether or not the differences followed a specific pattern by investigating the age groups.

All results for the individual races were combined using meta-analysis both at the overall race level and for each age group at all four race distances. We performed a separate meta-analysis for the qualifying marathons and for the non-qualifying races.

Several differences between the male and female population of distance runners were discovered through our research. These inequalities were not what we expected to see when we began this study.

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CHAPTER 1. INTRODUCTION

Running is easily accessible to any person who is interested in trying it. This is just one of the many aspects of running that has contributed to the massive increase in the popularity of the sport. The total number of finishers for road races in the United States has been increasing greatly over since 1990, from 4.8 million to 19.03 million in 2013 [Running USA 2014]. Along with the increase in numbers, the years have also seen an increase in the proportion of female race finishers, from twenty-five percent in 1990 to fifty-seven percent in 2013 [Running USA 2014]. This increase in popularity has brought up questions regarding the differences between male and female athletes, specifically, whether the differences between the populations of finishers substantiate the beliefs that are held by the public.

The common belief among the public is that men are more competitive than women, especially when it comes to sports. When asked about what kind of runner they would classify themselves as, a larger percent of women chose to identify as a fun runner or a fitness participant while a larger percent of men chose to identify as a competitor [Running USA 2014]. These results appear to back up the public's perception of male and female runners competitiveness, as men identify themselves with competition but women identify with fun or fitness, but a direct comparison of race results does not directly back up the view of public. Between 1976 and 2005, the best male marathon performance dropped 2.83% but the best female marathon performance dropped 14.46% [Burfoot 2007]. The difference between the best male and female marathon finish times also changed notably from an 18.71% difference in 1976 to a 7.73% difference in 2005 [Burfoot 2007]. The divergence between the views of the public, the attitudes of the runners, and the actual results needs to be examined thoroughly.

When the performances of men and the performances of women are only compared within their respective genders the gap between male and female competitiveness can only be estimated. In order to determine the truth behind the opinions of the public, we need to be able to compare the performances between genders. In 1989 the World Masters Athletics (WMA), formerly the World Association of Veteran Athletes (WAVA), developed the first set of tables for grading the performance of an athlete based on sex and age which were updated, with the help of Howard Grubb and Alan Jones, in 1994, 2004, and most recently in 2010 in order to more accurately estimate the performance data [World Masters Athletics 2010]. These age grading tables were designed to enable runners to compare performances to all other running performances without worrying about a gender or age bias. To calculate the age graded scores for this paper, we used the 2010 open standard tables, the finish times of the racers, and the ages of the runners and inserted these values into the following equation: $AG = 100 * \frac{Open\ Standard\ for\ Distance}{Age\ Factor * Time(in\ seconds)}$ [World Masters Athletics 2010]. In this paper, we will analyze the results, both age grade scores and finish times, of multiple races in an attempt to determine if any differences are present in the data.

The underlying motivation for our research is the wide held belief that men are more competitive than women and, based on this belief, we formed several hypotheses to test using our research data. If men are truly more competitive than women, we would expect to find significant differences between the two populations when compared statistically; specifically, we would expect to see more men finishing races faster but few men finishing races. In respect to age graded scores, we would like to determine if men finish higher than women by looking at the proportion of runners that finish with an age graded score of sixty percent or higher and the proportion that finished with an age graded score of seventy percent or higher. We would also like to investigate if women finish lower than men by looking at the proportion of runners that finish with an age graded score of forty percent or lower. We hypothesize that male race finishers have a higher average age graded score and age than female race finishers both overall and within age groups; we also believe that women are more variable, in age and age graded scores, than male race finishers. Additionally, we mused that the level of competition and the distribution of ages among women is different when compared across race differences; to be thorough, we will also investigate how the distribution of race finishers differ between distances for both male and female finishers, independently. The specific statistical tests that will be used to investigate these research hypotheses will be explained in detail in Chapter 4: Statistical Tests.

Our specific research hypotheses are formally written out below:

- Age graded scores of sixty percent or higher and seventy percent or higher

  H_0: Proportion of Male Finishers ≤ Proportion of Female Finishers

  H_α: Proportion of Male Finishers > Proportion of Female Finishers

- Age graded scores of forty percent or lower

  H_0: Proportion of Male Finishers ≥ Proportion of Female Finishers

  H_α: Proportion of Male Finishers < Proportion of Female Finishers

- Are women more variable than men?

  H_0: Variance of Male Finishers ≥ Variance of Female Finishers

  H_α: Variance of Male Finishers < Variance of Female Finishers

- Are men older than women?

  H_0: Mean Age of Male Finishers ≤ Mean Age of Female Finishers

  H_α: Mean Age of Male Finishers > Mean Age of Female Finishers

  H_0: Median Age of Male Finishers ≤ Median Age of Female Finishers

  H_α: Median Age of Male Finishers > Median Age of Female Finishers

- Are men more competitive than women (overall and within age groups)?

H_0: Mean Age Graded Score of Male Finishers ≤ Mean Age Graded Score of Female Finishers

H_α: Mean Age Graded Score of Male Finishers > Mean Age Graded Score of Female Finishers

H_0: Median Age Graded Score of Males ≤ Median Age Graded Score of Females

H_α: Median Age Graded Score of Males > Median Age Graded Score of Females

- Are women/men more competitive at longer distances than at shorter distances (within gender only)?

H_0: Age Graded Score of Marathon Finishers ≤ Age Graded Score of Half Marathon Finishers

H_α: Age Graded Score of Marathon Finishers > Age Graded Score of Half Marathon Finishers

H_0: Age Graded Score of Marathon Finishers ≤ Age Graded Score of Ten Kilometer Finishers

H_α: Age Graded Score of Marathon Finishers > Age Graded Score of Ten Kilometer Finishers

H_0: Age Graded Score of Marathon Finishers ≤ Age Graded Score of Five Kilometer Finishers

H_α: Age Graded Score of Marathon Finishers > Age Graded Score of Five Kilometer Finishers

H_0: Age Graded Score of Half Marathon Finishers ≤ Age Graded Score of Ten K Finishers

H_α: Age Graded Score of Half Marathon Finishers > Age Graded Score of Ten K Finishers

H_0: Age Graded Score of Half Marathon Finishers ≤ Age Graded Score of Five K Finishers

H_α: Age Graded Score of Half Marathon Finishers > Age Graded Score of Five K Finishers

H_0: Age Graded Score of Ten K Finishers ≤ Age Graded Score of Five K Finishers

H_α: Age Graded Score of Ten K Finishers > Age Graded Score of Five K Finishers

- Are women/men older at longer than at shorter distances (within gender only)?

H_0: Age of Marathon Finishers ≤ Age of Half Marathon Finishers

H_α: Age of Marathon Finishers > Age of Half Marathon Finishers

H_0: Age of Marathon Finishers ≤ Age of Ten Kilometer Finishers

H_α: Age of Marathon Finishers > Age of Ten Kilometer Finishers

H_0: Age of Marathon Finishers ≤ Age of Five Kilometer Finishers

H_α: Age of Marathon Finishers > Age of Five Kilometer Finishers

H_0: Age of Half Marathon Finishers ≤ Age of Ten Kilometer Finishers

H_α: Age of Half Marathon Finishers > Age of Ten Kilometer Finishers

H_0: Age of Half Marathon Finishers ≤ Age of Five Kilometer Finishers

H_α: Age of Half Marathon Finishers > Age of Five Kilometer Finishers

H_0: Age of Ten Kilometer Finishers ≤ Age of Five Kilometer Finishers

H_α: Age of Ten Kilometer Finishers > Age of Five Kilometer Finishers

These hypotheses are the same for the mean, median, and variance for each variable investigated. We looked at age graded score and age individually within each gender and only compared the data of the finishers for each distance, combining all race finisher data for each gender and race distance.

CHAPTER 2. LITERATURE REVIEW

There is no current literature available that concerns our exact topic, but there is a plethora of literature concerning the underlying topics of our research – the competition between men and women and the history of marathon running for women. These topics are so different that we will consider them separately and in depth throughout this chapter.

2.1. Competition between Sexes

The first topic that we will discuss at length is the competition between men and women. This competition can be broken down into several distinct forms: competition in athletics, competition in everyday life, and the reasons behind the competition. The topics are often intermingled when reviewed and researched in the literature. Researchers often use a setting of competition in order to test the beliefs that are held by male and female contestants, both consciously and unconsciously. Two papers that follow this design were written by Dato and Nieken [2014] and Booth and Nolen [2011].

Dato and Nieken [2014] examined the behavior of males and females in a controlled tournament setting with the opportunity for sabotage. They noted that although the females make up nearly half of the workforce, they are underrepresented in the upper levels of companies worldwide. The study was designed to examine the reasons behind this disparity by implementing four different treatments: baseline, belief, cheating, and gender. The researchers found that males, on average, selected twice as much sabotage as females but that the genders did not differ significantly on any other treatment investigated. Dato and Nieken concluded that males and females systematically differed in their sabotage decisions, resulting in males winning the tournament more often, and that the gender gap was already present in the beliefs of the participants before they entered the study.

Booth and Nolen [2011] also examined the behavior of men and women in a controlled competition setting to determine why women hesitate to compete while men choose to compete too much. They theorized that if men enjoy competition and women dislike it there will be two effects: fewer women will choose to compete and fewer women will succeed in competitions. In order to test these theories, the researchers designed a controlled experiment constructed around boys and girls solving puzzles in three rounds: solving puzzles in groups, mandatory tournament, and choice of whether to enter the tournament or not. The children also filled out an exit survey so that researchers could determine the background information and beliefs of each participant. Booth and Nolen found that girls solved fewer puzzles than boys in all settings and that the environment mattered in the decision to enter the tournament. The results from the study supported the following beliefs: men choose to enter competition more than women, girls in same gender groups enter competition more than girls in mixed gender groups, and girls from same sex schools enter competition more than girls from coed schools. Specifically, single sex schooling decreases the gender gap in choosing to compete by over sixty percent; girls from same sex schools are forty-two percent more likely to enter the tournament than girls from a coed school and girls from coed schools are seventy-one percent less likely to enter the tournament than boys from coed schools.

While researchers use competition to investigate how men and women react to competition and what their beliefs about competition are, surveys and discussion are used to study the reason behind why men and women compete in the first place. We reviewed two papers that follow this study design, the first was by Warner and Dixon [2015] and the other was written by Cashdan [1998].

Women are often viewed as not aggressive or competitive enough to succeed in the sports setting. Warner and Dixon [2015] theorized that men and women tend to view competition differently in addition to possessing physiological, psychological, and social reactions to it. The researchers conducted interviews, both individually and in groups, with current and former collegiate athletes to determine how competition impacted their sport experience. The interviews focused on internal and external competition as well as the reasons behind the competitive feelings. Both genders viewed external competition enhanced the sport experience by making it more meaningful as there was something at stake for the participants. There were differences in respect to internal competition, women found that it was often taken to a personal level while men affirmed that it created and nurtured a mutual respect among the competitors. Both genders agreed that when teammates were motivated by trying to beat each other out of a spot on the team, rather than bettering themselves, then competition could become problematic. The interviews suggested that, while competitiveness may be a biological tendency of males, the social arena surrounding sports creates an atmosphere where men feel the need to live up to an expectation of being competitive and where women feel the need to restrain from it.

Cashdan [1998] conducted a behavioral study using diary entries to investigate the reasons behind competition between men and women. The participants were asked to fill out forms about when they felt competition, their background information, and how they felt about feeling competitive. These forms were all filled out by college students in a school setting, which may have influenced the results. Cashdan found that students were more likely to report conflict which resolved in their favor and that more forms focused on school related conflicts than sports related ones. Additionally, the few forms that were related to sport conflicts were authored by men.

Each of these papers approaches the topic of male and female competition in a different manner and from a different angle. In contrast to the reviews of the reasons behind competition and the reactions to competition, the papers comparing the differences between the performance of male and female runners generally focus on the gap between the sexes. Several papers that studied this gap in performance are by Frick [2011], Thibault et al. [2010], and Pate and O'Neill [2007].

Frick [2011] used the top two hundred male and female finishes from professional distance running at the four most popular distances: five kilometer (track), ten kilometer, half marathon, and marathon; only including races where men and women were competing against their own sex. The differences between the genders were calculated as a percentage of male finishing time, for both genders. Specifically, the percentage difference in fishing times was calculated by dividing the difference between the female and male finishing time by the male finishing time. Frick found the top two hundred performances of all times by men and women vary greatly by average age and that the number of fast female marathon runners increased far more than the number of fast male runners.

Thibault et al. [2010] also compared same sex events between male and female athletes and calculated the gender gap based on the male results. Specifically, the researchers compared the world records for eighty-two Olympic events and calculated the gender gap between the world records by subtracting the men's world record from the women's world record for timed events and by subtracting the women's world record from the men's world record for non-timed events. Thibault et al. found that the number of women participating in the Olympics has increased at a higher rate than the number of men since 1986, while the gender gap in Olympic performance has been stable since 1983. The increase in the number of participants could also be as a result of the increase in the number of Olympic events available to women. In the 1984 summer Olympic Games, 221 total events were available with only 76 offered for women; by contrast, the 2012 summer Olympic Games hosted 302 total events with 144 of those events available for women [International Olympic Committee 2015].

Pate and O'Neill [2007] looked specifically at the marathon time differences between male and female runners between 1976 and 2005. Before 1976, the public believed that women were not physiologically able to run a marathon and were barred from running long distances. Despite the obstructions, women's participation has grown dramatically over the years. To compare the physiological differences between male and female runners, the authors performed a literature review of three earlier papers which compared the physiological profiles of elite female runners, broken into elite middle-distance runners and elite long-distance runners, and good female distance runners. The authors also compared highly-trained male and female distance runners and elite male and female distance runners, and found that the physiological differences in these runners are comparable to the differences seen in marathon performance. The researchers found that from 1976 to 2005 the best marathon times of American men stayed fairly constant, from 2:10:10 to 2:11:14, while the times of American women decreased from 2:47:10 to 2:21:25, a difference of 15.6%.

2.2. History of Running

Finally, we will examine the literature surrounding the history of women's running. Women's distance running came into the public viewpoint during the 1960s and entered the Olympic Games in 1984. The popularity of women's distance running has increased since the marathon first appeared in the 1984 Olympic Games in Los Angeles with the total number of finishers for the marathon and half marathon increasing every year. Between the years of 1990 and 2013, the total number of marathon finishers increased from 224,000 (10% female finishers) to

550,637 (43% female finishers) and the total number of half marathon finishers increased from 303,000 to 2,046,600 (61% female finishers) [Running USA 2014].

The men's marathon was first contested in the Olympics in 1896 followed by the 5,000 meter (five kilometer) and the 10,000 meter (ten kilometer) races in 1912 but the women's marathon was not contested until 1984 followed by the five kilometer race in 1988 and the ten kilometer race in 1996 [International Association of Athletics Federations 2015]. The majority of the literature concerning the history of women's distance running consists of discussion about the fight for the inclusion of the marathon to the women's Olympic track and field program. There are many sources that review the fight for the addition of the women's long distance running in the Olympic Games and we reviewed two for this paper: Lovett [1997] and Schultz [2015]. Each of these sources took a slightly different approach to the data but both covered the main points of the struggle for inclusion, detailed below.

Women were excluded from track and field competition entirely until the 1928 Olympics where they were granted the opportunity to run the 100 and 800 meter races. The media reported that many of the female competitors had difficulties finishing the 800 meter race due to poor preparation and that multiple women collapsed upon finishing the race but the historical records show that all nine contestants finished the 800m finals without a single woman collapsing on or after the finish line. Nevertheless, the International Olympic Committee (IOC) built on the false reports and removed the 800 meter race from the women's program, considering it too strenuous for women. The IOC restricted women's track and field races to 100 meters and under until 1948 when the 200 meter race was added to the roster. The women's length restrictions were increased again in 1960 when the 800 meter race was reintroduced and in 1972 when the 1500 meter race was added but the distances were not extended again until 1984 when the 3000 meter and marathon races were added.

Prior to 1967, very few women ran in major competitions because, outside of the Olympic Games, women were banned from taking part in organized distance running races worldwide. In 1967, rules forbade men and women from racing in the same event as well as prohibiting women from competing in races over 1.5 miles (2.4 kilometers). That same year K. Switzer was able to obtain an official registration to the Boston marathon and, after race officials attempted to forcibly remove her from the course, women's long distance running was thrust into the public eye around the world. This global attention, in addition to the performances of early women marathoners, elicited an increase in the popularity of women's distance running in addition to triggering a gradual transformation of the American and international rules for distance running.

Throughout the 1970s the worldwide popularity of women's marathon running exploded, from around twenty in 1970 to more than eight thousand in 1979. This expansion brought about changes to the guidelines concerning long distance running for women; by the end of the decade the Amateur Athletic Union (AAU), the International Association of Athletics Federations (IAAF), and individual events around the world officially allowed women to compete in marathons. Despite the clear popularity of the marathon among female competitors, the IOC did not include the race in the 1980 Olympic Games. The IOC stated several qualifications that needed to be met before an event could be added to the Olympics, the most difficult being that the event needed to be popular in at least twenty-five countries and on at least two continents. The popularity of the women's marathon came to the attention of the international press when the third Avon international marathon championship was covered by major worldwide media in 1980, as a result of the boycott of the Olympic Games in Moscow.

Women also needed to show the IOC that they could maintain an organization and race structure, separate from men. To accomplish this many companies, led by Avon Inc. and Nike, began to support the women's running movement by creating women's only races, producing ad campaigns that featured women running, and putting pressure on the IOC to include the marathon, along with the 5k and 10k race distances, in the 1984 Olympic Games. These advocacy groups were put to the test when the IOC and the Los Angeles Olympic Organizing Committee (LAOOC) attempted to delay making the decision for inclusion of the women's marathon in the 1984 Games. The LAOOC initially attempted to block the inclusion stating that expanding the women's program would create an excessive strain on the Olympic officials and the city of Los Angeles; this verdict was quickly reversed after the United States Olympic Committee, the IAAF, and several LA bureaucrats received heavy criticism from women's advocacy groups. The IOC had cited the need for more medical research data on the effects of long distance running on the female body and the need for more experience for women. The support groups, and the popularity of the third Avon International marathon championship, put pressure on the IOC by publicly refuting these excuses, given as an attempt to delay making a decision on the inclusion of the women's races, using medical professionals and the research that had been done to that point.

Faced with all of the data, the IOC voted to include the women's marathon and the 3000 meter race in the 1984 Olympic Games and the LAOOC quickly accepted the decision. The women's running movement, and their supporters, succeeded in their mission to add the marathon but the mission to add the 10,000 meter and the 5,000 meter races would not succeed for another four years for the 10,000 meter race and another twelve years for the 5,000 meter race.

CHAPTER 3. METHODS

We used several statistical tests to determine what differences exist between male and female distance runners and to test if those differences are significant. In this section, we will discuss the data that we have collected and examine each statistical test used to answer the research hypotheses detailed in chapter one of this paper.

3.1. Data Description

Our overall data is comprised of the age and gender of the runner, the timed race results, and the associated age grade scores, calculated using the WMA age-grading tables developed by Howard Grubb [World Masters Athletics 2010], with one dataset for each major road running distance (Five kilometer, ten kilometer, half marathon, and marathon) and a separate dataset for major marathons. Our goal is to examine any differences that exist in the race populations and if those differences could have an effect on the age grading calculations. This paper will focus on two separate areas of analysis: Qualifying races and non-qualifying races. Qualifying races were defined as marathons that require a runner to reach a qualifying time or participate in a specific qualifying race prior to registration.

For the marathons which require runners to qualify before participating, referred to as major marathons, we will be including races from 2013 and 2012 depending on the race. The 2012 running of the New York marathon was cancelled in connection with the destruction of the Superstorm Sandy hitting the east coast [Runner's World 2013] and the 2013 running of the Boston marathon was disrupted when two bombs exploded near the finish line [Runner's World 2013]. As a result, we included the results from the 2013 New York marathon and the results of the 2012 Boston marathon in our results. For the Chicago marathon, no particular difficulty occurred during either the 2012 or 2013 races so we included the 2013 results, in fitting with our previously stated plan. For all of the major marathons, we are only concerned with runners that finished with an age graded score of sixty percent or higher and finishers with an age graded score of seventy percent or higher. The lower limit of sixty percent for the age graded scores was chosen based on the time qualifications for the 2013 Boston marathon; after being converted to age graded scores the lowest qualifying percent for the qualifying times is sixty percent. The Boston marathon and the New York marathon only allow runners aged eighteen years and older while the Chicago marathon allows runners over the age of sixteen. In order to be consistent across the races, we only included data from finishers that were eighteen years old and older in our research.

To get a larger picture of the differences between male and female running populations, we will consider the results from races at each of the four popular running distances: marathon, half marathon, ten kilometer, and five kilometer. The number of finishers in road races varies greatly between race distances so we will select results from eight races of varying sizes for each distance. By selecting variable sized races we feel confident that the data set is a good representation of the US road running population. Healthy running practices observe that runners should limit competitive training and competition until they have undergone puberty which happens between the ages of thirteen and fifteen, depending on the gender of the athlete [Road Runners Club of America 2015]. In order to consider competitive runners and in an attempt to remove the possibility of counting a single runner twice in the same race, we only included runners aged fourteen years and older in our data. For each race, we will consider all of the age graded scores and finishing times, as well as the ages and genders. All race results considered in this section were taken from races run during 2013.

3.2. Research Hypotheses

We will use the previously described data to answer our research hypotheses that were stated in Chapter 1: Introduction. The main question that we would like to answer using this data is: Are male runners more competitive than female runners? In order to investigate this question, we broke it down into several sections and tested those using the following hypotheses:

1. Are men faster than women? (Age graded scores of sixty percent or higher)

   H_0: Proportion of Male Finishers = Proportion of Female Finishers

   H_α: Proportion of Male Finishers > Proportion of Female Finishers

2. Are women slower than men? (Age graded scores of forty percent or lower)

   H_0: Proportion of Male Finishers = Proportion of Female Finishers

   H_α: Proportion of Male Finishers < Proportion of Female Finishers

3. Are women more variable than men?

   H_0: Variance of Male Finishers = Variance of Female Finishers

   H_α: Variance of Male Finishers < Variance of Female Finishers

4. Are men older than women?

   H_0: Mean Age of Male Finishers = Mean Age of Female Finishers

   H_α: Mean Age of Male Finishers > Mean Age of Female Finishers

5. Are men more competitive than women (overall and within age groups)?

H_0: Mean Age Graded Score of Male Finishers = Mean Age Graded Score of Female Finishers

H_α: Mean Age Graded Score of Male Finishers > Mean Age Graded Score of Female Finishers

6. Are women more competitive at longer distance races?

H_0: Mean Age Graded Score equal for all race distances

H_α: Mean Age Graded Score – Marathon > Half Marathon > Ten Kilometer > Five Kilometer

7. Are women older at longer distance races?

H_0: Mean Age equal for all race distances

H_α: Mean Age – Marathon > Half Marathon > Ten Kilometer > Five Kilometer

8. Are men more competitive at longer distance races?

H_0: Mean Age Graded Score equal for all race distances

H_α: Mean Age Graded Score – Marathon > Half Marathon > Ten Kilometer > Five Kilometer

9. Are men older at longer distance races?

H_0: Mean Age equal for all race distances

H_α: Mean Age – Marathon > Half Marathon > Ten Kilometer > Five Kilometer

Through testing the proportions, the mean ages, the mean age graded scores, the median ages, the median age graded scores, the variances of the ages, and the variances of the age graded scores we will be able to draw conclusions about the overall populations of male and female race finishers and the differences between them. Also, through testing the mean ages, mean age graded scores, the median ages, the median age graded scores, the variance of the ages, and the variance of the age graded scores we will be able to draw conclusions about the populations of finishers for each race distance within each gender.

To investigate the differences between the populations of race finishers who compete in marathons that require qualification to participate, we will employ a number of statistical tests in order to answer our main research question: Are male runners more competitive than female runners? Using the data we have described above, we will run several statistical analyses to answer the following research hypothesis: Do male runners finish with a higher age graded score than women? Specifically, we will employ the proportion of race finishers, the overall descriptive statistics of the race finishers, and the descriptive statistics of the race finishers separated by age groups. To test these variables we will use Pearson's chi-square test of proportions, Student's two sample t-test for the equality of means, Wilcoxon-Mann-Whitney test for equal medians, Fisher's F-test and Levene's test of equal variances, and the Kolmogorov-Smirnov test for equal distributions.

Due to the large size of the non-qualifying races dataset, we are able to test more hypotheses than with the qualifying races dataset. Specifically, we will employ the proportion of race finishers to determine if the proportion of male runners who finish with an age graded score of sixty percent or higher, seventy percent or higher, and forty percent or lower is equal to the proportion of female race finishers. We will use the overall descriptive statistics of the race finishers, and the descriptive statistics of the race finishers separated by age groups to determine whether or not the two populations have equal means, medians, variances, and distributions. To accomplish this, we will use Pearson's chi-square test of proportions, Student's two sample t-test for the equality of means, Wilcoxon-Mann-Whitney test for equal medians, Fisher's F-test and Levene's test of equal variances, and the Kolmogorov-Smirnov test for equal distributions. We also wish to test if the trends that appear in the results of the previous statistical analyses are statistically significant and will accomplish this using Stouffer's Z-score method.

We will also use the large non-qualifying races dataset to answer questions about how the populations of the individual race distances vary within each gender. Specifically, we will determine which distance has the largest descriptive statistics for both age graded scores and ages by comparing the mean, median, and variance for male race finishers between the marathon, half marathon, ten kilometer, and five kilometer race distances which will enable us to determine which distance's population was the most competitive. These comparisons will also be conducted for the populations of female finishers at each race distance. To discover which race distance is the most competitive we will use Student's two sample t-test for the equality of means, Wilcoxon-Mann-Whitney test for equal medians, Fisher's F-test and Levene's test of equal variances, and the Kolmogorov-Smirnov test for equal distributions. We will describe each of these tests in detail in the next chapter.

CHAPTER 4. STATISTICAL TESTS

In this section, we will examine each statistical test in detail as they are found throughout the literature. We will discuss several statistical tests for each of the following sections: tests of proportion, tests of variance, tests of means, tests of medians, and tests of distribution. Finally, we will examine several meta-analytic procedures which we utilized in this paper.

4.1. Test of Proportions

For this paper we wish to test if the proportions of race finishers with an age graded score of sixty percent or higher, an age graded score of seventy percent or higher, and an age graded score of forty percent or lower are equal to one another, specifically we wish to test if the following hypotheses are true or not for each level:

H_0: Proportion of Male Finishers = Proportion of Female Finishers

H_α: Proportion of Male Finishers ≠ Proportion of Female Finishers

To test these hypotheses, we will use the chi-square test originally proposed by Karl Pearson in 1900. The data used must meet a number of assumptions in order to use the Pearson's chi-square test correctly. It is assumed that the data for each sample comes from a simple random sample taken from two (or more) independent populations. Furthermore, the samples must be sufficiently large which ensures that every expected cell count is larger than five for every cell in the contingency table, some table sizes require an expected cell count of ten or more, if this assumption is not met a different test of proportion needs to be used [Pearson 1900]. In the case that the samples are not sufficiently large, we will use Fisher's exact test of proportions to determine if the two proportions are equal to one another; we will describe Fisher's exact test in detail following Pearson's chi-square explanation.

Pearson's chi-square test is conducted through several steps: calculate the test statistic, calculate the degrees of freedom, and compare the test statistic with the value from the chi-square distribution also called the critical value. The first step of the procedure is to build a contingency table to view the data. The test statistic is then calculated using the observed value of each cell and the expected value of each, which is determined using the row and column totals. Specifically, if we denote the observed value of each cell as O_{ij} and the expected value of each cell as E_{ij}, the test statistic is defined as

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}}$$

and the expected value of each cell is defined as

$$E_{ij} = Np_i p_j = N \sum_{i=1}^{r} \frac{O_{ij}}{N} \sum_{j=1}^{c} \frac{O_{ij}}{N} = N \left(\frac{O_{.j}}{N}\right)\left(\frac{O_{i.}}{N}\right)$$

where r indicates the number of rows, c indicates the number of columns, and N indicates the total number of observations in the contingency table. The number of degrees of freedom for this test statistic is equal to the number of rows minus one multiplied by the number of columns minus one, $\mathrm{df} = (\mathrm{r} - 1)(\mathrm{c} - 1)$. This number is then combined with the level of confidence to determine the critical value or the value of the chi-square distribution that will be used to decide if the test is statistically significant or not. The null hypothesis is rejected if the test statistic is larger than the critical value [Pearson 1900].

Pearson's chi-square test is used when the size of both samples being tested are large, when the sample sizes are not sufficiently large Fisher's exact test is used to determine the p-value of the contingency table. The hypotheses for this test are identical to those of the Pearson chi-square test, given above. The exact test was originally proposed by Ronald A. Fisher in 1922 and is used to analyze contingency tables when the sample sizes are small, though it can also be used when the sample sizes are large.

Specifically, Fisher's exact test should be used if the chi-squared test is not appropriate when the expected value of any cell in the contingency table is below five. Using computer programs, we are able to calculate the p-value for any size contingency table but for calculations by hand only a 2 x 2 table is feasible [Fisher 1922].

To calculate the Fisher's exact test by hand, the first step is to draw a 2 x 2 contingency table, as follows

	1	2	Row Total
1	a	b	a + b
2	c	d	c + d
Column Total	a + c	b + d	n

where n is the total number of observations contained in the contingency table. To obtain the p-value, we calculate the probability of obtaining any combination of the row and column totals that is equal to the combination seen in the table of interest. Fisher showed that this probability is given by the hypergeometric distribution and is calculated as follows

$$p = \frac{\binom{a+b}{a}\binom{c+d}{c}}{\binom{n}{a+c}} = \frac{(a+b)!\,(c+d)!\,(a+c)!\,(b+d)!}{a!\,b!\,c!\,d!\,n!}$$

where a, b, c, d, and n are the values of the cells of the contingency table, as above, and the symbol ! indicates the factorial operator, defined as the product of all positive integers less than or equal to the value in front of the factorial operator [Fisher 1922]. Once the p-value is calculated, we can compare it to our chosen level of significance to determine if the null hypothesis should be rejected or not.

4.2. Test of Variances

We wish to test if two population variances are equal to one another for the variables age and age graded score, specifically we wish to test if the following hypotheses are true or not:

H_0: Variance for Male Finishers = Variance for Female Finishers

H_α: Variance for Male Finishers ≠ Variance for Female Finishers

To test these hypotheses, we will use the F-test originally proposed by Ronald Fisher in 1924 and Levene's test of equal variance originally put forward by Howard Levene in 1960. To use the F-test for the equality of two variances, it is assumed that the data is from random samples of two independent, normally-distributed populations [Fisher 1924].

The F test for equal variances is conducted using only the variances for each sample. The first step of this procedure is to calculate the sample means, $\overline{X}$ and $\overline{Y}$, defined as

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \ and\ \bar{Y} = \frac{1}{m}\sum_{i=1}^{m} Y_i$$

where X_i indicates the ith value of the first sample, Y_i indicates the ith value of the second sample, n indicates the sample size of the first sample, and m indicates the sample size of the second sample. The sample variances are then calculated using the sample means, defined as

$$S_X^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2 \ and\ S_Y^2 = \frac{1}{m-1}\sum_{i=1}^{m}(Y_i - \bar{Y})^2$$

where n indicates the sample size of the first sample and m indicates the sample size of the second sample. Finally, the test statistic is defined to be

$$F = \frac{S_X^2}{S_Y^2}$$

which has $\mathrm{n} - 1$ numerator degrees of freedom and $\mathrm{m} - 1$ denominator degrees of freedom. To determine if the null hypothesis is statistically significant, the test statistic is compared to two critical value from the F distribution, one for the level of significance (α) and the second for one minus the level of significance (1 - α), with the degrees of freedom of the test statistic [Fisher 1924].

As stated previously, one of the assumptions of the F test is that the underlying populations follow a normal distribution but this may not always be the case when comparing two populations. In cases where the underlying populations cannot be shown to follow a normal distribution or when there is some doubt of the normality, Howard Levene proposed a test for equality of variances that does not rely on the assumption of normality as the populations under consideration only need to be approximately normal.

Levene's test only assumes that the data is from two independent, random samples and that the populations only need to be approximately normal [Levene 1960]. Levene's test for equal variances employs the sample means and sample sizes for each sample under investigation in the calculation of the test statistic. The test statistic is defined, in general, as

$$W = \frac{(N-k)}{(k-1)} \frac{\sum_{i=1}^{k} N_i (\bar{Z}_{i.} - \bar{Z}_{..})^2}{\sum_{i=1}^{k} \sum_{j=1}^{N_i} \left(Z_{ij} - \bar{Z}_{i.}\right)^2}$$

where N indicates the combined size of all samples, k indicates the number of different samples under investigation, N_i indicates the individual sample size for the i^{th} sample, and Z_{ij} and $Z_{..}$ are defined as

$$Z_{ij} = \left|Y_{ij} - \bar{Y}_{i.}\right| \; and \; Z_{..} = \frac{1}{N} \sum\nolimits_{i=1}^{k} \sum\nolimits_{j=1}^{N_i} Z_{ij}$$

with Y_{ij} the observed value of the data in the j^{th} position from the i^{th} sample. Furthermore, $\overline{Y}_{i.}$ is the mean of the observed data for the i^{th} sample, $Z_{..}$ is the mean of all Z_{ij}, and $\bar{Z}_{i.}$ is the mean of the Z_{ij} for the i^{th} sample. The test statistic follows an F distribution with $k - 1$ numerator degrees of freedom and $N - k$ denominator degrees of freedom [Levene 1960]. To determine if the null hypothesis is statistically significant, the test statistic is compared to a value of the F distribution with the degrees of freedom of the test statistic and the level of significance of the test. For both tests of variances, the test statistic is compared to the respective critical values from the F distribution; the only differences in the rejection ruling arise at the level of the degrees of freedom which can result in different critical values and the number of critical values used in the test statistic comparisons.

4.3. Test of Means

For this paper, we wish to test if two population means are equal to one another for the variables age and age graded score, specifically we wish to test if the following hypotheses are true or not:

H_0: Mean for Male Finishers = Mean for Female Finishers

H_α: Mean for Male Finishers ≠ Mean for Female Finishers

To test these hypotheses, we will use the two sample t-test originally proposed by William Gossett in 1908, under the pen name Student, and the analysis of variance (ANOVA) originally put forward by Ronald Fisher in 1924. The two sample t-test assumes that the samples are from independent, random samples drawn from large populations which are assumed to follow a normal distribution [Student 1908].

The two sample t-test uses the mean, standard deviation, and size of each sample in the calculation of the test statistic. There are two forms for the test statistic, one if the population variances are equal and another if the population variances are not equal to one another.

For two samples from populations with equal variances, indicated by the subscripts 1 and 2, the test statistic is defined as

$$T = \frac{\bar{X}_1 - \bar{X}_2}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

$$S_p = \sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}}$$

where $\overline{X}$ indicates the sample mean, S_p indicates the pooled sample standard deviation, n indicates the sample size, and S^2 indicates the sample variance. For testing the significance of the null hypothesis, the degrees of freedom are equal to the total sample size minus two, $df = (n_1 - 1) + (n_2 - 1) = n_1 + n_2 - 2$.

For two samples from populations with unequal variances, indicated by the subscripts 1 and 2, the test statistic is defined as

$$T = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where $\overline{X}$ indicates the sample mean, n indicates the sample size, and s^2 indicates the sample variance. For testing the significance of the null hypothesis, the degrees of freedom are defined to be

$$df = \frac{\left({s_1^2}/{n_1} + {s_2^2}/{n_2} \right)^2}{\frac{\left({s_1^2}/{n_1} \right)^2}{n_1 - 1} + \frac{\left({s_2^2}/{n_2} \right)^2}{n_2 - 1}}$$

To perform the statistical testing, the degrees of freedom and the level of significance are used to determine a critical value from the Student’s t distribution. The null hypothesis is rejected if the absolute value of the test statistic is larger than the critical value [Student 1908].

Another method for testing equality of means between several populations is the one-way ANOVA test of treatment means. Specifically, we wish to test if the following hypotheses are true or not:

H_0: Mean for Marathon = Mean for Half Marathon = Mean for 10k = Mean for 5k

H_α: Mean for the Race Distances are not all equal

The one-way ANOVA procedure assumes that the residuals for the response variable are normally distributed with the responses for a specific sample independent and identically distributed from normal populations [Fisher 1924]. Also, the procedure assumes that the samples are independent, from populations with equal variances.

The test statistic uses summary statistics, specifically the sums of squares and the mean square for calculations. The test statistic is defined as

$$F = \frac{MS_{trt}}{MS_{error}} = \frac{SS_{trt}/df_{trt}}{SS_{error}/df_{error}} = \frac{\dfrac{\sum_{j=1}^{k} n_j * \bar{y}_{.j}^2 - N\bar{y}_{..}^2}{k-1}}{\dfrac{\sum_{i=1}^{n_j}\sum_{j=1}^{k} y_{ij}^2 - \sum_{j=1}^{k} n_j * \bar{y}_{.j}^2}{N-k}}$$

where MS is the mean square, SS is the sum of squares, df is the degrees of freedom, N is the total number of observations, k is the number of levels of the treatment being investigated, and n_j is the sample size for the j^{th} level of the treatment. Also, y_{ij} is the i^{th} observation at the j^{th} level of the treatment, $\bar{y}_{.j}$ is the mean for the j^{th} level of the treatment, and $\bar{y}_{..}$ is the overall mean of all levels of the treatment under investigation. To determine if the null hypothesis is statistically significant or not, the test statistic is compared to a critical value calculated from the F distribution using the chosen level of significance, the degrees of freedom of the sum of squares for the treatment, and the degrees of freedom for the sum of squares for the error. The null hypothesis is rejected when the test statistic is larger than the critical value [Fisher 1924].

4.4. Test of Medians

We also wish to test if two population medians are equal to one another for the variables age and age graded score, specifically we wish to test if the following hypotheses are true or not:

H_0: Median for Male Finishers = Median for Female Finishers

H_α: Median for Male Finishers ≠ Median for Female Finishers

To test these hypotheses, we will use the Mann-Whitney-Wilcoxon test which is a combination of the Mann-Whitney U-test originally proposed by Henry Mann and Donald Whitney in 1947 and the Wilcoxon rank sum test originally put forward by Frank Wilcoxon in 1945. Because the Mann-Whitney test and the Wilcoxon test differ by only a constant, the two are usually combined and referred to as the Mann-Whitney-Wilcoxon test.

The Mann-Whitney-Wilcoxon test assumes that both samples are random and independent from one another, the observations in each sample are continuous or ordinal, and that the distribution functions of the two populations differ only with respect to location, if they differ at all [Mann and Whitney 1947, Wilcoxon 1945]. The test statistic computation employs the sample sizes and the ranks of the observations of both populations. The first step in the calculation is to combine the observations of the two samples and rank them from smallest to largest. Then the test statistic is defined as,

$$T = S - \frac{n_1(n_1 + 1)}{2}$$

where S indicates the sum of the ranks assigned to the sample from the first population and n_1 is the number of observations in the first sample. For a two sided alternative hypothesis (H_α: $M_1 \neq M_2$) the null hypothesis is rejected when the test statistic is larger than $w_{1-\alpha/2}$ or when the test statistic is smaller than $w_{\alpha/2}$ with $w_{1-\alpha/2}$ given by $w_{1-\alpha/2} = n_1 n_2 - w_{\alpha/2}$. SAS gives the significance test results using a normal approximation, both one-sided and two-sided, and the accompanying p-value [Mann and Whitney 1947, Wilcoxon 1945].

4.5. Test of Distributions

Finally, we wish to test if the distributions of two populations are equal to one another for the variables age and age graded score, specifically we wish to test if the following hypotheses are true or not:

H_0: Distribution of Male Finishers = Distribution of Female Finishers

H_α: Distribution of Male Finishers ≠ Distribution of Female Finishers

To test these hypotheses, we will use the Kolmogorov-Smirnov test which is a combination of the Kolmogorov distribution originally proposed by Andrei Kolmogorov in 1933 and the Smirnov tables of the Kolmogorov distribution originally put forward by Nikolai Smirnov in 1948. The Kolmogorov-Smirnov test (KS test) only assumes that the data consists of two independent, random samples and that the data are measured on a numerical or ordinal scale [Kolmogorov 1933, Smirnov 1948]. The null and alternative hypotheses can be rewritten as

$\mathrm{H_0}: \mathrm{F_1(x)} = \mathrm{F_2(x)}$ for all x

$\mathrm{H_\alpha}: \mathrm{F_1(x)} \neq \mathrm{F_2(x)}$ for at least one value of x

These new hypotheses are tested using the sample distribution functions of the observed values of each sample, defined as

$$S_1(x) = \frac{Number\ of\ Observations\ in\ Sample\ 1 \leq x}{n_1}$$

$$S_2(x) = \frac{Number\ of\ Observations\ in\ Sample\ 2 \leq x}{n_2}$$

$$D = maximum|S_1(x) - S_2(x)|$$

where n_1 denotes the size of the sample from the first population and n_2 denotes the size of the sample from the second population. The null hypothesis is rejected if

$$D > q_{\alpha}\sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

where q_{α} is the critical value based on the level of significance chosen for the hypothesis test, for $\alpha = 0.05$ $q_{\alpha} = 1.36$, and the sample sizes are defined as above [Kolmogorov 1933, Smirnov 1948].

For our research, we are also interesting in the one-sided test of hypotheses for the male and female running populations. Specifically, we wish to test if the following hypotheses are true or not:

H_0: Distribution of Male Finishers ≤ Distribution of Female Finishers

H_{α}: Distribution of Male Finishers > Distribution of Female Finishers

In terms of the Kolmogorov-Smirnov test, we can rewrite the null and alternative hypotheses as follows:

$\mathrm{H_0: F_1(x) \leq F_2(x)}$ for all x

$\mathrm{H_{\alpha}: F_1(x) > F_2(x)}$ for at least one value of x

We want to know if the cumulative distribution function of the first population is stochastically larger than the cumulative distribution function of the second population. To determine if the test is statistically significant, we look at the test statistics, $\mathrm{D^+}$or $\mathrm{D^-}$, which use the sample distribution functions, defined as follows

$$S_1(x) = \frac{Number\ of\ Observations\ in\ Sample\ 1 \leq x}{n_1}$$

$$S_2(x) = \frac{Number\ of\ Observations\ in\ Sample\ 2 \leq x}{n_2}$$

$$D^+ = maximum\big(S_1(x) - S_2(x)\big)$$

$$D^- = maximum\big(S_2(x) - S_1(x)\big)$$

where n_1 denotes the size of the sample from the first population and n_2 denotes the size of the sample from the second population. The test statistic will be D^+ if the alternative hypothesis is $\mathrm{F}_1(\mathrm{x}) > \mathrm{F}_2(\mathrm{x})$ and will be D^- if the alternative hypothesis is $\mathrm{F}_1(\mathrm{x}) < \mathrm{F}_2(\mathrm{x})$; the null hypothesis is rejected if

$$D^+ or\ D^- > q_\alpha \sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

where q_α is the critical value based on the level of significance chosen for the hypothesis test, for $\alpha = 0.05$ $q_\alpha = 1.36$, and the sample sizes are defined as above [Kolmogorov 1933, Smirnov 1948].

4.6. Meta-Analysis

For this paper, we wish to combine the test results to see if the overall results follow a similar pattern. To do this, we will be testing the following hypotheses:

H_0: All Separate Null Hypotheses are True

H_α: At Least one of the Separate Alternative Hypotheses is True

To test these hypotheses, we will use Stouffer's Z-score method, named after and proposed by Samuel Stouffer in 1949, which is an expansion of Fisher's method originally put forward by Ronald Fisher in 1925.

Fisher's method is used to combine the p-value for several independent tests with the same null hypothesis [Fisher 1925]. The test statistic is defined as

$$T = -2 \sum_{i=1}^{k} ln(p_i)$$

Where p_i denotes the p-value for the i^{th} hypothesis test and k indicates the total number of hypothesis tests included in the meta-analysis. The test statistic follows a chi-squared distribution with 2k degrees of freedom, which is used to determine the critical value for the hypothesis test [Fisher 1925].

In Fisher's method of combining p-values, all the p-values are given equal weight with no consideration of the sample size the p-value originated from. Because the sample sizes in our research have large differences between them, we want to include the sample sizes in our test statistic in the form of weights.

Stouffer's Z-score method uses a more straight forward approach to combining p-values of several hypothesis tests [Stouffer et al 1949]. The test statistic is calculated using the standard normal distribution based on the individual p-values and the individual sample sizes for each hypothesis test. The test statistic is defined as

$$Z_i = \phi^{-1}(1 - p_i) \qquad\qquad w_i = {n_i}/{\sum_{i=1}^{k} n_i}$$

$$Z = \frac{\sum_{i=1}^{k} w_i Z_i}{\sqrt{\sum_{i=1}^{k} w_i^2}}$$

where ϕ is defined as the standard normal cumulative distribution function, Z_i denotes the Z-score based on the i^{th} p-value, and w_i denotes the weight based on the sample size of the i^{th} hypothesis test. The null hypothesis is rejected when the test statistic is larger than the critical value from the standard normal distribution based on the chosen level of significance [Stouffer et al 1949].

CHAPTER 5. QUALIFYING RACES

For the first part of our analyses, we examined three marathons that require qualification before participation, hereafter referred to as major marathons. These races are three of the largest and most respected races in the United States: the Boston Marathon, the ING New York City Marathon, and the Bank of America Chicago Marathon. Specifically, we included data from the 2012 Boston Marathon, the 2013 ING New York City Marathon, and the 2013 Bank of America Chicago Marathon.

5.1. Race Descriptions

All three races have over twenty thousand participants, with the exact numbers given in Table 1 which follows below. The number of male and female race finishers with an age graded score of sixty percent or higher and with an age graded score of seventy percent or higher are also included in Table 1. Examining each of these values reveals that the number of male finishers is larger than the number of female finishers for each race. To test if these differences are statistically significant, we will compare the proportion of male finishers to the proportion of female finishers at each level of interest using a Chi square test of proportions.

Table 1. Major Marathons by the Numbers

Marathon	Total	Male Finishers	Female Finishers
Boston	21,563	12,570	8,993
Chicago	38,757	21,416	17,341
New York	50,136	30,589	19,547

As a further investigation of the races, we visually inspected the distribution of age graded scores by gender and marathon, given in Figure 1 below. For the 2012 Boston Marathon, the male population appears to follow a normal distribution with a center between fifty and sixty percent; the mean age graded score of 55.5 percent fits with this observation. The distribution of the female finishers is similar to the male population with the center of the data located between fifty and sixty percent and the mean age graded score of 55.6 percent within this range. Both populations of finishers for the 2013 Chicago Marathon appear to be slightly skewed with a center between forty and sixty percent; the mean age graded scores for the male and female finishers fit with this finding at 52.2 percent for females and 51.2 percent for males. The populations for the 2013 New York City Marathon are similar to those of the 2012 Boston Marathon; the male finishers appear to have a normal distribution with a center between fifty and sixty years, with a mean age graded score of 52.6, and the female finishers have a similar distribution with a center between fifty and sixty percent, with a mean age graded score of 53.0 percent.

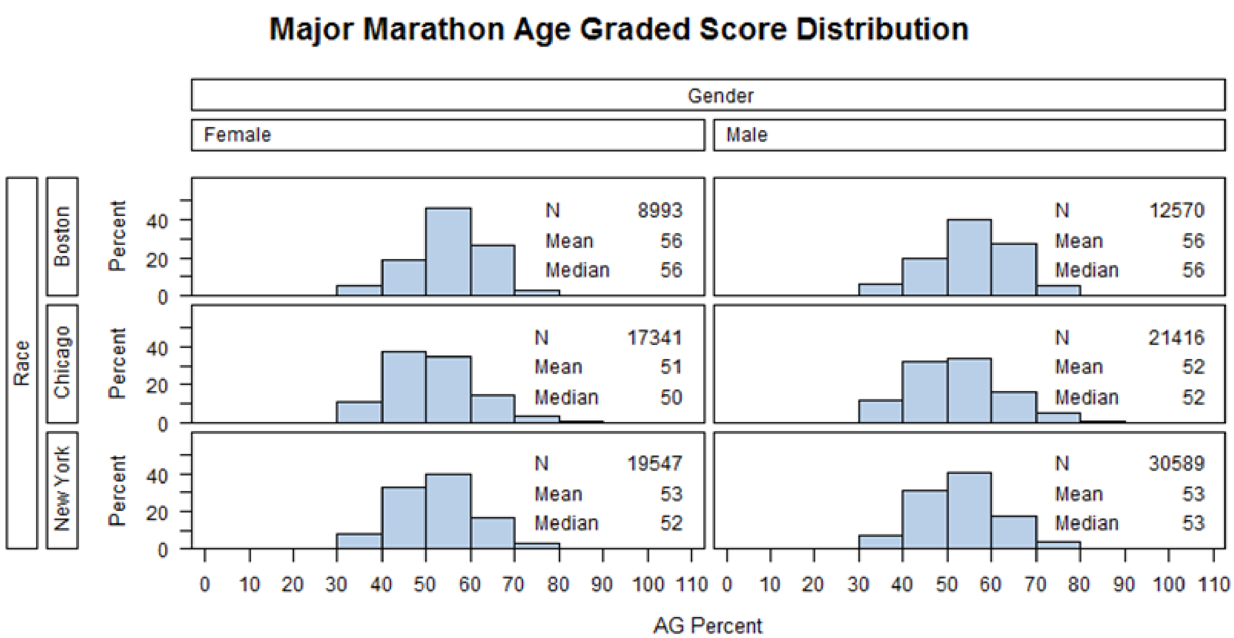

Figure 1. Age Distributions for Major Marathons by Gender

5.2. Results

For the previously discussed marathons, we performed a Chi Square test of proportions to compare the proportion of men and the proportion of women who finished with an age graded score of sixty percent or higher for each race. For each of the three races, we found that the proportion of men who finished with a score of sixty percent or higher was larger than the proportion of women who finished with a score of sixty percent or higher. We used a significant level of 0.05 as comparison for the test statistics. We found that the proportions were highly significantly different for all three of the marathons with each having a p-value less than 0.0001. This means that for all qualifying races, the proportion of male participants who finished with an age graded score of sixty percent or higher is significantly larger than the proportion of female participants who finished with an age graded score of sixty percent or higher.

Table 2. Proportion of Major Marathon Finishers and Test Results

Marathon		**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Boston	60% and above	P_M = 32.94%	P_F = 29.76%	24.6295	$p < 0.0001$
	70% and above	P_M = 5.91%	P_F = 3.19%	85.2406	$p < 0.0001$
	40% and below	P_M = 6.54%	P_F = 5.18%	17.2027	$p < 0.0001$
Chicago	60% and above	P_M = 21.74%	P_F = 17.23%	122.8513	$p < 0.0001$
	70% and above	P_M = 5.50%	P_F = 3.23%	114.9892	$p < 0.0001$
	40% and below	P_M = 12.08%	P_F = 10.86%	13.7648	$p = 0.0002$
New York	60% and above	P_M = 21.40%	P_F = 19.91%	16.0790	$p < 0.0001$
	70% and above	P_M = 4.23%	P_F = 3.41%	21.5090	$p < 0.0001$
	40% and below	P_M = 7.44%	P_F = 7.84%	2.7916	$p = 0.0948$

The Pearson's chi-square test of independence was used to determine if the proportion of male finishers was significantly different from the proportion of female finishers for age graded scores at or above sixty percent, at or above seventy percent, and at or below forty percent. The very large sample sizes for each marathon make Pearson's chi-square the appropriate test for this data.

We also compared the proportion of male and female finishers with age graded scores of seventy percent and above for each race. As with the previous test, we found that the proportion of male finishers was significantly larger than the proportion of female finishers with age graded scores of seventy percent and above. All three races had p-values less than 0.0001, which are highly significant when compared to the significance level of 0.05.

Finally, we compared the proportion of male and female race finishers with age graded scores of forty percent and lower for each race. Unlike the previous tests for proportion, the only races that have a highly significant difference between the male and female proportions are Boston, with a p-value less than 0.0001, and Chicago, with a p-value equal to 0.0002. Both of these races have a larger proportion of male finishers with an age graded score of forty percent or below than the proportion of female race finishers. The New York Marathon is marginally non-significant, with a p-value of 0.0948, which is less than a significance level of 0.10 but larger than our chosen significance level of 0.05. The New York Marathon is the only result to have the proportion of female runners finishing with an age graded score of forty percent or lower larger than the proportion of male runners.

Table 3. Descriptive Statistics for Major Marathons

Marathon	**Mean**		**Median**		**Variance**	
Boston	M: 55.6	F: 55.5	M: 56.2	F: 56.3	M: 91.7	F: 73.4
Chicago	M: 52.2	F: 51.2	M: 51.7	F: 50.5	M: 108.4	F: 86.4
New York	M: 53.0	F: 52.6	M: 52.8	F: 52.1	M: 85.9	F: 83.2

To further explore the differences between the male and female race finisher populations, we looked at the mean, median, and variance for males and females, individually, for each marathon that requires prequalification to participate. When we examine these variables, in depth, we can see that the mean age graded score and variance of the age graded scores for male race finishers is higher than the mean age graded score and variance of the age graded scores for female race finishers for all three races. The median age graded score for the has the opposite trend for the Boston Marathon while the Chicago Marathon and the New York Marathon follow the male greater than female pattern. These findings were tested statistically to determine if they were significant.

Table 4. Major Marathon Test Results

Marathon	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Boston	$p < 0.0001$	$p < 0.0001$	$p = 0.2948$	$p = 0.3944$	$p < 0.0001$
Chicago	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
New York	$p = 0.0142$	$p = 0.0202$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

The assumptions for the Mann-Whitney-Wilcoxon test include equal variances for the two populations which is not true for the major marathon data, however even without this assumption met the results are still very similar to the t-test results. For all three major marathons, the non-pooled test statistic was used for the t-test.

After reviewing the results of the statistical tests for all of the major marathons, we can see that the variance of the age graded scores for the male race finishers is significantly higher than the variance of the age graded scores for the female race finishers (all p-values are less than 0.03). For the Chicago and New York marathons, the mean and median age graded scores for male runners are significantly larger than the mean and median age graded scores for female runners (all p-values are less than 0.0001); the difference between the mean and median age graded scores for male and female race finishers is highly non-statistically significant with both p-values greater than 0.29. For all three races we reviewed, the distribution of the age graded scores for the male race finishers is significantly different from the distribution of the age graded scores for female race finishers; this follows from the significant differences between the variances and mean/medians.

We were interested in discovering if the overall results given above are consistent across all three races. To determine if this is true, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results; the test for proportions of less than or equal to forty percent was converted to answer the alternative hypothesis of female results larger than male results. These conversions were performed for every statistical test that was performed on the overall qualifying marathon data. After the p-values were converted, we performed a meta-analysis to combine the p-values of the three qualifying marathons using Stouffer's Z-score method. For these combinations, we used the value of 0.99999 for any p-values equal to 1.000 and the value of 0.00009 for any p-values less than 0.0001; these values were chosen for convenience of calculation and to keep the calculation for breaking down as we were using computer programs to calculate the final Z value.

Table 5. Meta-Analysis for Major Marathon Results

	Age Graded Scores		
Variable	**Z value**	**P value: M > F**	**P value: F > M**
Proportions			
60%	6.181	$p < 0.0001$	$p = 1.0000$
70%	6.181	$p < 0.0001$	$p = 1.0000$
40%	-2.276	$p = 0.0114$	$p = 0.9886$
Variances			
F Test	5.212	$p < 0.0001$	$p = 1.0000$
Levene's Test	5.115	$p < 0.0001$	$p = 1.0000$
Means	5.312	$p < 0.0001$	$p = 1.0000$
Medians	4.700	$p < 0.0001$	$p = 1.0000$
Distributions	6.181	$p < 0.0001$	$p = 1.0000$

For the proportions of race finishers, at the sixty percent and higher and the seventy percent and higher levels the proportion of male race finishers is significantly higher than the proportion of female race finishers. For the proportion of race finishers at the forty percent and lower level the interpretation is a bit different, we hypothesized that the proportion of female finishers was larger than the proportion of male finishers so the result above means that the proportion of male finishers is significantly higher than the proportion of female finishers. The variance of age graded scores, the mean age graded score, and the median age graded score for the male race finishers are higher than the variance of age graded scores, the mean age graded score, and the median age graded score for the female race finishers. Finally, the distribution for the male finishers is significantly different from the distribution for the female finishers. The p-values for the sixty percent and higher proportions, the seventy percent and higher proportions, and the distributions were not included in the meta-analysis because all of the p-values were less than 0.0001 which would result in a p-value of less than 0.0001 not matter how you combined them.

To fully examine the differences between the male and female running populations, we broke down the statistical analysis down by race and age group. Once we separated the data into age groups, we ran several analyses to determine where the exact differences lie between the male and female race finisher populations. First, we compared the proportion of the total male race finishers to the proportion of female race finishers that lie in each age group and tested if these proportions are statistically different. Then we examined the descriptive statistics by age group and performed a visual review of the differences between the mean, median, and variances of the age graded scores for male and female race finishers. Finally, we performed several statistical tests to determine if the differences observed visually are significant.

Table 6. Proportion of Boston Finishers by Age Group

Age Group	**Proportion of Finishers**		**χ^2 P-value**	**Age Group P**
1 - 19	$P_M = 0.21\%$	$P_F = 0.26\%$	$p < 0.0001$	$p = 0.4571$
20 - 29	$P_M = 11.75\%$	$P_F = 20.76\%$		$p < 0.0001$
30 - 39	$P_M = 22.55\%$	$P_F = 30.10\%$		$p < 0.0001$
40 - 49	$P_M = 33.60\%$	$P_F = 32.95\%$		$p = 0.3196$
50 - 59	$P_M = 23.56\%$	$P_F = 13.40\%$		$p < 0.0001$
60 - 69	$P_M = 7.56\%$	$P_F = 2.34\%$		$p < 0.0001$
70 - 79	$P_M = 0.79\%$	$P_F = 0.19\%$		$p < 0.0001$
80 - 99	$P_M = 0.02\%$	$P_F = 0.01\%$		$p = 0.7687$

For the 80 – 99 year old age group there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the Pearson's chi-square test was appropriate for this data.

For the 2012 Boston Marathon, the p-value of less than 0.0001 indicates that at least one of the age groups has a significant difference between the proportion of male and female race finishers. For the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups the proportion of female finishers is larger than the proportion of male finishers. All other age groups have a larger proportion of male finishers than the proportion of female finishers. The majority of the data falls between thirty and fifty-nine years of age, around eighty percent, for male race finishers and between twenty and forty-nine years of age, around eighty-four percent, for female race finishers. To determine which age groups had significant differences between the proportions of race finishers of the male and female race finishers. The proportion of male race finishers is significantly different from the proportion of female finishers for the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 40 – 49, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the proportions of male and female race finishers.

Table 7. Boston Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	$P_M = 30.77\%$	$P_F = 13.04\%$	$p = 0.1378$
20 - 29	$P_M = 40.54\%$	$P_F = 21.91\%$	$p < 0.0001$
30 - 39	$P_M = 34.02\%$	$P_F = 22.13\%$	$p < 0.0001$
40 - 49	$P_M = 31.30\%$	$P_F = 33.28\%$	$p = 0.0780$
50 - 59	$P_M = 32.76\%$	$P_F = 44.65\%$	$p < 0.0001$
60 - 69	$P_M = 26.32\%$	$P_F = 61.90\%$	$p < 0.0001$
70 - 79	$P_M = 28.28\%$	$P_F = 58.82\%$	$p = 0.0132$
80 - 99	$P_M = 50.00\%$	$P_F = 100\%$	$p = 1.0000$

For the 80 – 99 year old age group there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the chi-square test was appropriate for this data.

We wished to test if the age groups for the 2012 Boston marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or above sixty percent. For the 20 – 29 and 30 – 39 year old age groups, the proportion of male race finishers is significantly larger than the proportion of female race finishers. The 50 – 59, 60 – 69, and 70 – 79 year old age groups have a significantly larger proportion of female race finishers than the proportion of male runners. There is weak statistical evidence that the proportion of female runners is significantly larger than the proportion of male runners for the 40 – 49 year old age group as the p-value is larger than our chosen level of significance but would be considered significant if we had decided on a larger level of significance. There is no statistical evidence of a significance difference between the proportion of male and female finishers for the 1 – 19 and 80 – 99 year old age groups.

Table 8. Boston Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 19.23%	P_F = 8.70%	p = 0.4238
20 - 29	P_M = 9.29%	P_F = 10.98%	p = 0.1090
30 - 39	P_M = 9.92%	P_F = 6.32%	p < 0.0001
40 - 49	P_M = 5.52%	P_F = 2.80%	p < 0.0001
50 - 59	P_M = 4.69%	P_F = 0.41%	p < 0.0001
60 - 69	P_M = 2.63%	P_F = 0.00%	p = 0.0144
70 - 79	P_M = 2.02%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19, 60 – 69, 70 – 79, and 80 – 99 year old age groups there was at least one cell in the contingency table with an expected frequency of five or lower; as a result, the p-value was calculated using Fisher's exact test. All other age groups had sufficiently large sample sizes for Pearson's chi-square test to be appropriate for the data.

We also wanted to see if the age groups for the 2012 Boston marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or below forty percent. The proportion of the male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower for the 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. There is no statistical evidence of a significant difference between the proportions of male and female race finishers for the 1 – 19, 20 – 29, 70 – 79, and 80 – 99 year old age groups.

Table 9. Boston Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 26	F: 23	M: 53.9	F: 49.7	M: 55.0	F: 49.4	M: 143.5	F: 75.7
20 - 29	M: 1475	F: 1867	M: 56.5	F: 52.7	M: 57.0	F: 53.3	M: 138.1	F: 86.6
30 - 39	M: 2834	F: 2707	M: 54.9	F: 54.1	M: 55.8	F: 55.1	M: 109.0	F: 68.6
40 - 49	M: 4223	F: 2963	M: 55.7	F: 56.7	M: 56.4	F: 57.1	M: 81.0	F: 58.8
50 - 59	M: 2961	F: 1205	M: 56.0	F: 59.1	M: 56.2	F: 59.3	M: 75.2	F: 58.5
60 - 69	M: 950	F: 210	M: 55.2	F: 62.2	M: 55.5	F: 62.2	M: 63.9	F: 62.1
70 - 79	M: 99	F: 17	M: 56.2	F: 63.6	M: 55.8	F: 62.1	M: 75.8	F: 55.1
80 - 99	M: 2	F: 1	M: 58.6	F: 83.0	M: 58.6	F: 83.0	M: 8.56	F: NA

The mean age graded score for the male race finishers of the Boston marathon is larger than the mean age graded score for the female race finishers for the 1 – 19, 20 – 29, and 30 – 39 year old age group but the opposite is true for all other age groups. The median age graded scores for the Boston marathon age groups follow the same pattern as the mean age graded scores. The variance of the age graded scores for the male race finishers is larger than the variance of the age graded score for the female race finishers for all age groups in this marathon. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 10. Boston Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.1337	p = 0.0564	p = 0.1729	p = 0.2255	p = 0.1615
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
30 - 39	p < 0.0001	p < 0.0001	p = 0.0016	p < 0.0001	p < 0.0001
40 - 49	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
60 - 69	p = 0.8054	p = 0.7688	p < 0.0001	p < 0.0001	p < 0.0001
70 - 79	p = 0.4786	p = 0.3904	p = 0.0012	p = 0.0009	p = 0.0006
80 - 99	NA	NA	p = 0.0931	p = 0.5403	p = 0.5176

The assumptions for the Mann-Whitney-Wilcoxon test include equal variances for the two populations which is not true for the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, though even without this assumption being met the results are still very similar to the t-test results for these age groups. For the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, the non-pooled variance test statistic was used for the t-test since the variances are not equal. For all other age groups, the equal variances assumption was met for the Mann-Whitney-Wilcoxon test and the pooled variance test statistic was used to the t-test.

The difference between the variance of the age graded scores for the male and female runners is non-significant for the 1 – 19, 60 – 69, 70 – 79, and 80 – 89 year old age groups but is highly significant for all remaining age groups, with all p-values less than 0.0001. For the mean and median age graded scores, the 1 – 19 and 80 – 89 year old age groups are not statistically significant but all the other age groups have significant differences, with all p-values less than 0.0002. In the same trend as the means and medians, the distribution of age graded scores are not significantly different for the 1 – 19 and 80 – 89 year old age groups but the differences in the distributions are statistically significant for all other age groups. The distributions follow the results of the mean age graded score, the median age graded score, and the variance of the age graded scores since if two distributions have different means and different variances, they will also have different distributions.

Table 11. Proportion of Chicago Finishers by Age Group

Age Group	Proportion of Finishers		χ^2 P-value	Age Group P
1 - 19	$P_M = 0.53\%$	$P_F = 0.65\%$	$p < 0.0001$	$p = 0.1109$
20 - 29	$P_M = 19.54\%$	$P_F = 31.88\%$		$p < 0.0001$
30 - 39	$P_M = 33.87\%$	$P_F = 35.18\%$		$p = 0.0067$
40 - 49	$P_M = 28.46\%$	$P_F = 22.74\%$		$p < 0.0001$
50 - 59	$P_M = 14.05\%$	$P_F = 8.23\%$		$p < 0.0001$
60 - 69	$P_M = 3.25\%$	$P_F = 1.23\%$		$p < 0.0001$
70 - 79	$P_M = 0.30\%$	$P_F = 0.07\%$		$p < 0.0001$
80 - 99	$P_M = 0.01\%$	$P_F = 0.00\%$		$p = 0.1191$

The p-value was calculated using Fisher's exact test for the 80 – 99 year old age group as at least one cell of the contingency table has an expected value of five or lower. Pearson's chi-square test was used for all other age groups as the sample sizes were sufficiently large enough.

For the 1 – 19, 20 – 29, and 30 – 39 year old age groups, the proportion of female finishers is larger than the proportion of male finishers. All other age groups have a larger proportion of male finishers than the proportion of female finishers. The highly significant p-value, less than 0.0001, indicates that at least one age group has a significant difference between the proportion of male and female race finishers. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 12. Chicago Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 19.47%	P_F = 7.96%	p = 0.0119
20 - 29	P_M = 17.97%	P_F = 10.80%	p < 0.0001
30 - 39	P_M = 17.15%	P_F = 12.93%	p < 0.0001
40 - 49	P_M = 23.68%	P_F = 23.53%	p = 0.8632
50 - 59	P_M = 31.48%	P_F = 38.24%	p < 0.0001
60 - 69	P_M = 32.52%	P_F = 51.40%	p < 0.0001
70 - 79	P_M = 30.77%	P_F = 75.00%	p = 0.0073
80 - 99	P_M = 33.33%	P_F = 0.00%	NA

For the 70 – 79 and 80 – 99 year old age groups there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the Pearson's chi-square test was appropriate for this data.

We wished to test if the age groups for the 2013 Chicago marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or above sixty percent. The proportion of male race finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female race finishers with an age graded score at or above sixty percent for the 1 – 19, 20 – 29, and 30 – 39 year old age groups. The 50 – 59, 60 – 69, and 70 – 79 year old age groups have a significantly larger proportion of female race finishers with an age graded score of sixty percent or above than male race finishers with an age graded score of sixty percent or above. There is no statistical evidence of a difference between the proportion of male and female finishers for the 40 – 49 and 80 – 99 year old age groups.

Table 13. Chicago Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 15.93%	P_F = 19.47%	p = 0.4857
20 - 29	P_M = 16.08%	P_F = 14.79%	p = 0.0815
30 - 39	P_M = 14.78%	P_F = 13.13%	p = 0.0062
40 - 49	P_M = 9.93%	P_F = 5.91%	p < 0.0001
50 - 59	P_M = 6.52%	P_F = 0.70%	p < 0.0001
60 - 69	P_M = 2.73%	P_F = 0.00%	p = 0.0145
70 - 79	P_M = 4.62%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 60 – 69, 70 – 79, and 80 – 99 year old age groups there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the Pearson's chi-square test was appropriate for this data.

We also wished to see if the age groups for the 2013 Chicago marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or below forty percent. The proportion of male finishers with an age graded score at or below forty percent is significantly larger than the proportion of female finishers with an age graded score at or below forty percent. The 20 – 29 year old age group gives weak statistical evidence for a significant difference between the proportions of male and female finishers since the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. There is no statistical evidence of a difference between the proportions of male and female race finishers for the 1 – 19, 70 – 79, and 80 – 99 year old age groups.

Table 14. Chicago Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 113	F: 113	M: 50.6	F: 47.5	M: 49.6	F: 46.2	M: 99.7	F: 66.4
20 - 29	M: 4185	F: 5529	M: 50.7	F: 49.1	M: 49.8	F: 48.5	M: 117.3	F: 73.8
30 - 39	M: 7253	F: 6101	M: 50.7	F: 50.1	M: 50.1	F: 49.4	M: 103.3	F: 79.7
40 - 49	M: 6094	F: 3944	M: 53.1	F: 53.3	M: 52.7	F: 52.7	M: 100.4	F: 81.0
50 - 59	M: 3008	F: 1428	M: 55.3	F: 57.5	M: 54.6	F: 56.7	M: 105.1	F: 88.1
60 - 69	M: 695	F: 214	M: 55.8	F: 61.1	M: 55.0	F: 60.3	M: 97.1	F: 93.0
70 - 79	M: 65	F: 12	M: 55.1	F: 65.8	M: 54.5	F: 63.6	M: 129.9	F: 75.2
80 - 99	M: 3	F: 0	M: 58.5	F: NA	M: 56.9	F: NA	M: 22.4	F: NA

The 1 – 19, 20 – 29, and 30 – 39 year old age groups in this race have a larger mean age graded score for the male race finishers than the mean age graded score for the female race finishers. All other age groups have a larger mean age graded score for the female finishers than the mean age graded score for the male finishers. The median age graded scores follow the same trend as the mean age graded scores except for the 40 – 49 year old age group, which has an equal median age graded score for the male and female race finishers. The variance of the age graded scores for the male finishers is larger than the variance of the age graded scores for the female finishers for all age groups in the Chicago marathon. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 15. Chicago Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0323	p = 0.0152	p = 0.0087	p = 0.0178	p = 0.0276
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
30 - 39	p < 0.0001	p < 0.0001	p < 0.0001	p = 0.0018	p < 0.0001
40 - 49	p < 0.0001	p < 0.0001	p = 0.2689	p = 0.2592	p = 0.0002
50 - 59	p = 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
60 - 69	p = 0.7154	p = 0.6547	p < 0.0001	p < 0.0001	p < 0.0001
70 - 79	p = 0.3323	p = 0.3142	p = 0.0029	p = 0.0017	p = 0.0090

The assumptions for the Mann-Whitney-Wilcoxon test include equal variances for the two populations which is not true for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, though even without this assumption being met the results are still very similar to the t-test results for these age groups. For the 1 – 19, 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, the non-pooled variance test statistic was used for the t-test since the variances are not equal. For all other age groups, the equal variances assumption was met for the Mann-Whitney-Wilcoxon test and the pooled variance test statistic was used to the t-test.

The difference between the variances for the male and female race finishers is highly non-significant for the 60 – 69 and 70 – 79 year old age groups with all p-values greater than 0.3; all other age groups are statistically significant for both the F and Levene's test for equal variances. The mean age graded score and the median age graded score for the 40 – 49 year old age group are both highly non-significant, all p-values are larger than 0.25, but all other age groups have statistically significant differences between the male and female race finishers for these two variables, with all p-values less than 0.02. The distribution of the age graded scores for the male race finishers is significantly different than the distribution of the age graded scores for the female finishers for all age groups in the New York marathon; all p-values are less than 0.03.

Table 16. Proportion of New York Finishers by Age Group

Age Group	**Proportion of Finishers**		**χ² P-value**	**Age Group P**
1 - 19	P_M = 0.23%	P_F = 0.23%	p < 0.0001	p = 0.9913
20 - 29	P_M = 10.23%	P_F = 18.46%		p < 0.0001
30 - 39	P_M = 30.30%	P_F = 35.62%		p < 0.0001
40 - 49	P_M = 35.08%	P_F = 30.72%		p < 0.0001
50 - 59	P_M = 18.64%	P_F = 12.54%		p < 0.0001
60 - 69	P_M = 4.85%	P_F = 2.20%		p < 0.0001
70 - 79	P_M = 0.63%	P_F = 0.20%		p < 0.0001
80 - 99	P_M = 0.05%	P_F = 0.02%		p = 0.1089

All age groups in the New York marathon have sufficiently large sample sizes so that Pearson's chi-square test was appropriate to find the p-value.

The proportion of female finishers was larger than the proportion of male finishers for the 20 – 29 and the 30 – 39 year old age groups. The proportion of race finishers is equal for the 1 – 19 year old age group and every other age group has a larger proportion of male finisher than the proportion of female finishers. The highly significant result from the test for equal proportions means that the difference between the proportion of male and female race finishers is significant for at least one age group. To determine which groups were significantly different, we conducted chi-square tests of independence and found that the proportion of male finishers is significantly different from the proportion of female finishers for the 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 and 80 – 99 year old age groups there is no statistical evidence that the proportion of male race finishers is different from the proportion of female race finishers.

Table 17. New York Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 15.94%	P_F = 9.09%	p = 0.2953
20 - 29	P_M = 18.57%	P_F = 12.00%	p < 0.0001
30 - 39	P_M = 15.77%	P_F = 11.27%	p < 0.0001
40 - 49	P_M = 21.87%	P_F = 24.81%	p < 0.0001
50 - 59	P_M = 30.08%	P_F = 38.87%	p < 0.0001
60 - 69	P_M = 26.15%	P_F = 47.56%	p < 0.0001
70 - 79	P_M = 20.31%	P_F = 43.59%	p = 0.0020
80 - 99	P_M = 13.33%	P_F = 100%	p = 0.0039

For the 80 – 99 year old group there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the Pearson's chi-square test was appropriate for this data.

We wished to test if the age groups for the 2013 New York marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or above sixty percent. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent for the 20 – 29 and 30 – 39 year old age groups. The proportion of female finishers is significantly larger than the proportion of male finishers for the 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups. There is no statistical evidence that the proportion of male race finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female race finishers with an age graded score at or above sixty percent.

Table 18. New York Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 13.04%	P_F = 20.45%	p = 0.2938
20 - 29	P_M = 10.04%	P_F = 10.11%	p = 0.9150
30 - 39	P_M = 9.26%	P_F = 10.71%	p = 0.0021
40 - 49	P_M = 6.50 %	P_F = 5.45%	p = 0.0065
50 - 59	P_M = 4.74%	P_F = 3.38%	p = 0.0060
60 - 69	P_M = 7.14%	P_F = 0.70%	p < 0.0001
70 - 79	P_M = 10.42%	P_F = 0.00%	p = 0.0295
80 - 99	P_M = 6.67%	P_F = 0.00%	p = 1.0000

For the 70 – 79 and 80 – 99 year old groups there was at least one cell in the contingency table has an expected value of five or less, so we used Fisher's exact test to determine the p-value. All other age groups had large sample sizes, so the Pearson's chi-square test was appropriate for this data.

We wished to test if the age groups for the 2013 New York marathon follow the same pattern seen in the overall race for the proportion of runners that finished with an age graded score at or below forty percent. The proportion of female finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male finishers with an age graded score at or below forty percent for the 30 – 39 year old age group. For the 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups, the proportion of male race finishers is significantly larger than the proportion of female race finishers. There is no statistical evidence of a significant difference between the proportions of male and female finishers with an age graded score of forty percent or lower for the 1 – 19, 20 – 29, and 80 – 99 year old age groups.

Table 19. New York Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 69	F: 44	M: 50.2	F: 48.1	M: 49.3	F: 48.4	M: 88.5	F: 67.1
20 - 29	M: 3129	F: 3609	M: 52.0	F: 50.4	M: 51.7	F: 49.9	M: 100.7	F: 70.7
30 - 39	M: 9268	F: 6963	M: 51.5	F: 50.3	M: 51.3	F: 50.0	M: 79.5	F: 67.9
40 - 49	M: 10730	F: 6005	M: 53.4	F: 54.0	M: 53.3	F: 53.9	M: 80.8	F: 77.0
50 - 59	M: 5702	F: 2452	M: 55.3	F: 57.6	M: 55.0	F: 57.5	M: 85.7	F: 93.6
60 - 69	M: 1484	F: 431	M: 54.1	F: 59.9	M: 53.8	F: 59.4	M: 90.9	F: 100.1
70 - 79	M: 192	F: 39	M: 52.4	F: 58.8	M: 50.4	F: 57.1	M: 108.1	F: 105.0
80 - 99	M: 15	F: 4	M: 51.9	F: 81.3	M: 50.3	F: 81.2	M: 75.4	F: 71.2

In the 1 – 19, 20 – 29, and 30 – 39 year old age groups for the New York marathon male race finishers have a larger mean age graded score than the female race finishers; all other age groups have a larger average age graded score for female race finishers than for male race finishers. The median age graded scores follow the same trend as the mean age graded scores, with the separation occurring at the 40 – 49 year old age group. The variance of the age graded scores for male runners is larger than the variance of the age graded scores for female runners for all age groups except the 50 – 59 and 60 – 69 year old age groups. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 20. New York Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.3318$	$p = 0.2904$	$p = 0.2136$	$p = 0.3211$	$p = 0.6597$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
40 - 49	$p = 0.0334$	$p = 0.0334$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.0091$	$p = 0.0083$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
60 - 69	$p = 0.2062$	$p = 0.1815$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
70 - 79	$p = 0.9516$	$p = 0.8462$	$p = 0.0005$	$p = 0.0003$	$p = 0.0008$
80 - 99	$p = 1.0000$	$p = 0.7836$	$p < 0.0001$	$p = 0.0032$	$p = 0.0036$

The assumptions for the Mann-Whitney-Wilcoxon test include equal variances for the two populations which is not true for the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, though even without this assumption being met the results are still very similar to the t-test results for these age groups. For the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups, the non-pooled variance test statistic was used for the t-test since the variances are not equal. For all other age groups, the equal variances assumption was met for the Mann-Whitney-Wilcoxon test and the pooled variance test statistic was used to the t-test.

The difference between the variances of the age graded scores for male and female race finishers are highly non-significant for the 1 – 19, 60 – 69, 70 – 79, and 80 – 89 year old age groups; the variances for the remaining age groups are all significantly different, with all p-values less than our significance level of 0.05. The mean age graded score, the median age graded score, and the distribution of the age graded scores for male race finishers are not significantly different from the mean age graded score, the median age graded score, and the distribution of the age graded scores for female race finishers for the 1 – 19 year old age group but are highly significantly different for all other age groups for the New York marathon.

To determine if the trends seen in the age groups above hold true when combined across all three qualifying races. To accurately determine if the mean age graded score, median age graded score, and variance of the age graded scores are larger for male race finishers than for female race finishers we considered the one sided p-values for the statistical tests we have performed and explained above. Once the one-sided p-values were obtained, we used meta-analysis to determine the value of the standard normal distribution and the p-value of the combined information.

Table 21. Meta-Analysis: Major Marathons 1 – 19

Variable	Z value	P value: M > F	P value: F > M
Proportions	-1.547	p = 0.9391	p = 0.0609
		Age Graded Scores	
Proportions			
60%	2.948	p = 0.0016	p = 0.9984
40%	0.921	p = 0.8214	p = 0.1786
Variances			
F Test	2.590	p = 0.0048	p = 0.9952
Levene's Test	2.959	p = 0.0015	p = 0.9985
Means	3.468	p = 0.0003	p = 0.9997
Medians	2.747	p = 0.0030	p = 0.9970
Distributions	2.378	p = 0.0087	p = 0.9913

For the 1 – 19 year old age group, the mean age graded score, the median age graded score, and the variance of the age graded scores are significantly larger for male race finishers than for female race finishers. The difference in the proportions of male and female finishers is weakly non-significant that the proportion of female runners in the 1 – 19 year old age group is larger than the proportion of male runners; the p-value is larger than our chosen significance level but would be considered significant at a higher level of significance. The proportion of male race finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female race finishers with an age graded score of sixty percent or higher. There is no statistical evidence that the proportion of finishers with an age graded score of forty percent or lower is significantly different between the male and female running populations. The distribution of the male age graded scores is significantly larger than the distribution of the female age graded scores.

Table 22. Meta-Analysis: Major Marathons 20 – 29

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.035	$p < 0.0001$	$p = 1.0000$
		Age Graded Scores	
Proportions			
60%	6.035	$p < 0.0001$	$p = 1.0000$
40%	0.909	$p = 0.1816$	$p = 0.8184$
Variances			
F Test	6.035	$p < 0.0001$	$p = 1.0000$
Levene's Test	6.035	$p < 0.0001$	$p = 1.0000$
Means	6.035	$p < 0.0001$	$p = 1.0000$
Medians	6.035	$p < 0.0001$	$p = 1.0000$
Distributions	6.035	$p < 0.0001$	$p = 1.0000$

The one sided p-value for all statistical tests performed on the 20 – 29 year old age group is less than 0.0001 except one; there is no statistical evidence of a significant difference between the proportions of race finishers with an age graded score of forty percent or lower for the male and female running populations. For the 20 – 29 year old age group the proportion of finishers, the mean age graded score, the median age graded score, and the variation of age graded scores are larger for male runners than for female runners. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or larger. The distribution of age graded scores for male race finishers is significantly larger than the distribution of age graded scores for female race finishers.

Table 23. Meta-Analysis: Major Marathons 30 – 39

Variable	Z value	P value: M > F	P value: F > M
Proportions	5.414	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	6.053	p < 0.0001	p = 1.0000
40%	-0.582	p = 0.2802	p = 0.7198
Variances			
F Test	6.053	p < 0.0001	p = 1.0000
Levene's Test	6.053	p < 0.0001	p = 1.0000
Means	5.903	p < 0.0001	p = 1.0000
Medians	5.669	p < 0.0001	p = 1.0000
Distributions	6.053	p < 0.0001	p = 1.0000

For the 30 – 39 year old age group, the proportion of male finishers is significantly higher than the proportion of female finishers. The mean age graded score and the median age graded score for the male runners are significantly larger than the mean age graded score and median age graded score for the female runners. The variance of the age graded scores for the male race finishers is significantly larger than the variance of the age graded scores for the female race finishers. Similarly, the distribution of age graded scores of the male runners is significantly larger than the distribution of age graded scores of the female runners. The proportion of male finishers with an age graded score of sixty percent or larger is significantly larger than the proportion of female finishers with an age graded score of sixty percent or larger. There is no statistical evidence that the proportion of female finishers with an age graded score of forty percent or lower is significantly different from the proportion of male finishers with an age graded score at or below forty percent.

Table 24. Meta-Analysis: Major Marathons 40 – 49

Variable	Z value	P value: M > F	P value: F > M
Proportions	4.478	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-3.958	p = 1.0000	p < 0.0001
40%	-5.727	p < 0.0001	p = 1.0000
Variances			
F Test	4.814	p < 0.0001	p = 1.0000
Levene's Test	4.814	p < 0.0001	p = 1.0000
Means	-5.440	p = 1.0000	p < 0.0001
Medians	-5.451	p = 1.0000	p < 0.0001
Distributions	0.844	p = 0.1992	p = 0.8008

For the 40 – 49 year old age group, the proportion of male finishers is significantly larger than the proportion of female finishers, the variance of the age graded scores for the male finishers is significantly larger than the variance of the age graded scores, and the distribution of the age graded scores for the male race finishers is significantly different, and larger, than the distribution of the age graded scores for the female race finishers. The mean age graded score and the median age graded score for the female runners are significantly larger than the mean age graded score and the median age graded score for the male runners, the opposite of what we originally expected. The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower.

Table 25. Meta-Analysis: Major Marathons 50 – 59

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.168	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-7.024	p = 1.0000	p < 0.0001
40%	-5.808	p < 0.0001	p = 1.0000
Variances			
F Test	1.073	p = 0.1416	p = 0.8584
Levene's Test	1.048	p = 0.1473	p = 0.8527
Means	6.168	p < 0.0001	p = 1.0000
Medians	6.168	p < 0.0001	p = 1.0000
Distributions	-6.164	p = 1.0000	p < 0.0001

There is no statistical evidence that the variance of the age graded scores for the male race finishers is larger than the variance of the age graded scores for the female race finishers for the 50 – 59 year old age group. The proportion of male finishers is significantly larger than the proportion of female finishers, the mean age graded score for the male finishers is significantly larger than the mean age graded score for the female finishers, the median age graded score for the male finishers is significantly larger than the median age graded score for the female finishers, and the distribution of the age graded scores for the male finishers is significantly different from the distribution of the age graded scores for the female finishers. The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower.

Table 26. Meta-Analysis: Major Marathons 60 – 69

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.175	$p < 0.0001$	$p = 1.0000$
		Age Graded Scores	
Proportions			
60%	-7.032	$p = 1.0000$	$p < 0.0001$
40%	-5.475	$p < 0.0001$	$p = 1.0000$
Variances			
F Test	-0.746	$p = 0.7722$	$p = 0.2278$
Levene's Test	-0.749	$p = 0.7731$	$p = 0.2269$
Means	6.175	$p < 0.0001$	$p = 1.0000$
Medians	6.175	$p < 0.0001$	$p = 1.0000$
Distributions	-7.032	$p = 1.0000$	$p < 0.0001$

There is no statistical evidence that the variance of the age graded scores for the male race finishers is significantly larger than the variance of the age graded scores for the female race finishers. The proportion of male finishers is significantly larger than the proportion of female finishers and the distribution of age graded scores for male finishers is significantly different than the distribution of age graded scores for female finishers. The mean age graded score and the median age graded score for female race finishers are significantly larger than the mean age graded score and the median age graded score for the male race finishers. The proportion of female finishers with an age graded score at or above sixty percent and the proportion of female finishers with an age graded score at or below forty percent are significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher and the proportion of male finishers with an age graded score of forty percent or lower. The distribution of age graded scores for the female runners is significantly larger than the distribution of age graded scores for the male runners.

Table 27. Meta-Analysis: Major Marathons 70 – 79

Variable	Z value	P value: M > F	P value: F > M
Proportions	5.888	$p < 0.0001$	$p = 1.0000$
		Age Graded Scores	
Proportions			
60%	-4.480	$p = 1.0000$	$p < 0.0001$
40%	-1.865	$p = 0.0311$	$p = 0.9689$
Variances			
F Test	0.633	$p = 0.2634$	$p = 0.7366$
Levene's Test	0.823	$p = 0.2053$	$p = 0.7947$
Means	-5.272	$p = 1.0000$	$p < 0.0001$
Medians	-5.338	$p = 1.0000$	$p < 0.0001$
Distributions	-4.415	$p = 1.0000$	$p < 0.0001$

The proportion of male race finishers is significantly larger than the proportion of female finishers for the 70 – 79 year old age group; the p-value was not included in the meta-analysis because all races have a p-value less than 0.0001 and any combination of these values would result in a p-value less than 0.0001. There is no statistical evidence that the variance of the age graded scores for the male finishers is significantly larger than the variance of the age graded scores for the female finishers; both tests for equal variances have highly non-significant p-values. The mean age graded score and the median age graded score for the female runners is significantly higher than the mean age graded score and the median age graded score for the male runners. The distribution of the age graded scores for the male finishers is significantly different from the distribution of the age graded scores for the female finishers; specifically, the distribution of age graded scores for the male runners is significantly larger than the distribution of age graded scores for the female runners. The proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher and the proportion of female finishers with an age graded score at or below forty percent is significantly larger than the proportion of male finishers with an age graded score of forty percent or lower.

Table 28. Meta-Analysis: Major Marathons 80 – 99

Variable	**Z value**	**P value: M > F**	**P value: F > M**
Proportions	-1.851	p = 0.9679	p = 0.0321
		Age Graded Scores	
Proportions			
60%	-2.859	p = 0.9979	p = 0.0021
40%	0.000	p = 0.5000	p = 0.5000
Variances			
F Test	NA	NA	NA
Levene's Test	NA	NA	NA
Means	-4.475	p = 1.0000	p < 0.0001
Medians	-3.007	p = 0.9987	p = 0.0013
Distributions	-4.878	p = 1.0000	p < 0.0001

There is not enough information for the 80 – 99 year old age group to include the tests of variance in the meta-analysis. The proportion of female race finishers is significantly larger than the proportion of male finishers; the mean age graded score and the median age graded score for the female finishers is significantly larger than the mean age graded score and the median age graded score for the male finishers. The distribution of the age graded scores for the male runners is significantly different from the distribution of the age graded scores for the female runners; specifically, the distribution of age graded scores for the male finishers is significantly larger than the distribution of age graded scores for the female finishers. The proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher; there is no statistical evidence that the proportion of female finishers with an age graded score at or below forty percent is significantly different from the proportion of male finishers with an age graded score of forty percent or lower.

CHAPTER 6. NON-QUALIFYING RACES

For the larger part of our results, we examined eight races from each of the popular running distances: marathon, half marathon, ten kilometers (10k), and five kilometer (5k). For each race included in our dataset, we ran several statistical tests for the distribution of age graded scores as well as the statistical tests for the distribution of ages. We included the age, time, and gender of each race finisher aged fourteen years and older. This information was used to calculate the age graded score for each finisher based on the WMA age grading tables. All races were contested in the year 2013.

6.1. Race Descriptions

We included races of varying sizes from each distance in order to make the various comparisons more even. Tables 3-6, given below, give the total number of finishers, the total number of male finishers, and the total number of female finishers for each race at a given distance with Table 3 for marathons, Table 4 for half marathons, Table 5 for 10k races, and Table 6 for 5k races.

Table 29. Total Finishers – Marathon

Marathon	Total	Male	Female
Air Force	3,297	2,232	1,065
Grandma's	5,618	3,275	2,343
Los Angeles	18,691	11,287	7,404
Ogden	2,530	1,322	1,208
Philadelphia	10,913	6,017	4,896
San Francisco	5,823	3,905	1,918
Surf City USA	2,305	1,392	913
Twin Cities	8,852	4,924	3,928

The eight marathons that we included in our research are the following: The United States Air Force Marathon on Wright-Patterson AFB, OH, Grandma's Marathon in Duluth, MN, ASICS LA, Zions Bank Ogden, GORE-TEX Philadelphia, Wipro San Francisco, Surf City USA in

Huntington Beach, CA, and Medtronic Twin Cities in Minneapolis and St. Paul, MN. For each of these races, the total number of male finishers was greater than the total number of female finishers and will discuss the statistical significance of these numbers later in this chapter. These differences can be seen, explicitly, in Table 3 above.

Table 30. Total Finishers – Half Marathon

Half Marathon	Total	Male	Female
Berkeley	4,667	2,152	2,515
Brooklyn	21,423	10,822	10,601
Capital City	8,102	3,387	4,715
Columbus	10,200	3,672	6,528
Duluth	6,802	2,850	3,952
Manhattan	4,923	2,981	1,942
New York City	14,531	6,919	7,612
Surf City	14,698	5,881	8,817

The half marathons that we included are the following: The Berkeley Half Marathon, New York Road Runners (NYRR) Brooklyn Half Marathon, Capital City Half Marathon in Columbus, OH, Nationwide Children's Hospital Columbus, Garry Bjorklund Half Marathon in Duluth, MN, Manhattan Half-Marathon, New York City (NYC) Half, Surf City USA in Huntington Beach, CA. The total number of female finishers is greater than the number of male finishers for five of the eight races, almost equal in two of the eight races, and the total number of male finishers are greater than the total number of female finishers for one of the races. The results from the statistical testing of the differences can be seen in the results section of this chapter.

Table 31. Total Finishers – Ten Kilometer

Ten K	Total	Male	Female
Cooper River	30,737	12,625	18,112
Crescent City	17,016	7,909	9,107
Fargo	3,479	958	2,521
Joe Kleinerman	3,137	1,714	1,423
Manhattan Beach	3,455	1,716	1,739
Queens	6,479	3,663	2,816
Scotland Run	7,255	3,936	3,319
UAE Healthy Kidney	5,854	3,156	2,698

The ten kilometer races that we included are the following: The Cooper River Bridge Run in Mount Pleasant, SC, Crescent City Classic in New Orleans, LA, Radio Fargo Moorhead 10k in Fargo, ND, NYRR Joe Kleinerman Classic, Manhattan Beach in Manhattan Beach, CA, NYRR 5-Borough Series: Queens 10k, NYRR Scotland Run 10k in Manhattan, and the UAE Healthy Kidney 10k in Central Park, NYC. The total number of female finishers is greater than the number of male finishers for three of the eight races, almost equal in two of the races, and the total number of male finishers are greater than the total number of female finishers for three races. The results from the statistical testing of the differences can be seen in the results section of this chapter.

Table 32. Total Finishers – Five Kilometer

Five K	Total	Male	Female
Boston	5,477	2,422	3,055
Chelsea's Run	1,626	646	980
Gasparilla	9,915	3,961	5,954
McGuire's	11,977	5,237	6,740
MLB All Star	4,722	2,469	2,253
NYRR Dash	7,993	3,598	4,395
OC	1,881	644	1,237
Percy Sutton	3,464	1,711	1,753

The five kilometer races that we included are the following: the Boston Athletic Association 5k in Boston, Publix Super Markets Gasparilla Distance Classic in Tampa Bay, FL, MLB All-Star Run Benefitting Sandy Relief in Prospect Park, Brooklyn, NY, OC Marathon 5k in Newport Beach, CA, Finish Chelsea's Run in San Diego, CA, McGuire's St. Patrick's Day 5k in Pensacola, FL, NYRR Dash to the Finish Line 5k in NYC, and the Percy Sutton Harlem 5k Run. The total number of female finishers is greater than the number of male finishers for six of the eight races, and almost equal in the other two races. The results from the statistical testing of the differences can be seen in the results section of this chapter.

6.1.1. Marathon Distributions

For the eight marathon races we examined in this paper, we looked at the distributions of age graded score for male and female race finishers and the distributions of the ages for male and female race finishers. We looked at these distributions for each race, individually, and examined them separately by variable.

We are only inspecting the distributions visually during this part of our research but we will test the findings of our visual inspection, statistically, later in this chapter. We will also conduct other statistical tests to answer several different questions and discuss those results in this chapter.

6.1.1.1. Age Graded Score Distributions

For an initial look at the distributions of age graded scores by race, we will visually inspect the histograms of age graded scores by gender for each race, individually. These histograms are given in Figures 2 – 9, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

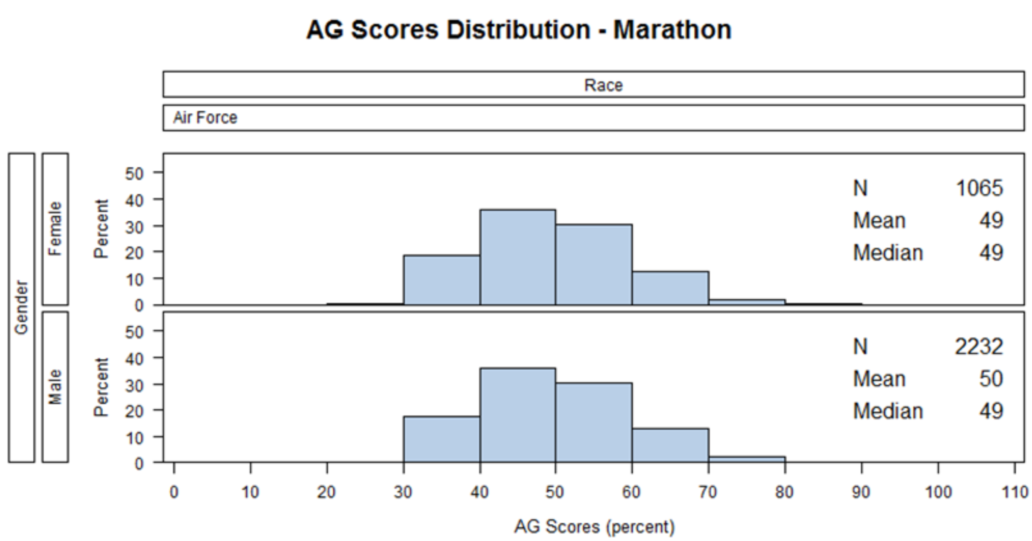

Figure 2. Marathon Age Graded Score Histograms - Air Force

The distribution of the age graded scores for the male and female finishers of the Air Force marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

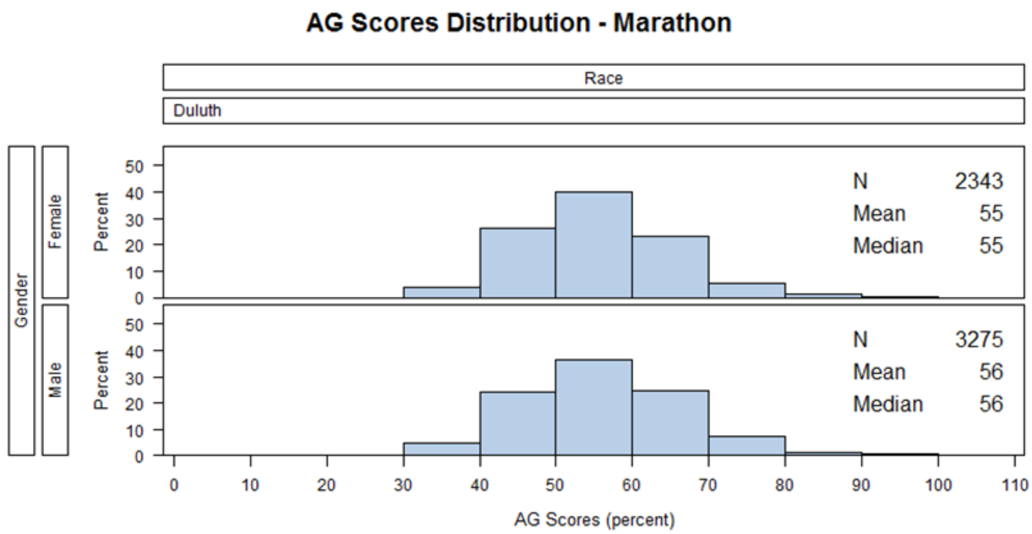

Figure 3. Marathon Age Graded Score Histograms – Grandma's

The distribution of the age graded scores for the male and female finishers of Grandma's marathon in Duluth, MN look similar to one another and bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

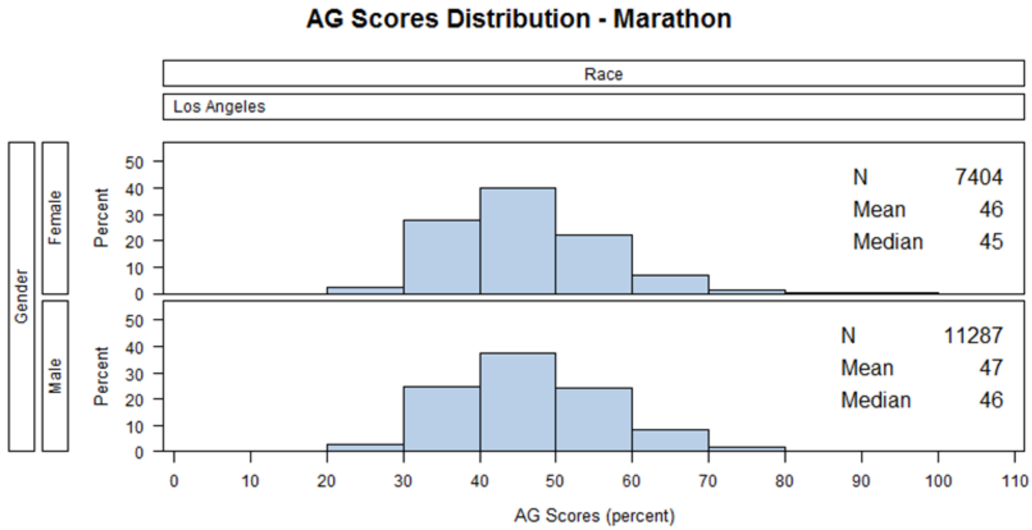

Figure 4. Marathon Age Graded Score Histograms – Los Angeles

The distribution of the age graded scores for the male and female finishers of the Los Angeles marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

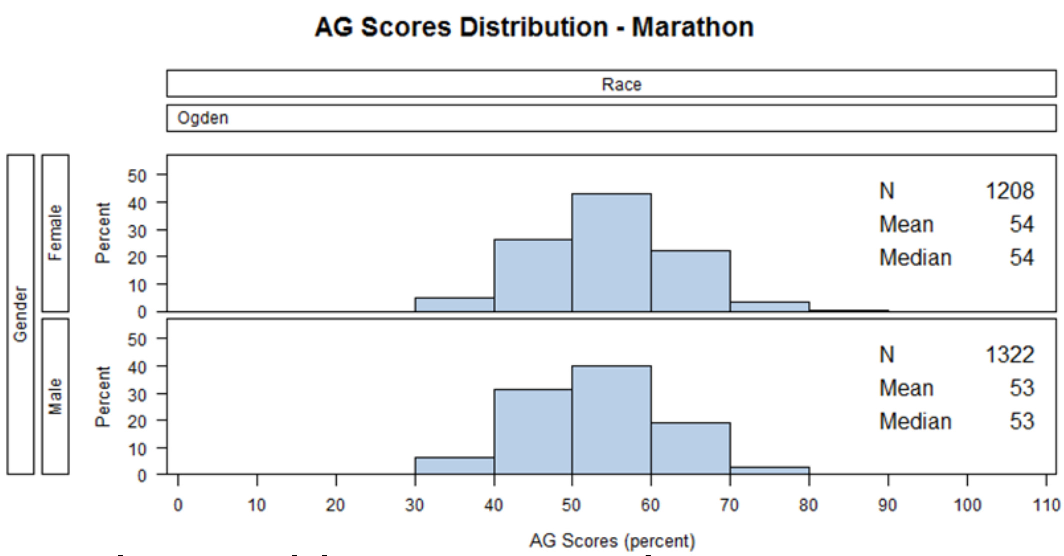

Figure 5. Marathon Age Graded Score Histograms – Ogden

The distribution of the age graded scores for the male and female finishers of the Ogden marathon look similar to one another as well as normally shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

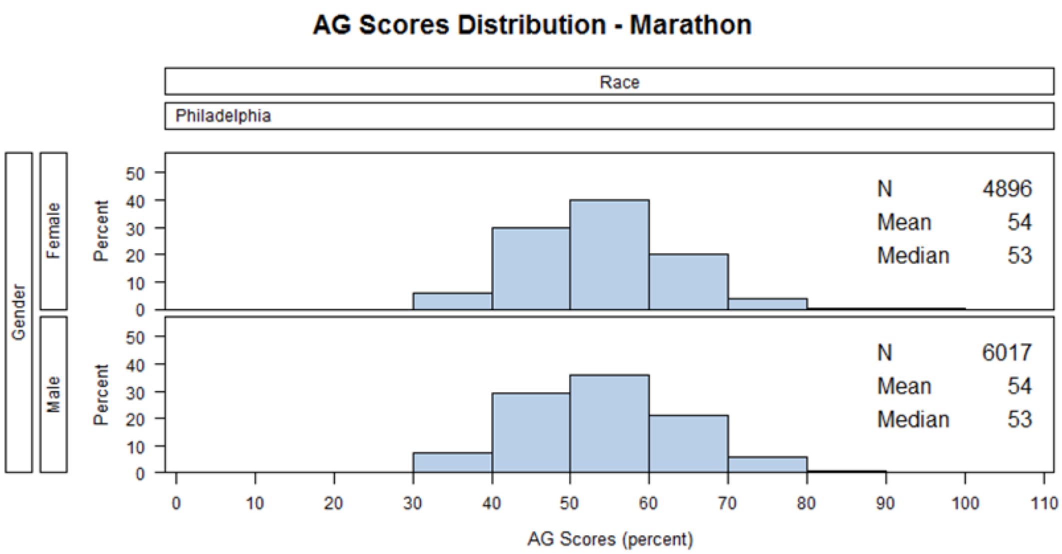

Figure 6. Marathon Age Graded Score Histograms – Philadelphia

The distribution of the age graded scores for the male and female finishers of the Philadelphia marathon look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

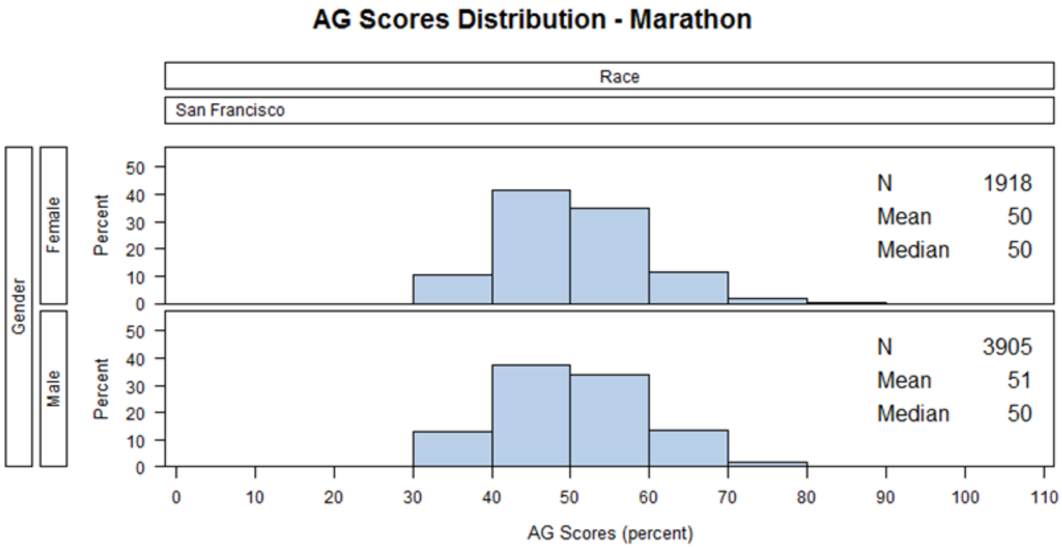

Figure 7. Marathon Age Graded Score Histograms – San Francisco

The distribution of the age graded scores for the male and female finishers of the San Francisco marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender lie at the edge of this range which could give further evidence of the skewed nature of the distributions. Though the distributions appear to be the same, we will test this statistically later in this chapter.

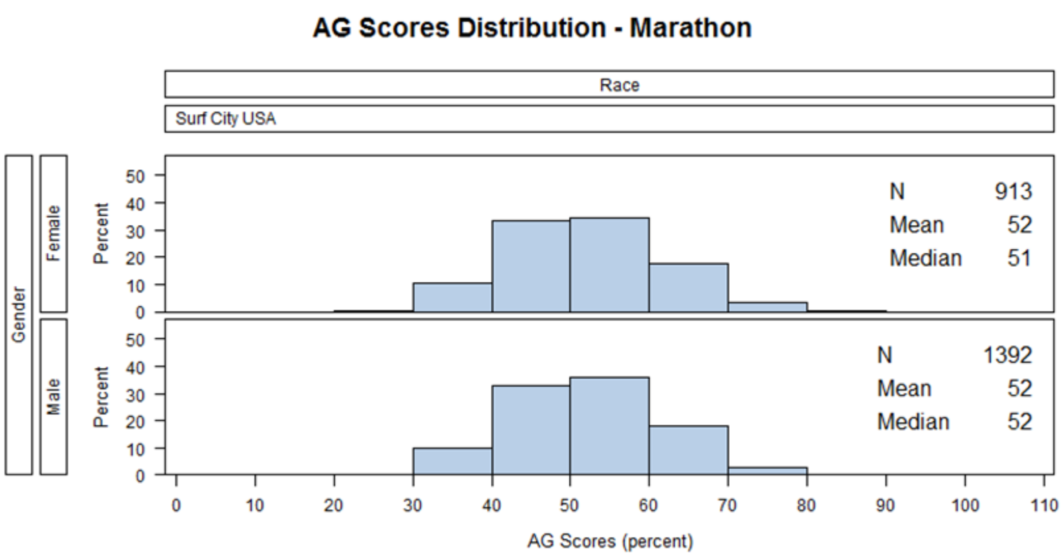

Figure 8. Marathon Age Graded Score Histograms – Surf City

The distribution of the age graded scores for the male and female finishers of the Surf City marathon look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

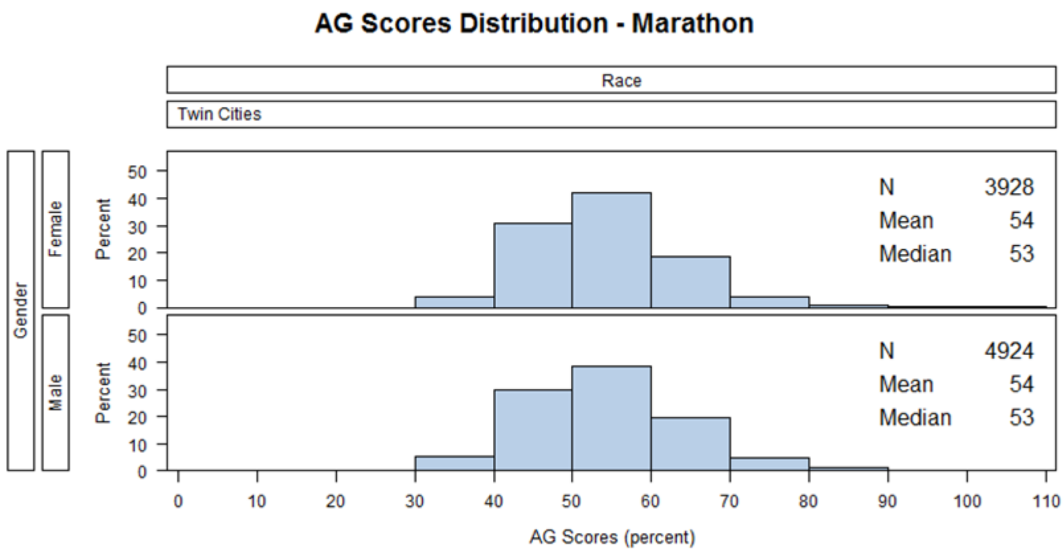

Figure 9. Marathon Age Graded Score Histograms – Twin Cities

The distribution of the age graded scores for the male and female finishers of the Twin Cities marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.1.2. Age Distributions

For an initial look at the distributions of ages of race finishers by race, we will visually inspect the histograms of age by gender for each race, individually. These histograms are given in Figures 10 – 17, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

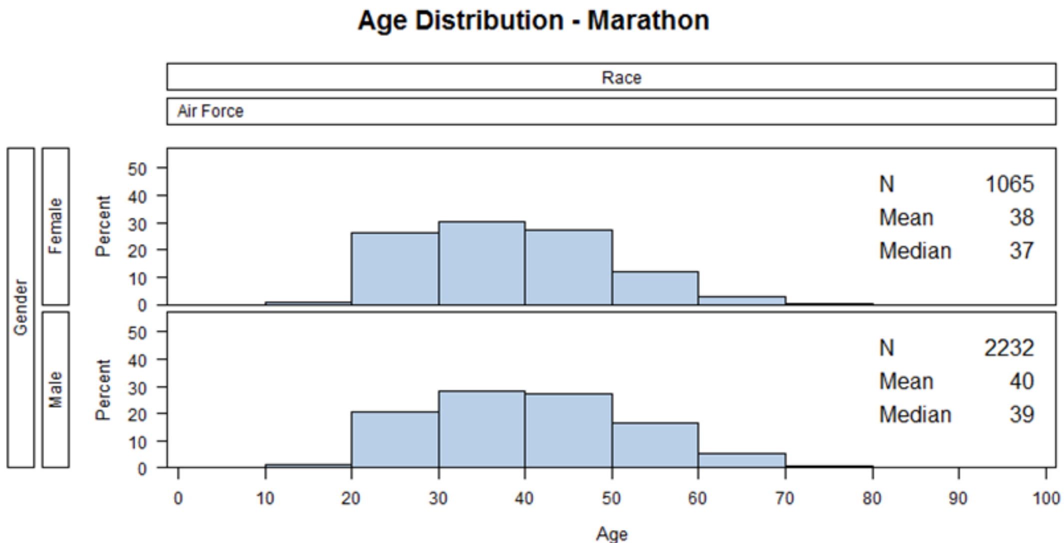

Figure 10. Marathon Age Histograms - Air Force

The distribution of the ages for the male and female finishers of the Air Force marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding and give evidence that the distributions are possibly skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

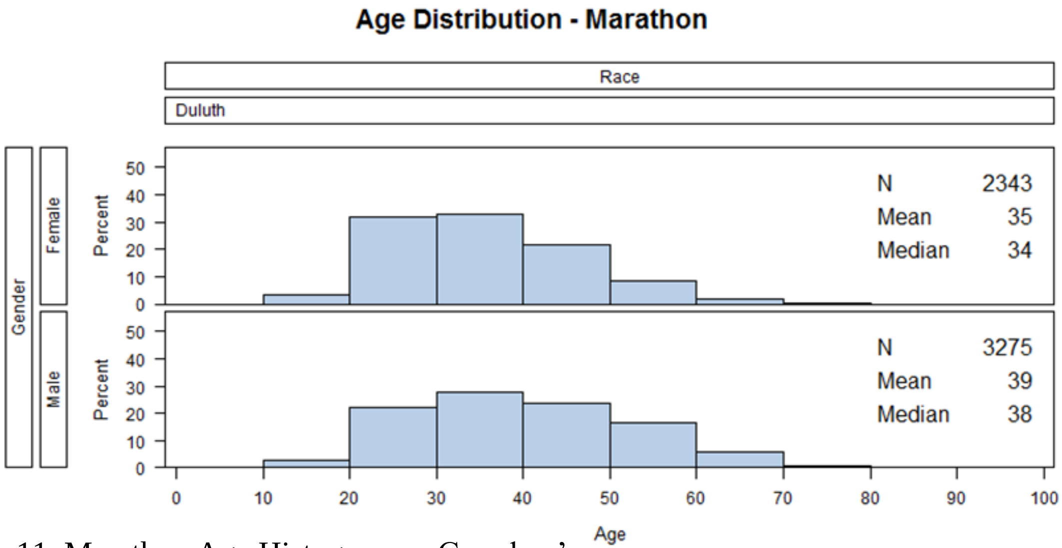

Figure 11. Marathon Age Histograms – Grandma's

The distribution of the ages for the male and female finishers of the Grandma's marathon in Duluth, MN look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another which gives evidence that the distributions are both skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

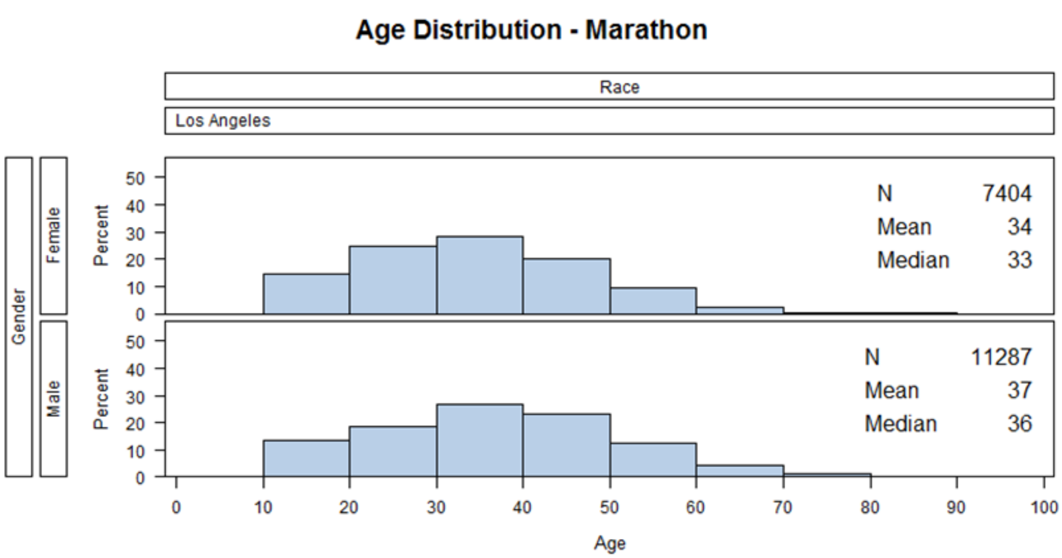

Figure 12. Marathon Age Histograms – Los Angeles

The distribution of the ages for the male and female finishers of the Los Angeles marathon look similar to one another as well as possibly bell shaped. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding and give evidence that the distributions are more likely skewed than symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

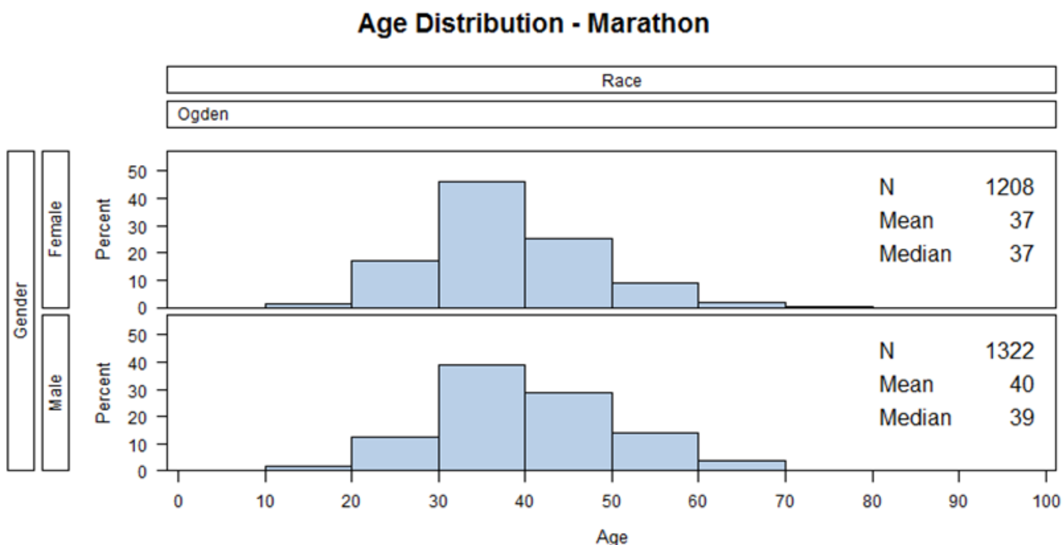

Figure 13. Marathon Age Histograms – Ogden

The distribution of the ages for the male and female finishers of the Ogden marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are equal to one another for the female race finishers but not for the male race finishers; this shows that there is evidence that the female distribution is symmetrical but the male distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

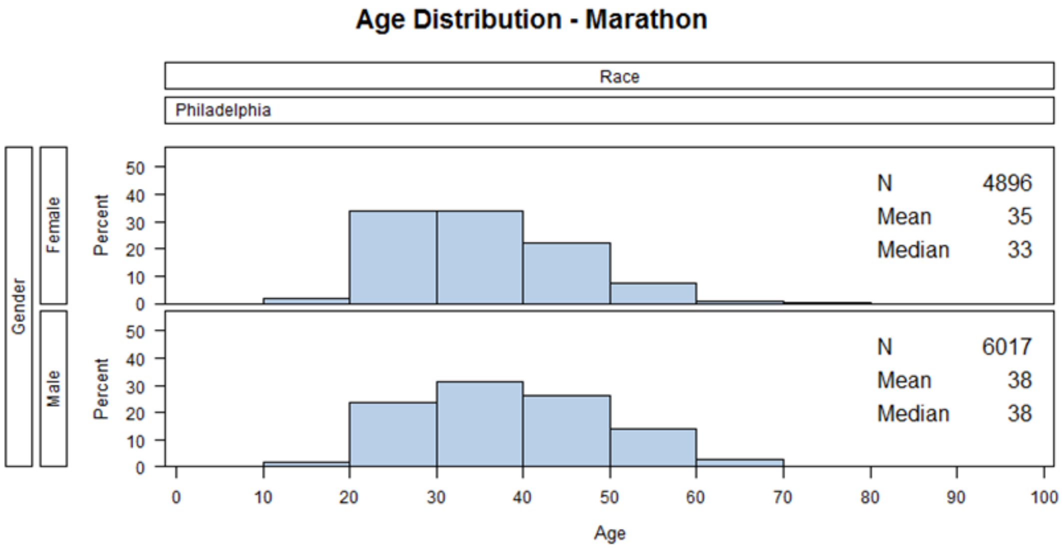

Figure 14. Marathon Age Histograms – Philadelphia

The distribution of the ages for the male and female finishers of the Philadelphia marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

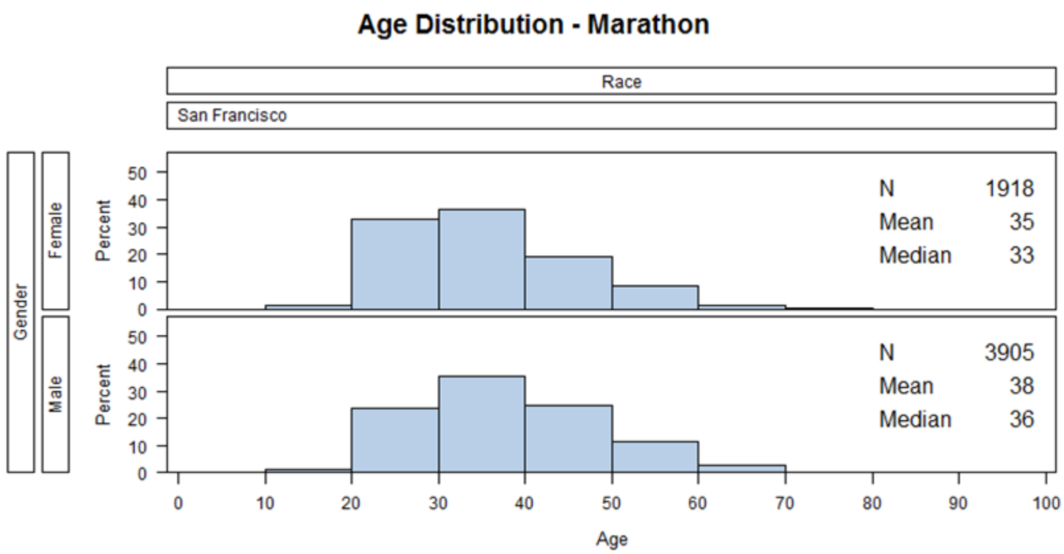

Figure 15. Marathon Age Histograms – San Francisco

The distribution of the ages for the male and female finishers of the San Francisco marathon look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another which gives evidence that the distributions are both skewed not symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

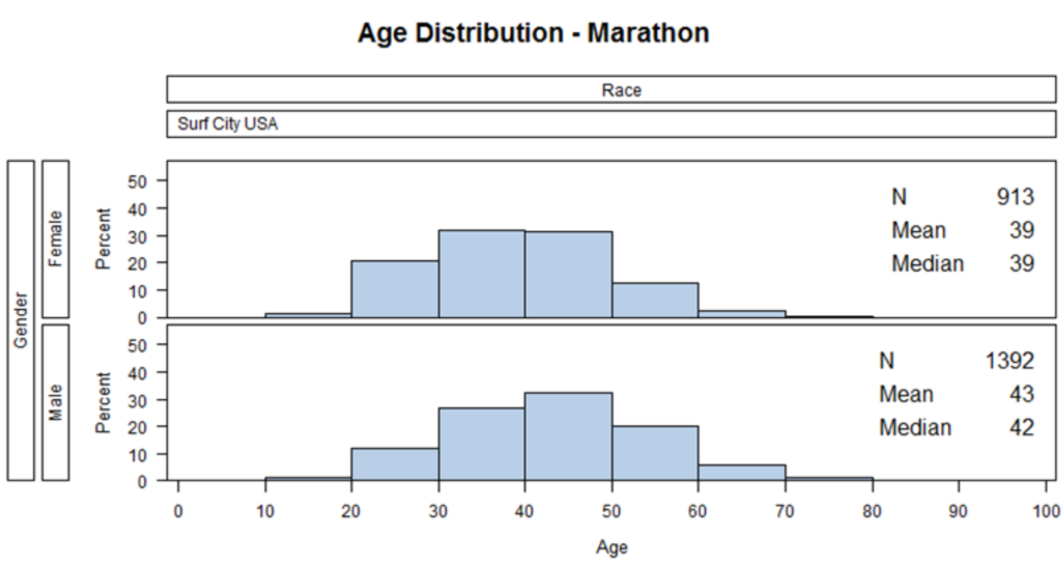

Figure 16. Marathon Age Histograms – Surf City

The distribution of the ages for the male and female finishers of the Surf City marathon look similar to one another as well as bell shaped. For the distribution of the female finishers, the center appears to lie between the ages of thirty and forty years; the mean and median back up this finding. For the distribution of the male finishers, the center appears to lie between the ages of forty and fifty years; the mean and median back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

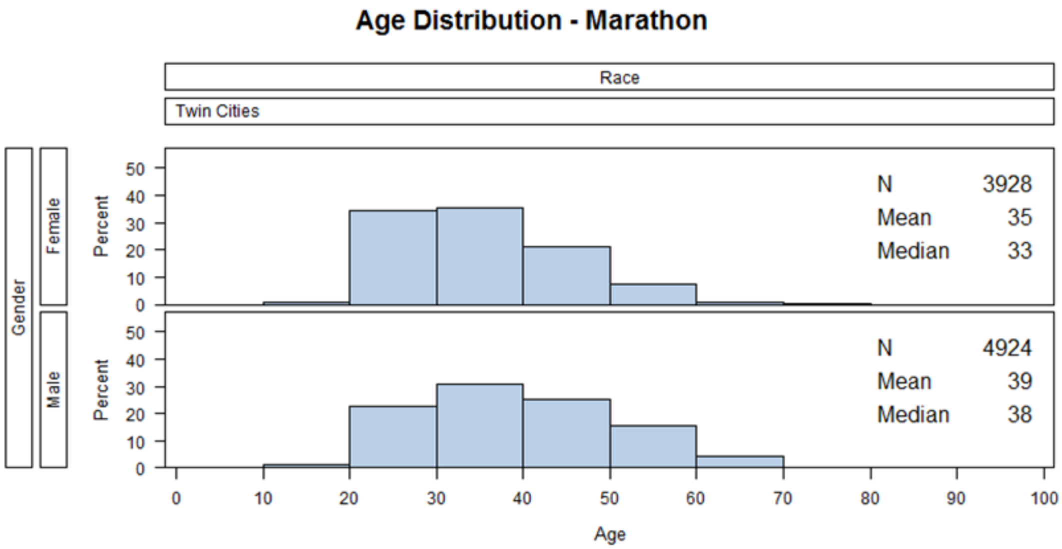

Figure 17. Marathon Age Histograms – Twin Cities

The distribution of the ages for the male and female finishers of the Twin Cities marathon look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another which gives evidence that the distributions are both skewed. Though the distributions appear to be close to one another, we will test this statistically later in this chapter.

6.1.2. Half Marathon Distributions

For the eight half marathon races we examined in this paper, we looked at the distributions of age graded score for male and female race finishers and the distributions of the ages for male and female race finishers. We looked at these distributions for each race, individually, and examined them separately by variable. We are only inspecting the distributions visually during this part of our research but we will test the findings of our visual inspection, statistically, later in this chapter. We will also conduct other statistical tests to answer several different questions and discuss those results in this chapter.

6.1.2.1. Age Graded Score Distributions

For an initial look at the distributions of age graded scores by race, we will visually inspect the histograms of age graded scores by gender for each race, individually. These histograms are given in Figures 18 – 25, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

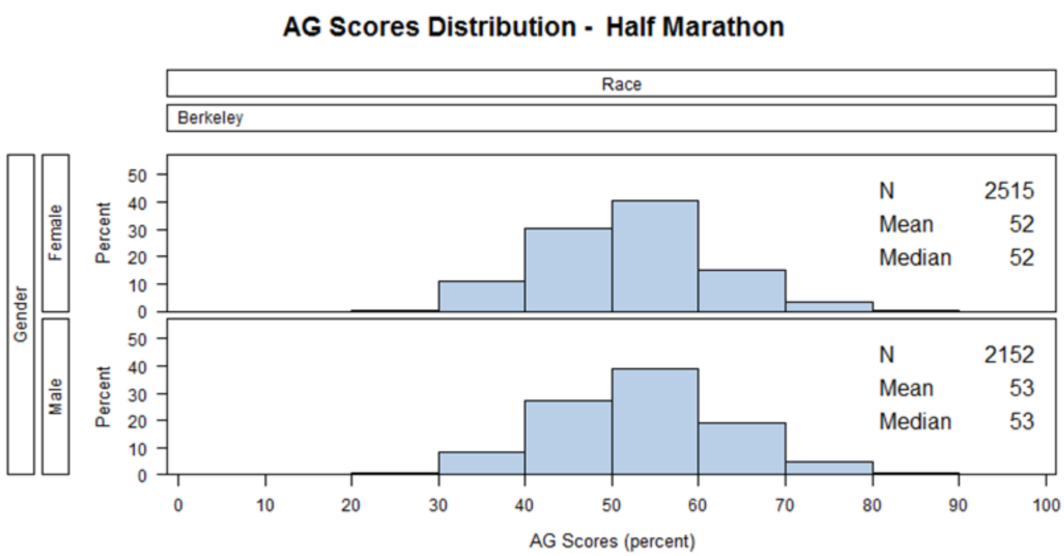

Figure 18. Half Marathon Age Graded Score Histograms – Berkeley

The distribution of the age graded scores for the male and female finishers of the Berkeley half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

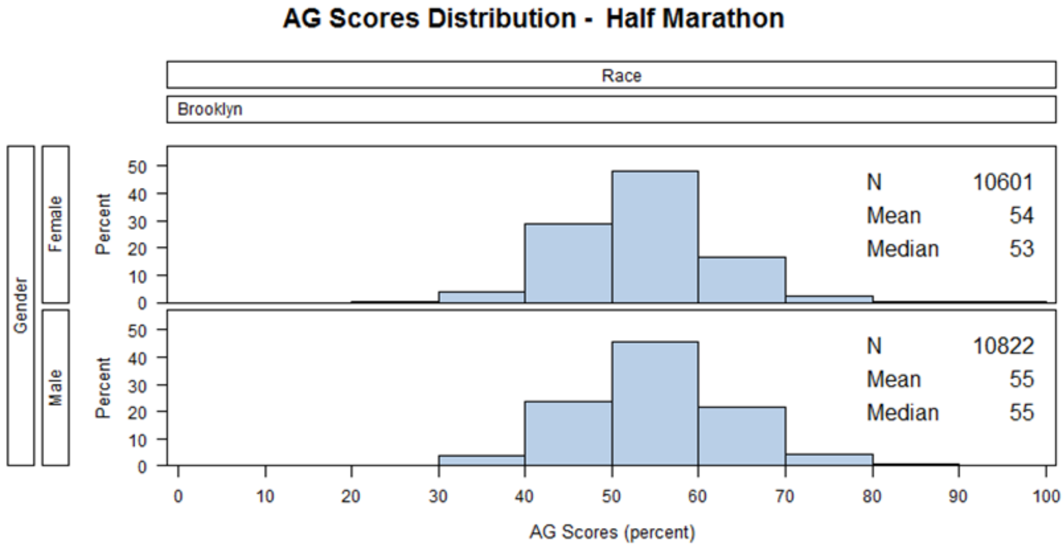

Figure 19. Half Marathon Age Graded Score Histograms – Brooklyn

The distribution of the age graded scores for the male and female finishers of the Brooklyn half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

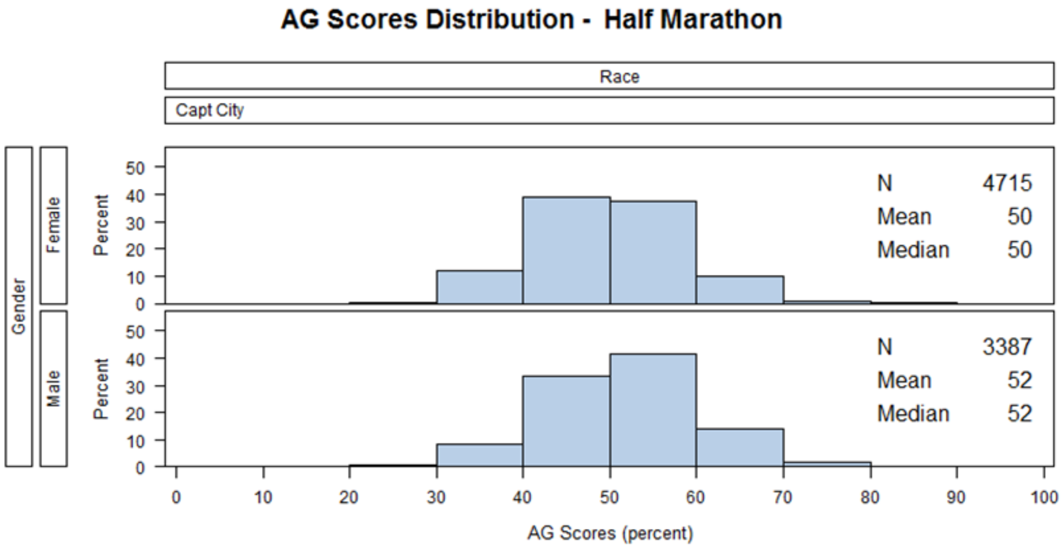

Figure 20. Half Marathon Age Graded Score Histograms – Capital City

The distribution of the age graded scores for the male and female finishers of the Capital City half marathon look similar to one another as well as symmetric. The center for the female distribution appears to be between the age graded scores of forty and fifty percent but the mean and median fall on the extreme edge of this range. The center for the male distribution appears to be between the age graded scores of fifty and sixty percent; the mean and median agree with this finding. The mean and median age graded scores for both distributions provide evidence that the distributions of age graded scores are symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

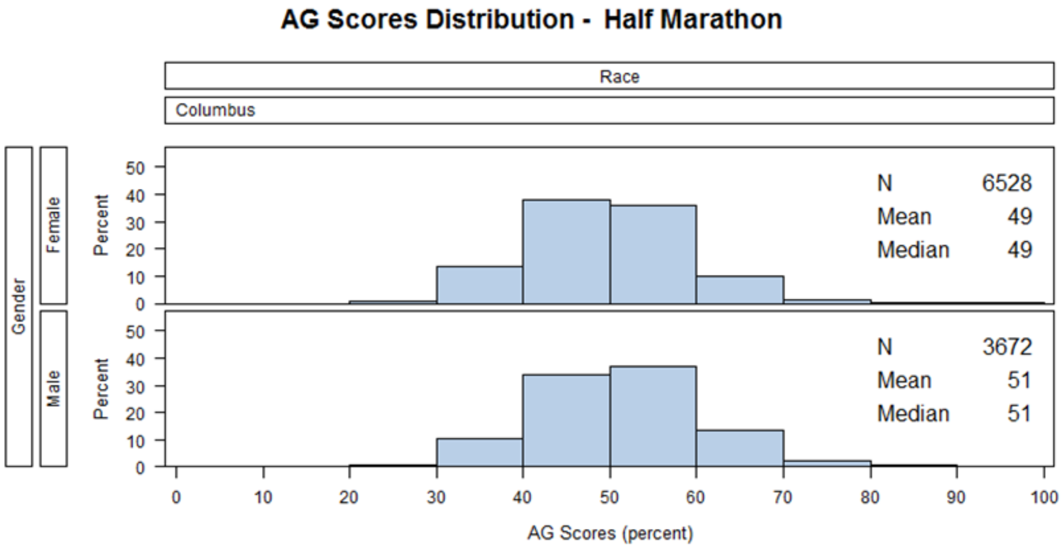

Figure 21. Half Marathon Age Graded Score Histograms – Columbus

The distribution of the age graded scores for the male and female finishers of the Columbus half marathon look similar to one another as well as bell shaped. The center for the female distribution appears to be between the age graded scores of forty and fifty percent and the center for the male distribution appears to be between the age graded scores of fifty and sixty percent; the mean and medians agree with these findings. Though the distributions appear to be the same, we will test this statistically later in this chapter.

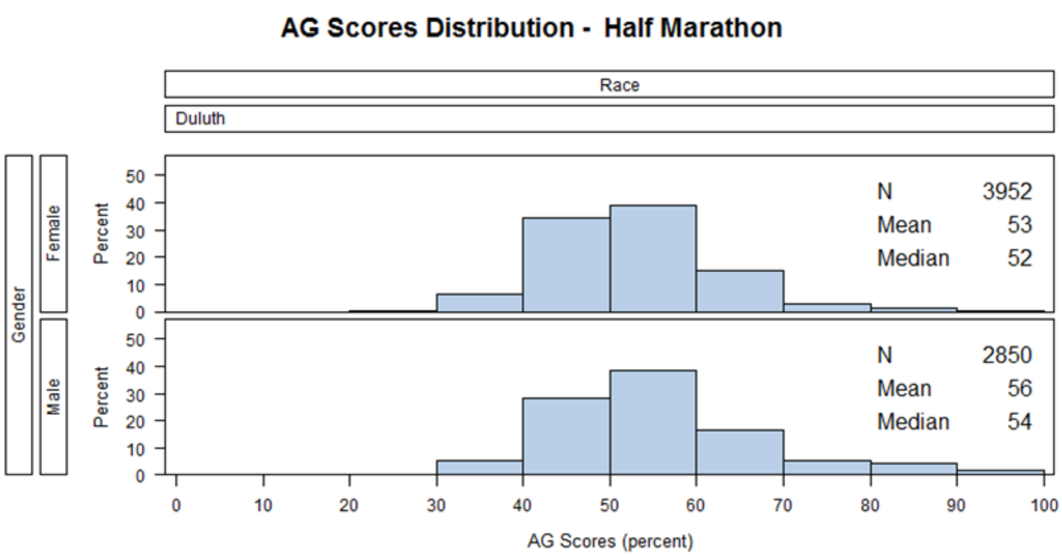

Figure 22. Half Marathon Age Graded Score Histograms – Duluth

The distribution of the age graded scores for the male and female finishers of the Duluth half marathon look similar to one another as well as possibly skewed. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

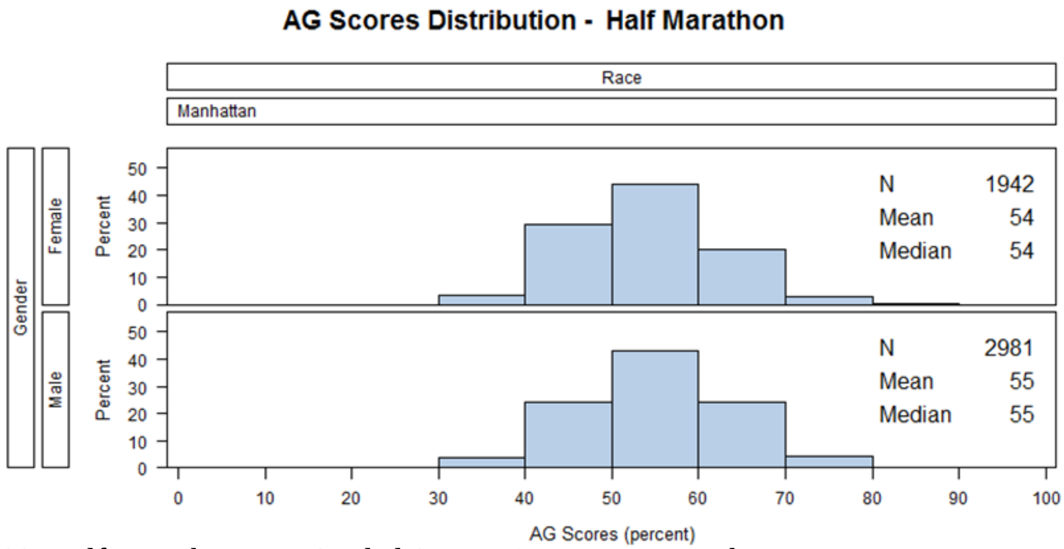

Figure 23. Half Marathon Age Graded Score Histograms – Manhattan

The distribution of the age graded scores for the male and female finishers of the Manhattan half marathon look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median for both genders are equal to one another which gives evidence that the distributions are both symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

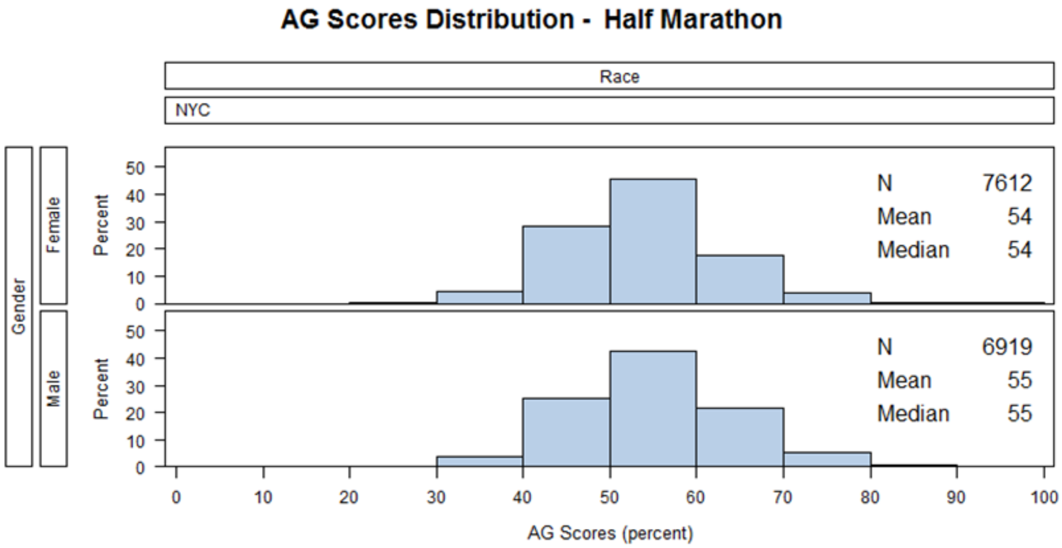

Figure 24. Half Marathon Age Graded Score Histograms – NYC

The distribution of the age graded scores for the male and female finishers of the NYC half marathon look similar to one another as well as bell shaped. For both distribution of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. Though the distributions appear to be the same, we will test this statistically later in this chapter.

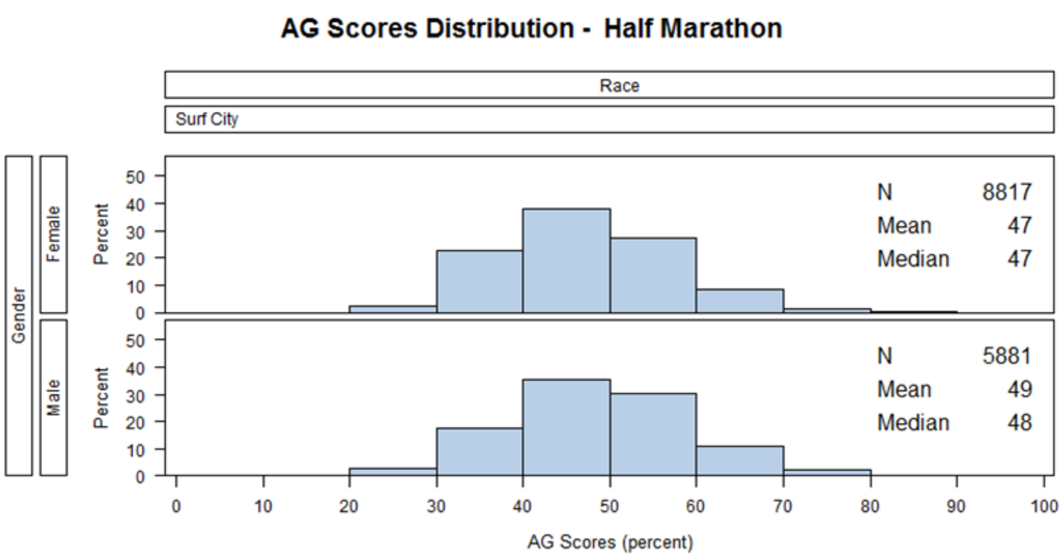

Figure 25. Half Marathon Age Graded Score Histograms – Surf City

The distribution of the age graded scores for the male and female finishers of the Surf City half marathon look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the female race finishers but not for the male race finishers; this shows that there is evidence that the female distribution is symmetrical but the male distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.2.2. Age Distributions

For an initial look at the distributions of age of finishers by race, we will visually inspect the histograms of age for each race, individually. These histograms are given in Figures 26 – 33, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

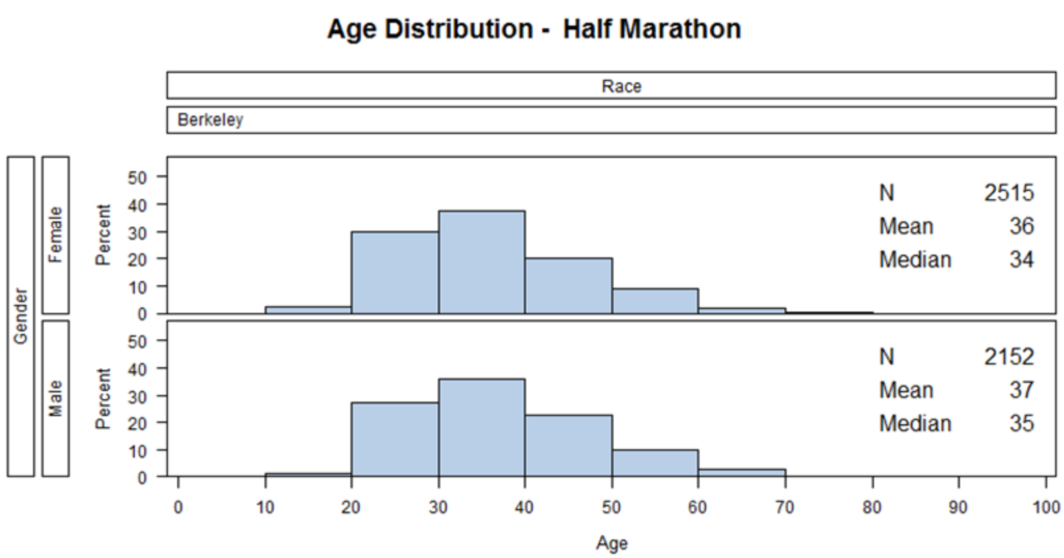

Figure 26. Half Marathon Age Histograms – Berkeley

The distribution of the ages for the male and female finishers of the Berkeley half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and medians are not equal to one another for either distribution; this gives evidence both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

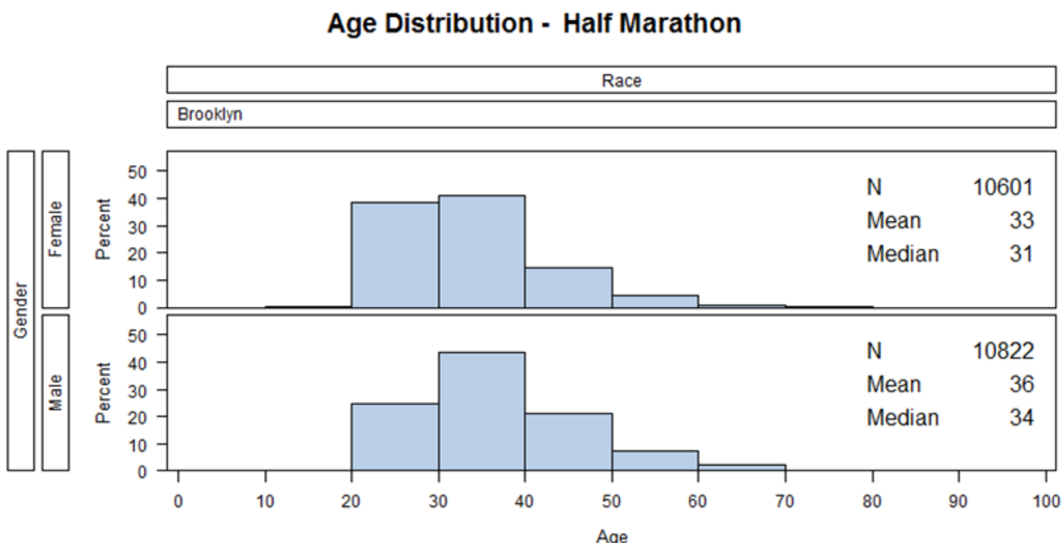

Figure 27. Half Marathon Age Histograms – Brooklyn

The distribution of the ages for the male and female finishers of the Brooklyn half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

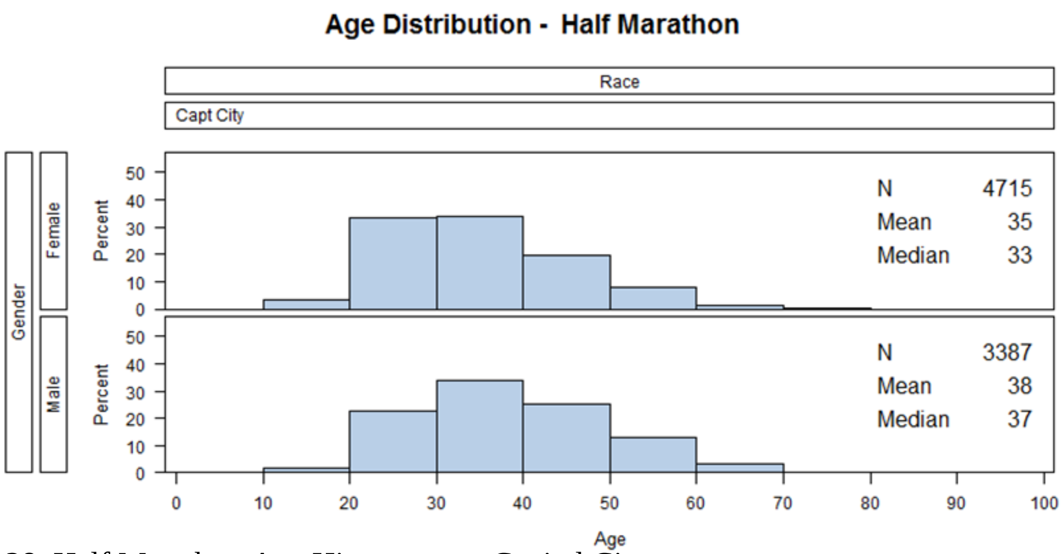

Figure 28. Half Marathon Age Histograms – Capital City

The distribution of the ages for the male and female finishers of the Capital City half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

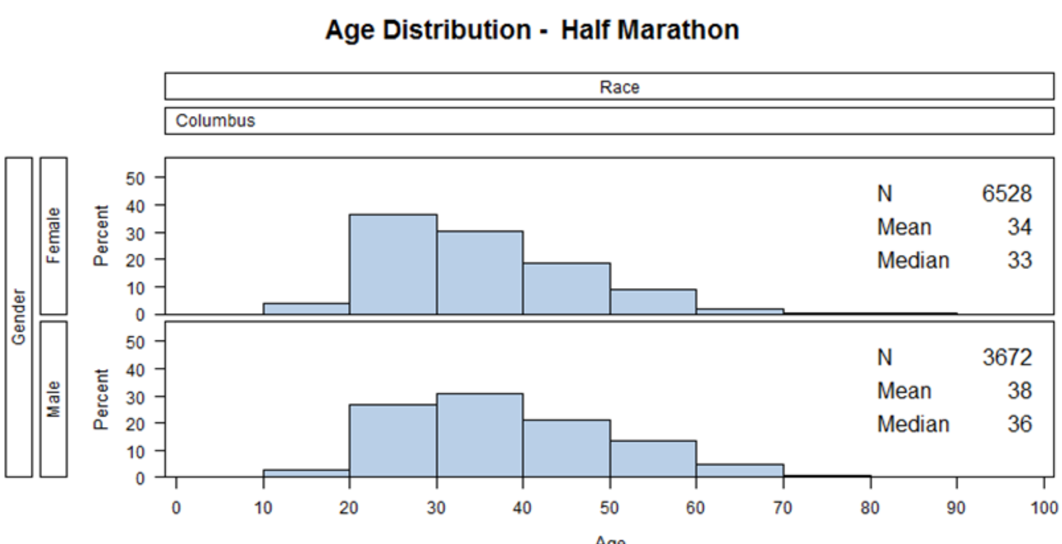

Figure 29. Half Marathon Age Histograms – Columbus

The distribution of the ages for the male and female finishers of the Columbus half marathon look similar to one another as well as possibly skewed to the right. The center of the male distribution appears to lie between the ages of thirty and forty years and the mean and median back up this finding. The largest portion of the female distribution lies between the ages of twenty and thirty years but the mean and median fall between the ages of thirty and forty. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

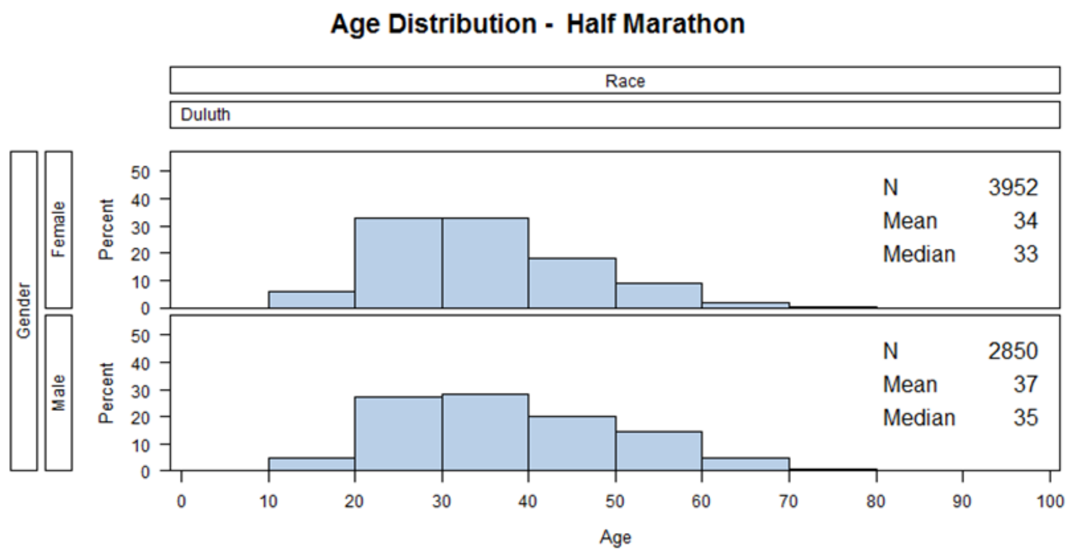

Figure 30. Half Marathon Age Histograms – Duluth

The distribution of the ages for the male and female finishers of the Duluth half marathon look similar to one another as well as possibly skewed to the right. For both distributions, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

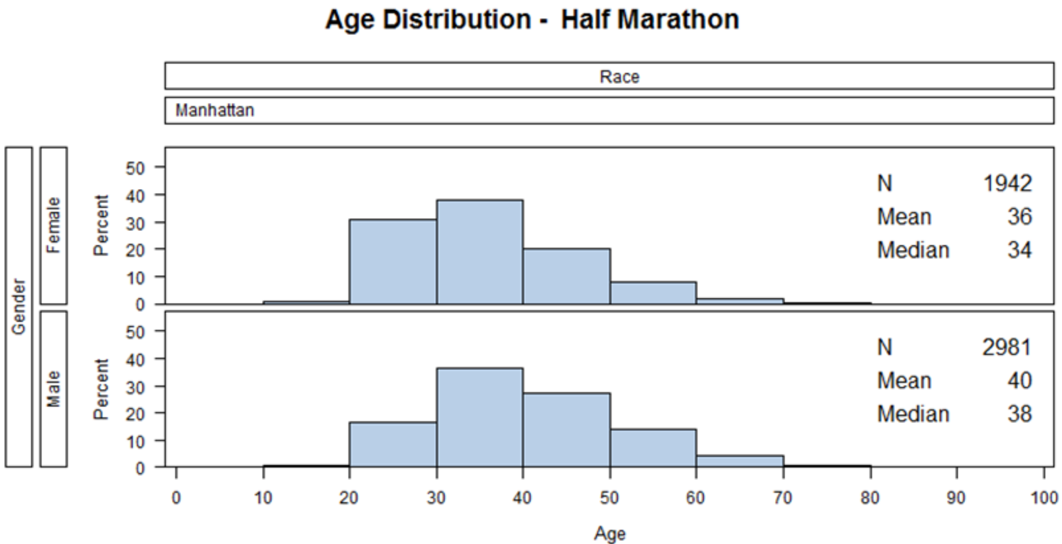

Figure 31. Half Marathon Age Histograms – Manhattan

The distribution of the ages for the male and female finishers of the Manhattan half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

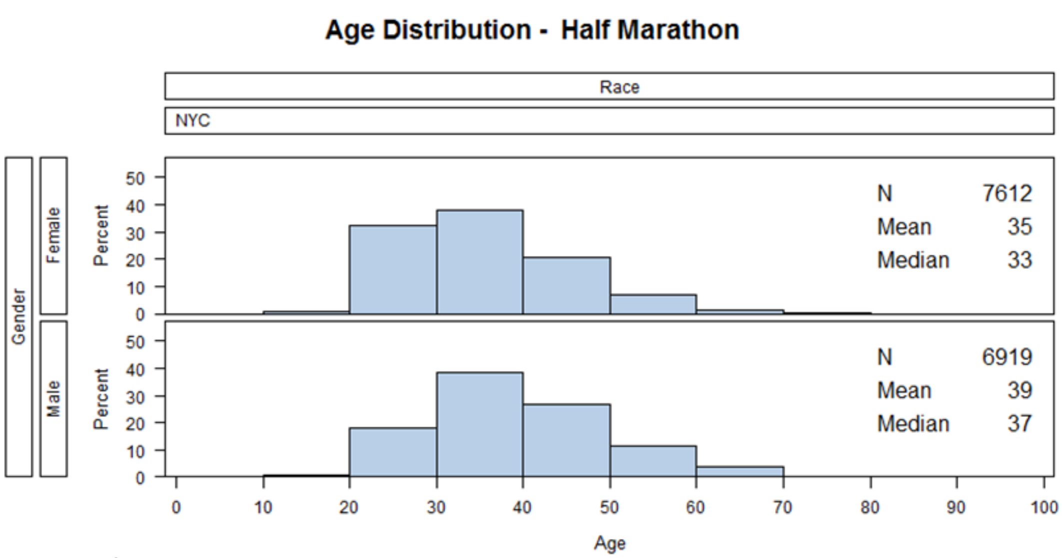

Figure 32. Half Marathon Age Histograms – NYC

The distribution of the ages for the male and female finishers of the NYC half marathon look similar to one another as well as possibly skewed to the right. For both distributions of the finishers, the center appears to lie between the ages of fifty and sixty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

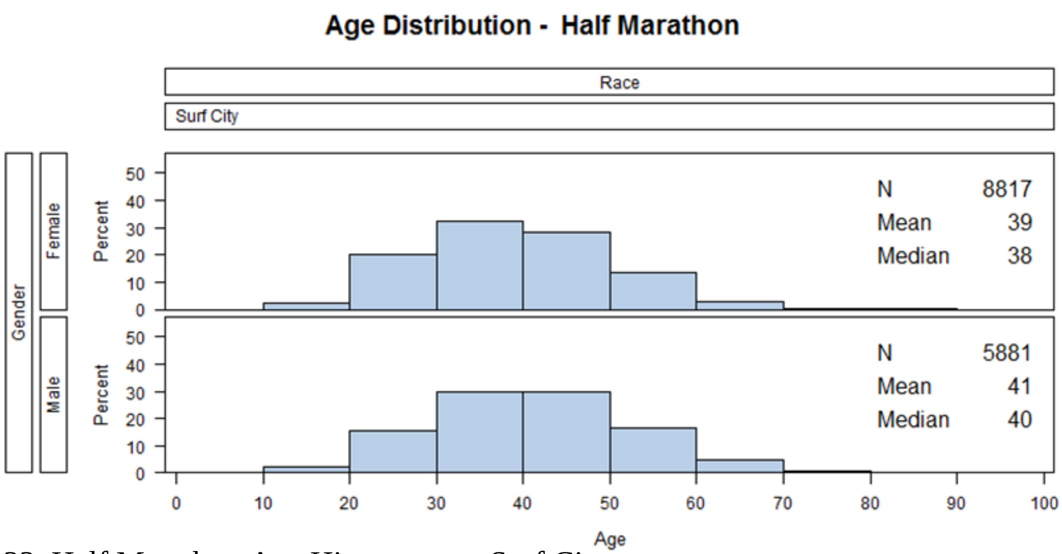

Figure 33. Half Marathon Age Histograms – Surf City

The distribution of the ages for the male and female finishers of the Surf City half marathon look similar to one another as well as possibly skewed to the right. The center of the female distribution appears to lie between the ages of thirty and forty and the levels of center agreed with this finding. The center of the male distribution appears to lie between the ages of thirty and fifty years with the mean and median falling directly between these values. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.3. Ten K Distributions

For the eight ten kilometer races we examined in this paper, we looked at the distributions of age graded score for male and female race finishers and the distributions of the ages for male and female race finishers. We looked at these distributions for each race, individually, and examined them separately by variable. We are only inspecting the distributions visually during this part of our research but we will test the findings of our visual inspection, statistically, later in this chapter. We will also conduct other statistical tests to answer several different questions and discuss those results in this chapter.

6.1.3.1. Age Graded Score Distributions

For an initial look at the distributions of age graded scores by race, we will visually inspect the histograms of age graded scores by gender for each race, individually. These histograms are given in Figures 34 – 41, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

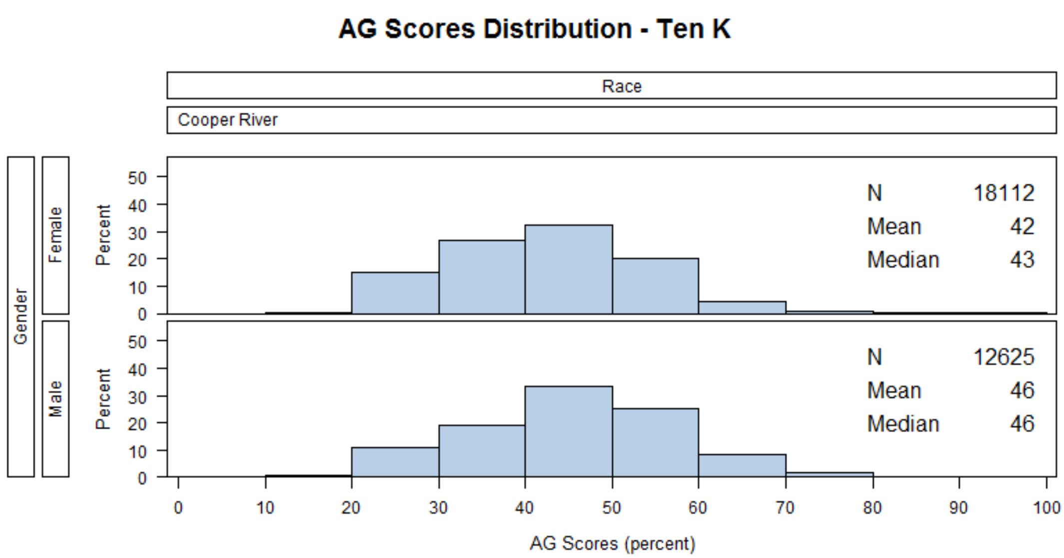

Figure 34. Ten K Age Graded Score Histograms – Cooper River

The distribution of the age graded scores for the male and female finishers of the Cooper River ten kilometer race look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

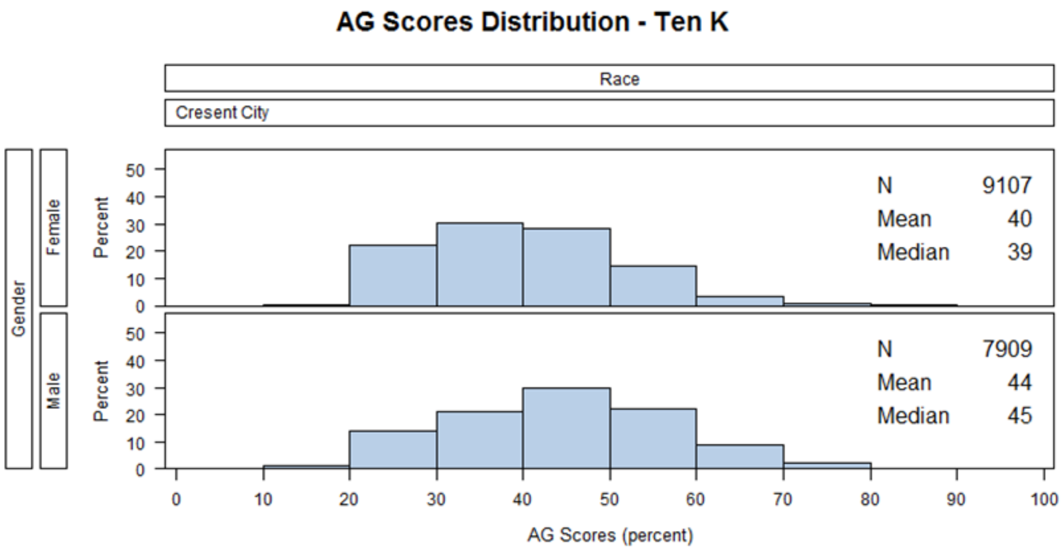

Figure 35. Ten K Age Graded Score Histograms – Crescent City

The distribution of the age graded scores for the male and female finishers of the Crescent City ten kilometer race look similar to one another as well as bell shaped. The center for the female distribution falls between the age graded scores of thirty and forty percent and the center for the male distribution falls between the age graded scores of forty and fifty percent; the mean and median of each distribution agree with these findings. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

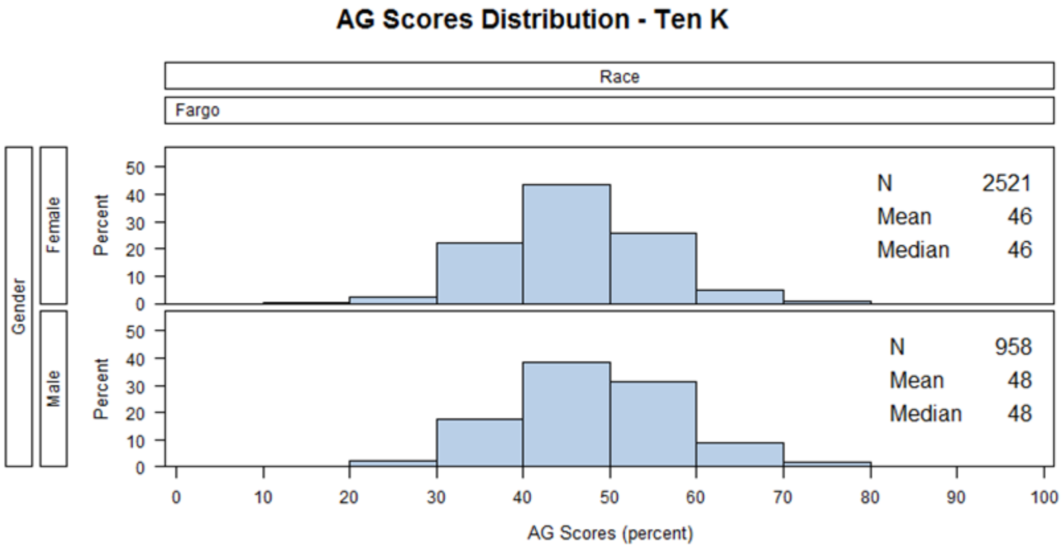

Figure 36. Ten K Age Graded Score Histograms – Fargo

The distribution of the age graded scores for the male and female finishers of the Fargo ten kilometer race look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. The mean and median are equal for each gender which gives evidence that the distributions are symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

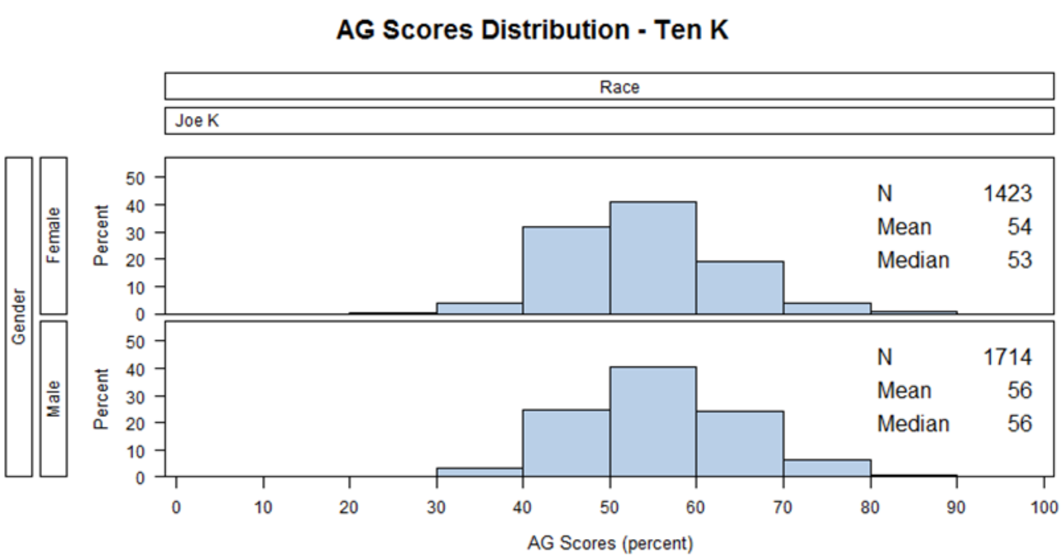

Figure 37. Ten K Age Graded Score Histograms – Joe Kleinerman

The distribution of the age graded scores for the male and female finishers of the Joe Kleinerman ten kilometer race look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

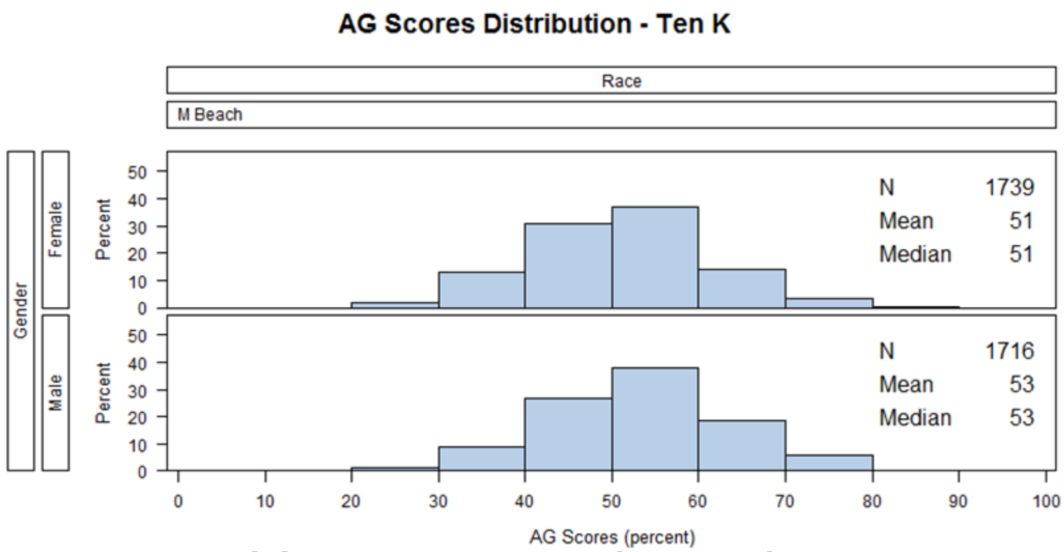

Figure 38. Ten K Age Graded Score Histograms – Manhattan Beach

The distribution of the age graded scores for the male and female finishers of the Manhattan Beach ten kilometer race look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal for each gender which gives evidence that the distributions are symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

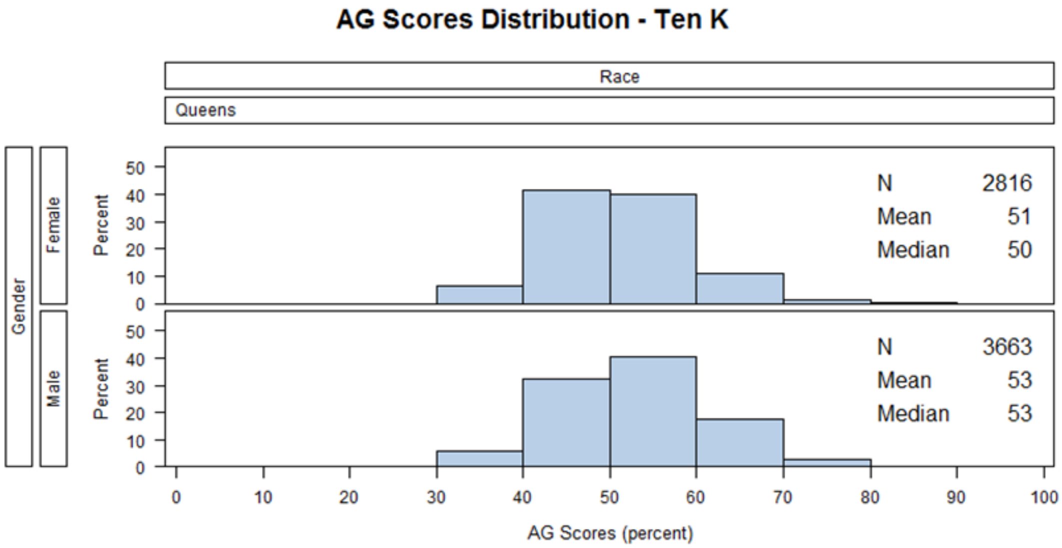

Figure 39. Ten K Age Graded Score Histograms – Queens

The distribution of the age graded scores for the male and female finishers of the Queens ten kilometer race look similar to one another as well as bell shaped. The center for the female distribution appears to fall between the age graded scores of forty and fifty percent but the mean and median fall between fifty and sixty percent. The center for the male distribution lies between the age graded scores of fifty and sixty percent; the mean and median for the male finishers back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

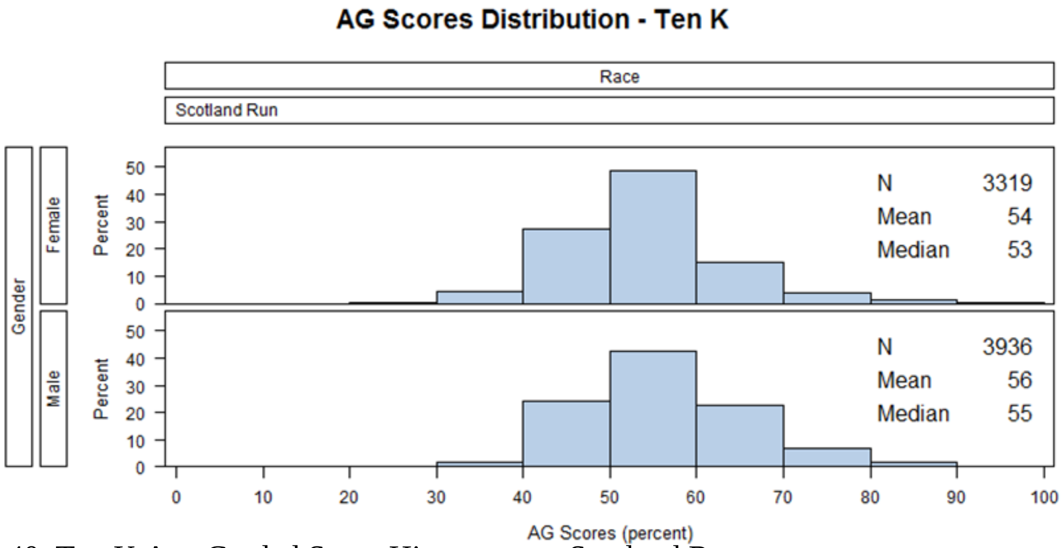

Figure 40. Ten K Age Graded Score Histograms – Scotland Run

The distribution of the age graded scores for the male and female finishers of the Scotland Run ten kilometer race look similar to one another as well as bell shaped. For both distributions of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

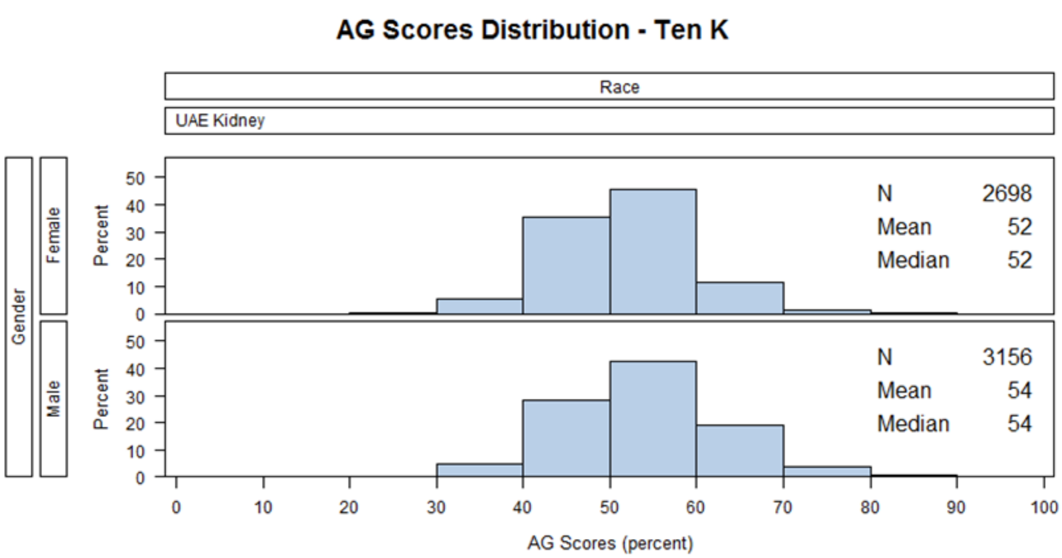

Figure 41. Ten K Age Graded Score Histograms – UAE Healthy Kidney

The distribution of the age graded scores for the male and female finishers of the UAE Healthy Kidney ten kilometer race look similar to one another as well as bell shaped. For both distributions, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal for each gender which gives evidence that the distributions are symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.3.2. Age Distributions

For an initial look at the distributions of age of finishers by race, we will visually inspect the histograms of age by gender for each race, individually. These histograms are given in Figures 42 – 49, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

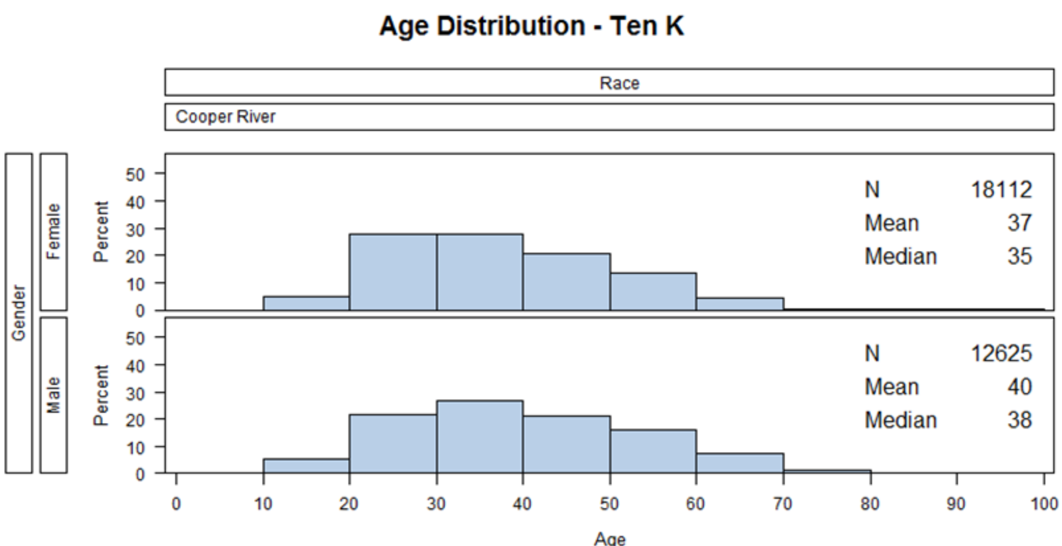

Figure 42. Ten K Age Histograms – Cooper River

The distribution of the ages for the male and female finishers of the Cooper River ten kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of race finishers, the center appears to lie between the ages of thirty and forty years;

the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

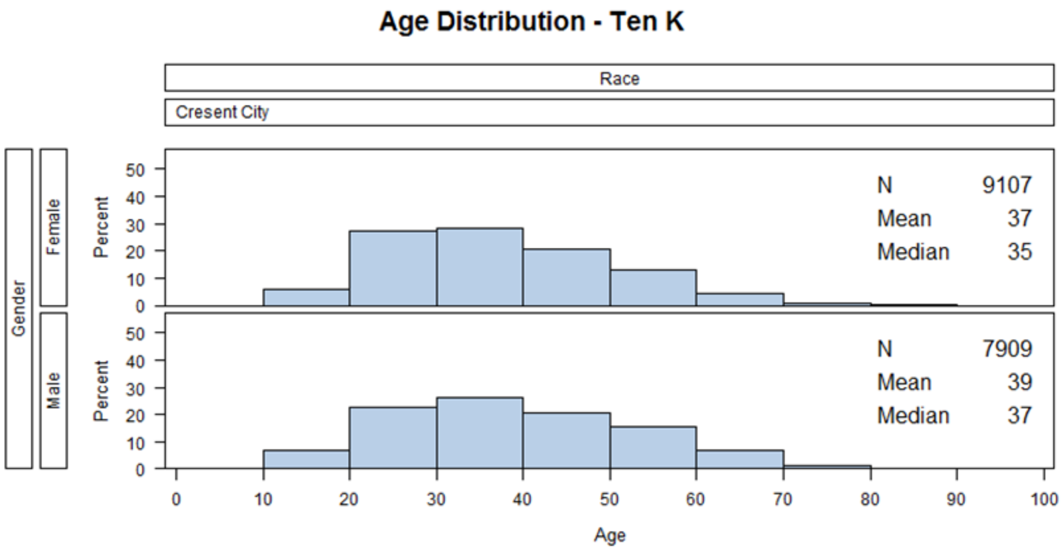

Figure 43. Ten K Age Histograms – Crescent City

The distribution of the ages for the male and female finishers of the Crescent City ten kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of race finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

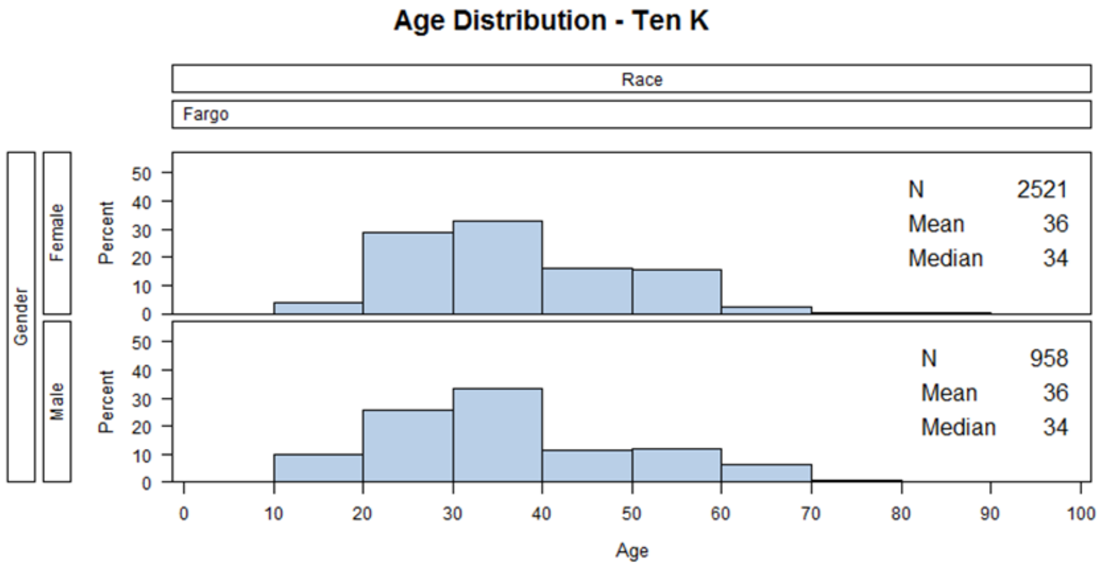

Figure 44. Ten K Age Histograms – Fargo

The distribution of the ages for the male and female finishers of the Fargo ten kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

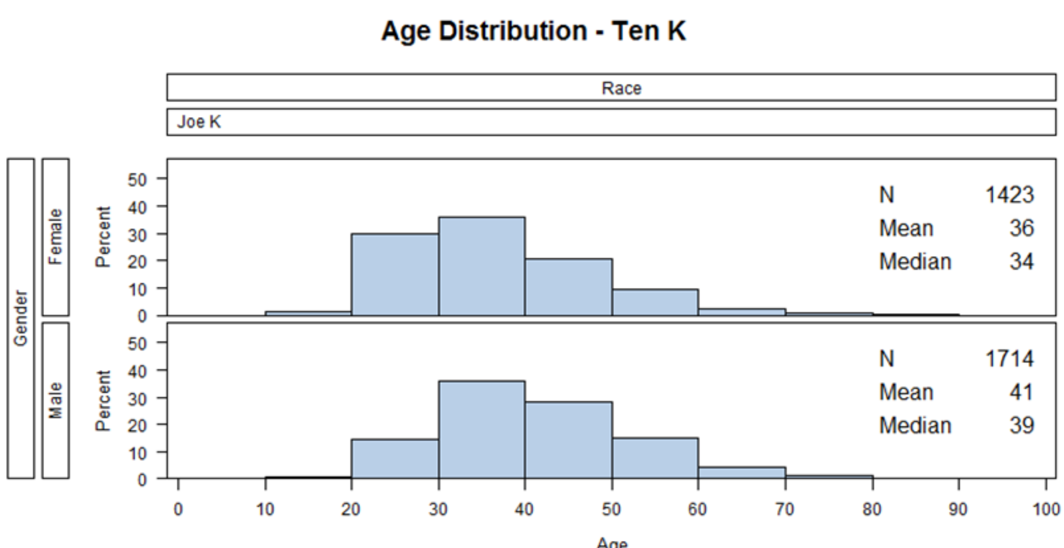

Figure 45. Ten K Age Histograms – Joe Kleinerman

The distribution of the ages for the male and female finishers of the Joe Kleinerman ten kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

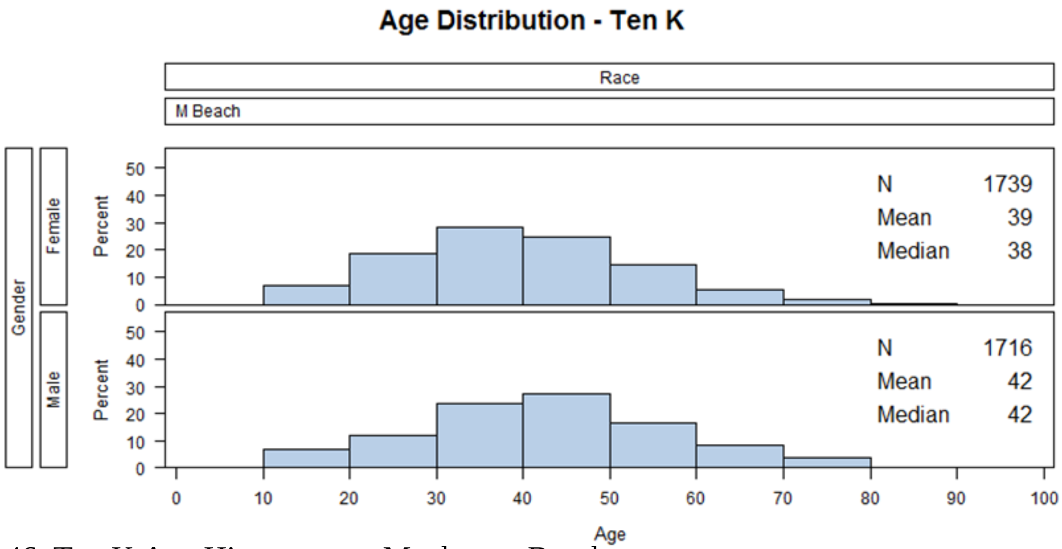

Figure 46. Ten K Age Histograms – Manhattan Beach

The distribution of the ages for the male and female finishers of the Manhattan Beach ten kilometer race look similar to one another as well as possibly skewed to the right. The center of the female distribution appears to lie between the ages of thirty and forty years and the center of the male distribution appears to lie between the ages of forty and fifty years; the mean and median for each gender back up these findings. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

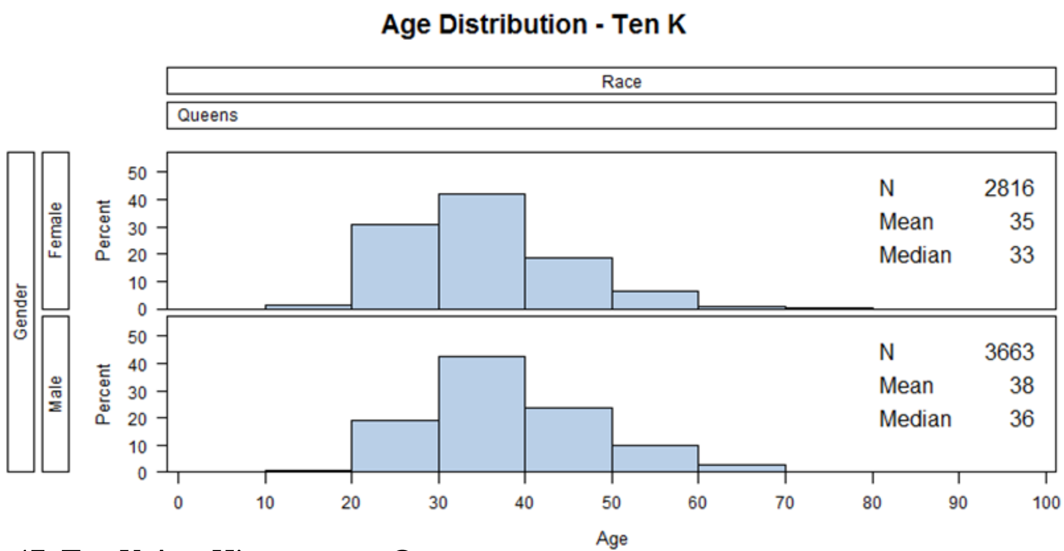

Figure 47. Ten K Age Histograms – Queens

The distribution of the ages for the male and female finishers of the Queens ten kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

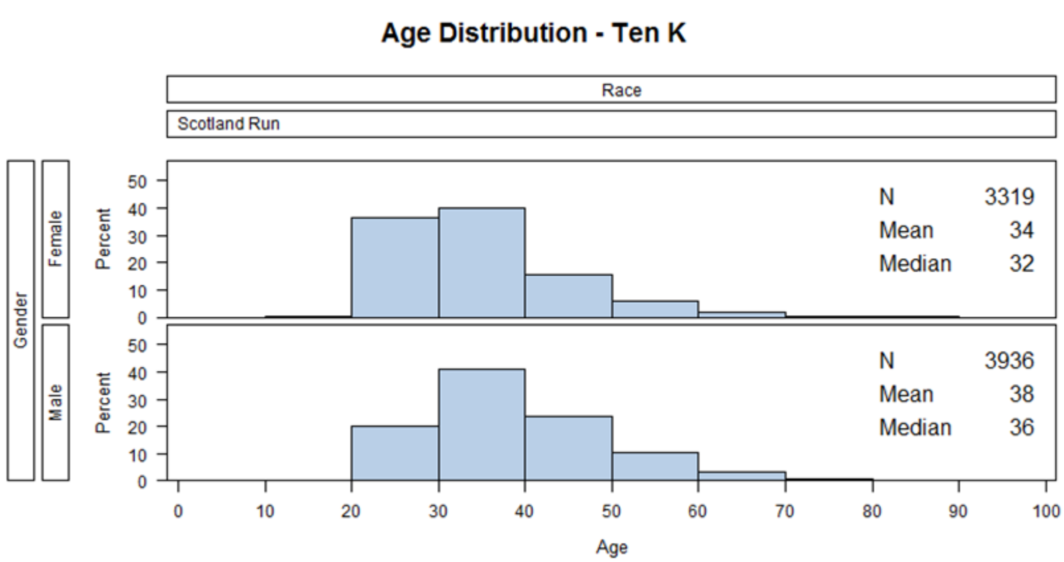

Figure 48. Ten K Age Histograms – Scotland Run

The distribution of the ages for the male and female finishers of the Scotland Run ten kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

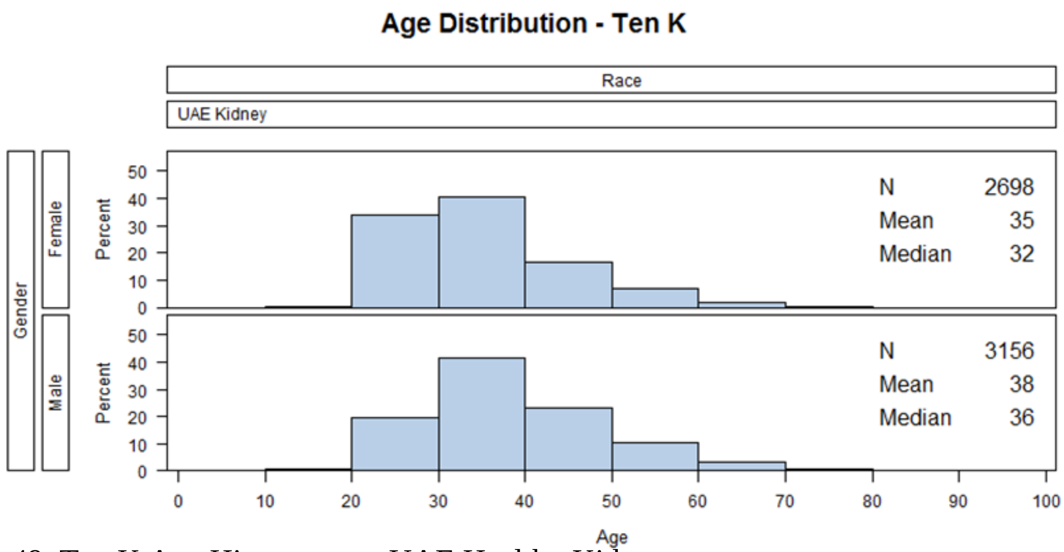

Figure 49. Ten K Age Histograms – UAE Healthy Kidney

The distribution of the ages for the male and female finishers of the UAE Healthy Kidney ten kilometer look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.4. Five K Distributions

For the eight five kilometer races we examined in this paper, we looked at the distributions of age graded score for male and female race finishers and the distributions of the ages for male and female race finishers. We looked at these distributions for each race, individually, and examined them separately by variable. We are only inspecting the distributions visually during this part of our research but we will test the findings of our visual inspection, statistically, later in this chapter. We will also conduct other statistical tests to answer several different questions and discuss those results in this chapter.

6.1.4.1. Age Graded Score Distributions

For an initial look at the distributions of age graded scores by race, we will visually inspect the histograms of age graded scores by gender for each race, individually. These histograms are given in Figures 50 – 57, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

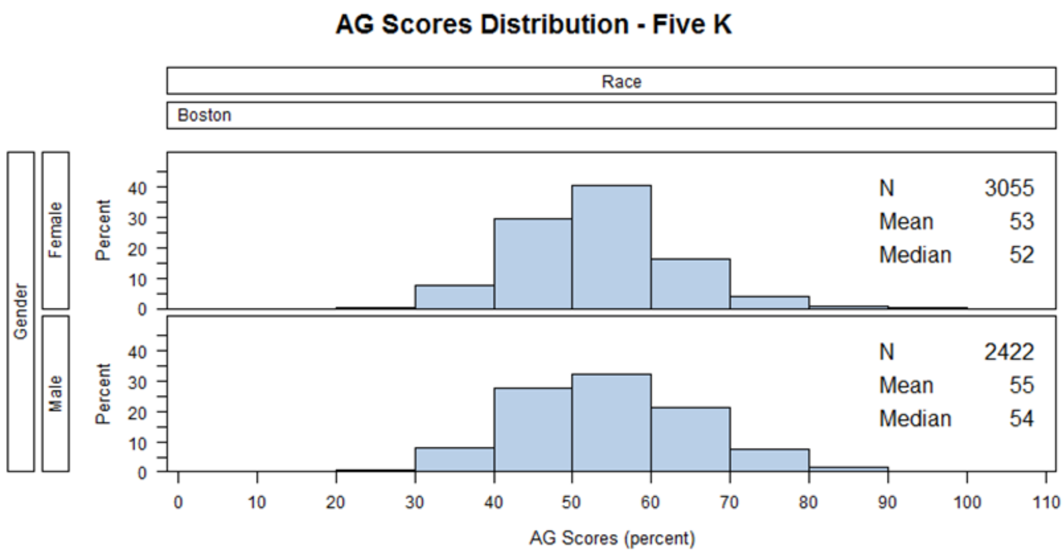

Figure 50. Five K Age Graded Score Histograms – Boston

The distribution of the age graded scores for the male and female finishers of the Boston five kilometer race look similar to one another as well as bell shaped. For both distribution of race finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this view statistically later in this chapter.

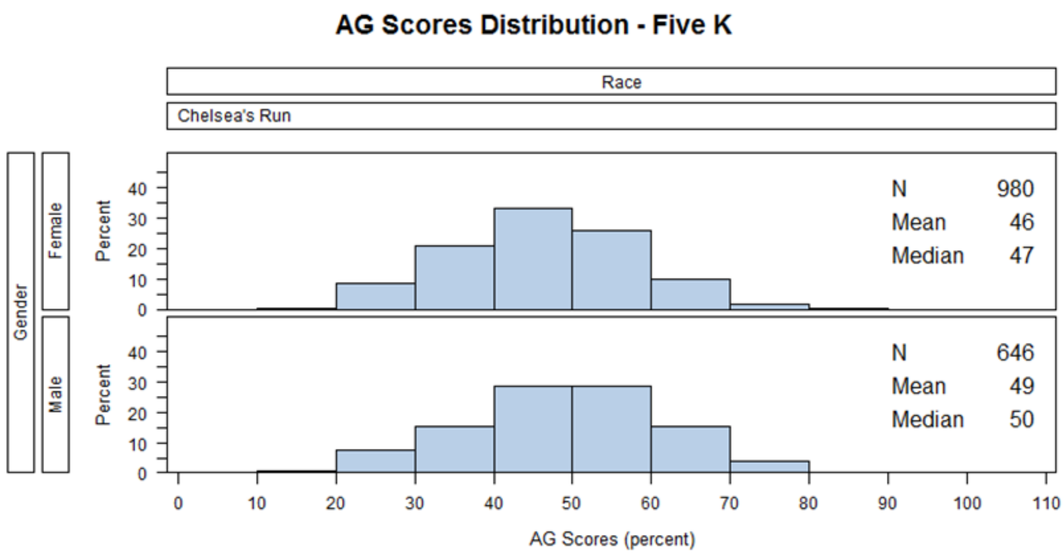

Figure 51. Five K Age Graded Score Histograms – Chelsea's Run

The distribution of the age graded scores for the male and female finishers of the Chelsea's Run five kilometer race look similar to one another as well as possibly bell shaped. For both distribution of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

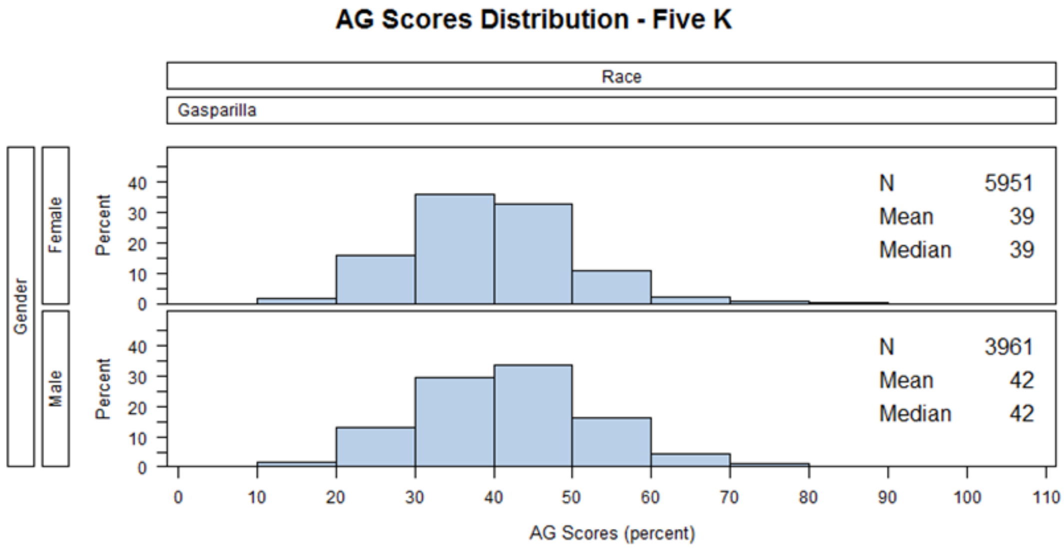

Figure 52. Five K Age Graded Score Histograms – Gasparilla

The distribution of the age graded scores for the male and female finishers of the Gasparilla five kilometer race look similar to one another as well as bell shaped. The center of the female distribution appears to lie between the age graded scores of thirty and forty percent while the center of the male distribution appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up these finding. The mean and median are equal for each gender which gives evidence that the distributions are symmetrical. Though the distributions appear to be the same, we will test this statistically later in this chapter.

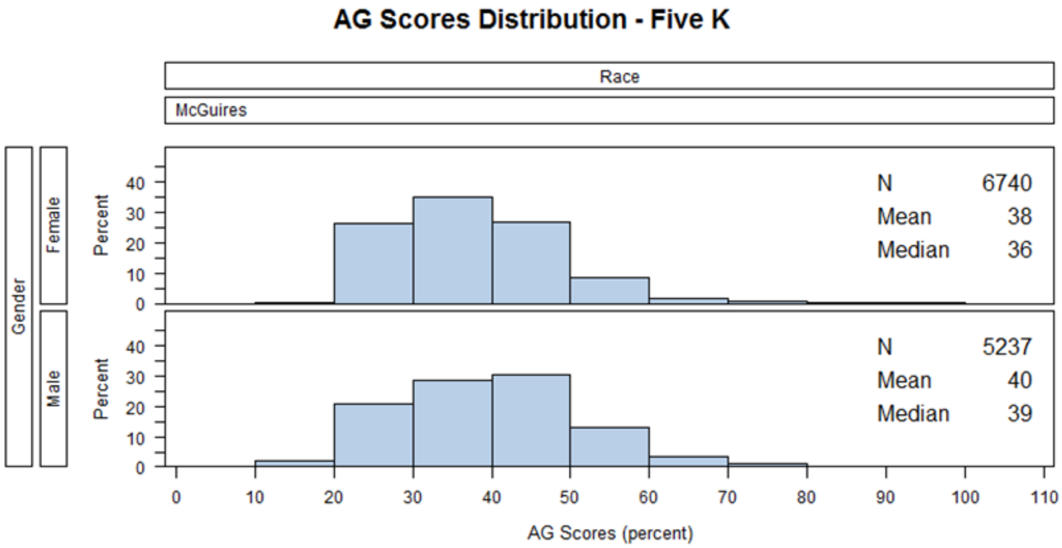

Figure 53. Five K Age Graded Score Histograms – McGuire's

The distribution of the age graded scores for the male and female finishers of the McGuire's five kilometer race look similar to one another as well as bell shaped. The center of the female distribution appears to lie between the age graded scores of thirty and forty percent and the measures of center confirm this finding. The center of the male distribution appears to lie between the age graded scores of forty and fifty percent but the mean and median lie between the age graded scores of thirty and forty percent. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

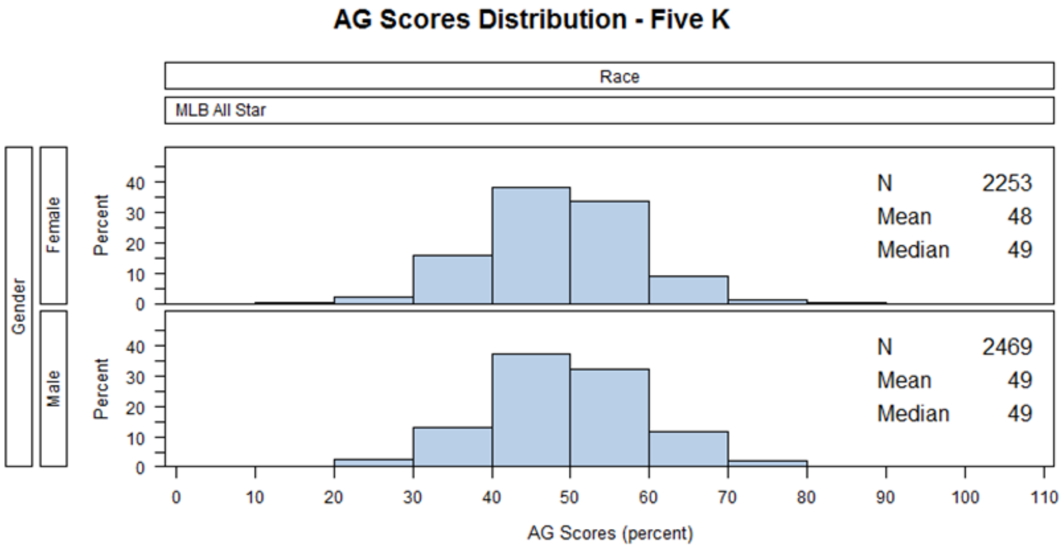

Figure 54. Five K Age Graded Score Histograms – MLB All-Star

The distribution of the age graded scores for the male and female finishers of the MLB All-Star five kilometer race look similar to one another as well as bell shaped. For both distribution of the finishers, the center appears to lie between the age graded scores of forty and fifty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

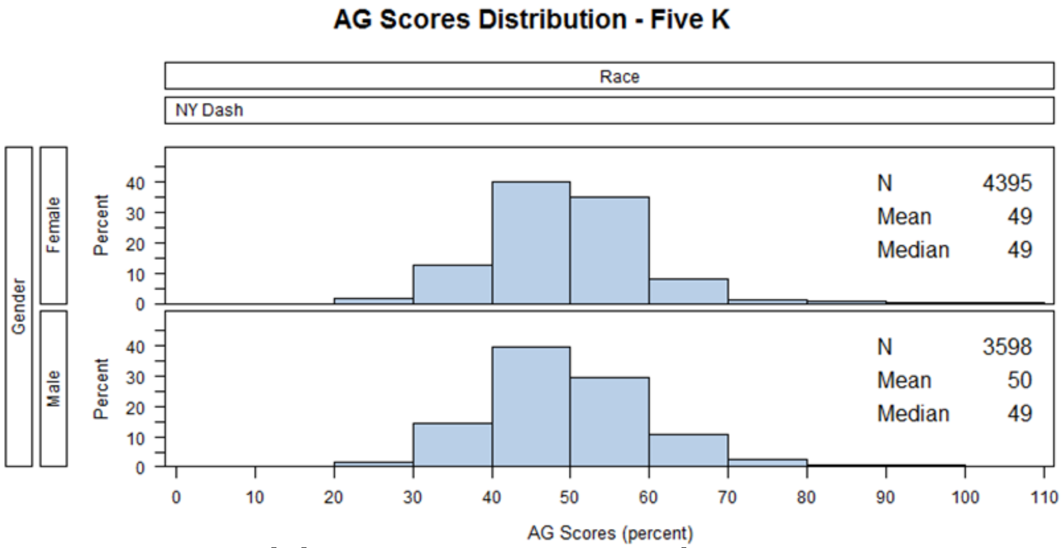

Figure 55. Five K Age Graded Score Histograms – NY Dash

The distribution of the age graded scores for the male and female finishers of the NY Dash five kilometer race look similar to one another as well as bell shaped. For both distribution of the finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the female race finishers but not for the male race finishers; this shows that there is evidence that the female distribution is symmetrical but the male distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

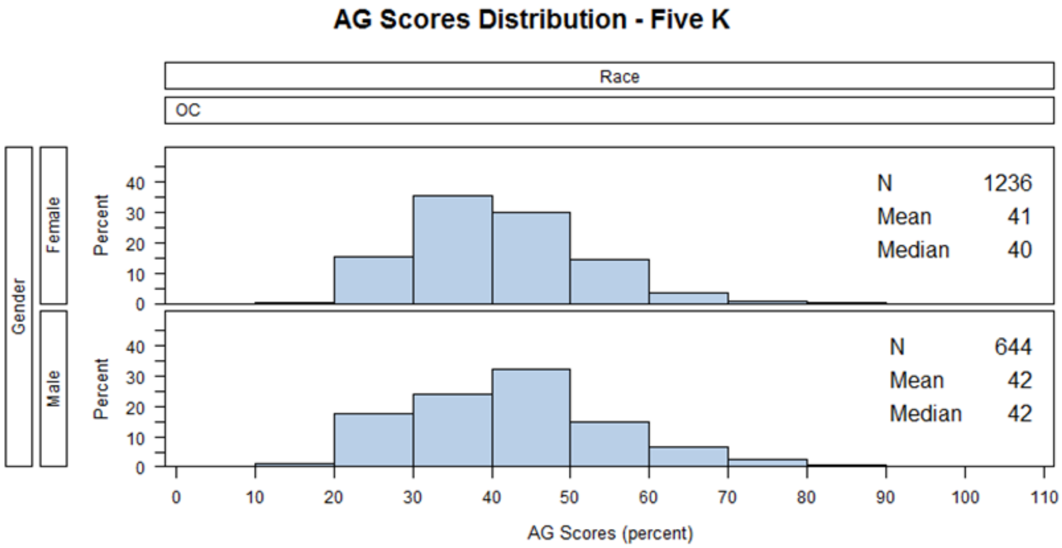

Figure 56. Five K Age Graded Score Histograms – OC

The distribution of the age graded scores for the male and female finishers of the OC five kilometer race look similar to one another as well as possibly skewed to the right. The center for the female distribution appears to fall between the age graded scores of thirty and forty percent but the mean and median fall between forty and fifty percent. The center for the male distribution lies between the age graded scores of forty and fifty percent; the mean and median for the male finishers back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

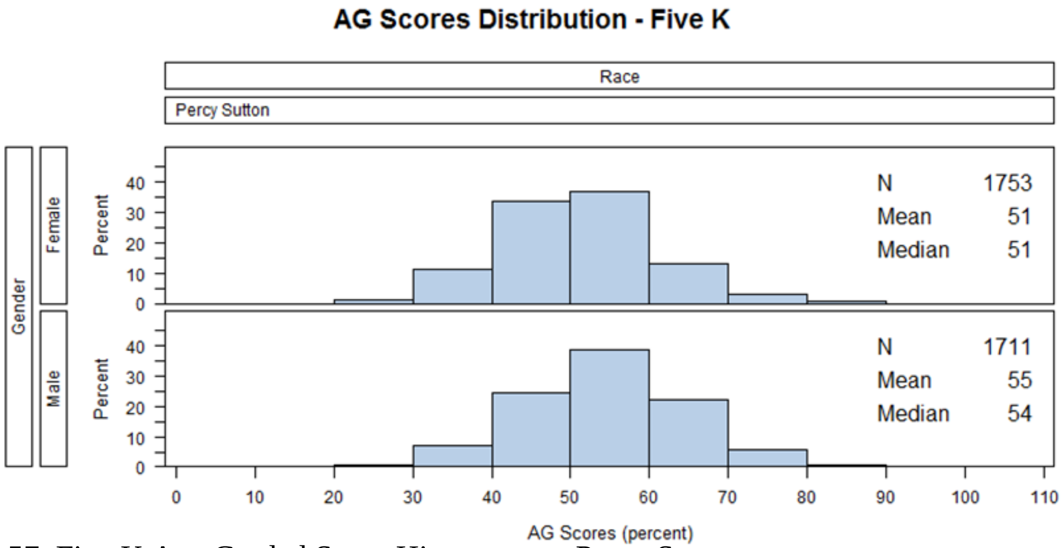

Figure 57. Five K Age Graded Score Histograms – Percy Sutton

The distribution of the age graded scores for the male and female finishers of the Percy Sutton five kilometer race look similar to one another as well as bell shaped. For both distribution of finishers, the center appears to lie between the age graded scores of fifty and sixty percent; the mean and median for each gender back up this finding. The mean and median are equal to one another for the female race finishers but not for the male race finishers; this shows that there is evidence that the female distribution is symmetrical but the male distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

6.1.4.2. Age Distributions

For an initial look at the distributions of ages of finishers by race, we will visually inspect the histograms of age by gender for each race, individually. These histograms are given in Figures 58 – 65, with each figure showing two marathons in alphabetical order. After each figure, we included a brief discussion of the shape of the distributions and a brief comparison between the male and female finishers.

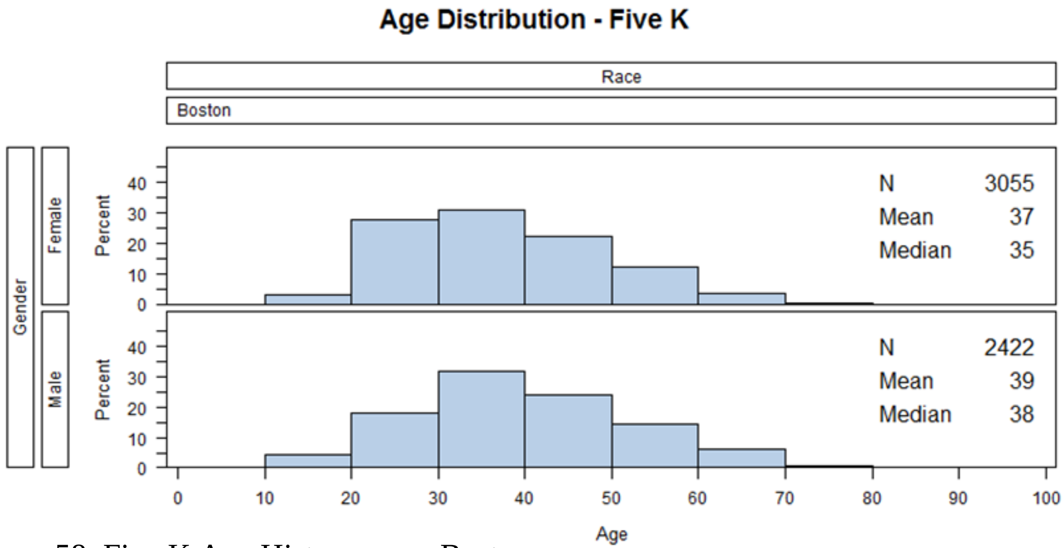

Figure 58. Five K Age Histograms – Boston

The distribution of the ages for the male and female finishers of the Boston five kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this view statistically later in this chapter.

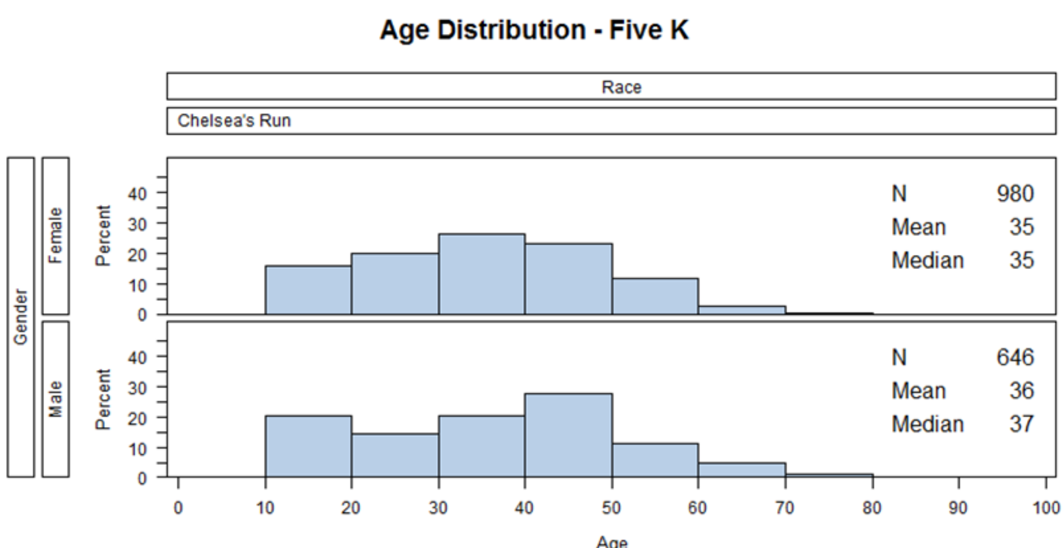

Figure 59. Five K Age Histograms – Chelsea's Run

The distribution of the ages for the male and female finishers of the Chelsea's Run five kilometer look similar to one another as well as possibly skewed to the right. The center for the male distribution appears to fall between the ages of forty and fifty years but the mean and median fall between thirty and forty years. The center for the female distribution lies between the ages of thirty and forty years; the mean and median for the female finishers back up this finding. The mean and median are equal to one another for the female race finishers but not for the male race finishers; this shows that there is evidence that the female distribution is symmetrical but the male distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

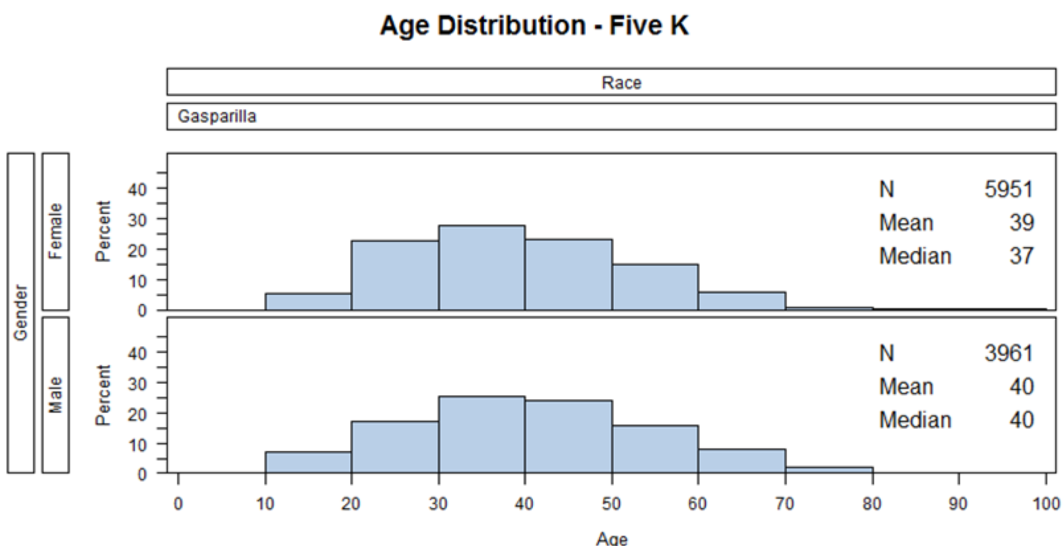

Figure 60. Five K Age Histograms – Gasparilla

The distribution of the ages for the male and female finishers of the Gasparilla five kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are equal to one another for the male race finishers but not for the female race finishers; this shows that there is evidence that the male distribution is symmetrical but the female distribution is skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

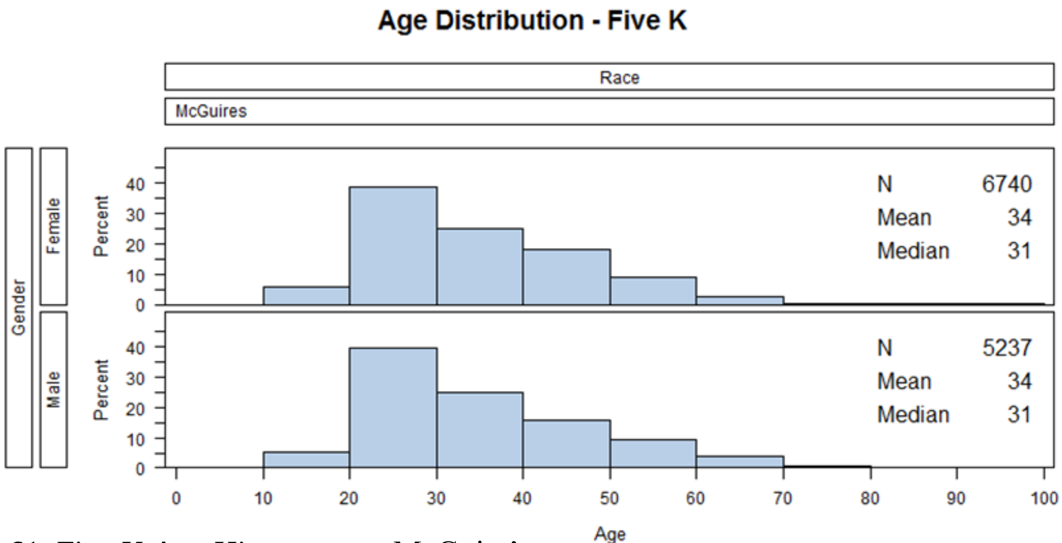

Figure 61. Five K Age Histograms – McGuire’s

The distribution of the ages for the male and female finishers of McGuire’s five kilometer race look similar to one another as well as possibly skewed to the right. For both distributions of race finishers, the center appears to lie between the ages of twenty and thirty years though the mean and median for each gender fall between the ages of thirty and forty years. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

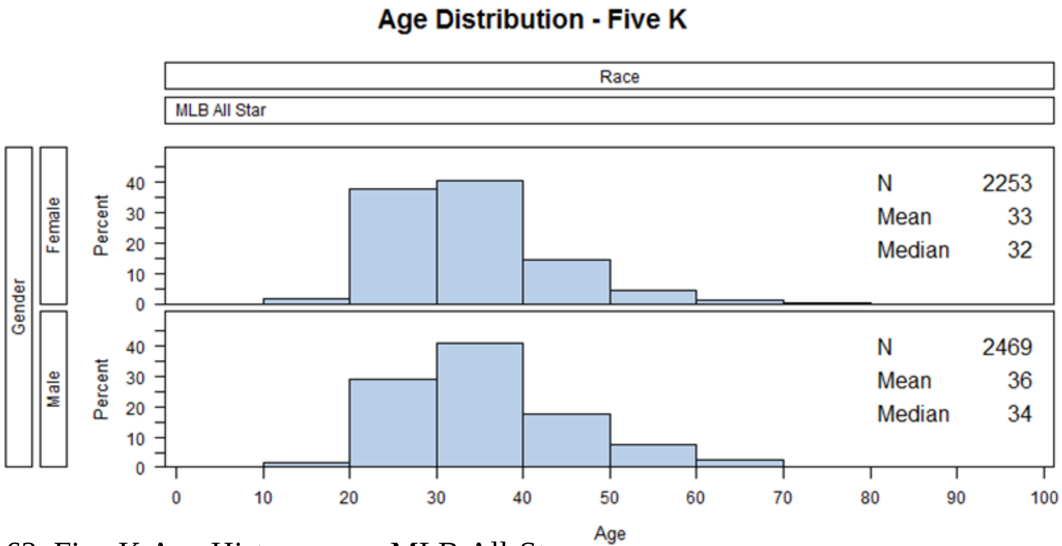

Figure 62. Five K Age Histograms – MLB All-Star

The distribution of the ages for the male and female finishers of the MLB All-Star five kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

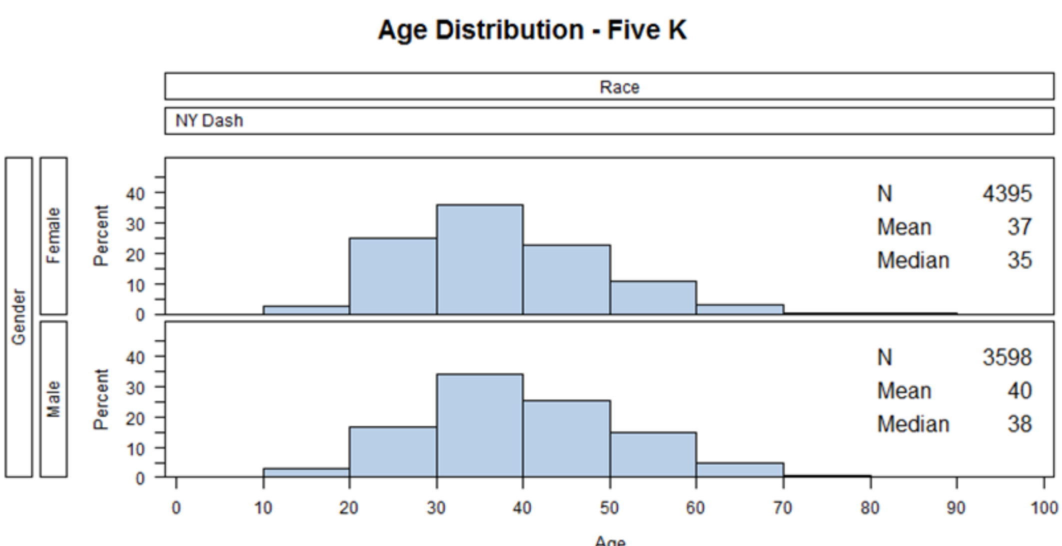

Figure 63. Five K Age Histograms – NY Dash

The distribution of the ages for the male and female finishers of the NY Dash five kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

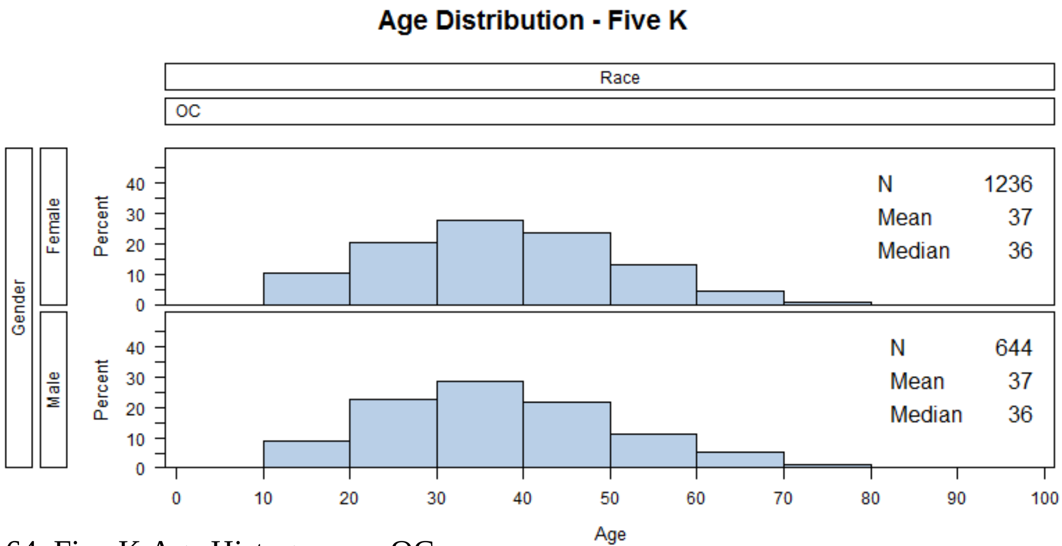

Figure 64. Five K Age Histograms – OC

The distribution of the age graded scores for the male and female finishers of the OC five kilometer race look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this statistically later in this chapter.

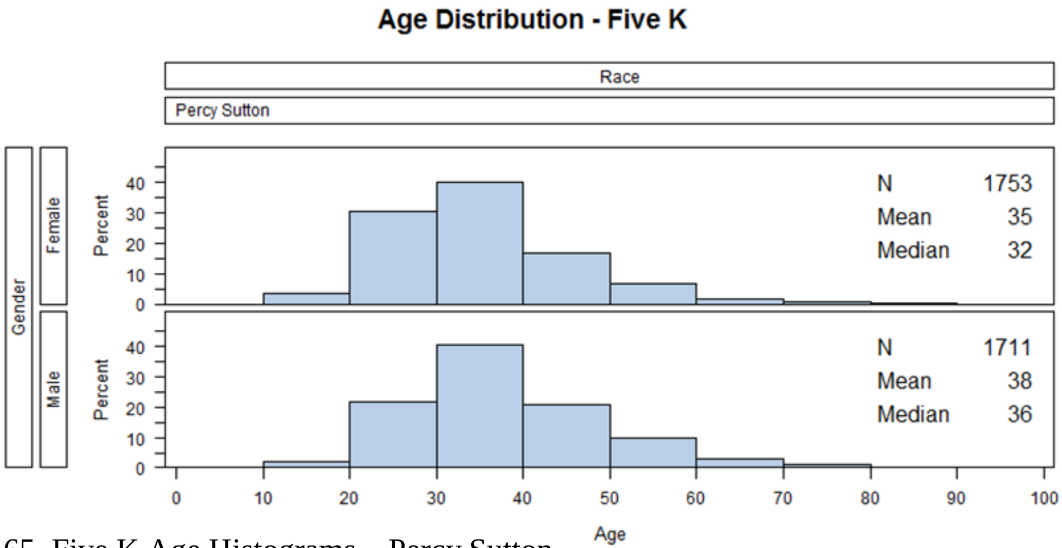

Figure 65. Five K Age Histograms – Percy Sutton

The distribution of the ages for the male and female finishers of the Percy Sutton five kilometer look similar to one another as well as possibly skewed to the right. For both distribution of the finishers, the center appears to lie between the ages of thirty and forty years; the mean and median for each gender back up this finding. The mean and median are not equal to one another for either distribution; this shows that there is evidence that both distributions are skewed. Though the distributions appear to be the same, we will test this view statistically later in this chapter.

6.2. Tests for Proportions

We conducted a Pearson chi square test of proportions for each race at each distance, individually, to determine if the proportion of male finishers was equal to the proportion of female finishers for each race. These proportions were tested at three levels: finishers with an age graded score of sixty percent and higher, finishers with an age graded score of seventy percent and higher, and finishers with an age graded score of forty percent or lower. We will use these results to make conclusions about the distributions of the male and female finishers for each race and distance.

6.2.1. Marathon Results

As previously stated, we used a chi square test to compare the proportions of male and female finishers for each marathon race individually. Table 33 shows the test results for the proportion of male and female finishers with an age graded score of sixty percent and higher. Table 34 shows the test results of the proportion of male and female finishers with an age graded score of seventy percent and higher. Table 35 shows the test results for the proportion of male and female finishers with an age graded score of forty percent and lower. For each of these tests, we will use a significance level of $\alpha = 0.05$ to make our decisions of significant differences.

The Pearson's chi-square test of independence was used to determine if the proportion of male finishers was significantly different from the proportion of female finishers for age graded scores at or above sixty percent, at or above seventy percent, and at or below forty percent. The very large sample sizes for each marathon make Pearson's chi-square the appropriate test for this data.

Table 33. Proportion of Marathon Finishers – 60% and Above

Marathon	**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Air Force	P_M = 15.82%	P_F = 14.84%	0.5284	p = 0.4673
Duluth	P_M = 34.47%	P_F = 29.58%	14.9397	p = 0.0001
Los Angeles	P_M = 10.22%	P_F = 8.04%	25.2348	p < 0.0001
Ogden	P_M = 22.24%	P_F = 25.75%	4.2644	p = 0.0389
Philadelphia	P_M = 27.57%	P_F = 24.14%	16.4904	p < 0.0001
San Francisco	P_M = 15.75%	P_F = 13.35%	5.8330	p = 0.0157
Surf City	P_M = 20.91%	P_F = 21.25%	0.0391	p = 0.8432
Twin Cities	P_M = 26.20%	P_F = 23.47%	8.6604	p = 0.0033

For marathon finishers, the trend over all eight races is that the proportion of male finishers with an age graded score of sixty percent and higher is larger than the proportion of female finishers with an age graded score of sixty percent and higher. Individually, the proportion of male finishers is significantly larger than the proportion of female finishers for the Duluth, Los Angeles, Philadelphia, San Francisco, and the Twin Cities marathons as all of these races have a p-value less than our significance level of 0.05. The proportion of female finishers is significantly larger than the proportion of male finishers for the Ogden marathon. The Air Force and Surf City USA marathons are highly non-significant with p-values of 0.4673 and 0.8432, respectively, which are much larger than our significance level.

Table 34. Proportion of Marathon Finishers – 70% and Above

Marathon	**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Air Force	P_M = 2.64%	P_F = 2.16%	0.6957	p = 0.4042
Duluth	P_M = 9.50%	P_F = 6.40%	17.3598	p < 0.0001
Los Angeles	P_M = 1.81%	P_F = 1.31%	6.9782	p = 0.0083
Ogden	P_M = 3.33%	P_F = 3.64%	0.1855	p = 0.6667
Philadelphia	P_M = 6.51%	P_F = 4.21%	27.7476	p < 0.0001
San Francisco	P_M = 2.23%	P_F = 2.09%	0.1223	p = 0.7266
Surf City	P_M = 3.02%	P_F = 3.50%	0.4220	p = 0.5159
Twin Cities	P_M = 6.62%	P_F = 4.94%	11.1762	p = 0.0008

As with the results of the age graded scores of sixty percent and higher, the trend for the marathon races is that the proportion of male finishers with an age graded score of seventy percent is larger than the proportion of female finishers. This difference is significant for the Duluth, Los Angeles, Philadelphia, and the Twin Cities marathons; all of these races have p-values much smaller than our significance level of 0.05. The p-values for the Air Force, Ogden, San Francisco, and Surf City USA marathons are much higher than our significance level at 0.4042, 0.6667, 0.7266, and 0.5159, respectively.

Table 35. Proportion of Marathon Finishers – 40% and Below

Marathon	Proportion of Finishers		χ^2 Statistic	P-value
Air Force	P_M = 17.70%	P_F = 18.69%	0.4768	p = 0.4899
Duluth	P_M = 3.93%	P_F = 4.85%	2.7581	p = 0.0968
Los Angeles	P_M = 27.91%	P_F = 29.81%	7.8941	p = 0.0050
Ogden	P_M = 6.51%	P_F = 4.88%	3.0706	p = 0.0797
Philadelphia	P_M = 7.40%	P_F = 5.94%	9.0501	p = 0.0026
San Francisco	P_M = 12.88%	P_F = 10.22%	8.6284	p = 0.0033
Surf City	P_M = 10.42%	P_F = 10.51%	0.0057	p = 0.9400
Twin Cities	P_M = 5.54%	P_F = 3.62%	18.1991	p < 0.0001

There is no distinct trend across all eight races for the proportions of male and female finishers with age graded scores of forty percent and lower. For the Air Force, Duluth, and Los Angeles marathons, the proportion of female finishers with an age graded score of forty percent and lower is larger than the proportion of male finishers. The Ogden, Philadelphia, San Francisco, and the Twin Cities marathons have a larger proportion of male finishers with an age graded score of forty percent or lower than female finishers. The proportion of female finishers for the Surf City USA marathon is only nine one-hundredths of a percent larger than the proportion of male finishers, which is so small that they are almost identical. The p-values for the Los Angeles, Philadelphia, San Francisco, and the Twin Cities marathons are much smaller than our significance level, making the male and female proportions significantly different for these races. The Air Force and Surf City USA marathons have very large p-values so the differences for these races are highly non-significant but the Duluth and Ogden races are only slightly non-significant so that if we were to choose a significance level of $\alpha = 0.10$ for our comparisons, we would consider the difference in proportions of male and female finishers significant.

6.2.2. Half Marathon Results

We used a chi square test to compare the proportions of male and female finishers for each half marathon race individually. Table 36 shows the test results for the proportion of male and female finishers with an age graded score of sixty percent and higher. Table 37 shows the test results of the proportion of male and female finishers with an age graded score of seventy percent and higher. Table 38 shows the test results for the proportion of male and female finishers with an age graded score of forty percent and lower. For each of these tests, we will use a significance level of $\alpha = 0.05$ to make our decisions of significant differences.

The Pearson's chi-square test of independence was used to determine if the proportion of male finishers was significantly different from the proportion of female finishers for age graded scores at or above sixty percent, at or above seventy percent, and at or below forty percent. The very large sample sizes for each marathon make Pearson's chi-square the appropriate test for this data.

Table 36. Proportion of Half Marathon Finishers – 60% and Above

Half Marathon	**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Berkeley	P_M = 24.54%	P_F = 18.29%	27.1022	$p < 0.0001$
Brooklyn	P_M = 27.00%	P_F = 19.00%	193.3983	$p < 0.0001$
Capital City	P_M = 16.18%	P_F = 10.80%	50.3700	$p < 0.0001$
Columbus	P_M = 17.10%	P_F = 11.53%	62.2280	$p < 0.0001$
Duluth	P_M = 27.72%	P_F = 19.66%	60.6467	$p < 0.0001$
Manhattan	P_M = 28.92%	P_F = 23.22%	19.4872	$p < 0.0001$
New York City	P_M = 28.11%	P_F = 21.69%	80.2565	$p < 0.0001$
Surf City	P_M = 13.98%	P_F = 9.62%	8.6604	$p < 0.0001$

For all eight half marathons that we investigated, the proportion of male finishers with an age graded score of sixty percent and higher is larger than the proportion of female finishers. These differences are all highly significant with p-values less than 0.0001, which is much smaller than our significance level of $\alpha = 0.05$.

Table 37. Proportion of Half Marathon Finishers – 70% and Above

Half Marathon	Proportion of Finishers		χ^2 Statistic	P-value
Berkeley	P_M = 5.58%	P_F = 3.42%	12.7852	p = 0.0003
Brooklyn	P_M = 5.27%	P_F = 2.55%	105.1774	p < 0.0001
Capital City	P_M = 2.01%	P_F = 0.91%	17.5123	p < 0.0001
Columbus	P_M = 3.38%	P_F = 1.38%	45.6845	p < 0.0001
Duluth	P_M = 11.19%	P_F = 4.38%	114.6287	p < 0.0001
Manhattan	P_M = 4.76%	P_F = 3.09%	8.3737	p = 0.0038
New York City	P_M = 6.62%	P_F = 4.30%	38.2927	p < 0.0001
Surf City	P_M = 2.81%	P_F = 1.44%	33.7696	p < 0.0001

Similar to the findings for the age graded scores of sixty percent and above, the proportion of male finishers with an age graded score of seventy percent or higher is larger than the proportion of female finishers. For six of the eight half marathons these differences are highly significant with a p-value of less than 0.0001 and the other two races also have p-values much smaller than our significant level of $\alpha = 0.05$, $p = 0.0003$ for the Berkeley half marathon and $p = 0.0038$ for the Manhattan half marathon.

Table 38. Proportion of Half Marathon Finishers – 40% and Below

Half Marathon	Proportion of Finishers		χ^2 Statistic	P-value
Berkeley	P_M = 9.25%	P_F = 11.25%	5.0353	p = 0.0248
Brooklyn	P_M = 3.66%	P_F = 4.00%	1.6858	p = 0.1942
Capital City	P_M = 8.77%	P_F = 12.45%	27.4730	p < 0.0001
Columbus	P_M = 11.63%	P_F = 14.29%	14.4303	p = 0.0001
Duluth	P_M = 5.44%	P_F = 6.48%	3.1494	p = 0.0760
Manhattan	P_M = 3.69%	P_F = 3.50%	0.1199	p = 0.7292
New York City	P_M = 3.93%	P_F = 4.16%	0.5071	p = 0.4764
Surf City	P_M = 20.47%	P_F = 25.03%	41.1349	p < 0.0001

Seven of the eight half marathon races that we investigated have a larger proportion of female finishers than male finishers with an age graded score of forty percent and lower. The difference between the male and female proportions for the Manhattan half marathon is only 0.19% and the proportion of male finishers is larger than the proportion of female finishers. The differences for the proportion of finishers is highly significant ($p \leq 0.0001$) for the Capital City, Columbus, and Surf City half marathons, and significantly different for the Berkeley half marathon ($p = 0.0248$). The p-value for the Duluth half marathon ($p = 0.760$) is larger than our significance level of $\alpha = 0.05$, but if we chose to use a significance level of $\alpha = 0.10$ the results would be considered significantly different. The other three races have very large p-values ($p \geq 0.1942$) so the differences between the proportion of male finishers and the proportion of female finishers for these races are not significant.

6.2.3. Ten K Results

As stated previously, we used a chi square test to compare the proportions of male and female finishers for each ten kilometer race individually. Table 39 shows the test results for the proportion of male and female finishers with an age graded score of sixty percent and higher. Table 40 shows the test results of the proportion of male and female finishers with an age graded score of seventy percent and higher. Table 41 shows the test results for the proportion of male and female finishers with an age graded score of forty percent and lower. For each of these tests, we will use a significance level of $\alpha = 0.05$ to make our decisions of significant differences.

The Pearson's chi-square test of independence was used to determine if the proportion of male finishers was significantly different from the proportion of female finishers for age graded scores at or above sixty percent, at or above seventy percent, and at or below forty percent. The very large sample sizes for each marathon make Pearson's chi-square the appropriate test for this data.

Table 39. Proportion of Ten K Finishers – 60% and Above

Ten K Race	**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Cooper River	P_M = 10.50%	P_F = 5.20%	306.0013	$p < 0.0001$
Crescent City	P_M = 11.42%	P_F = 4.25%	310.4056	$p < 0.0001$
Fargo	P_M = 10.75%	P_F = 5.43%	30.5590	$p < 0.0001$
Joe K	P_M = 31.45%	P_F = 23.47%	24.6230	$p < 0.0001$
M Beach	P_M = 24.88%	P_F = 17.42%	28.8411	$p < 0.0001$
Queens	P_M = 21.02%	P_F = 12.04%	90.5488	$p < 0.0001$
Scotland Run	P_M = 31.28%	P_F = 19.67%	126.0492	$p < 0.0001$
UAE	P_M = 23.92%	P_F = 12.97%	113.8950	$p < 0.0001$

For each of the eight ten kilometer races that we tested, the proportion of male finishers with an age graded score of sixty percent or higher is larger than the proportion of female finishers with an age graded score of sixty percent or higher. All of these differences are highly significant with a p-value less than 0.0001 for every race.

Table 40. Proportion of Ten K Finishers – 70% and Above

Ten K Race	**Proportion of Finishers**		**χ^2 Statistic**	**P-value**
Cooper River	P_M = 2.25%	P_F = 0.93%	89.7261	$p < 0.0001$
Crescent City	P_M = 2.62%	P_F = 0.82%	83.5640	$p < 0.0001$
Fargo	P_M = 1.88%	P_F = 0.75%	8.3536	$p = 0.0038$
Joe K	P_M = 7.00%	P_F = 4.57%	8.2957	$p = 0.0040$
M Beach	P_M = 6.12%	P_F = 3.51%	12.8750	$p = 0.0003$
Queens	P_M = 3.22%	P_F = 1.14%	30.6041	$p < 0.0001$
Scotland Run	P_M = 8.43%	P_F = 4.70%	40.0319	$p < 0.0001$
UAE	P_M = 4.82%	P_F = 1.59%	46.9061	$p < 0.0001$

Similarly to the proportion of finishers with an age graded score of sixty percent and above, the proportion of male finishers with an age graded score of seventy percent and higher is larger than the proportion of female finishers with an age graded score of seventy percent and higher for all eight races. Five of the eight races have p-values of $p < 0.0001$, highly significant, and the remaining three races have p-values that are much smaller than our significance level, $\alpha = 0.05$. These results show that all of the eight ten kilometer races have highly significant differences between the proportions of male and female finishers with age graded scores of seventy percent and above.

Table 41. Proportion of Ten K Finishers – 40% and Below

Ten K Race	Proportion of Finishers		χ^2 Statistic	P-value
Cooper River	P_M = 30.92%	P_F = 42.35%	413.6307	p < 0.0001
Crescent City	P_M = 36.54%	P_F = 52.86%	455.0133	p < 0.0001
Fargo	P_M = 19.83%	P_F = 24.87%	9.8061	p = 0.0017
Joe K	P_M = 3.38%	P_F = 3.65%	0.1680	p = 0.6819
M Beach	P_M = 10.31%	P_F = 14.55%	14.2087	p = 0.0002
Queens	P_M = 5.65%	P_F = 6.50%	2.0212	p = 0.1551
Scotland Run	P_M = 2.01%	P_F = 4.37%	33.5640	p < 0.0001
UAE	P_M = 5.07%	P_F = 5.74%	1.3028	p = 0.2537

For five of the eight ten kilometer races that we investigated, the proportion of female finishers with an age graded score of forty percent and lower is larger than the proportion of male finishers with an age graded score of forty percent and lower. For the remaining three races, Joe Kleinerman, Queens, and UAE Healthy Kidney, have proportions that are very close to one another (less than one percent difference). These three races have very large p-values, all $p \geq 0.15$, so the differences in the proportions are highly non-significant. The p-values for the remaining races are all highly significant, with three less than 0.0001 and the other two less than 0.002.

6.2.4. Five K Results

As previously stated, we used a chi square test to compare the proportions of male and female finishers for each five kilometer race individually. Table 42 shows the test results for the proportion of male and female finishers with an age graded score of sixty percent and higher. Table 43 shows the test results of the proportion of male and female finishers with an age graded score of seventy percent and higher. Table 44 shows the test results for the proportion of male and female finishers with an age graded score of forty percent and lower. For each of these tests, we will use a significance level of $\alpha = 0.05$ to make our decisions of significant differences.

The Pearson's chi-square test of independence was used to determine if the proportion of male finishers was significantly different from the proportion of female finishers for age graded scores at or above sixty percent, at or above seventy percent, and at or below forty percent. The very large sample sizes for each marathon make Pearson's chi-square the appropriate test for this data.

Table 42. Proportion of Five K Finishers – 60% and Above

Five K Race	Proportion of Finishers		χ^2 Statistic	P-value
Boston	P_M = 31.30%	P_F = 21.51%	67.5867	$p < 0.0001$
Chelsea's Run	P_M = 19.50%	P_F = 11.43%	20.3242	$p < 0.0001$
Gasparilla	P_M = 5.78%	P_F = 2.99%	47.0962	$p < 0.0001$
McGuire's	P_M = 4.45%	P_F = 2.58%	31.3104	$p < 0.0001$
MLB All Star	P_M = 14.14%	P_F = 10.12%	17.7082	$p < 0.0001$
NYRR Dash	P_M = 14.73%	P_F = 10.24%	37.1007	$p < 0.0001$
OC	P_M = 9.63%	P_F = 4.53%	18.7367	$p < 0.0001$
Percy Sutton	P_M = 28.93%	P_F = 17.17%	67.6577	$p < 0.0001$

For each of the eight five kilometer races that we tested, the proportion of male finishers with an age graded score of sixty percent or higher is larger than the proportion of female finishers with an age graded score of sixty percent or higher. All of these differences are highly significant with a p-value of less than 0.0001 for every race.

Table 43. Proportion of Five K Finishers – 70% and Above

Five K Race	Proportion of Finishers		χ^2 Statistic	P-value
Boston	P_M = 9.74%	P_F = 5.01%	45.9223	$p < 0.0001$
Chelsea's Run	P_M = 4.18%	P_F = 1.73%	8.8396	$p = 0.0029$
Gasparilla	P_M = 1.51%	P_F = 0.77%	12.3878	$p = 0.0004$
McGuire's	P_M = 1.15%	P_F = 0.83%	3.0456	$p = 0.0810$
MLB All Star	P_M = 2.39%	P_F = 1.15%	10.1746	$p = 0.0014$
NYRR Dash	P_M = 3.81%	P_F = 2.21%	17.8354	$p < 0.0001$
OC	P_M = 2.95%	P_F = 1.13%	8.1260	$p = 0.0044$
Percy Sutton	P_M = 6.78%	P_F = 3.99%	13.2315	$p = 0.0003$

The proportions of male and female finishers with an age graded score of seventy percent and higher follow the same trend as the proportions of finishers with an age graded score of sixty percent and higher. For these races only one, McGuire's St. Patrick's Day 5k, has a p-value greater than our significance level but if had chosen a significance level of $\alpha = 0.10$, the difference between the proportions of male and female finishers for McGuire's 5k would be considered significant ($p = 0.0810$).

Table 44. Proportion of Five K Finishers – 40% and Below

Five K Race	Proportion of Finishers		χ^2 Statistic	P-value
Boston	P_M = 8.55%	P_F = 8.12%	0.3261	p = 0.5680
Chelsea's Run	P_M = 23.53%	P_F = 29.39%	6.7700	p = 0.0093
Gasparilla	P_M = 44.23%	P_F = 53.43%	80.4445	p < 0.0001
McGuire's	P_M = 51.80%	P_F = 61.91%	123.2474	p < 0.0001
MLB All Star	P_M = 15.92%	P_F = 17.75%	2.8441	p = 0.0917
NYRR Dash	P_M = 16.12%	P_F = 14.04%	6.7311	p = 0.0095
OC	P_M = 43.01%	P_F = 50.69%	9.9933	p = 0.0016
Percy Sutton	P_M = 7.77%	P_F = 12.21%	18.8893	p < 0.0001

The proportion of female finishers with an age graded score of forty percent and below is larger than the proportion of male finishers with an age graded score at this level. The differences in the proportions for the Boston 5k do not follow this trend but the p-value is so large that this result is highly non-significant when it is compared to our level of significance. The p-value for the MLB All-Star race is larger than our significance level but if we had chosen a significance level of $\alpha = 0.10$, we would consider the difference between the proportion of male and female finishers to be significant. For the remaining six races, all of the p-values are highly significant ($p \leq 0.01$) and all of these races follow the previously mentioned trend except the NYRR Dash.

6.3. Tests of Distributions

To further determine where the differences lie between the distributions of male and female finishers we ran several tests to compare whether the distributions were equal. We tested the equality of the means, medians, variances, and overall distributions of age graded scores for both populations. We used the two-sample T test, the F test, Levene's test, the Wilcoxon test, and the

KS test. We will use the results of these tests to draw our conclusions about the differences between the distributions of male and female distance runners.

6.3.1. Marathon Results

We examined the differences between the male and female marathon finishers in several ways to determine if there are any significant differences between the populations. We looked at the differences of the age graded scores between male and female race finishers and the differences of the ages between the male and female race finishers.

6.3.1.1. Age Graded Score Results

To determine where the differences in the age graded scores between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 45, and proceeded to test these differences statistically with the results given in Table 46.

Table 45. Descriptive Statistics for Age Graded Score – Marathon

Marathon	**Mean**		**Median**		**Variance**	
Air Force	M: 49.6	F: 49.3	M: 49.0	F: 48.5	M: 96.8	F: 95.1
Duluth	M: 56.4	F: 55.3	M: 55.8	F: 54.6	M: 113.2	F: 89.3
Los Angeles	M: 46.6	F: 45.8	M: 45.7	F: 44.7	M: 102.5	F: 90.7
Ogden	M: 53.2	F: 54.2	M: 52.9	F: 54.1	M: 83.2	F: 74.9
Philadelphia	M: 54.1	F: 53.7	M: 53.4	F: 53.1	M: 102.1	F: 83.3
San Francisco	M: 50.6	F: 50.4	M: 49.9	F: 49.6	M: 84.3	F: 73.4
Surf City	M: 52.0	F: 52.1	M: 51.8	F: 51.4	M: 91.9	F: 93.6
Twin Cities	M: 54.4	F: 54.1	M: 53.4	F: 53.4	M: 97.6	F: 81.0

The total number of male finishers is larger than the total number of female finishers for all eight of the marathons that we have examined. For the Surf City USA marathon and the Ogden marathon, the mean age graded score for the female finishers is larger than the mean score of the male finishers. For the other six races that were investigated, the mean age graded score for the male finishers is larger than the mean age graded score for the female finishers. The median age graded scores follow this same pattern. The variance of the age graded scores for the female finishers is larger than the variance of the age graded scores for the male finishers for the Surf City USA marathon. The variances of the age graded scores for all other marathons under consideration follow the trend of the value for the male finishers being larger than the value for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 46. Test Results for Age Graded Score – Marathon

Marathon	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Air Force	$p = 0.7405$	$p = 0.7131$	$p = 0.4022$	$p = 0.3675$	$p = 0.8068$
Duluth	$p < 0.0001$	$p < 0.0001$	$p = 0.0001$	$p = 0.0005$	$p = 0.0002$
Los Angeles	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Ogden	$p = 0.0634$	$p = 0.0503$	$p = 0.0033$	$p = 0.0018$	$p = 0.0054$
Philadelphia	$p < 0.0001$	$p < 0.0001$	$p = 0.0258$	$p = 0.1720$	$p = 0.0002$
San Francisco	$p = 0.0005$	$p = 0.0006$	$p = 0.4024$	$p = 0.3143$	$p = 0.0539$
Surf City	$p = 0.7469$	$p = 0.7330$	$p = 0.8384$	$p = 0.9995$	$p = 0.9649$
Twin Cities	$p < 0.0001$	$p < 0.0001$	$p = 0.0905$	$p = 0.3489$	$p = 0.0096$

The equal variance assumption for the Mann-Whitney-Wilcoxon test is not met for the Duluth, Los Angeles, Philadelphia, San Francisco, and Twin Cities but the results are still very similar to the t-test results for those marathons. For the Air Force, Ogden, and Surf City marathons the pooled test statistic was used for the t-test; for all other marathons, the non-pooled test statistic was used for the t-test.

We considered two tests for the differences in the variances between the male and female finishers, the F test and Levene's test. The results of both these tests followed the same trend for the eight marathon races we investigated, highly significant differences for five of the eight races and highly non-significant for two of the races. The final race, the Ogden marathon, have similar results for both tests but the differences between the tests occur around the margin of our level of significance $\alpha = 0.05$; these results provide weak statistical evidence of a significant difference between the male and female race finishers as the p-values are considered non-significant at our current level of significance but would be considered significant aqt a higher level of significance. The results of the T test for the mean age graded scores and the Wilcoxon test for the median age graded scores follow the same pattern, in general, for all eight races, highly significant for three races and highly non-significant for three races. For the Philadelphia marathon, the mean age graded score is significantly different between the genders ($p = 0.0258$) but the median age graded score is not significantly different between the genders ($p = 0.1720$). For the Ogden marathon there is no significant difference for either the mean age graded score or the median age graded score between the two genders ($p = 0.0905$, $p = 0.3489$, respectively) but the p-value for the T test is only mildly non-significant as the p-value would be considered significant if we had chosen a significant level of $\alpha = 0.10$. To test the equality of the distributions of the age graded scores for the male and female finishers we performed a KS test and found that six of the eight races had statistically significant distributions between the two genders. The Air Force and the Surf City USA marathons had highly non-significant differences.

6.3.1.2. Age Results

To determine where the differences in the age graded scores between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 47, and proceeded to test these differences statistically with the results given in Table 48.

Table 47. Descriptive Statistics for Age – Marathon

Marathon	Mean		Median		Variance	
Air Force	M: 40.0	F: 37.7	M: 39.0	F: 37.0	M: 136.9	F: 116.4
Duluth	M: 39.3	F: 35.1	M: 38.0	F: 34.0	M: 155.7	F: 110.5
Los Angeles	M: 36.7	F: 34.1	M: 36.0	F: 33.0	M: 182.3	F: 153.6
Ogden	M: 39.9	F: 37.4	M: 39.0	F: 37.0	M: 105.0	F: 82.2
Philadelphia	M: 38.3	F: 34.8	M: 38.0	F: 33.0	M: 120.4	F: 91.8
San Francisco	M: 37.7	F: 35.1	M: 36.0	F: 33.0	M: 113.8	F: 95.4
Surf City	M: 42.6	F: 38.7	M: 42.0	F: 39.0	M: 134.4	F: 105.7
Twin Cities	M: 39.0	F: 34.7	M: 38.0	F: 33.0	M: 130.9	F: 91.6

The total number of male finishers is larger than the total number of female finishers for all eight of the marathons that we have examined. The mean age of the male finishers is larger than the mean age of the female finishers in all eight races. The median age of the race finishers and the variance of the ages for the race finishers both follow this same pattern. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 48. Test Results for Age – Marathon

Marathon	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Air Force	$p = 0.0023$	$p = 0.0005$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Duluth	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Los Angeles	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Ogden	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Philadelphia	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
San Francisco	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Surf City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Twin Cities	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

For all eight marathons, the variance equality assumption was not met for the Mann-Whitney-Wilcoxon test but the test results were very similar to the t-test results. The non-pooled test statistic was used for the t-test for all eight marathons examined.

All eight races that were examined were found to have statistically significant differences in the variances, means, medians, and distributions of the ages of race finishers between the male and female marathon finishers. These findings were all highly significant with all p-values less than 0.003 and the majority of the p-values less than 0.0001.

6.3.2. Half Marathon Results

We examined the differences between the male and female half marathon finishers in several ways to determine if there are any significant differences between the populations. We looked at the differences of the age graded scores between male and female race finishers and the differences of the ages between the male and female race finishers.

6.3.2.1. Age Graded Score Results

To determine where the differences in the age graded scores between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 49, and proceeded to test these differences statistically with the results given in Table 50. The statistical results were all evaluated a level of significance of $\alpha = 0.05$ to determine if the differences found in the descriptive statistics were statistically significant.

Table 49. Descriptive Statistics for Age Graded Score – Half Marathon

Half Marathon	Mean		Median		Variance	
Berkeley	M: 53.5	F: 52.0	M: 53.0	F: 52.0	M: 104.8	F: 88.3
Brooklyn	M: 55.1	F: 53.6	M: 54.7	F: 53.3	M: 76.3	F: 61.9
Capital City	M: 51.8	F: 49.7	M: 51.7	F: 49.7	M: 76.9	F: 70.4
Columbus	M: 51.2	F: 49.5	M: 51.0	F: 49.5	M: 98.1	F: 78.8
Duluth	M: 55.6	F: 52.8	M: 54.0	F: 51.9	M: 149.5	F: 91.2
Manhattan	M: 55.2	F: 54.1	M: 55.1	F: 53.7	M: 76.0	F: 68.1
New York City	M: 55.3	F: 54.0	M: 54.5	F: 53.7	M: 89.6	F: 74.4
Surf City	M: 48.8	F: 47.1	M: 48.4	F: 46.6	M: 109.4	F: 93.8

The Brooklyn half marathon and the Manhattan half marathon have a larger number of total male finishers than total female finishers but the six other races that were examined have a larger number of total female finishers than total male finishers. For all eight races, the mean age graded score for male finishers is higher than the mean age graded score for female finishers. This trend holds true for the median age graded scores and the variance for the age graded scores between the male and female half marathon finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 50. Test Results for Age Graded Score – Half Marathon

Half Marathon	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Berkeley	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p = 0.0006$
Brooklyn	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Capital City	$p = 0.0055$	$p = 0.0067$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Columbus	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Duluth	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Manhattan	$p = 0.0076$	$p = 0.0074$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
New York City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Surf City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

None of the eight half marathons examined met the equal variances assumption for the Mann-Whitney-Wilcoxon test but the test results were still very similar to the t-test results. The non-pooled test statistic was used for the t-test for all eight half marathons investigated.

All eight races that were examined were found to have significant differences in the variances, means, medians, and distributions of the age graded scores between the male and female half marathon finishers. These findings were all highly significant with all p-values less than 0.01 and the majority of the p-values less than 0.0001.

6.3.2.2. Age Results

To determine where the differences in the ages between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 51, and proceeded to test these differences statistically with the results given in Table 52. The statistical results were all evaluated a level of significance of $\alpha = 0.05$ to determine if the differences found in the descriptive statistics were statistically significant.

Table 51. Descriptive Statistics for Age – Half Marathon

Half Marathon	Mean		Median		Variance	
Berkeley	M: 36.8	F: 35.6	M: 35.0	F: 34.0	M: 110.7	F: 102.6
Brooklyn	M: 36.3	F: 33.3	M: 34.0	F: 31.0	M: 89.2	F: 66.2
Capital City	M: 38.2	F: 34.5	M: 37.0	F: 33.0	M: 123.1	F: 106.6
Columbus	M: 37.8	F: 34.3	M: 36.0	F: 33.0	M: 152.2	F: 118.2
Duluth	M: 37.3	F: 34.1	M: 35.0	F: 33.0	M: 155.9	F: 118.3
Manhattan	M: 39.8	F: 35.5	M: 38.0	F: 33.5	M: 114.4	F: 94.3
New York City	M: 38.9	F: 35.0	M: 37.0	F: 33.0	M: 105.3	F: 83.8
Surf City	M: 40.7	F: 38.6	M: 40.0	F: 38.0	M: 135.2	F: 115.9

The Brooklyn half marathon and the Manhattan half marathon have a larger number of total male finishers than total female finishers but the six other races that were examined have a larger number of total female finishers than total male finishers. For all eight races, the mean age of the male finishers is higher than the mean age of the female finishers. This trend holds true for the median age and the variance for the ages of the male and female half marathon finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 52. Test Results for Age – Half Marathon

Half Marathon	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Berkeley	$p = 0.0656$	$p = 0.0695$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Brooklyn	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Capital City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Columbus	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Duluth	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Manhattan	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
New York City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Surf City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

The assumption of equal population variances of the Mann-Whitney-Wilcoxon test was not met for the Brooklyn, Capital City, Columbus, Duluth, Manhattan, New York City, and Surf City half marathon races but the test results were still very similar to the t-test results. The pooled test statistic for the t-test was used for the Berkeley half marathon but the non-pooled test statistic for the t-test was used for all other races that were examined.

The difference between the variance of the ages of the male and female race finishers are not significant for the Berkeley half marathon but all other tests were found to be significantly different. The rest of the eight races that were examined were found to have significant differences in the variances, means, medians, and distributions of the age graded scores between the male and female half marathon finishers. These findings were all highly significant with all of the p-values less than 0.0001.

6.3.3. Ten K Results

We examined the differences between the male and female ten kilometer finishers in several ways to determine if there are any significant differences between the populations. We looked at the differences of the age graded scores between male and female race finishers and the differences of the ages between the male and female race finishers.

6.3.3.1. Age Graded Score Results

To determine where the differences in the age graded scores between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 53, and proceeded to test these differences statistically with the results given in Table 54. All the statistical results were evaluated at the significance level $\alpha = 0.05$ to make decisions.

Table 53. Descriptive Statistics for Age Graded Score – Ten Kilometer

Ten K Race	Mean		Median		Variance	
Cooper River	M: 45.6	F: 42.4	M: 46.0	F: 42.5	M: 142.2	F: 121.4
Crescent City	M: 44.4	F: 39.8	M: 44.7	F: 39.0	M: 163.6	F: 123.0
Fargo	M: 48.2	F: 46.2	M: 48.3	F: 46.3	M: 90.7	F: 77.0
Joe K	M: 55.9	F: 53.9	M: 55.7	F: 53.3	M: 85.7	F: 78.2
M Beach	M: 53.3	F: 50.9	M: 53.1	F: 51.1	M: 108.8	F: 100.3
Queens	M: 53.1	F: 50.9	M: 52.5	F: 50.5	M: 75.3	F: 57.1
Scotland Run	M: 56.3	F: 54.0	M: 55.4	F: 53.0	M: 89.9	F: 71.3
UAE	M: 54.2	F: 51.8	M: 53.7	F: 51.6	M: 89.7	F: 61.7

The total number of male finishers is larger than the total number of female finishers for half of the ten kilometer races that we investigated and the total number of female finishers was larger than the total number of male finishers for the other four races. The mean age graded score for the male ten k finishers was larger than the mean age graded score for the female finishers and this difference was the same for the median age graded scores and the variance of the age graded scores. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 54. Test Results for Age Graded Score – Ten Kilometer

Ten K Race	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Cooper River	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Crescent City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Fargo	$p = 0.0019$	$p = 0.0026$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Joe K	$p = 0.0698$	$p = 0.0827$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
M Beach	$p = 0.0926$	$p = 0.0929$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Queens	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Scotland Run	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
UAE	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

The equal population variance assumption for the Mann-Whitney-Wilcoxon test was not met for the Cooper River, Crescent City, Fargo, Queens, Scotland Run, and UAE Healthy Kidney ten kilometer races but the test results were still very similar to the t-test results. The pooled test statistic for the t-test was used for the Joe Kleinerman and Manhattan Beach ten kilometer races and the non-pooled test statistic for the t-test was used for all other ten kilometer races that were examined.

The differences between the variances for the age graded scores for the male and female ten k finishers are highly significant for six of the eight races that were examined. For the Manhattan Beach ten k the results of the F test and the Levene's test were not statistically significant when compared to the significance level of $\alpha = 0.05$ but if we had chosen a significance level of $\alpha = 0.10$ the results would be considered significantly different. The same can be shown for the results of the F test and Levene's test for the Joe Kleinerman ten kilometer race. The differences between the male and female finishers for the mean age graded score, the median age graded score, and the distributions of age graded scores by gender are highly statistically significant for all eight races with all p-values less than 0.0001.

6.3.3.2. Age Results

To determine where the differences in the ages between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 55, and proceeded to test these differences statistically with the results given in Table 56. All the statistical results were evaluated at the significance level $\alpha = 0.05$ to make decisions.

Table 55. Descriptive Statistics for Age – Ten Kilometer

Ten K Race	**Mean**		**Median**		**Variance**	
Cooper River	M: 39.5	F: 37.1	M: 38.0	F: 35.0	M: 184.9	F: 155.9
Crescent City	M: 38.6	F: 36.6	M: 37.0	F: 35.0	M: 186.5	F: 156.2
Fargo	M: 35.6	F: 36.3	M: 34.0	F: 34.0	M: 178.6	F: 132.7
Joe K	M: 40.6	F: 36.2	M: 39.0	F: 34.0	M: 121.7	F: 110.8
M Beach	M: 42.3	F: 38.8	M: 42.0	F: 38.0	M: 213.9	F: 175.8
Queens	M: 37.9	F: 34.7	M: 36.0	F: 33.0	M: 98.5	F: 79.2
Scotland Run	M: 38.2	F: 34.3	M: 36.0	F: 32.0	M: 108.0	F: 86.8
UAE	M: 38.2	F: 34.7	M: 36.0	F: 32.0	M: 109.5	F: 87.5

The total number of male finishers is larger than the total number of female finishers for half of the ten kilometer races that we investigated and the total number of female finishers was larger than the total number of male finishers for the other four races. For the Fargo ten k, the mean age for the male finishers is larger than the mean age for the female finishers, and the median age for the female finishers is equal to the median age for the male finishers. For the remaining seven ten kilometer races, the mean and median age for the male finishers are larger than the mean and median age for the female finishers. All eight races have the variance for the age of the male finishers larger than the variance for the age of the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 56. Test Results for Age – Ten Kilometer

Ten K Race	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Cooper River	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Crescent City	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Fargo	$p < 0.0001$	$p < 0.0001$	$p = 0.1975$	$p = 0.0376$	$p = 0.0163$
Joe K	$p = 0.0642$	$p = 0.0917$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
M Beach	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Queens	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Scotland Run	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
UAE	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the Cooper River, Crescent City, Fargo, Manhattan Beach, Queens, Scotland Run, and UAE Healthy Kidney ten kilometer races but the test results were still very similar to the t-test for all races except the Fargo ten kilometer race. The pooled test statistic was used for the t-test for the Joe Kleinerman ten kilometer race but the non-pooled test statistic for the t-test for all other ten kilometer races.

The differences between the variances for the age of the male and female ten k finishers are highly significant for seven of the eight races that were examined. For the Joe Kleinerman ten k the results of the F test and the Levene's test were not statistically significant when compared to the significance level of $\alpha = 0.05$ but if we had chosen a significance level of $\alpha = 0.10$ the results would be considered significantly different. The difference between the mean age for the male and female race finishers are highly statistically significant for seven of the eight races all with p-values less than 0.0001. For the Fargo ten k, the difference between the mean age for the male race finishers and the mean age for the female race finishers are highly non-significant with a p-value of 0.1975. The differences between the male and female finishers for the median age, and the distributions of age of race finishers by gender are highly statistically significant for all eight races with all p-values less than 0.04 and the majority of p-values less than 0.0001.

6.3.4. Five K Results

We examined the differences between the male and female five kilometer finishers in several ways to determine if there are any significant differences between the populations. We looked at the differences of the age graded scores between male and female race finishers and the differences of the ages between the male and female race finishers.

6.3.4.1. Age Graded Score Results

To determine where the differences in the age graded scores between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 57, and proceeded to test these differences statistically with the results given in Table 58. All the statistical results were evaluated at the significance level $\alpha = 0.05$ to make decisions.

Table 57. Descriptive Statistics for Age Graded Score – Five Kilometer

Five K Race	Mean		Median		Variance	
Boston	M: 54.8	F: 53.0	M: 54.1	F: 52.4	M: 130.7	F: 97.8
Chelsea's Run	M: 49.0	F: 46.4	M: 49.6	F: 46.6	M: 156.0	F: 128.2
Gasparilla	M: 41.9	F: 39.4	M: 41.7	F: 39.0	M: 129.1	F: 101.5
McGuire's	M: 39.6	F: 37.6	M: 39.5	F: 36.3	M: 134.1	F: 105.9
MLB All Star	M: 49.3	F: 48.4	M: 49.2	F: 48.6	M: 99.1	F: 84.4
NYRR Dash	M: 49.7	F: 49.4	M: 48.6	F: 49.1	M: 110.8	F: 86.5
OC	M: 42.4	F: 40.9	M: 42.1	F: 39.9	M: 163.4	F: 112.0
Percy Sutton	M: 54.5	F: 51.2	M: 54.4	F: 50.8	M: 107.0	F: 95.8

The total number of male finishers is larger than the total number of female finishers for the McGuire's St Patrick's Day five kilometer race but for all other races that were examined the total number of female finishers was larger than the total number of male finishers. The mean age graded score for the male finishers is larger than the mean age graded score for the female finishers for all races. This trend is constant for the median age graded score and the variance of the age graded scores for all races. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 58. Test Results for Age Graded Score – Five Kilometer

Five K Race	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Boston	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Chelsea's Run	$p = 0.0057$	$p = 0.0028$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Gasparilla	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
McGuire's	$p = 0.0001$	$p = 0.0003$	$p = 0.0008$	$p = 0.0025$	$p = 0.0008$
MLB All Star	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
NYRR Dash	$p < 0.0001$	$p < 0.0001$	$p = 0.2007$	$p = 0.5261$	$p < 0.0001$
OC	$p < 0.0001$	$p < 0.0001$	$p = 0.0102$	$p = 0.0161$	$p = 0.0035$
Percy Sutton	$p = 0.0210$	$p = 0.0285$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

All eight five kilometer races failed to meet the equal variance assumption of the Mann-Whitney-Wilcoxon test but the test results were very similar to the t-test results for all races except

McGuire's St. Patrick's Day and the NYRR Dash five kilometer races. The non-pooled test statistic for the t-test was used for all eight five kilometer races that we investigated.

For the tests of variance, the F test and Levene's test, all of the races were found to have a highly significantly difference between the variances of the male and female finishers of the five kilometer races. This result is found to be the same for the differences between the distributions of age graded scores for the male and female finishers for the five kilometer races, with all p-values less than 0.004. For the comparisons of mean age graded score and median age graded score between the male and female finishers, seven of the eight races are highly significant and the last race is highly non-significant with p-values of 0.2007 for the T test and a p-value of 0.5261 for the Wilcoxon test.

6.3.4.2. Age Results

To determine where the differences in the ages between the male and female race finishers existed, we first investigated the descriptive statistics for each race, the results can be seen in Table 59, and proceeded to test these differences statistically with the results given in Table 60. All the statistical results were evaluated at the significance level $\alpha = 0.05$ to make decisions.

Table 59. Descriptive Statistics for Age – Five Kilometer

Five K Race	**Mean**		**Median**		**Variance**	
Boston	M: 39.4	F: 36.9	M: 38.0	F: 35.0	M: 154.5	F: 129.1
Chelsea's Run	M: 36.2	F: 35.1	M: 37.0	F: 35.0	M: 216.6	F: 171.8
Gasparilla	M: 40.3	F: 38.5	M: 40.0	F: 37.0	M: 201.2	F: 166.6
McGuire's	M: 34.3	F: 33.9	M: 31.0	F: 31.0	M: 154.4	F: 138.9
MLB All Star	M: 35.5	F: 33.2	M: 34.0	F: 32.0	M: 101.1	F: 77.8
NYRR Dash	M: 39.5	F: 36.9	M: 38.0	F: 35.0	M: 133.9	F: 115.0
OC	M: 37.0	F: 37.0	M: 36.0	F: 36.0	M: 173.1	F: 170.1
Percy Sutton	M: 37.6	F: 34.6	M: 36.0	F: 32.0	M: 124.6	F: 104.9

The total number of male finishers is larger than the total number of female finishers for the McGuire's St Patrick's Day five kilometer race but for all other races that were examined the total number of female finishers was larger than the total number of male finishers. The mean and median age for the male and female finishers are equal for the OC five kilometer race. The mean age for the male finishers is larger than the mean age for the female finishers for the seven remaining races. The median age for the male and female finishers are equal for the McGuire's St Patrick's Day five kilometer race. The median age and the variance of the ages of the male finishers are larger than the median age and the variance of the ages of the female race finishers for all other races. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 60. Test Results for Age – Five Kilometer

Five K Race	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Boston	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Chelsea's Run	$p = 0.0011$	$p < 0.0001$	$p = 0.1280$	$p = 0.1753$	$p = 0.0461$
Gasparilla	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
McGuire's	$p < 0.0001$	$p < 0.0001$	$p = 0.0911$	$p = 0.3831$	$p = 0.2264$
MLB All Star	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
NYRR Dash	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
OC	$p = 0.7950$	$p = 0.7890$	$p = 0.9653$	$p = 0.7642$	$p = 0.9905$
Percy Sutton	$p = 0.0003$	$p = 0.0044$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

The equal population variance assumption for the Mann-Whitney-Wilcoxon test was not met for the Boston, Finish Chelsea's Run, Gasparilla, McGuire's St. Patrick's Day, NYRR Dash, and Percy Sutton five kilometer races but the test results were still similar to the t-test results for all races except the Finish Chelsea's Run and McGuire's St. Patrick's Day five kilometer races. The pooled test statistic for the t-test was used for the OC five kilometer race but the non-pooled test statistic for the t-test was used for all other five kilometer races that were examined.

For the tests of variance, the F test and Levene's test, seven of the eight races were found to have a highly significantly difference between the variances of the ages for the male and female finishers of the five kilometer races. For the comparisons of mean age, and median age between the male and female finishers, five of the eight races are highly significant with all p-values less than 0.0001. The results for the OC, the McGuire's St Patrick's Day, and the Finish Chelsea's Run five kilometer races are all highly non-significant with all p-values larger than 0.09 for the T test, and all p-values larger than 0.17 for the Wilcoxon test. The differences between the distributions of male and female finishers for the five kilometer races are statistically significant for six of the eight races and the other two races are highly non-significant with p-values of 0.2264 for the McGuire's St Patrick's Day five kilometer race and a p-value of 0.9905 for the OC five kilometer race.

6.4. Distance Comparisons

Having tested the distribution for each race, individually, we now wish to know if differences exist between the populations for each race distance. To do this comparison, we combined the results for all eight races at each distance (marathon, half marathon, ten kilometer, and five kilometer) and used these results to do pairwise comparisons of the distances. We compared the differences between distances individually by gender. We performed these comparisons for the age graded scores for the race finishers and for the ages of the race finishers.

6.4.1. Female Populations

We wanted to determine if there were any differences between the distributions of female finishers by race distance and where these possible distances appear, if they exist. We examined the distributions of the age graded scores for female finishers and the distributions of the ages of male race finishers for each of the four major road race distances (marathon, half marathon, ten kilometer, and five kilometer).

6.4.1.1. Age Graded Score Distributions

To make a determination as to whether or not the distributions are different across race distance, we first did a visual comparison of the age graded scores across the four major road race distances (marathon, half marathon, ten kilometer, and five kilometer) using histograms and descriptive statistics. We then tested if these differences were statistically significant by performing an analysis of variance (ANOVA) with pairwise comparisons of means followed by the same tests for distribution that we performed earlier. Figure 66 shows the histogram of the age graded scores for each race distance, Table 61 shows the descriptive statistics for the finishers by race distance, and Table 62 shows the results of the tests for distribution that were performed.

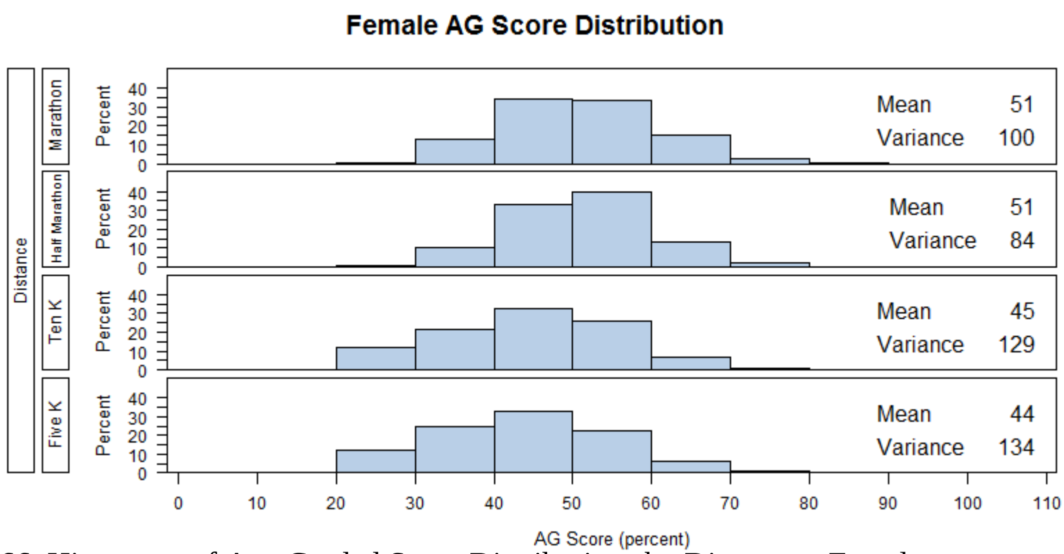

Figure 66. Histogram of Age Graded Score Distributions by Distance – Female

Visually inspecting the distribution of age graded scores, we observed that there do appear to be differences between the race distributions. The mean age graded score for the marathon and half marathon are similar (50.9 versus 51.3) and the mean age graded score for the ten kilometer and five kilometer races are similar (45 versus 44) but the scores are not similar between these two sets of distances. The variances follow a comparable pattern with the marathon and half marathon being alike (99.7 versus 84.4) and the variances of the ten kilometer and five kilometer races being alike (129.3 and 134.5) but the variances are not similar between the two groups of distances. At first glance, the shapes appear to follow the same grouping as the mean age graded scores and the variance of age graded scores with the marathon and half marathon shapes being close and the ten kilometer and five kilometer shapes being close but between the two groups the shapes don't appear to be similar. The exact differences are hard to see using visual inspection, so we performed statistical analyses to determine the true differences, the results of these analyses are discussed later in this section.

Table 61. Descriptive Statistics for AG Score by Distance – Women

Distance	Total	Mean	Median	Variance	Std Dev
Marathon	23,675	50.94	50.53	99.65	9.98
Half	46,682	51.33	51.22	84.36	9.19
Ten K	41,735	44.92	45.71	129.31	11.37
Five K	26,363	44.08	44.02	134.47	11.60

Examining the descriptive statistics for the age graded scores by race distance, we observed that the total number of finishers is similar between the marathon and five kilometer finishers and the total number of finishers is similar between the half marathon and ten kilometer finishers. As observed in the histograms, the mean age score, median age score, and variance of age graded scores are similar between the marathon and half marathon populations and between the ten kilometer and five kilometer populations but not between the two groups of distances.

In order to test the observed differences statistically, we first performed an ANOVA, using the distances as the level of comparison, followed by a comparison of the distance means, performing pairwise comparisons of all pairwise groupings of race distance means. The overall ANOVA was found to be highly significant ($p < 0.0001$) and every pairwise comparison of distance means were found to be significant (all $p < 0.05$). All determinations were done at the 95% level of significance ($\alpha = 0.05$).

Table 62. Test Results for Age Graded Score by Distance Comparison – Women

Comparison	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Full vs Half	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Full vs 10k	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Full vs 5k	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Half vs 10k	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
Half vs 5k	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
10k vs 5k	$p = 0.0004$	$p = 0.0004$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$

Once we determined which pairwise differences between distance populations were significantly different using the ANOVA analysis, we performed different tests of distributions on the significant pairwise differences. We examined the differences between the marathon and half marathon populations, the marathon and ten kilometer populations, the marathon and five kilometer populations, the half marathon and ten kilometer populations, the half marathon and five kilometer populations, and the differences between the ten kilometer and five kilometer race populations. We performed the F test, Levene's test, T test, Wilcoxon test, and KS test in order to determine the true differences between the distance populations and draw conclusions from those differences. For all differences that were considered, the results for all of the tests performed were highly significant ($p \leq 0.0004$).

6.4.1.2. Age Distributions

To make a determination as to whether or not the distributions are different across race distance, we first did a visual comparison of the ages of the race finishers across the four major road race distances (marathon, half marathon, ten kilometer, and five kilometer) using histograms and descriptive statistics. We then tested if these differences were statistically significant by performing an analysis of variance (ANOVA) with pairwise comparisons of means followed by the same tests for distribution that we performed earlier. Figure 67 shows the histogram of the race finisher's ages for each race distance, Table 63 shows the descriptive statistics for the finishers by race distance, and Table 64 shows the results of the tests for distribution that were performed.

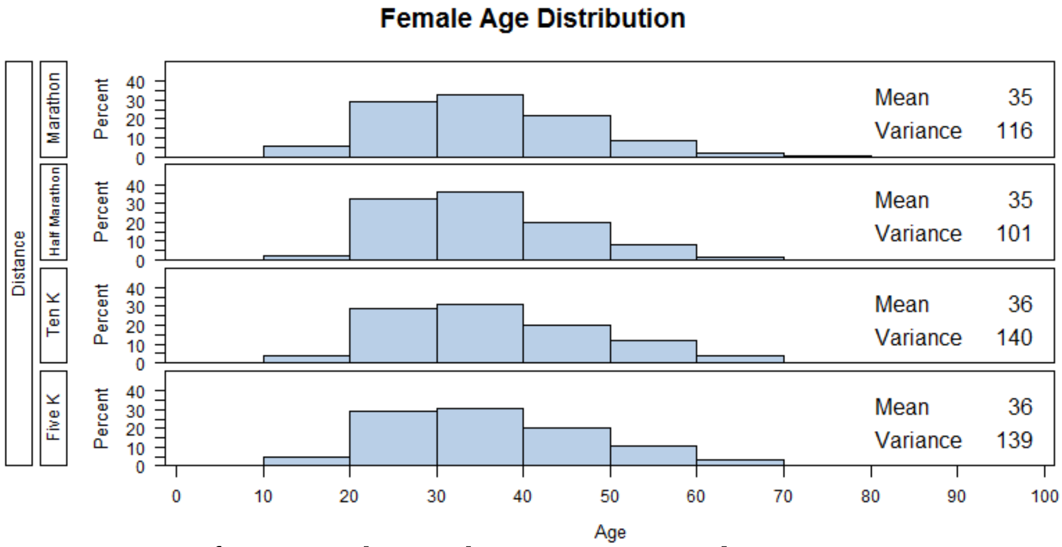

Figure 67. Histogram of Age Distributions by Distance – Female

Visually inspecting the distribution of ages of race finishers, we observed that there do appear to be slight differences between the race distributions. The mean race finisher age for the marathon and half marathon are similar (35.0 years versus 35.1 years) and the mean race finisher age for the ten k and five k races are similar (36.5 years versus 36.0 years) but the means are not as close between these two sets of distances. The variances follow a comparable pattern with the marathon and half marathon being alike (115.7 versus 100.6) and the variances of the ten kilometer and five kilometer races being alike (139.9 and 138.8) but the variances are not similar between the two groups of distances. At first glance, the shapes do not appear to follow the same grouping as the mean age and the variance of ages, with the shapes of all four race distances appear to be close and possibly similar to one another. The exact differences are hard to see using visual inspection, so we performed statistical analyses to determine the true differences, the results of these analyses are discussed later in this section.

Table 63. Descriptive Statistics for Age by Distance – Women

Distance	Total	Mean	Median	Variance	Std Dev
Marathon	23,675	35.03	34.0	115.74	10.76
Half	46,682	35.09	33.0	100.60	10.03
Ten K	41,735	36.46	34.0	139.92	11.83
Five K	26,363	35.98	34.0	138.82	11.78

Examining the descriptive statistics for the age by race distance, we observed that the total number of finishers is similar between the marathon and five kilometer finishers and the total number of finishers is similar between the half marathon and ten kilometer finishers. As observed in the histograms, the mean age and variance of ages are similar between the marathon and half marathon populations and between the ten kilometer and five kilometer populations but not between the two groups of distances. The median ages do not follow the same pattern as the means and variances, with the median ages for the marathon, the half marathon, and the five kilometer race finishers all equal to one another.

In order to test the observed differences statistically, we first performed an ANOVA, using the distances as the level of comparison, followed by a comparison of the distance means, performing pairwise comparisons of all pairwise groupings of race distance means. The overall ANOVA was found to be highly significant ($p < 0.0001$) and the comparison of the mean age for the marathon and half marathon finishers is not statistically significant ($p > 0.05$) but every other pairwise comparison of distance means were found to be significant (all $p < 0.05$). All determinations were done at the 95% level of significance ($\alpha = 0.05$).

Table 64. Test Results for Age by Distance Comparison – Women

Comparison	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Full vs Half	p < 0.0001	p < 0.0001	p = 0.4712	p = 0.8252	p < 0.0001
Full vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Full vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
10k vs 5k	p = 0.4786	p = 0.4631	p < 0.0001	p < 0.0001	p = 0.0009

Once we determined which pairwise differences between distance populations were significantly different using the ANOVA analysis, we performed different tests of distributions on the significant pairwise differences. We examined the differences between the marathon and half marathon populations, the marathon and ten kilometer populations, the marathon and five kilometer populations, the half marathon and ten kilometer populations, the half marathon and five kilometer populations, and the differences between the ten kilometer and five kilometer race populations. We performed the F test, Levene's test, T test, Wilcoxon test, and KS test in order to determine the true differences between the distance populations and draw conclusions from those differences. The differences in the variation of ages for the ten kilometer versus five kilometer race comparison is not statistically significant based on both the F test and Levene's test. The differences in the mean ages and the median ages for the marathon versus half marathon comparison is not statistically significant based on the T test and Wilcoxon's test. For all other differences that were considered, the results for all of the tests performed were highly significant ($p \leq 0.0009$).

6.4.2. Male Populations

We also wanted to determine if there were any differences between the distributions of male finishers by race distance and where these possible distances appear, if they exist. We examined the distributions of the age graded scores for male finishers and the distributions of the ages of male race finishers for each of the four major road race distances (marathon, half marathon, ten kilometer, and five kilometer).

6.4.2.1. Age Graded Score Distributions

To make a determination as to whether or not the distributions are different across race distance, we first did a visual comparison of the age graded scores across the four race distances using histograms and descriptive statistics. We then tested if these differences were statistically significant by performing an analysis of variance (ANOVA) with pairwise comparisons of means followed by the same tests for distribution that we performed earlier. Figure 68 shows the histogram of the age graded scores for each race distance, Table 65 shows the descriptive statistics for the finishers by race distance, and Table 66 shows the results of the tests for distribution that were performed.

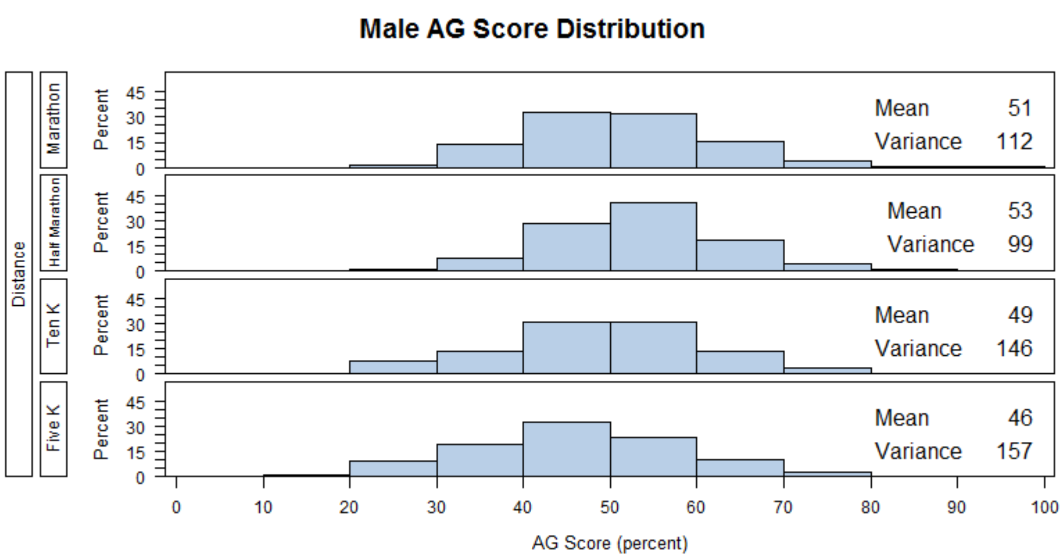

Figure 68. Histogram of Age Graded Score Distributions by Distance - Male

After visually inspecting the distributions for each race distance, we observed that the mean age graded score for the marathon finishers is similar to the mean age graded score for the half marathon finishers, the mean age graded scores for the ten kilometer race finishers, and the mean age graded score for the five kilometer race finishers with all mean age graded scores fall in the range between forty-five percent and fifty-five percent. The variances of the age graded scores do not follow the same pattern as the mean age graded scores, with the variance of age graded scores similar between the marathon and the half marathon finishers and the variance of age graded scores similar between the ten kilometer and five kilometer race finishers but no similarity between these two groups. The shapes of the distributions also appear similar across the race distances with only small possible differences between the shapes of the marathon, half marathon, and ten kilometer races and the five kilometer races. We tested these small differences between distributions statistically and discuss the results of these tests later in this section.

Table 65. Descriptive Statistics for AG Score by Distance – Men

Distance	Total	Mean	Median	Variance	Std Dev
Marathon	34,354	51.08	50.48	111.95	10.58
Half	38,664	53.47	53.16	98.74	9.94
Ten K	35,677	48.97	49.46	145.79	12.08
Five K	20,688	46.36	46.10	156.60	12.51

To further examine the differences between the race distributions, we compared the descriptive statistics for these distributions across race distance. The total number of finishers for the marathon, the half marathon, and the ten kilometer races are between thirty-four and forty thousand finishers but the number of five kilometer finishers is only around twenty-one thousand. The mean age graded score for all race distances are similar and between the age graded scores of forty-six and fifty-four percent; the median age graded scores for all distances fall into this same range. The variance for the age graded scores for the marathon and half marathon finishers are alike (111.95 versus 98.74) and the variance for the age graded scores for the ten kilometer and five kilometer are similar (145.79 versus 156.60) but between the two groups the variances are not comparable.

To determine whether differences exist, statistically, between the distributions of the races we first performed an ANOVA, using the race distances as levels for comparison, followed by a comparison of the means for each race distance, performing pairwise comparisons of all pairwise groupings of race distance means. The overall ANOVA was found to be highly significant ($p < 0.0001$) and every pairwise comparison of distance means were found to be significant (all $p < 0.05$). All determinations were done at the 95% level of significance ($\alpha = 0.05$).

Table 66. Test Results for Age Graded Score by Distance Comparison – Men

Comparison	**F Test**	**Levene's Test**	**T Test**	**Wilcoxon**	**KS Test**
Full vs Half	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Full vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Full vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
10k vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001

Once we determined which pairwise differences between distance populations were significantly different using the ANOVA analysis, we performed different tests of distributions on the significant pairwise differences. We examined the differences between the marathon and half marathon populations, the marathon and ten kilometer populations, the marathon and five kilometer populations, the half marathon and ten kilometer populations, the half marathon and five kilometer populations, and the differences between the ten kilometer and five kilometer race populations. We performed the F test, Levene's test, T test, Wilcoxon test, and KS test in order to determine the true differences between the distance populations and draw conclusions from those differences. For all differences that were considered, the results for all of the tests performed were highly significant ($p < 0.0001$).

6.4.2.2. Age Distributions

To make a determination as to whether or not the distributions are different across race distance, we first did a visual comparison of the ages of the male race finishers across the four major road race distances using histograms and descriptive statistics. We then tested if these differences were statistically significant by performing an analysis of variance (ANOVA) with pairwise comparisons of means followed by the same tests for distribution that we performed earlier. Figure 69 shows the histogram of the race finisher's ages for each race distance, Table 67 shows the descriptive statistics for the finishers by race distance, and Table 68 shows the results of the tests for distribution that were performed.

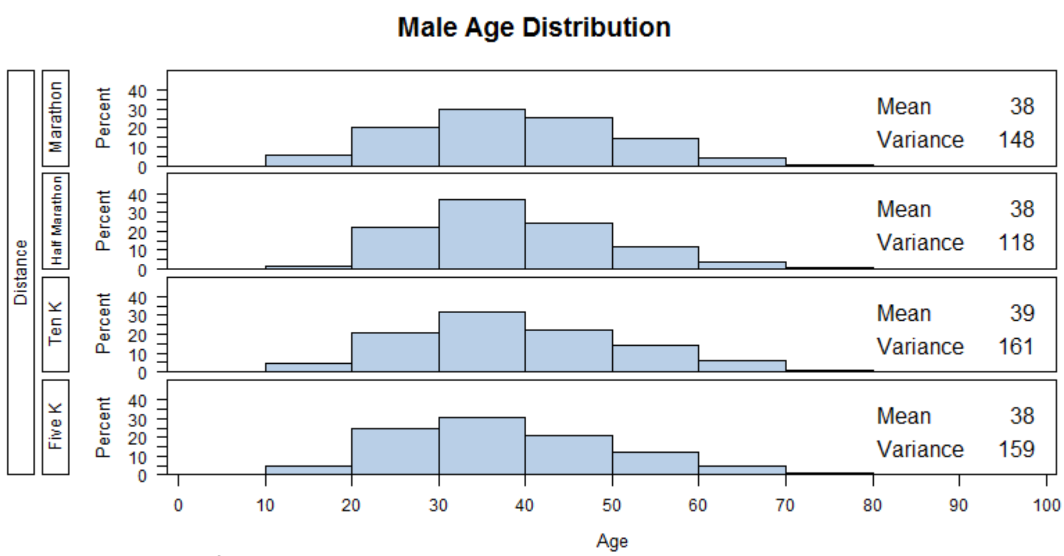

Figure 69. Histogram of Age Distributions by Distance – Male

After visually inspecting the distributions for each race distance, we observed that the mean age graded score for the marathon finishers is similar to the mean age for the half marathon finishers, the mean age for the ten kilometer race finishers, and the mean age graded score for the five kilometer race finishers with all mean ages falling in the range between thirty-seven and thirty-nine years old. The variances of age of race finishers do not follow the same pattern as the mean age of race finishers, with the variance of age similar between the marathon, the ten kilometer, and five kilometer race finishers but no similarity between these variances and the variance of age for the half marathon finishers. The shapes of the distributions also appear similar across the race distances with only small possible differences between the shapes of the marathon, half marathon, and ten kilometer races and the five kilometer races. We tested these small differences between distributions statistically and discuss the results of these tests later in this section.

Table 67. Descriptive Statistics for Age by Distance – Men

Distance	Total	Mean	Median	Variance	Std Dev
Marathon	34,354	38.23	37.0	147.99	12.17
Half	38,664	38.11	36.0	118.47	10.89
Ten K	35,677	38.96	37.0	160.74	12.68
Five K	20,688	37.52	36.0	159.22	12.62

To further examine the differences between the race distributions, we compared the descriptive statistics for these distributions across race distance. The total number of finishers for the marathon, the half marathon, and the ten kilometer races are between thirty-four and thirty-nine thousand finishers but the number of five kilometer finishers is only around twenty-one thousand. The mean age graded score for all race distances are similar and between the ages of thirty-seven and thirty-nine years; the median ages for all distances fall into the range of thirty-six and thirty-seven. The variance for the ages for the marathon, ten kilometer, and five kilometer race finishers are similar (147.99 versus 160.74 versus 159.22) but the variance for the ages of the half marathon finishers (118.47) is not comparable to this group.

In order to test the observed differences statistically, we first performed an ANOVA, using the distances as the level of comparison, followed by a comparison of the distance means, performing pairwise comparisons of all pairwise groupings of race distance means. The overall ANOVA was found to be highly significant ($p < 0.0001$) and the comparison of the mean age for the marathon and half marathon finishers is not statistically significant ($p > 0.05$) but every other pairwise comparison of distance means were found to be significant (all $p < 0.05$). All determinations were done at the 95% level of significance ($\alpha = 0.05$).

Table 68. Test Results for Age by Distance Comparison – Men

Comparison	F Test	Levene's Test	T Test	Wilcoxon	KS Test
Full vs Half	p < 0.0001	p < 0.0001	p = 0.1422	p = 0.0145	p < 0.0001
Full vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Full vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 10k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
Half vs 5k	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
10k vs 5k	p = 0.4444	p = 0.4244	p < 0.0001	p < 0.0001	p < 0.0001

Once we determined which pairwise differences between distance populations were significantly different using the ANOVA analysis, we performed different tests of distributions on the significant pairwise differences. We examined the differences between the marathon and half marathon populations, the marathon and ten kilometer populations, the marathon and five kilometer populations, the half marathon and ten kilometer populations, the half marathon and five kilometer populations, and the differences between the ten kilometer and five kilometer race populations. We performed the F test, Levene's test, T test, Wilcoxon test, and KS test in order to determine the true differences between the distance populations and draw conclusions from those differences. The differences in the variation of ages for the ten kilometer versus five kilometer race comparison is not statistically significant based on both the F test and Levene's test, and the differences in the mean ages for the marathon versus half marathon comparison is not statistically significant based on the T test. For all other differences that were considered, the results for all of the tests performed were highly significant ($p \leq 0.0145$).

6.5. Meta-Analysis

Having performed statistical tests to find differences between male and female race finishers for each race individually, we wanted to combine the results in order to draw conclusions for each race distance. To accomplish this task, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results; the test for proportions of less than or equal to forty percent was converted to answer the alternative hypothesis of female results larger than male results; these conversions were performed for every statistical test. After the p-values were converted, we performed a meta-analysis to combine the p-values of the three qualifying marathons using Stouffer's weighted Z-score method for combining the p-values. For ease of computation, we used a p-value of 0.00009 for all p-values less than 0.0001 and a p-value of 0.99999 for all p-values equal to 1.000 that appeared in the test results.

Table 69. Meta-Analysis for Marathon Results

	Age Graded Scores		Ages	
Variable	**Z value**	**P value: M > F**	**Z value**	**P value: M > F**
Proportions				
60%	5.678	$p < 0.0001$	NA	NA
70%	6.687	$p < 0.0001$	NA	NA
40%*	-1.106	$p = 0.8656$	NA	NA
Variances				
F Test	7.545	$p < 0.0001$	8.533	$p < 0.0001$
Levene's Test	7.558	$p < 0.0001$	8.585	$p < 0.0001$
Means	5.158	$p < 0.0001$	8.626	$p < 0.0001$
Medians	4.501	$p < 0.0001$	8.626	$p < 0.0001$
Distributions	2.248	$p = 0.0123$	-7.079	$p = 1.0000$

*40% proportions were tested for males less than females

The results for all marathons included in this paper were combined in order to determine if the individual hypotheses held for the larger population of marathon finishers; we used the combined data for the eight non-major marathons to examine the variables age graded score and age of race finisher. For the variable age graded scores, there is no statistical evidence that the proportion of race finishers with an age graded score of forty percent or lower for female runners is larger than the proportion of race finishers with an age graded score of forty percent or lower for male runners. All other tests produce highly significant results with p-values less than 0.0001 which means that the mean, median, and variance of age graded scores and ages for male finishers are significantly larger than the mean, median, and variance of age graded scores and ages for female finishers. We can also say that the distributions of age graded scores and ages for male finishers is significantly different, and significantly larger, than the distributions of age graded scores and ages for female finishers.

Table 70. Meta-Analysis for Half Marathon Results

	Age Graded Scores		**Ages**	
Variable	**Z value**	**P value: M > F**	**Z value**	**P value: M > F**
Proportions				
60%	9.434	p < 0.0001	NA	NA
70%	9.235	p < 0.0001	NA	NA
40%*	5.381	p < 0.0001	NA	NA
Variances				
F Test	9.045	p < 0.0001	9.172	p < 0.0001
Levene's Test	9.031	p < 0.0001	9.168	p < 0.0001
Means	9.434	p < 0.0001	9.434	p < 0.0001
Medians	9.434	p < 0.0001	9.434	p < 0.0001
Distributions	-3.266	p = 0.9995	-4.957	p = 1.0000
Distributions: F > M		p = 0.0005		p < 0.0001

*40% proportions were tested for males less than females

The results for all half marathons included in this paper were combined in order to determine if the individual hypotheses held for the larger population of half marathon finishers. The results of the meta-analysis for the combined half marathon finishers are all highly significant with p-values less than 0.0001. As a results we can easily see that the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for male runners are significantly higher than the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for female runners. For the proportion of finishers with an age graded score of forty percent or lower, the proportion of female finishers is significantly higher than the proportion of male finishers. We can also see that the mean, median, and variance of age graded scores and ages for male finishers are significantly larger than the mean, median, and variance of age graded scores and ages for female finishers. We can also say that the distributions of age graded scores and ages for female finishers are significantly different from, and significantly larger than, the distributions of age graded scores and ages for male finishers.

Table 71. Meta-Analysis for Ten Kilometer Results

	Age Graded Scores		Ages	
Variable	**Z value**	**P value: M > F**	**Z value**	**P value: M > F**
Proportions				
60%	7.757	$p < 0.0001$	NA	NA
70%	7.586	$p < 0.0001$	NA	NA
40%*	6.594	$p < 0.0001$	NA	NA
Variances				
F Test	7.343	$p < 0.0001$	7.598	$p < 0.0001$
Levene's Test	7.329	$p < 0.0001$	7.585	$p < 0.0001$
Means	7.757	$p < 0.0001$	7.289	$p < 0.0001$
Medians	7.757	$p < 0.0001$	7.601	$p < 0.0001$
Distributions	-0.121	$p = 0.5482$	-1.009	$p = 0.8436$

*40% proportions were tested for males less than females

The results for all ten kilometer races included in this paper were combined in order to determine if the individual hypotheses held for the larger population of ten kilometer finishers. The results of the meta-analysis for the combined ten kilometer race finishers are all highly significant with p-values less than 0.0001. As a results we can easily see that the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for male runners are significantly higher than the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for female runners. For the proportion of finishers with an age graded score of forty percent or lower, the proportion of female finishers is significantly higher than the proportion of male finishers. We can also see that the mean, median, and variance of age graded scores and ages for male finishers are significantly larger than the mean, median, and variance of age graded scores and ages for female finishers. We have no statistical evidence that the distributions of age graded scores and ages for male finishers are significantly different from, and significantly larger than, the distributions of age graded scores and ages for female finishers.

Table 72. Meta-Analysis for Five Kilometer Results

	Age Graded Scores		Ages	
Variable	**Z value**	**P value: M > F**	**Z value**	**P value: M > F**
Proportions				
60%	9.088	p < 0.0001	NA	NA
70%	7.424	p < 0.0001	NA	NA
40%*	4.603	p < 0.0001	NA	NA
Variances				
F Test	8.732	p < 0.0001	8.671	p < 0.0001
Levene's Test	8.619	p < 0.0001	8.590	p < 0.0001
Means	7.715	p < 0.0001	7.272	p < 0.0001
Medians	6.699	p < 0.0001	6.781	p < 0.0001
Distributions	3.123	p = 0.0009	-0.475	p = 0.6827

*40% proportions were tested for males less than females

The results for all five kilometer races included in this paper were combined in order to determine if the individual hypotheses held for the larger population of five kilometer finishers. The results of the meta-analysis for the combined five kilometer race finishers are all highly significant with p-values less than 0.0001. As a results we can easily see that the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for male runners are significantly higher than the proportion of finishers with an age graded score of sixty percent or higher and seventy percent or higher for female runners. For the proportion of finishers with an age graded score of forty percent or lower, the proportion of female finishers is significantly higher than the proportion of male finishers. We can also see that the mean, median, and variance of age graded scores and ages for male finishers are significantly larger than the mean, median, and variance of age graded scores and ages for female finishers. We can also say that the distributions of age graded scores for male finishers is significantly different, and significantly larger, than the distributions of age graded scores for female finishers; there is no statistical evidence that the distribution of ages is significantly different between the male and female race finishers.

6.6. Age Group Analysis

To further examine the differences between the populations of male and female distance runners, we chose to look at the distribution of male and female finishers grouped by age groups. We defined our age groups to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99.

6.6.1. Marathon Race Results

To explore the differences that exist between the male and female marathon finishers, we employed several techniques, both statistical and visual. We first tested the proportion of male and female marathon finishers, then we visually inspect the descriptive statistics of the age graded scores, finally we ran several statistical tests to determine if the distribution of age graded scores was equal for the male and female marathon finishers. Each of these tests were conducted for the individual age groups, as we defined them previously, for each individual race we examined in this paper.

6.6.1.1. United States Air Force Marathon

The Air Force Marathon was run on Saturday, September 21, 2013 at Wright-Patterson Air Force Base near Dayton, OH [Running USA 2014]. There were 3,297 total finishers, made up of 2,232 male finishers and 1,065 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 73. Proportion of Air Force Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.25%	P_F = 0.75%	p < 0.0001	p = 0.1959
20 - 29	P_M = 20.65%	P_F = 26.48%		p = 0.0010
30 - 39	P_M = 28.23%	P_F = 30.33%		p = 0.2936
40 - 49	P_M = 27.46%	P_F = 27.32%		p = 0.9427
50 - 59	P_M = 16.53%	P_F = 12.02%		p = 0.0018
60 - 69	P_M = 6.20%	P_F = 2.72%		p = 0.0015
70 - 79	P_M = 0.67%	P_F = 0.38%		p = 0.2944

All age groups for the Air Force marathon had a large enough sample size to use Pearson's chi-square to find the appropriate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 50 – 59, and 60 – 69 year old age groups. For the 1 – 19, 30 – 39, 40 – 49, and 70 – 79 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 74. Air Force Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 21.43%	P_F = 25.00%	p = 1.0000
20 - 29	P_M = 13.88%	P_F = 9.57%	p = 0.0821
30 - 39	P_M = 10.48%	P_F = 8.67%	p = 0.3757
40 - 49	P_M = 17.29%	P_F = 17.53%	p = 0.9309
50 - 59	P_M = 20.87%	P_F = 26.56%	p = 0.1825
60 - 69	P_M = 25.00%	P_F = 48.28%	p = 0.0141
70 - 79	P_M = 33.33%	P_F = 50.00%	p = 0.5392

The 1 – 19 and 70 – 79 year old age groups had at least one cell in the contingency table with an expected frequency of five or less so we used Fisher's exact test to find the accurate p-value. All other age groups were sufficiently large enough to use Pearson's chi-square test to find the appropriate p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 60 – 69 year old age group. The 20 – 29 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 30 – 39, 40 – 49, 50 – 59, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 75. Air Force Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 14.29%	P_F = 50.00%	p = 0.0538
20 - 29	P_M = 24.51%	P_F = 27.66%	p = 0.3407
30 - 39	P_M = 22.86%	P_F = 23.53%	p = 0.8157
40 - 49	P_M = 13.38 %	P_F = 11.68%	p = 0.4770
50 - 59	P_M = 11.92%	P_F = 5.47%	p = 0.0381
60 - 69	P_M = 6.90%	P_F = 0.00%	p = 0.3579
70 - 79	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 60 – 69 year old age groups there was at least one cell of the contingency table that had a value of five or lower so the Fisher's exact test was used to find the appropriate p-value. The 70 – 79 year old age group did not have enough data to perform a test of proportions.

All other age groups had a sufficiently large enough sample size to use Pearson's chi-square to find the appropriate p-value.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19 year old age group. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 50 – 59 year old age group. For the 20 – 29, 30 – 39, 40 – 49, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 76. Air Force Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 28	F: 8	M: 50.0	F: 47.8	M: 48.6	F: 44.0	M: 103.4	F: 141.1
20 - 29	M: 461	F: 282	M: 48.3	F: 46.5	M: 47.0	F: 45.7	M: 110.6	F: 84.3
30 - 39	M: 630	F: 323	M: 47.6	F: 47.1	M: 46.9	F: 46.5	M: 87.1	F: 78.9
40 - 49	M: 613	F: 291	M: 50.7	F: 51.2	M: 50.3	F: 50.8	M: 89.5	F: 81.9
50 - 59	M: 369	F: 128	M: 51.5	F: 54.0	M: 51.2	F: 53.0	M: 95.1	F: 94.4
60 - 69	M: 116	F: 29	M: 52.6	F: 60.2	M: 52.1	F: 59.2	M: 83.4	F: 135.3
70 - 79	M: 15	F: 4	M: 55.0	F: 60.1	M: 53.3	F: 60.9	M: 99.9	F: 17.1

For the 1 – 19 and the 20 – 29 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers but the variance for the female finishers is larger than the variance for the male finishers for the 1 – 19 age group and the variance for the male finishers is larger than the variance for the female finishers for the 20 – 29 age group. For the 30 – 39 and the 40 – 49 year old age groups, the mean and median age graded scores for the male and female finishers are very close, less than 0.5 percent different, and the variance for the age graded scores for the male finishers is larger than the variance for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the male finishers. The variances for the 50 – 59 and the 70 – 79 year old age groups are larger for the male finishers than for the female finishers but the variance of the age graded scores for the 60 – 69 year old age group follows the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 77. Air Force Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.5196	p = 0.6294	p = 0.5953	p = 0.4581	p = 0.4055
20 - 29	p = 0.0129	p = 0.0112	p = 0.0125	p = 0.0400	p = 0.0730
30 - 39	p = 0.3129	p = 0.2800	p = 0.4240	p = 0.4967	p = 0.7265
40 - 49	p = 0.3877	p = 0.3620	p = 0.4895	p = 0.4680	p = 0.4092
50 - 59	p = 0.9764	p = 0.9163	p = 0.0138	p = 0.0212	p = 0.0449
60 - 69	p = 0.0796	p = 0.0329	p = 0.0002	p = 0.0029	p = 0.0229
70 - 79	p = 0.1724	p = 0.1415	p = 0.3402	p = 0.3421	p = 0.3302

The assumption of equal variances for the Mann-Whitney-Wilcoxon test was not met for the 20 – 29 and 60 – 69 year old age groups but the test results were still similar to the t-test results. The pooled test statistic was used for the t-test for the 1 – 19, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups and the non-pooled test statistic was used for the t-test for the 20 – 29 year old age group.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. The tests results for the 60 – 69 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 20 –

29, the 50 – 59, and the 60 – 69 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.1.2. Grandma's Marathon (Duluth)

Grandma's Marathon was run on Saturday, June 22, 2013 in Duluth, MN [Running USA 2014]. There were 5,618 total finishers, made up of 3,275 male finishers and 2,343 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 78. Proportion of Duluth Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	$P_M = 2.90\%$	$P_F = 3.07\%$	$p < 0.0001$	$p = 0.0001$
20 - 29	$P_M = 22.29\%$	$P_F = 32.01\%$		$p < 0.0001$
30 - 39	$P_M = 27.79\%$	$P_F = 32.91\%$		$p = 0.0005$
40 - 49	$P_M = 23.88\%$	$P_F = 21.55\%$		$p = 0.0727$
50 - 59	$P_M = 16.70\%$	$P_F = 8.54\%$		$p < 0.0001$
60 - 69	$P_M = 5.68\%$	$P_F = 1.75\%$		$p < 0.0001$
70 - 79	$P_M = 0.76\%$	$P_F = 0.17\%$		$p = 0.0023$

All age group had a sufficiently large enough sample size to use Pearson's chi-square test to find the appropriate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 40 – 49 year old age group there is weak statistical evidence of a significant difference between the male and female proportions of race finishers as the p-value is not significant at our chosen level of significance, 0.05, but would be significant if we chose a larger level of significance.

Table 79. Duluth Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 48.42%	P_F = 16.67%	$p < 0.0001$
20 - 29	P_M = 27.26%	P_F = 19.73%	$p = 0.0006$
30 - 39	P_M = 30.00%	P_F = 26.85%	$p = 0.1540$
40 - 49	P_M = 33.25%	P_F = 39.60%	$p = 0.0202$
50 - 59	P_M = 46.98%	P_F = 47.50%	$p = 0.9004$
60 - 69	P_M = 45.70%	P_F = 65.85%	$p = 0.0195$
70 - 79	P_M = 36.00%	P_F = 100%	$p = 0.0301$

For the 70 – 79 year old age group there is at least one cell in the contingency table with an expected value of five or less so we used the Fisher's exact test to find the appropriate p-value. All other age groups had a sufficiently large enough sample size to use the Pearson's chi-square test to find the appropriate p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 40 – 49, 60 – 69, and 70 – 79 year old age groups. The 1 – 19 and 20 – 29 year old age group results show strong statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 30 – 39 and 50 – 59 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 80. Duluth Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 3.16%	P_F = 9.72%	p = 0.1021
20 - 29	P_M = 5.75%	P_F = 4.40%	p = 0.2353
30 - 39	P_M = 6.92%	P_F = 4.54%	p = 0.0377
40 - 49	P_M = 4.22 %	P_F = 2.77%	p = 0.1764
50 - 59	P_M = 2.74%	P_F = 1.50%	p = 0.4261
60 - 69	P_M = 1.61%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 19, 50 – 59, and 60 – 69 year old age groups had at least one cell in the contingency table with an expected value of five or lower so we used Fisher's exact test to find the accurate p-value. There is not enough information to perform a test of proportions for the 70 – 79 year old age group. All other age groups were sufficiently large enough to use Pearson's chi-square test to find the accurate p-value.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 30 – 39 year old age group. For the 1 – 19, 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 81. Duluth Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 95	F: 72	M: 58.9	F: 51.7	M: 59.6	F: 51.3	M: 126.9	F: 78.4
20 - 29	M: 730	F: 750	M: 54.8	F: 53.2	M: 53.0	F: 52.9	M: 123.3	F: 76.1
30 - 39	M: 910	F: 771	M: 55.1	F: 54.4	M: 53.9	F: 53.7	M: 124.1	F: 81.6
40 - 49	M: 782	F: 505	M: 56.3	F: 57.4	M: 56.2	F: 56.9	M: 91.2	F: 83.3
50 - 59	M: 547	F: 200	M: 59.3	F: 60.4	M: 59.5	F: 59.4	M: 98.4	F: 96.7
60 - 69	M: 186	F: 41	M: 59.4	F: 65.4	M: 59.7	F: 64.3	M: 100.3	F: 104.9
70 - 79	M: 25	F: 4	M: 57.4	F: 76.5	M: 57.3	F: 77.3	M: 97.1	F: 24.0

For the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups in this race, the mean and median age graded score and the variance for the age graded scores for male finishers is larger than the mean and median age graded score and the variance for the age graded scores for the female finishers. For the 40 – 49 and 50 – 59 year old age groups, the mean age graded score for the female finishers is larger than the mean age graded score for the male finishers, the median age graded scores for the male and female finishers are very close, less than one percent different, and the variance of the age graded scores for the male finishers is larger than the variance for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the male finishers. The variances for the 70 – 79 year old age groups are larger for the male finishers than for the female finishers but the variances of the age graded scores for the 60 – 69 year old age group follows the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 82. Duluth Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.0342$	$p = 0.0498$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.0024$	$p = 0.0646$	$p = 0.0075$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p = 0.1847$	$p = 0.5446$	$p = 0.0029$
40 - 49	$p = 0.2720$	$p = 0.2803$	$p = 0.0408$	$p = 0.0404$	$p = 0.0531$
50 - 59	$p = 0.8972$	$p = 0.8481$	$p = 0.1701$	$p = 0.2644$	$p = 0.4454$
60 - 69	$p = 0.8113$	$p = 0.9126$	$p = 0.0006$	$p = 0.0021$	$p = 0.0384$
70 - 79	$p = 0.2750$	$p = 0.1409$	$p = 0.0008$	$p = 0.0040$	$p = 0.0154$

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, and 30 – 39 year old age groups and the test results were not similar to the t-test except for the 1 – 19 year old age group. The pooled test statistic for the t-test was used for the 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups but the non-pooled test statistic for the t-test was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The test of the difference between the mean age graded score and test of the difference between the median age graded score are not statistically significant for the 30 – 39 and the 50 – 59 year old age groups. The test for equal distributions of age graded scores for male and female finishers is not statistically significant for the 30 – 39 year old age group. The results for the 20 – 29 year old age group are significant for the test of the difference between the mean age graded scores and the test for equal distributions of the age graded scores for the male and female finishers but are not significant for the test of the difference between the median age graded scores for the male and female finishers. The results for the 40 – 49 year old age group are significant for the test of the difference between the mean age graded scores and the test of the difference between the median age graded scores for the male and female finishers but are not significant for the test for equal distributions of the age graded scores for the male and female finishers. All other age groups were statistically significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores.

6.6.1.3. Asics Los Angeles Marathon

The Los Angeles Marathon was run on Sunday, March 17, 2013 in Los Angeles, CA [Running USA 2014]. There were 18,691 total finishers, made up of 11,287 male finishers and 7,404 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 83. Proportion of Los Angeles Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 13.39%	P_F = 14.59%	p < 0.0001	p = 0.0312
20 - 29	P_M = 18.64%	P_F = 24.50%		p < 0.0001
30 - 39	P_M = 26.83%	P_F = 28.54%		p = 0.0291
40 - 49	P_M = 23.37%	P_F = 20.04%		p < 0.0001
50 - 59	P_M = 12.49%	P_F = 9.41%		p < 0.0001
60 - 69	P_M = 4.12%	P_F = 2.47%		p < 0.0001
70 - 79	P_M = 1.05%	P_F = 0.43%		p < 0.0001
80 - 99	P_M = 0.12%	P_F = 0.01%		p = 0.0130

All age groups have a sufficiently large enough sample size to use Pearson's chi-square test to determine the appropriate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for all age groups.

Table 84. Los Angeles Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 5.16%	P_F = 1.67%	p < 0.0001
20 - 29	P_M = 7.37%	P_F = 4.91%	p = 0.0015
30 - 39	P_M = 9.21%	P_F = 5.40%	p < 0.0001
40 - 49	P_M = 12.81%	P_F = 13.61%	p = 0.4655
50 - 59	P_M = 16.10%	P_F = 17.65%	p = 0.3691
60 - 69	P_M = 13.55%	P_F = 20.77%	p = 0.0226
70 - 79	P_M = 11.02%	P_F = 31.25%	p = 0.0104
80 - 99	P_M = 7.69%	P_F = 100%	p = 0.1429

For the 70 – 79 and 80 – 99 year old age groups there is at least one cell of the contingency table with an expected value of five or less so we used Fisher's exact test to determine the p-value. All other age groups had a sufficiently large enough sample size to use Pearson's chi-square test to determine the p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 60 – 69 and 70 - 79 year old age groups. The 1 – 19, 20 – 29, and 30 – 39 year old age groups show very strong statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 40 – 49, 50 – 59, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 85. Los Angeles Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 34.75%	P_F = 46.02%	$p < 0.0001$
20 - 29	P_M = 34.51%	P_F = 33.08%	$p = 0.3457$
30 - 39	P_M = 30.05%	P_F = 31.33%	$p = 0.3282$
40 - 49	P_M = 22.29 %	P_F = 21.83%	$p = 0.7345$
50 - 59	P_M = 18.51%	P_F = 16.07%	$p = 0.1671$
60 - 69	P_M = 24.73%	P_F = 6.56%	$p < 0.0001$
70 - 79	P_M = 20.34%	P_F = 0.00%	$p = 0.0024$
80 - 99	P_M = 7.69%	P_F = 0.00%	$p = 1.0000$

The 80 – 99 age group has at least one cell of the contingency table with an expected count of five or lower so we used Fisher's exact test to find the accurate p-value. All other age groups had a large enough sample size to use Pearson's chi-square test to find the accurate p-value.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19 year old age group. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 60 – 69 and 70 – 79 year old age groups. For the 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 86. Los Angeles Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 1511	F: 1080	M: 44.5	F: 41.5	M: 43.3	F: 40.7	M: 79.0	F: 47.2
20 - 29	M: 2104	F: 1814	M: 44.9	F: 44.4	M: 44.0	F: 43.5	M: 106.0	F: 77.9
30 - 39	M: 3028	F: 2113	M: 45.9	F: 45.0	M: 45.0	F: 44.3	M: 102.5	F: 80.9
40 - 49	M: 2638	F: 1484	M: 48.2	F: 48.5	M: 47.6	F: 47.7	M: 103.3	F: 100.4
50 - 59	M: 1410	F: 697	M: 49.3	F: 50.3	M: 48.6	F: 49.4	M: 100.1	F: 110.0
60 - 69	M: 465	F: 183	M: 48.0	F: 53.0	M: 47.4	F: 51.3	M: 104.7	F: 97.3
70 - 79	M: 118	F: 32	M: 47.1	F: 56.8	M: 46.2	F: 54.3	M: 78.8	F: 91.7
80 - 99	M: 13	F: 1	M: 50.6	F: 60.6	M: 48.6	F: 60.6	M: 74.2	F: NA

For the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. For the 40 – 49 and the 70 – 79 year old age groups, the variance for the age graded scores for the female finishers is larger than the variance for the male finishers. For all other age groups in this marathon, the variance of the age graded scores for the male finishers is larger than the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 87. Los Angeles Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.0946$	$p = 0.4354$	$p = 0.0699$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p = 0.0008$	$p = 0.0077$	$p = 0.0009$
40 - 49	$p = 0.5356$	$p = 0.5216$	$p = 0.4471$	$p = 0.6422$	$p = 0.6026$
50 - 59	$p = 0.1474$	$p = 0.1489$	$p = 0.0225$	$p = 0.0955$	$p = 0.2226$
60 - 69	$p = 0.5705$	$p = 0.5667$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
70 - 79	$p = 0.5541$	$p = 0.6944$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
80 - 99	NA	NA	$p = 0.2849$	$p = 0.2148$	$p = 0.4074$

The equal variance assumption for the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, and 30 – 39 year old age groups but the test results were still very similar to the t-test for all of these age groups except the 20 – 29 year old age group. The pooled test statistic was used for the t-test for the 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups but the non-pooled test statistic was used for the t-test for the 1 – 19, 20 – 29, and 30 – 39 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly statistically significant for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups based on both the F and Levene's test results with all p-values less than 0.0001. All other age groups are highly non-significant for both tests. The difference between the mean age graded score, the difference between the median age graded score, and the test for equal distributions of the age graded scores for male and female race finishers are statistically significant for the 1 – 19, the 30 – 39, the 60 – 69, and the 70 – 79 year old age groups. The 50 – 59 year old age group is significant for the test for the difference between the mean age graded scores and non-significant for the test of the difference between the median age graded scores and for the test for equal distributions of the age graded scores for male and female race finishers. All other age groups were highly non-significant for all three statistical tests.

6.6.1.4. Zions Bank Ogden Marathon

The Ogden Marathon was run on Saturday, May 18, 2013 in Ogden, UT [Running USA 2014]. There were 2,530 total finishers, made up of 1,322 male finishers and 1,208 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 88. Proportion of Ogden Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.74%	P_F = 1.32%	p < 0.0001	p = 0.4007
20 - 29	P_M = 12.71%	P_F = 16.89%		p = 0.0062
30 - 39	P_M = 38.96%	P_F = 45.94%		p = 0.0069
40 - 49	P_M = 28.67%	P_F = 25.17%		p = 0.0903
50 - 59	P_M = 13.84%	P_F = 8.86%		p = 0.0002
60 - 69	P_M = 3.71%	P_F = 1.66%		p = 0.0018
70 - 79	P_M = 0.38%	P_F = 0.17%		p = 0.3098

The 70 – 79 year old age group had at least one cell in the contingency table with an expected value of five or lower so we used Fisher's exact test to determine the p-value; all other age groups had a large enough sample size to use Pearson's chi-square test to determine the p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 50 – 59, and 60 – 69 year old age groups. For the 1 – 19, and 70 – 79 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The p-value for the 40 – 49 year old age group shows that there is weak statistical evidence of a significant difference between the male and female proportions of race finishers as the value is larger than the level of significance chosen for this paper but would be significant at a different level of significance.

Table 89. Ogden Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 8.70%	P_F = 6.25%	p = 1.0000
20 - 29	P_M = 16.67%	P_F = 15.69%	p = 0.7981
30 - 39	P_M = 18.06%	P_F = 21.26%	p = 0.1883
40 - 49	P_M = 24.01%	P_F = 32.57%	p = 0.0131
50 - 59	P_M = 32.24%	P_F = 47.66%	p = 0.0090
60 - 69	P_M = 40.82%	P_F = 50.00%	p = 0.4851
70 - 79	P_M = 20.00%	P_F = 0.00%	p = 1.0000

For the 1 – 19 and 70 – 79 year old age groups, there was at least one cell in the contingency table with an expected cell count of five or lower so we used Fisher's exact test to determine the accurate p-value. All other age groups had a sufficiently large sample size to use Pearson's chi-square test to determine the accurate p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 40 – 49 and 50 – 59 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 90. Ogden Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 4.35%	P_F = 25.00%	p = 0.1387
20 - 29	P_M = 11.90%	P_F = 9.31%	p = 0.4169
30 - 39	P_M = 7.38%	P_F = 5.59%	p = 0.2328
40 - 49	P_M = 5.80 %	P_F = 1.64%	p = 0.0056
50 - 59	P_M = 2.73%	P_F = 0.00%	p = 0.1617
60 - 69	P_M = 0.00%	P_F = 0.00%	NA
70 - 79	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 1 and 50 – 59 year old age groups had at least one cell in the contingency table with an expected value of five or less so we used Fisher's exact test to find the appropriate p-value. For the 60 – 69 and 70 – 79 there is not enough data to properly conduct a test of proportions. All other age groups had a sufficiently large enough sample size to use Pearson's chi-square test to find the appropriate p-value.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 40 – 49 year old age group. For the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 91. Ogden Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 23	F: 16	M: 52.5	F: 45.7	M: 52.1	F: 44.9	M: 49.4	F: 48.3
20 - 29	M: 168	F: 204	M: 50.9	F: 50.6	M: 50.3	F: 49.9	M: 101.6	F: 70.2
30 - 39	M: 515	F: 555	M: 52.2	F: 53.4	M: 52.4	F: 53.3	M: 79.4	F: 67.4
40 - 49	M: 379	F: 304	M: 53.9	F: 56.0	M: 53.7	F: 56.2	M: 78.8	F: 65.4
50 - 59	M: 183	F: 107	M: 55.5	F: 59.7	M: 54.0	F: 59.4	M: 77.9	F: 67.0
60 - 69	M: 49	F: 20	M: 58.1	F: 63.1	M: 57.6	F: 60.6	M: 64.1	F: 66.2
70 - 79	M: 5	F: 2	M: 54.5	F: 57.0	M: 51.7	F: 57.0	M: 61.6	F: 9.3

For the 1 – 19 and the 20 – 29 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. The variance for the 60 – 69 year old age group is larger for the male finishers than for the female finishers but the variance of the age graded scores for all the remaining age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 92. Ogden Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.9856	p = 0.9390	p = 0.0051	p = 0.0045	p = 0.0242
20 - 29	p = 0.0120	p = 0.0241	p = 0.7797	p = 0.9440	p = 0.9147
30 - 39	p = 0.0578	p = 0.0590	p = 0.0148	p = 0.0076	p = 0.0117
40 - 49	p = 0.0899	p = 0.0599	p = 0.0014	p = 0.0010	p = 0.0096
50 - 59	p = 0.3934	p = 0.2889	p < 0.0001	p = 0.0001	p = 0.0040
60 - 69	p = 0.8896	p = 0.9957	p = 0.0208	p = 0.0306	p = 0.1144
70 - 79	p = 0.5663	NA	p = 0.6896	p = 0.5613	p = 0.6826

The assumption of equal population variances was not met for the 20 – 29 and 30 – 39 year old age groups but the test results were similar to the t-test results. The pooled test statistic for the t-test was used for the 1 – 19, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups but the non-pooled test statistic for the t-test was used for the 20 – 29 and 30 – 39 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score, the difference between the median age graded score, and the test for equal distributions of the age graded scores for the male and female race finishers are not statistically significant for the 20 – 29 and the 70 – 79 year old age groups. In addition, the test for equal distributions of the age graded scores is not statistically significant for the 60 – 69 year old age group. All other age groups were statistically significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the test for the equal distributions of the age graded scores for the male and female finishers.

6.6.1.5. Gore-Tex Philadelphia Marathon

The Philadelphia Marathon was run on Sunday, November 17, 2013 in Philadelphia, PA [Running USA 2014]. There were 10,913 total finishers, made up of 6,017 male finishers and 4,896 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 93. Proportion of Philadelphia Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.91%	P_F = 1.82%	p < 0.0001	p = 0.7225
20 - 29	P_M = 23.52%	P_F = 33.84%		p < 0.0001
30 - 39	P_M = 31.13%	P_F = 33.97%		p = 0.0096
40 - 49	P_M = 26.26%	P_F = 22.20%		p < 0.0001
50 - 59	P_M = 14.01%	P_F = 7.25%		p < 0.0001
60 - 69	P_M = 2.93%	P_F = 0.84%		p < 0.0001
70 - 79	P_M = 0.23%	P_F = 0.08%		p = 0.0534
80 - 99	P_M = 0.02%	P_F = 0.00%		p = 0.3670

All age groups had a sufficiently large enough sample size to use Pearson's chi-square test to determine the appropriate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 1 – 19, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The result for the 70 – 79 year old age group shows that there is weak statistical evidence of a significant difference between the male and female proportions of finishers as the p-value is not significant at the level of significance chosen for this paper but would be considered significant if a different level was chosen.

Table 94. Philadelphia Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 18.26%	P_F = 7.87%	p = 0.0324
20 - 29	P_M = 24.31%	P_F = 18.83%	p = 0.0002
30 - 39	P_M = 21.86%	P_F = 19.78%	p = 0.1662
40 - 49	P_M = 28.92%	P_F = 30.82%	p = 0.2927
50 - 59	P_M = 42.47%	P_F = 49.58%	p = 0.0238
60 - 69	P_M = 39.77%	P_F = 48.78%	p = 0.2917
70 - 79	P_M = 21.43%	P_F = 75.00%	p = 0.0833
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 70 –79 year old age group there was at least one cell in the contingency table had an expected value of five of lower so we used Fisher’s exact test to determine the appropriate p-value; there is not enough information to perform a test of proportions for the 80 – 99 year old age group. All other age groups had sufficiently large enough sample sizes to use the Pearson’s chi-square to determine the appropriate p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 50 – 59 year old age group. The 70 – 79 year old age group result shows that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. The proportion of male race finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female race finishers for the 1 – 19 and 20 – 29 year old age groups. For the 30 – 39, 40 – 49, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 95. Philadelphia Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 20.00%	P_F = 26.97%	p = 0.2413
20 - 29	P_M = 8.13%	P_F = 6.76%	p = 0.1485
30 - 39	P_M = 10.30%	P_F = 6.98%	p = 0.0005
40 - 49	P_M = 5.76 %	P_F = 3.13%	p = 0.0016
50 - 59	P_M = 2.49%	P_F = 1.13%	p = 0.1314
60 - 69	P_M = 1.14%	P_F = 2.44%	p = 0.4682
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 60 – 69 year old age group had at least one cell of the contingency table with an expected cell count of five or fewer so we used Fisher's exact test to find the accurate p-value. For the 70 – 79 and 80 – 99 year old age groups there is not enough information to conduct a test of proportions. All other age groups had a sufficiently large enough sample to use Pearson's chi-square test to find the accurate p-value.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 30 – 39 and 40 – 49 year old age groups. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 –

99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 96. Philadelphia Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 115	F: 89	M: 49.5	F: 46.2	M: 49.0	F: 44.7	M: 119.6	F: 72.3
20 - 29	M: 1415	F: 1657	M: 53.5	F: 52.7	M: 52.5	F: 52.1	M: 109.7	F: 73.5
30 - 39	M: 1873	F: 1663	M: 52.2	F: 52.4	M: 51.4	F: 51.9	M: 97.3	F: 76.6
40 - 49	M: 1580	F: 1087	M: 54.8	F: 55.5	M: 54.5	F: 55.4	M: 92.1	F: 79.4
50 - 59	M: 843	F: 355	M: 57.8	F: 59.9	M: 57.8	F: 59.8	M: 91.3	F: 89.3
60 - 69	M: 176	F: 41	M: 57.5	F: 61.0	M: 57.7	F: 59.7	M: 87.9	F: 104.4
70 - 79	M: 14	F: 4	M: 56.0	F: 67.5	M: 52.6	F: 68.6	M: 115.1	F: 76.9
80 - 99	M: 1	F: 0	M: 49.9	F: NA	M: 49.9	F: NA	M: 0.00	F: NA

For the 1 – 19 and the 20 – 29 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. The variance for the 60 – 69 year old age group is larger for the male finishers than for the female finishers but the variance of the age graded scores for all the remaining age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 97. Philadelphia Marathon Test Results by Age Group

Age Group	**F Test**	**Levene's Test**	**T Test**	**Wilcoxon**	**KS Test**
1 - 19	p = 0.0140	p = 0.0059	p = 0.0181	p = 0.0312	p = 0.1219
20 - 29	p < 0.0001	p < 0.0001	p = 0.0166	p = 0.3443	p = 0.0009
30 - 39	p < 0.0001	p < 0.0001	p = 0.6174	p = 0.2068	p = 0.0022
40 - 49	p = 0.0082	p = 0.0056	p = 0.0632	p = 0.0404	p = 0.0464
50 - 59	p = 0.8221	p = 0.7845	p = 0.0005	p = 0.0010	p = 0.0173
60 - 69	p = 0.4502	p = 0.4275	p = 0.0326	p = 0.0598	p = 0.2447
70 - 79	p = 0.8274	p = 0.5760	p = 0.0676	p = 0.0495	p = 0.0429

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups but the test results were still similar to the t-test results for these age groups except for the 20 – 29 and 30 – 39 year old age groups. The pooled test statistic for the t-test was used for the 50 – 59, 60 – 69, and 70 – 79 year old age groups but the non-pooled test statistic for the t-test was used for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is not statistically significant for the 50 – 59, the 60 – 69, and the 70 – 79 year old age groups based on both the F and Levene's test results. All other age groups are highly significant for both tests with all p-values less than 0.015. The difference between the mean age graded score for the male and female race finishers is not statistically significant for the 30 – 39, the 40 – 49, and the 70 – 79 year old age groups. The difference between the median age graded score for the male and female race finishers is not statistically significant for the 20 – 29, the 30 – 39, and the 60 – 69 year old age groups. The test for equal distributions of the age graded sores for the male and female race finishers is not statistically significant for the 1 – 19 and the 60 – 69 year old age groups. The results for all other age groups were statistically significant for the three statistical tests.

6.6.1.6. Wipro San Francisco Marathon

The San Francisco Marathon was run on Sunday, June 16, 2013 in San Francisco, CA [Running USA 2014]. There were 5,823 total finishers, made up of 3,905 male finishers and 1,918 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 98. Proportion of San Francisco Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.28%	P_F = 1.51%	p < 0.0001	p = 0.4758
20 - 29	P_M = 23.59%	P_F = 33.00%		p = 0.5583
30 - 39	P_M = 35.36%	P_F = 36.34%		p < 0.0001
40 - 49	P_M = 24.92%	P_F = 19.08%		p < 0.0001
50 - 59	P_M = 11.42%	P_F = 8.55%		p = 0.0015
60 - 69	P_M = 3.00%	P_F = 1.41%		p = 0.0003
70 - 79	P_M = 0.41%	P_F = 0.10%		p = 0.0488
80 - 99	P_M = 0.03%	P_F = 0.00%		p = 0.4834

The 80 – 99 year old age group has one cell of the contingency table with an expected value of five or lower so we used Fisher's exact test to determine the accurate p-value; all other age groups had sufficiently large sample sizes so we used Pearson's chi-square test to determine the accurate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if these differences were statistically significant and found that there was at least one age group with a significant difference, $p < 0.0001$. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 20 – 29, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 99. San Francisco Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 16.00%	P_F = 20.69%	p = 0.5988
20 - 29	P_M = 12.05%	P_F = 8.69%	p = 0.0349
30 - 39	P_M = 11.66%	P_F = 8.46%	p = 0.0255
40 - 49	P_M = 18.81%	P_F = 18.85%	p = 0.9851
50 - 59	P_M = 26.23%	P_F = 33.54%	p = 0.0755
60 - 69	P_M = 25.64%	P_F = 40.74%	p = 0.1171
70 - 79	P_M = 31.25%	P_F = 50.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 70 – 79 year old age group had at least one cell of the contingency tables that had an expected value of five or lower so we used Fisher's exact test to determine the correct p-value; the 80 – 99 did not have enough data to perform a test of proportions. All other age groups had large enough sample sizes to use Pearson's chi-square test to determine the correct p-value.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 20 – 29 and 30 – 39 year old age group. The 50 – 59 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 40 – 49, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 100. San Francisco Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 20.00%	P_F = 10.34%	p = 0.3532
20 - 29	P_M = 17.92%	P_F = 13.43%	p = 0.0180
30 - 39	P_M = 15.28%	P_F = 11.62%	p = 0.0235
40 - 49	P_M = 9.87 %	P_F = 7.10%	p = 0.1174
50 - 59	P_M = 4.04%	P_F = 0.61%	p = 0.0308
60 - 69	P_M = 2.56%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 60 – 69 year old age groups there is at least one cell of the contingency table with an expected value of five or less so we used Fisher's exact test to determine the appropriate p-value. For the 70 – 79 and 80 – 99 year old age groups there is not enough information to conduct a test of proportions. All other age groups had a sufficiently large sample size to use Pearson's chi-square test to determine the appropriate p-value.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 20 – 29, 30 – 39, and 50 – 59 year old age groups. For the 1 – 19, 40 – 49, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 101. San Francisco Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 50	F: 29	M: 49.6	F: 49.9	M: 49.1	F: 49.4	M: 105.1	F: 96.6
20 - 29	M: 921	F: 633	M: 48.8	F: 48.8	M: 48.0	F: 48.1	M: 86.0	F: 61.8
30 - 39	M: 1381	F: 697	M: 49.4	F: 49.1	M: 48.7	F: 48.7	M: 78.9	F: 58.6
40 - 49	M: 973	F: 366	M: 51.7	F: 51.9	M: 50.9	F: 51.2	M: 81.2	F: 77.5
50 - 59	M: 446	F: 164	M: 54.1	F: 56.7	M: 53.7	F: 55.6	M: 72.5	F: 93.1
60 - 69	M: 117	F: 27	M: 54.4	F: 59.6	M: 54.1	F: 58.8	M: 82.9	F: 57.8
70 - 79	M: 16	F: 2	M: 56.6	F: 59.5	M: 54.1	F: 59.5	M: 82.5	F: 451.0
80 - 99	M: 1	F: 0	M: 52.8	F: NA	M: 52.8	F: NA	M: 0.00	F: NA

For the 30 – 39 year old age group in this race, the mean age graded score for male finishers is larger than the mean age graded score for the female finishers but and median age graded scores for male and female finishers are equal. For the 20 – 29 year old age group, the mean age graded score for male finishers is equal to the mean age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. The variances for the 50 – 59 and the 70 – 79 year old age groups are larger for the female finishers than for the male finishers but the variances of the age graded scores for the other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 102. San Francisco Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.8264	p = 0.7650	p = 0.9189	p = 0.8348	p = 0.9955
20 - 29	p < 0.0001	p < 0.0001	p = 0.9157	p = 0.7091	p = 0.1658
30 - 39	p < 0.0001	p < 0.0001	p = 0.4576	p = 0.7126	p = 0.2603
40 - 49	p = 0.6055	p = 0.5793	p = 0.7167	p = 0.8989	p = 0.6365
50 - 59	p = 0.0474	p = 0.0213	p = 0.0024	p = 0.0088	p = 0.0426
60 - 69	p = 0.2890	p = 0.2735	p = 0.0071	p = 0.0048	p = 0.0119
70 - 79	p = 0.0674	NA	p = 0.7179	p = 1.0000	p = 0.8856

The equal variance assumption of the Mann-Whitney-Wilcoxon test is not met for the 20 – 29, 30 – 39, and 50 – 59 year old age groups but the test results for the 50 – 59 year old age group are still similar to the results of the t-test. The pooled test statistic for the t-test is used for the 1 – 19, 40 – 49, 60 – 69, and 70 – 79 year old age groups but the non-pooled test statistic is used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29, the 30 – 39, and the 50 – 59 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores for the male and female race finishers are statistically significant for the 50 – 59 and the 60 – 69 year old age groups. All other age groups were highly non-significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores for the male and female race finishers.

6.6.1.7. Surf City USA Marathon

The Surf City Marathon was run on Sunday, February 3, 2013 in Huntington Beach, CA [Running USA 2014]. There were 2,305 total finishers, made up of 1,392 male finishers and 913 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 103. Proportion of Surf City Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.36%	P_F = 1.20%	p < 0.0001	p = 0.7417
20 - 29	P_M = 12.00%	P_F = 20.48%		p < 0.0001
30 - 39	P_M = 26.87%	P_F = 31.65%		p = 0.0361
40 - 49	P_M = 32.26%	P_F = 31.54%		p = 0.7677
50 - 59	P_M = 20.11%	P_F = 12.71%		p < 0.0001
60 - 69	P_M = 6.03%	P_F = 2.19%		p < 0.0001
70 - 79	P_M = 1.29%	P_F = 0.22%		p = 0.0068
80 - 99	P_M = 0.07%	P_F = 0.00%		p = 0.4180

The 80 – 99 year old age group has at least one cell of the contingency table that has an expected cell count of five or lower so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so we used Pearson's chi-square test to determine the p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 40 – 49, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 104. Surf City Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 21.05%	P_F = 0.00%	p = 0.2679
20 - 29	P_M = 12.57%	P_F = 12.83%	p = 0.9417
30 - 39	P_M = 15.51%	P_F = 11.07%	p = 0.0983
40 - 49	P_M = 20.94%	P_F = 28.47%	p = 0.0192
50 - 59	P_M = 31.79%	P_F = 40.52%	p = 0.0959
60 - 69	P_M = 27.38%	P_F = 40.00%	p = 0.2675
70 - 79	P_M = 11.11%	P_F = 50.00%	p = 0.2842
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 70 – 79 year old age groups there is at least one cell of the contingency tables with an expected cell count of five or fewer so we used Fisher's exact test in order to determine the p-value; for the 80 – 99 year old age group there is not enough information to perform a test of proportions. All other age groups had large enough sample sizes to use Pearson's chi-square test to determine the p-value.

The proportion of female race finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male race finishers with an age graded score of sixty percent or higher for the 40 – 49 year old age group. The 30 – 39 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. The 50 – 59 year old age group result shows weak statistical evidence that the proportion of female race finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male race finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 105. Surf City Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 10.53%	P_F = 9.09%	p = 1.0000
20 - 29	P_M = 21.56%	P_F = 17.65%	p = 0.3539
30 - 39	P_M = 16.31%	P_F = 13.84%	p = 0.3803
40 - 49	P_M = 5.35 %	P_F = 6.94%	p = 0.3713
50 - 59	P_M = 6.79%	P_F = 1.72%	p = 0.0408
60 - 69	P_M = 3.57%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 19 and 60 – 69 year old age groups have at least one cell of the contingency table has an expected value of five or lower so we used Fisher's exact test to find the appropriate p-value. For the 70 – 79 and 80 – 99 year old age groups there is not enough data to perform a test of proportions. For all other age groups we were able to use Pearson's chi-square test to find the appropriate p-value as the sample sizes were sufficiently large.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 50 – 59 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 106. Surf City Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 19	F: 11	M: 52.4	F: 48.6	M: 54.8	F: 47.4	M: 82.1	F: 30.4
20 - 29	M: 167	F: 187	M: 48.5	F: 48.6	M: 48.4	F: 47.9	M: 94.0	F: 87.2
30 - 39	M: 374	F: 289	M: 50.0	F: 49.4	M: 48.9	F: 48.6	M: 93.7	F: 72.4
40 - 49	M: 449	F: 288	M: 52.4	F: 54.2	M: 51.7	F: 53.3	M: 76.3	F: 85.8
50 - 59	M: 280	F: 116	M: 55.2	F: 58.1	M: 55.3	F: 58.0	M: 90.9	F: 86.9
60 - 69	M: 84	F: 20	M: 55.4	F: 60.5	M: 54.6	F: 58.2	M: 94.1	F: 84.6
70 - 79	M: 18	F: 2	M: 52.1	F: 62.3	M: 52.7	F: 62.3	M: 53.9	F: 200.7
80 - 99	M: 1	F: 0	M: 49.5	F: NA	M: 49.5	F: NA	M: 0.00	F: NA

For the 1 – 19 and the 30 – 39 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. The variances for the 40 – 49 and the 70 – 79 year old age groups are larger for the female finishers than for the male finishers and the variances of the age graded scores for the other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 107. Surf City Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.1119	p = 0.0703	p = 0.2158	p = 0.2632	p = 0.1425
20 - 29	p = 0.6155	p = 0.5599	p = 0.8788	p = 0.7828	p = 0.6397
30 - 39	p = 0.0213	p = 0.0184	p = 0.3576	p = 0.5216	p = 0.4753
40 - 49	p = 0.2710	p = 0.2164	p = 0.0080	p = 0.0136	p = 0.0238
50 - 59	p = 0.7897	p = 0.7213	p = 0.0062	p = 0.0117	p = 0.0439
60 - 69	p = 0.8285	p = 0.7157	p = 0.0329	p = 0.0310	p = 0.0783
70 - 79	p = 0.1408	NA	p = 0.0976	p = 0.4128	p = 0.7591

The assumption of equal variances for the Mann-Whitney-Wilcoxon test was not met for the 30 – 39 year old age group but the test results were similar to the t-test results. The non-pooled test statistic for the t-test was used for the 30 – 39 year old age group and the pooled test statistic for the t-test was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 30 – 39 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 40 – 49, the 50 – 59, and the 60 – 69 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The 60 – 69 year old age group is not significant for the test for equal distributions of the age graded scores but all other age groups follow the same trend as the test for means and the test for medians.

6.6.1.8. Medtronic Twin Cities Marathon

The Twin Cities Marathon was run on Sunday, October 6, 2013 in Minneapolis and St. Paul, MN [Running USA 2014]. There were 8,852 total finishers, made up of 4,924 male finishers and 3,928 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 108. Proportion of Twin Cities Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.08%	P_F = 0.97%	p < 0.0001	p = 0.6155
20 - 29	P_M = 22.73%	P_F = 34.32%		p < 0.0001
30 - 39	P_M = 30.95%	P_F = 35.46%		p = 0.0002
40 - 49	P_M = 25.18%	P_F = 21.00%		p = 0.0001
50 - 59	P_M = 15.43%	P_F = 7.23%		p < 0.0001
60 - 69	P_M = 4.14%	P_F = 0.99%		p < 0.0001
70 - 79	P_M = 0.45%	P_F = 0.03%		p = 0.0001
80 - 99	P_M = 0.04%	P_F = 0.00%		p = 0.2066

There is at least one cell of the contingency table for the 80 – 99 year old age group with an expected frequency of five or lower, we used Fisher's exact test to determine the p-value for this age group. All other age groups used Pearson's chi-square test to determine the p-value for the age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 109. Twin Cities Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 22.64%	P_F = 18.42%	p = 0.6252
20 - 29	P_M = 21.27%	P_F = 14.39%	p < 0.0001
30 - 39	P_M = 19.23%	P_F = 17.88%	p = 0.3489
40 - 49	P_M = 27.26%	P_F = 34.79%	p = 0.0003
50 - 59	P_M = 40.39%	P_F = 55.28%	p < 0.0001
60 - 69	P_M = 43.63%	P_F = 69.23%	p = 0.0034
70 - 79	P_M = 54.55%	P_F = 100%	p = 1.0000
80 - 99	P_M = 50.00%	P_F = 0.00%	NA

For the 70 – 79 year old age group there is at least one cell in the contingency table that has an expected value of five or lower so we used Fisher's exact test to determine the appropriate p-value. There was not enough information for the 80 – 99 year old age group to accurately perform a test of proportions. All other age groups had large enough sample sizes to use Pearson's chi-square test to determine the appropriate p-value.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 40 – 49, 50 – 59, and 60 – 69 year old age groups. The 20 – 29 year old age group result shows strong statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 1 – 19, 30 – 39, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 110. Twin Cities Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 3.77%	P_F = 0.00%	p = 0.5082
20 - 29	P_M = 7.33%	P_F = 5.34%	p = 0.0423
30 - 39	P_M = 8.27%	P_F = 4.95%	p = 0.0003
40 - 49	P_M = 4.92%	P_F = 0.12%	p < 0.0001
50 - 59	P_M = 0.26%	P_F = 0.00%	p = 1.0000
60 - 69	P_M = 0.00%	P_F = 0.00%	NA
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 19 and 50 – 59 year old age groups had at least one cell of the contingency table with an expected value of five or lower so we used Fisher's exact test to determine the appropriate p-value. For the 60 – 69, 70 – 79, and 80 – 99 year old age groups there was not enough information to perform a test of proportions. All other age groups had a large enough sample size to use Pearson's chi-square test to determine the appropriate p-value.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 20 – 29, 30 – 39, and 40 – 49 year old age groups. For the 1 – 19, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 111. Twin Cities Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 53	F: 38	M: 53.6	F: 52.4	M: 52.2	F: 50.7	M: 64.5	F: 57.8
20 - 29	M: 1119	F: 1348	M: 53.3	F: 51.6	M: 52.2	F: 50.7	M: 110.7	F: 66.5
30 - 39	M: 1524	F: 1393	M: 52.5	F: 52.9	M: 51.5	F: 52.5	M: 92.2	F: 72.7
40 - 49	M: 1240	F: 825	M: 54.9	F: 57.1	M: 54.4	F: 56.6	M: 88.3	F: 69.9
50 - 59	M: 760	F: 284	M: 58.1	F: 62.0	M: 57.4	F: 60.7	M: 81.9	F: 80.5
60 - 69	M: 204	F: 39	M: 58.6	F: 66.0	M: 58.0	F: 66.3	M: 82.8	F: 72.2
70 - 79	M: 22	F: 1	M: 62.0	F: 82.8	M: 61.9	F: 82.8	M: 99.8	F: 0.00
80 - 99	M: 2	F: 0	M: 58.9	F: NA	M: 58.9	F: NA	M: 65.9	F: NA

For the 1 – 19 and the 20 – 29 year old age groups in this race, the mean and median age graded score for male finishers is larger than the mean and median age graded score for the female finishers. For all other age groups in this marathon, the mean and median age graded scores for the female finishers are larger than the scores for the female finishers. The variances of the age graded scores for the age groups in this marathon are larger for the male finishers than for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the marathon race finisher population.

Table 112. Twin Cities Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.7355	p = 0.6701	p = 0.4759	p = 0.4813	p = 0.8448
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p = 0.0014	p = 0.0008
30 - 39	p < 0.0001	p = 0.0003	p = 0.2569	p = 0.0410	p = 0.0060
40 - 49	p = 0.0003	p = 0.0024	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.8767	p = 0.8508	p < 0.0001	p < 0.0001	p < 0.0001
60 - 69	p = 0.6304	p = 0.5860	p < 0.0001	p < 0.0001	p = 0.0010
70 - 79	NA	NA	p = 0.0537	p = 0.1134	p = 0.2943

The assumption of equal variances for the Mann-Whitney-Wilcoxon test is not met for the 20 – 29, 30 – 39, and 40 – 49 year old age groups but the test results for these age groups were similar to the results of the t-test except for the 30 – 39 year old age group. The pooled test statistic for the t-test was used for the 1 – 19, 50 – 59, and 60 – 69 year old age groups but the non-pooled t-test statistic was used for the 20 – 29, 30 – 39, and 40 – 49 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29, the 30 – 39, and the 40 – 49 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores for the male and female race finishers are not statistically significant for the 1 – 19 and the 70 – 79 year old age groups. The difference between the mean age graded scores is not significant for the 30 – 39 year old age group but the difference between the median age graded scores and the test for equal distributions of age graded scores for male and female finishers are both statistically significant. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2. Half Marathon Race Results

To explore the differences that exist between the male and female half marathon finishers, we employed several techniques, both statistical and visual. We first tested the proportion of male and female half marathon finishers, then we visually inspect the descriptive statistics of the age graded scores, finally we ran several statistical tests to determine if the distribution of age graded scores was equal for the male and female half marathon finishers. Each of these tests were conducted for the individual age groups, as we defined them previously, for each individual race we examined in this paper.

6.6.2.1. Berkeley Half Marathon

The Berkeley Half Marathon was run on Sunday, November 24, 2013 in Berkeley, CA [Running USA 2014]. There were 4,667 total finishers, made up of 2,152 male finishers and 2,515 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 113. Proportion of Berkeley Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.30%	P_F = 2.11%	p = 0.0020	p = 0.0005
20 - 29	P_M = 27.14%	P_F = 29.62%		p = 0.1128
30 - 39	P_M = 35.73%	P_F = 37.26%		p = 0.3912
40 - 49	P_M = 22.49%	P_F = 20.36%		p = 0.1159
50 - 59	P_M = 10.13%	P_F = 8.79%		p = 0.1360
60 - 69	P_M = 2.93%	P_F = 1.75%		p = 0.0081
70 - 79	P_M = 0.28%	P_F = 0.12%		p = 0.2161

The 70 – 79 year old age group has at least one cell of the contingency table with an expected value of five or smaller, to determine the p-value for this age group we used Fisher's exact test; Pearson's chi-square test was used to determine the p-value for all other age groups in this race.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19 and 60 – 69 year old age groups. For the 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 70 – 79 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 114. Berkeley Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 42.86%	P_F = 32.08%	p = 0.3357
20 - 29	P_M = 22.43%	P_F = 17.45%	p = 0.0233
30 - 39	P_M = 19.25%	P_F = 13.77%	p = 0.0023
40 - 49	P_M = 27.27%	P_F = 18.55%	p = 0.0010
50 - 59	P_M = 34.86%	P_F = 29.86%	p = 0.2630
60 - 69	P_M = 41.27%	P_F = 0.00%	p = 0.4643
70 - 79	P_M = 50.00%	P_F = 43.59%	p = 0.0020

For the 70 – 79 year old age group there is at least one cell of the contingency table with an expected value of five or smaller, Fisher's exact test was used to determine the appropriate p-value for this age group. For all other age groups, Pearson's chi-square test was used to determine the appropriate p-value for each age group.

The 20 – 29, 30 – 39, 40 – 49, and 70 – 79 year old age group results shows that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 1 – 19, 50 – 59, and 60 – 69 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 115. Berkeley Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 7.14%	P_F = 1.89%	p = 0.2732
20 - 29	P_M = 11.82%	P_F = 10.87%	p = 0.5899
30 - 39	P_M = 10.66%	P_F = 13.23%	p = 0.1050
40 - 49	P_M = 5.99 %	P_F = 11.52%	p = 0.0021
50 - 59	P_M = 6.42%	P_F = 7.24%	p = 0.7342
60 - 69	P_M = 3.17%	P_F = 4.55%	p = 1.0000
70 - 79	P_M = 16.67%	P_F = 0.00%	p = 1.0000

There is at least one cell in the contingency table for the 1 – 19, 60 – 69, and 70 – 79 year old age groups with an expected value of five or lower, to determine the accurate p-value of each age group we used Fisher's exact test. All other age group p-values were determined using Pearson's chi-square test.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 116. Berkeley Half Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 53	F: 28	M: 57.2	F: 56.5	M: 56.8	F: 56.2	M: 137.8	F: 74.9
20 - 29	M: 584	F: 745	M: 52.9	F: 52.1	M: 52.7	F: 52.4	M: 114.8	F: 84.0
30 - 39	M: 769	F: 937	M: 52.0	F: 50.8	M: 51.6	F: 51.1	M: 94.7	F: 79.8
40 - 49	M: 484	F: 512	M: 54.5	F: 51.7	M: 54.5	F: 51.6	M: 95.4	F: 92.6
50 - 59	M: 218	F: 221	M: 55.6	F: 54.5	M: 56.0	F: 53.9	M: 100.0	F: 98.7
60 - 69	M: 63	F: 44	M: 59.1	F: 59.5	M: 58.4	F: 62.1	M: 108.9	F: 124.0
70 - 79	M: 6	F: 3	M: 60.6	F: 55.5	M: 61.3	F: 57.4	M: 278.1	F: 14.4

For the 60 – 69 year old age group in this race, the mean age graded score, the median age graded score, and the variance of the age graded scores for female finishers is larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers. For all other age groups in this marathon, the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers are larger than the scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 117. Berkeley Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0592	p = 0.0576	p = 0.7505	p = 0.5815	p = 0.8025
20 - 29	p < 0.0001	p = 0.0001	p = 0.1644	p = 0.2646	p = 0.0203
30 - 39	p = 0.0132	p = 0.0146	p = 0.0071	p = 0.0336	p = 0.0345
40 - 49	p = 0.7412	p = 0.7406	p < 0.0001	p < 0.0001	p = 0.0001
50 - 59	p = 0.9229	p = 0.9163	p = 0.2207	p = 0.1934	p = 0.2069
60 - 69	p = 0.6325	p = 0.5882	p = 0.8149	p = 0.7206	p = 0.4679
70 - 79	p = 0.1001	p = 0.1623	p = 0.6267	p = 0.8973	p = 0.6994

The assumption of equal variances for the Mann-Whitney-Wilcoxon test is not met for the 20 – 29 and 30 – 39 year old age groups and the results for the Wilcoxon test are not very similar to the t-test results for these age groups. The pooled t-test statistic is used for the 1 – 19, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups but the non-pooled test statistic for the t-test is used for the 20 – 29 and 30 – 39 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 and the 30 – 39 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 30 – 39 and the 40 – 49 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2.2. NYRR Brooklyn Half Marathon

The Brooklyn Half Marathon was run on Saturday, May 18, 2013 from Prospect Park to Coney Island in Brooklyn, NY [Running USA 2014]. There were 21,423 total finishers, made up of 10,822 male finishers and 10,601 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 118. Proportion of Brooklyn Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.48%	P_F = 0.31%	p < 0.0001	p = 0.0493
20 - 29	P_M = 24.97%	P_F = 38.71%		p < 0.0001
30 - 39	P_M = 43.49%	P_F = 41.28%		p = 0.0131
40 - 49	P_M = 21.06%	P_F = 14.60%		p < 0.0001
50 - 59	P_M = 7.58%	P_F = 4.23%		p < 0.0001
60 - 69	P_M = 2.12%	P_F = 0.80%		p < 0.0001
70 - 79	P_M = 0.30%	P_F = 0.07%		p = 0.0001
80 - 99	P_M = 0.01%	P_F = 0.00%		p = 0.3223

The 80 – 99 year old age group has one or more cells of the contingency table with an expected count of five or fewer, to determine the p-value for this age group we used Fisher's exact test. All other age groups had sufficiently large sample sizes so we used Pearson's chi-square test to determine the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 80 – 99 year old age group there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 119. Brooklyn Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 23.08%	P_F = 12.12%	p = 0.2079
20 - 29	P_M = 17.54%	P_F = 23.58%	p < 0.0001
30 - 39	P_M = 20.91%	P_F = 16.25%	p < 0.0001
40 - 49	P_M = 33.74%	P_F = 22.80%	p < 0.0001
50 - 59	P_M = 46.95%	P_F = 40.18%	p = 0.0204
60 - 69	P_M = 52.84%	P_F = 49.41%	p = 0.5892
70 - 79	P_M = 42.42%	P_F = 57.14%	p = 0.6798
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

There is at least one cell in the contingency table for the 70 – 79 year old age group with an expected cell count of five or lower so we used Fisher's exact test to calculate the p-value. The 80 – 99 year old age group does not have enough information to conduct a test of proportions. All other age groups used Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 20 – 29 year old age group. The 30 – 39, 40 – 49, and 50 – 59 year old age group results show that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 1 – 19, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 120. Brooklyn Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 3.85%	P_F = 0.00%	p = 0.5193
20 - 29	P_M = 3.66%	P_F = 3.07%	p = 0.1801
30 - 39	P_M = 4.48%	P_F = 5.23%	p = 0.0965
40 - 49	P_M = 2.94 %	P_F = 4.13%	p = 0.0461
50 - 59	P_M = 1.59%	P_F = 1.12%	p = 0.4995
60 - 69	P_M = 1.31%	P_F = 0.00%	p = 0.5658
70 - 79	P_M = 3.03%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 70 – 79 year old age groups, there is at least one cell in the contingency tables that has an expected frequency of five or less so we employed Fisher's exact test to determine the appropriate p-value for each age group. There is not enough data to perform a test of proportions for the 80 – 99 year old age group. All other age groups calculate the appropriate p-value using Pearson's chi-square test.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. The 30 – 39 year old age group result shows that there is weak statistical evidence that the proportion of female finishers with an age graded score at or below forty percent is significantly larger than the proportion of male finishers with an age graded score at or below forty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 121. Brooklyn Half Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 52	F: 33	M: 54.3	F: 52.0	M: 52.3	F: 52.1	M: 101.1	F: 51.9
20 - 29	M: 2702	F: 4104	M: 54.5	F: 53.5	M: 54.0	F: 53.3	M: 73.4	F: 55.2
30 - 39	M: 4706	F: 4376	M: 53.8	F: 52.8	M: 53.5	F: 52.7	M: 68.1	F: 59.6
40 - 49	M: 2279	F: 1548	M: 56.5	F: 54.2	M: 56.6	F: 54.0	M: 73.6	F: 66.6
50 - 59	M: 820	F: 448	M: 59.4	F: 57.9	M: 59.2	F: 57.6	M: 86.1	F: 90.7
60 - 69	M: 229	F: 85	M: 60.7	F: 59.7	M: 60.8	F: 59.9	M: 102.6	F: 81.9
70 - 79	M: 33	F: 7	M: 59.6	F: 66.5	M: 56.0	F: 61.7	M: 125.4	F: 99.5
80 - 99	M: 1	F: 0	M: 59.9	F: NA	M: 59.9	F: NA	M: 0.00	F: NA

For the 70 – 79 year old age group in this race, the mean and median age graded score for female finishers is larger than the mean and median age graded score for the male finishers but the variance for the male finishers is larger than the variance for the female finishers. For the 50 – 59 year old age group, the variance of the age graded scores for the female finishers is larger than the variance of the age graded scores for the male finishers. For all other age groups in this marathon, the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers are larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 122. Brooklyn Half Marathon Test Results by Age Group

Age Group	**F Test**	**Levene's Test**	**T Test**	**Wilcoxon**	**KS Test**
1 - 19	$p = 0.0471$	$p = 0.1074$	$p = 0.2435$	$p = 0.4301$	$p = 0.3142$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
40 - 49	$p = 0.0320$	$p = 0.0369$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.5239$	$p = 0.5414$	$p = 0.0081$	$p = 0.0040$	$p = 0.0305$
60 - 69	$p = 0.2314$	$p = 0.1841$	$p = 0.4421$	$p = 0.5154$	$p = 0.6218$
70 - 79	$p = 0.8364$	$p = 0.5385$	$p = 0.1383$	$p = 0.1016$	$p = 0.0933$

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test is not met for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups but the test results are similar to the results of the t-test for all age groups expect the 1 – 19 year old age group. The pooled variance test statistic for the t-test was used for the 50 – 59, 60 – 69, and 70 – 79 year old age groups; the non-pooled test statistic for the t-test was used for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups.

The difference between the variances of the age graded scores for the male and female finishers is not statistically significant for the 20 – 29, the 50 – 59, and the 60 – 69 year old age groups based on both the F and Levene's test results. The tests results for the 1 – 19 year old age group are split; the difference between the variances for the male and female finishers is not statistically significant based on Levene's test but the difference is statistically significant based on the F test. All other age groups are highly significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are not statistically significant for the 1 – 19, the 60 – 69, and the 70 – 79 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2.3. Capital City Half Marathon

The Capital City Half Marathon was run on Saturday, May 4, 2013 in Columbus, OH [Running USA 2014]. There were 8,102 total finishers, made up of 3,387 male finishers and 4,715 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 123. Proportion of Capital City Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.95%	P_F = 3.14%	p < 0.0001	p = 0.0011
20 - 29	P_M = 22.53%	P_F = 33.40%		p < 0.0001
30 - 39	P_M = 33.66%	P_F = 34.17%		p = 0.6971
40 - 49	P_M = 25.18%	P_F = 19.85%		p < 0.0001
50 - 59	P_M = 12.99%	P_F = 7.78%		p < 0.0001
60 - 69	P_M = 3.22%	P_F = 1.51%		p < 0.0001
70 - 79	P_M = 0.41%	P_F = 0.15%		p = 0.0209
80 - 99	P_M = 0.06%	P_F = 0.00%		p = 0.0952

There is at least one cell of the contingency table for the 80 – 99 year old age group that has an expected frequency of five or less, to determine the accurate p-value for this age group we used Fisher's exact test. We used Pearson's chi-square test to determine the accurate p-value for all other age groups.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 30 – 39 year old age group there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The p-value for the 80 – 99 year old age group gives weak statistical evidence of a significant difference between the male and female proportions of race finishers because the value is not significant at the level of significance chosen for this paper but would be declared significant at a different level.

Table 124. Capital City Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 22.73%	P_F = 10.14%	p = 0.0143
20 - 29	P_M = 14.15%	P_F = 9.40%	p = 0.0006
30 - 39	P_M = 10.18%	P_F = 7.57%	p = 0.0168
40 - 49	P_M = 18.29%	P_F = 13.78%	p = 0.0093
50 - 59	P_M = 25.45%	P_F = 21.25%	p = 0.1613
60 - 69	P_M = 32.11%	P_F = 22.54%	p = 0.1635
70 - 79	P_M = 28.57%	P_F = 14.29%	p = 0.6244
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 70 – 79 year old age group has at least one cell of the contingency table with an expected frequency of five or smaller, to determine the p-value for this age group we used Fisher's exact test. The 80 – 99 year old age group does not have enough data to perform a test of proportions. All other age groups used Pearson's chi-square test to determine the p-value for each age group.

The 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age group results show that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent. For the 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 125. Capital City Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 10.61%	P_F = 12.16%	p = 0.7434
20 - 29	P_M = 9.57%	P_F = 10.60%	p = 0.4391
30 - 39	P_M = 10.00%	P_F = 14.53%	p = 0.0004
40 - 49	P_M = 6.68%	P_F = 13.57%	p < 0.0001
50 - 59	P_M = 7.27%	P_F = 10.08%	p = 0.1553
60 - 69	P_M = 11.01%	P_F = 5.63%	p = 0.2155
70 - 79	P_M = 14.29%	P_F = 0.00%	p = 0.5333
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

There is at least one cell with an expected count of five or lower for the 70 – 79 year old age group, to calculate the appropriate p-value for this age group we employed Fisher's exact test. There was not enough information for the 80 – 99 year old age group to conduct a test of proportions. For all other age groups we employed Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 30 – 39 and 40 – 49 year old age groups. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 126. Capital City Half Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 66	F: 148	M: 53.0	F: 50.4	M: 53.4	F: 51.1	M: 72.1	F: 65.1
20 - 29	M: 763	F: 1575	M: 51.4	F: 49.8	M: 51.4	F: 49.7	M: 82.0	F: 60.8
30 - 39	M: 1140	F: 1611	M: 50.3	F: 48.7	M: 50.3	F: 48.9	M: 67.1	F: 65.4
40 - 49	M: 853	F: 936	M: 52.4	F: 50.4	M: 52.5	F: 50.4	M: 70.7	F: 82.2
50 - 59	M: 440	F: 367	M: 54.1	F: 51.6	M: 54.9	F: 50.5	M: 83.8	F: 94.2
60 - 69	M: 109	F: 71	M: 54.3	F: 51.4	M: 56.2	F: 48.9	M: 109.3	F: 85.5
70 - 79	M: 14	F: 7	M: 52.5	F: 54.8	M: 54.5	F: 54.0	M: 116.1	F: 75.7
80 - 99	M: 2	F: 0	M: 64.5	F: NA	M: 64.5	F: NA	M: 2.8	F: NA

For the 70 – 79 year old age group in this race, the mean age graded score for the female finishers is larger than the mean age graded score for the male finishers but the median age graded score and the variance of the age graded scores for the male finishers are larger than the median age graded score and the variance of the age graded scores for the female finishers. For the 50 – 59 year old age group, the mean age graded score for the male finishers is larger than the mean age graded score for the female finishers but the median age graded score and the variance of the age graded scores for the female finishers are larger than the median age graded score and the variance of the age graded scores for the male finishers. For the 40 – 49 year old age group, the mean and median age graded score for the male finishers are larger than the mean and median age graded score for the female finishers but the variance of the age graded scores for the female finishers is larger than the variance of the age graded scores for the male finishers. For all other age groups in this half marathon, the mean age graded score, median age graded score, and the variance of the age graded scores for the male finishers are larger than the mean age graded score, median age graded score, and the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 127. Capital City Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.6087	p = 0.6158	p = 0.0328	p = 0.0416	p = 0.1535
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p = 0.0001
30 - 39	p = 0.6211	p = 0.6335	p < 0.0001	p < 0.0001	p = 0.0002
40 - 49	p = 0.0251	p = 0.0208	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.2433	p = 0.2098	p = 0.0002	p < 0.0001	p < 0.0001
60 - 69	p = 0.2721	p = 0.1776	p = 0.0652	p = 0.0534	p = 0.0361
70 - 79	p = 0.6225	p = 0.4131	p = 0.6331	p = 0.8520	p = 0.8407

The equal variance assumption for the Mann-Whitney-Wilcoxon test is not met for the 20 – 29 and 40 – 49 year old age groups but the test results for these age groups were very similar to the t-test results. The non-pooled test statistic for the t-test was used for the 20 – 29 and 40 – 49 year old age groups; the pooled test statistic for the t-test for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 and the 40 – 49 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score for male and female race finishers are not statistically significant for the 60 – 69 and the 70 – 79 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of age graded scores for male and female race finishers is not statistically significant for the 1 – 19 and the 70 – 79 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians.

6.6.2.4. Nationwide Children's Hospital Columbus Half

The Columbus Half Marathon was run on Sunday, October 20, 2013 in Columbus, OH [Running USA 2014]. There were 10,200 total finishers, made up of 3,672 male finishers and 6,528 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 128. Proportion of Columbus Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 2.56%	P_F = 3.68%	p < 0.0001	p = 0.0028
20 - 29	P_M = 26.58%	P_F = 36.31%		p < 0.0001
30 - 39	P_M = 30.94%	P_F = 30.51%		p = 0.7117
40 - 49	P_M = 21.00%	P_F = 18.52%		p = 0.2858
50 - 59	P_M = 13.40%	P_F = 8.96%		p < 0.0001
60 - 69	P_M = 4.74%	P_F = 1.87%		p < 0.0001
70 - 79	P_M = 0.65%	P_F = 0.14%		p < 0.0001
80 - 99	P_M = 0.14%	P_F = 0.02%		p = 0.0157

For the 80 – 99 year old age group, there is at least one cell of the contingency table with an expected value of five or less so we used Fisher's exact test to calculate the appropriate p-value. All other age groups employed the Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19 and the 20 – 29 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups. For the 30 – 39 and 40 – 49 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 129. Columbus Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 25.53%	P_F = 17.92%	p = 0.1181
20 - 29	P_M = 17.01%	P_F = 10.00%	p < 0.0001
30 - 39	P_M = 11.71%	P_F = 9.04%	p = 0.0166
40 - 49	P_M = 17.51%	P_F = 12.32%	p = 0.0013
50 - 59	P_M = 25.41%	P_F = 19.66%	p = 0.0239
60 - 69	P_M = 21.26%	P_F = 22.95%	p = 0.7301
70 - 79	P_M = 25.00%	P_F = 11.11%	p = 0.6418
80 - 99	P_M = 40.00%	P_F = 0.00%	p = 1.0000

For the 70 – 79 and 80 – 99 year old age groups, there is at least one cell in the contingency tables that has an expected frequency of five or fewer; to calculate the appropriate p-value for these age groups, we employed Fisher's exact test. The p-value for all other age groups was calculated using Pearson's chi-square test for each age group.

The 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups show very strong statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is much lower than our current level of significance. For the 1 – 19, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 130. Columbus Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 8.51%	P_F = 7.92%	p = 0.8579
20 - 29	P_M = 12.30%	P_F = 11.18%	p = 0.3588
30 - 39	P_M = 13.20%	P_F = 16.92%	p = 0.0059
40 - 49	P_M = 8.95 %	P_F = 17.04%	p < 0.0001
50 - 59	P_M = 8.54%	P_F = 16.58%	p < 0.0001
60 - 69	P_M = 20.11%	P_F = 7.38%	p = 0.0024
70 - 79	P_M = 8.33%	P_F = 0.00%	p = 0.3716
80 - 99	P_M = 20.00%	P_F = 0.00%	p = 1.0000

There is at least one cell of the contingency table for the 70 – 79 and 80 – 99 year old age groups with an expected cell count of five or smaller; to determine the p-value for these age groups, we used Fisher's exact test. For all other age groups, we calculated the p-value for each age group using Pearson's chi-square test.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 30 – 39, 40 – 49, and 50 – 59 year old age groups. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 60 – 69 year old age group. For the 1 – 19, 20 – 29, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 131. Columbus Half Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 94	F: 240	M: 54.1	F: 52.5	M: 54.9	F: 52.7	M: 101.1	F: 71.1
20 - 29	M: 976	F: 2370	M: 50.9	F: 49.6	M: 50.0	F: 49.4	M: 115.1	F: 67.6
30 - 39	M: 1136	F: 1992	M: 49.7	F: 48.5	M: 49.6	F: 48.8	M: 86.0	F: 77.9
40 - 49	M: 771	F: 1209	M: 51.8	F: 49.0	M: 52.1	F: 49.3	M: 80.3	F: 84.7
50 - 59	M: 492	F: 585	M: 54.0	F: 51.3	M: 54.0	F: 51.5	M: 89.3	F: 100.7
60 - 69	M: 174	F: 122	M: 51.5	F: 52.0	M: 50.8	F: 49.5	M: 140.5	F: 104.6
70 - 79	M: 24	F: 9	M: 51.7	F: 55.6	M: 50.7	F: 54.4	M: 108.5	F: 132.3
80 - 99	M: 5	F: 1	M: 50.3	F: 59.3	M: 50.4	F: 59.3	M: 244.5	F: 0.00

For the 70 – 79 and the 80 – 89 year old age groups in this race, the mean and median age graded score for the female finishers is larger than the mean and median age graded score for the male finishers but the variance for the female finishers is larger than the variance for the male finishers for the 70 – 79 age group and the variance for the male finishers is larger than the variance for the female finishers for the 80 – 89 age group. For the 60 – 69 year old age group, the mean age graded score for the female finishers is larger than the mean age graded score for the male finishers but the median age graded score and the variance of the age graded scores for the male finishers are larger than the median age graded score and the variance of the age graded scores for the female finishers. For the 40 – 49 and the 50 – 59 year old age groups, the mean and median age graded scores for the male finishers are larger than the mean age graded score for the female finishers but the variance of the age graded scores for the female finishers is larger than the variance of the age graded scores for the male finishers. For all other age groups in this half marathon, the mean age graded score, median age graded score, and the variance of the age graded scores for the male finishers are larger than the mean age graded score, median age graded score, and the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 132. Columbus Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.0349$	$p = 0.0703$	$p = 0.1637$	$p = 0.1253$	$p = 0.1804$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.0008$	$p = 0.0687$	$p = 0.0014$
30 - 39	$p = 0.0595$	$p = 0.0858$	$p = 0.0003$	$p = 0.0016$	$p = 0.0317$
40 - 49	$p = 0.4196$	$p = 0.3964$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.1643$	$p = 0.1366$	$p < 0.0001$	$p < 0.0001$	$p = 0.0002$
60 - 69	$p = 0.0838$	$p = 0.0894$	$p = 0.7456$	$p = 0.6534$	$p = 0.0902$
70 - 79	$p = 0.6638$	$p = 0.8180$	$p = 0.3529$	$p = 0.4546$	$p = 0.4611$
80 - 99	NA	NA	$p = 0.6256$	$p = 1.0000$	$p = 0.9251$

The pooled test statistic of the t-test was used for the 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups while the non-pooled test statistic for the t-test was used for the remaining age groups. The assumption of equal population variances was not met for the 1 – 19, 20 – 29, and 30 – 39 year old age groups but the test results for these age groups were similar to the t-test results for all ages except the 20 – 29 year old age group.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. The tests results for the 1 – 19 year old age group are split; the difference between the variances for the male and female finishers is not statistically significant based on Levene's test but the difference is statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 30 – 39, the 40 – 49, and the 50 – 59 year old age groups. The 20 – 29 year old age group has highly significant results for the test of mean age graded scores and the test for equal distributions of age graded scores between male and female finishers but the results are not statistically significant for the test of median age graded scores between the male and female race finishers. All other age groups were highly non-significant for the difference between the mean age graded scores and the difference between the median age graded scores between male and female finishers. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2.5. Garry Bjorklund Half (Duluth)

The Garry Bjorklund Half Marathon was run on Saturday, June 22, 2013 in Duluth, MN [Running USA 2014]. There were 6,802 total finishers, made up of 2,850 male finishers and 3,952 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 133. Proportion of Duluth Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 4.95%	P_F = 5.74%	p < 0.0001	p = 0.1635
20 - 29	P_M = 27.09%	P_F = 33.05%		p < 0.0001
30 - 39	P_M = 28.18%	P_F = 32.64%		p = 0.0011
40 - 49	P_M = 20.00%	P_F = 17.99%		p = 0.0596
50 - 59	P_M = 14.49%	P_F = 8.78%		p < 0.0001
60 - 69	P_M = 4.77%	P_F = 1.62%		p < 0.0001
70 - 79	P_M = 0.53%	P_F = 0.18%		p = 0.0125

The sample sizes of all age groups were sufficiently large so we employed Pearson's chi-square test to calculate the appropriate p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 year old age group there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The 40 – 49 year old age group shows that there is weak statistical evidence of a significant difference between the proportions of male and female race finishers as the value is not considered significant at the current level of significance but would be considered significant at a larger level.

Table 134. Duluth Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 39.72%	P_F = 27.75%	p = 0.0171
20 - 29	P_M = 28.89%	P_F = 14.40%	p < 0.0001
30 - 39	P_M = 17.56%	P_F = 15.74%	p = 0.2739
40 - 49	P_M = 28.95%	P_F = 21.24%	p = 0.0015
50 - 59	P_M = 36.32%	P_F = 38.62%	p = 0.5144
60 - 69	P_M = 35.29%	P_F = 54.69%	p = 0.0094
70 - 79	P_M = 46.67%	P_F = 42.86%	p = 1.0000

There is at least one cell in the contingency table of the 70 – 79 year old age group with an expected cell frequency of five or lower; we employed Fisher's exact test to calculate the p-value for this age group. All other age groups used Pearson's chi-square test to determine the p-value of each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, and 40 – 49 year old age groups. The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 60 – 69 year old age group. For the 30 – 39, 50 – 59, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 135. Duluth Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 3.55%	P_F = 2.64%	p = 0.7548
20 - 29	P_M = 5.96%	P_F = 8.42%	p = 0.0394
30 - 39	P_M = 7.97%	P_F = 6.98%	p = 0.3973
40 - 49	P_M = 4.74 %	P_F = 6.33%	p = 0.2188
50 - 59	P_M = 2.42%	P_F = 1.44%	p = 0.3331
60 - 69	P_M = 1.47%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 6.67%	P_F = 0.00%	p = 1.0000

Fisher's exact test was used to determine the p-value for the 1 – 19, 60 – 69, and 70 – 79 year old age group because at least one cell from the contingency table of each age group had an expected cell count of five or less. For all other age groups, Pearson's chi-square test was used to calculate the p-value.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 20 – 29 year old age group. For the 1 – 19, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 136. Duluth Half Marathon Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 141	F: 227	M: 58.9	F: 54.2	M: 57.7	F: 52.8	M: 123.7	F: 88.5
20 - 29	M: 772	F: 1306	M: 57.1	F: 51.6	M: 53.3	F: 50.3	M: 230.0	F: 97.3
30 - 39	M: 803	F: 1290	M: 52.7	F: 52.0	M: 51.2	F: 51.2	M: 130.8	F: 84.4
40 - 49	M: 570	F: 711	M: 55.1	F: 53.1	M: 54.8	F: 53.0	M: 102.2	F: 78.7
50 - 59	M: 413	F: 347	M: 57.6	F: 57.3	M: 56.8	F: 57.7	M: 97.6	F: 73.7
60 - 69	M: 136	F: 64	M: 58.0	F: 61.6	M: 57.2	F: 62.4	M: 94.3	F: 96.5
70 - 79	M: 15	F: 7	M: 54.5	F: 65.0	M: 53.2	F: 59.0	M: 169.8	F: 141.6

For the 60 – 69 and the 70 – 79 year old age groups in this race, the mean and median age graded score for female finishers is larger than the mean and median age graded score for the male finishers but the variance for the female finishers is larger than the variance for the male finishers for the 60 – 69 age group and the variance for the male finishers is larger than the variance for the female finishers for the 70 – 79 age group. For the 50 – 59 year old age group, the median age graded score for the female finishers is larger than the median age graded score for the male finishers but the mean age graded score and the variance of the age graded scores for the male finishers are larger than the mean age graded score and the variance of the age graded scores for the female finishers. For the 30 – 39 year old age group, the mean age graded score for the male finishers is larger than the age graded score for the female finishers, the median age graded scores for the male and female finishers are very close, less than 0.5 percent different, and the variance for the age graded scores for the male finishers is larger than the variance age graded scores for the female finishers. For all other age groups in this half marathon, the mean age graded scores, the median age graded scores, and the variance of the age graded scores for the male finishers are larger than the mean age graded scores, the median age graded scores, and the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 137. Duluth Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0257	p = 0.0261	p < 0.0001	p < 0.0001	p < 0.0001
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
30 - 39	p < 0.0001	p < 0.0001	p = 0.1859	p = 0.8802	p = 0.1363
40 - 49	p = 0.0010	p = 0.0047	p = 0.0003	p = 0.0007	p = 0.0030
50 - 59	p = 0.0068	p = 0.0155	p = 0.5853	p = 0.8798	p = 0.5888
60 - 69	p = 0.8945	p = 0.9394	p = 0.0163	p = 0.0190	p = 0.0202
70 - 79	p = 0.8734	p = 0.7006	p = 0.0875	p = 0.1388	p = 0.1324

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year age groups but the test results were similar to the t-test results for all these age groups except the 30 – 39 and 50 – 59 year old age groups. The pooled t-test statistic was used for the 60 – 69 and 70 – 79 year old age groups; all other age groups used the non-pooled test statistic for the t-test.

The difference between the variances of the age graded scores for the male and female finishers is not statistically significant for the 60 – 69 and the 70 – 79 year old age groups based on both the F and Levene's test results. All other age groups are highly significant for both tests with all p-values less than 0.03. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 1 – 19, the 20 – 29, the 40 – 49, and the 60 – 69 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2.6. NYRR 5-Borough Series: Manhattan Half

The Manhattan Half Marathon was run on Sunday, January 27, 2013 in Manhattan, NY [Running USA 2014]. There were 4,923 total finishers, made up of 2,981 male finishers and 1,942 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 138. Proportion of Manhattan Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.77%	P_F = 0.82%	p < 0.0001	p = 0.8402
20 - 29	P_M = 16.40%	P_F = 30.90%		p < 0.0001
30 - 39	P_M = 36.67%	P_F = 38.21%		p = 0.3863
40 - 49	P_M = 27.51%	P_F = 20.34%		p < 0.0001
50 - 59	P_M = 13.79%	P_F = 7.88%		p < 0.0001
60 - 69	P_M = 4.23%	P_F = 1.65%		p < 0.0001
70 - 79	P_M = 0.64%	P_F = 0.21%		p = 0.0304

Pearson's chi-square test was used for all age groups as all groups had large enough sample sizes for Pearson's to be appropriate.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 and 30 – 39 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 139. Manhattan Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 30.43%	P_F = 37.50%	p = 0.6452
20 - 29	P_M = 22.70%	P_F = 20.33%	p = 0.3436
30 - 39	P_M = 22.96%	P_F = 18.46%	p = 0.0205
40 - 49	P_M = 31.34%	P_F = 23.54%	p = 0.0049
50 - 59	P_M = 41.12%	P_F = 45.10%	p = 0.3950
60 - 69	P_M = 50.00%	P_F = 68.75%	p = 0.0575
70 - 79	P_M = 21.05%	P_F = 50.00%	p = 0.2705

The 70 – 79 year old age group has at least one cell in the contingency table with an expected cell frequency of five or lower so we employed the Fisher's exact test to determine the accurate p-value. All other age groups have large sample sizes so we used Pearson's chi-square test to determine the accurate p-values.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 30 – 39 and 40 – 49 year old age groups. The 60 – 69 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 50 – 59, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 140. Manhattan Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 0.00%	P_F = 0.00%	NA
20 - 29	P_M = 5.32%	P_F = 2.50%	p = 0.0151
30 - 39	P_M = 4.30%	P_F = 5.39%	p = 0.2806
40 - 49	P_M = 3.66 %	P_F = 3.04%	p = 0.5791
50 - 59	P_M = 1.70%	P_F = 0.65%	p = 0.3487
60 - 69	P_M = 0.00%	P_F = 0.00%	NA
70 - 79	P_M = 0.00%	P_F = 0.00%	NA

There was not enough data to perform a test of proportions for the 1 – 19, 60 – 69, and 70 – 79 year old age groups. The 50 – 59 year old age group has at least one cell of the contingency table with an expected cell count of five or lower so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so we used Pearson's chi-square test.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 20 – 29 year old age group. For the 1 – 19, 30 – 39, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 141. Manhattan Half Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 23	F: 16	M: 55.2	F: 56.9	M: 53.8	F: 56.4	M: 72.0	F: 51.0
20 - 29	M: 489	F: 600	M: 53.4	F: 53.6	M: 53.0	F: 53.3	M: 78.9	F: 54.2
30 - 39	M: 1093	F: 742	M: 54.1	F: 52.8	M: 54.0	F: 52.7	M: 67.4	F: 61.9
40 - 49	M: 820	F: 395	M: 55.8	F: 54.1	M: 55.9	F: 53.7	M: 77.8	F: 65.3
50 - 59	M: 411	F: 153	M: 57.8	F: 59.1	M: 58.0	F: 58.6	M: 73.5	F: 99.0
60 - 69	M: 126	F: 32	M: 59.7	F: 64.9	M: 59.9	F: 65.4	M: 74.6	F: 90.3
70 - 79	M: 19	F: 4	M: 55.2	F: 62.8	M: 54.0	F: 62.9	M: 58.0	F: 48.7

For the 30 – 39 and the 40 – 49 year old age groups in this race, the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers is larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the female finishers. For the 50 – 59 and the 60 – 69 year old age groups, the mean age graded score, the median age graded score, and the variance of the age graded scores for the female finishers is larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers. For all other age groups in this half marathon, the mean age graded scores and the median age graded scores are larger for the female finishers than for the male finishers but the variance of the age graded scores for the male finishers are larger than the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 142. Manhattan Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.4964$	$p = 0.3662$	$p = 0.5167$	$p = 0.4842$	$p = 0.7369$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.6061$	$p = 0.4901$	$p = 0.1036$
30 - 39	$p = 0.2110$	$p = 0.1930$	$p = 0.0010$	$p = 0.0010$	$p = 0.0029$
40 - 49	$p = 0.0461$	$p = 0.0429$	$p = 0.0008$	$p = 0.0008$	$p = 0.0011$
50 - 59	$p = 0.0222$	$p = 0.0114$	$p = 0.1587$	$p = 0.2404$	$p = 0.2744$
60 - 69	$p = 0.4604$	$p = 0.4539$	$p = 0.0035$	$p = 0.0074$	$p = 0.0165$
70 - 79	$p = 1.0000$	$p = 0.5598$	$p = 0.0799$	$p = 0.0964$	$p = 0.2180$

The assumption of equal variances does not hold for the 20 – 29, 40 – 49, and 50 – 59 year old age groups but the test results are similar to the t-test results for these age groups. The non-pooled t-test statistic was used for the 1 – 19, 30 – 39, 60 – 69, and 70 – 79 year old age groups while the pooled test statistic was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29, the 40 – 49, and the 50 – 59 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 30 – 39, the 40 – 49, and the 60 – 69 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.2.7. NYC Half Marathon

The New York City Half Marathon was run on Sunday, March 17, 2013 from Central Park to South Street Seaport in New York City, NY [Running USA 2014]. There were 14,531 total finishers, made up of 6,919 male finishers and 7,612 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 143. Proportion of NYC Half Marathon Finishers by Age Group

Age Group	**Proportion of Finishers**		**P-value**	**Age Group P**
1 - 19	P_M = 0.52%	P_F = 0.60%	$p < 0.0001$	$p = 0.5008$
20 - 29	P_M = 18.24%	P_F = 32.38%		$p < 0.0001$
30 - 39	P_M = 38.71%	P_F = 38.16%		$p = 0.5989$
40 - 49	P_M = 26.88%	P_F = 20.82%		$p < 0.0001$
50 - 59	P_M = 11.46%	P_F = 6.74%		$p < 0.0001$
60 - 69	P_M = 3.74%	P_F = 1.13%		$p < 0.0001$
70 - 79	P_M = 0.42%	P_F = 0.16%		$p = 0.0030$
80 - 99	P_M = 0.03%	P_F = 0.00%		$p = 0.1380$

Fisher's exact test was used to find the p-value for the 80 – 99 year old age group as at least one of the cells of the contingency table has an expected value of five or lower. All other age group p-values were found using Pearson's chi-square test.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19 and the 20 – 29 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 30 – 39, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 144. New York City Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 41.67%	P_F = 19.57%	p = 0.0290
20 - 29	P_M = 25.99%	P_F = 19.03%	p < 0.0001
30 - 39	P_M = 22.82%	P_F = 17.80%	p < 0.0001
40 - 49	P_M = 30.70%	P_F = 24.67%	p < 0.0001
50 - 59	P_M = 37.33%	P_F = 40.35%	p = 0.2737
60 - 69	P_M = 43.63%	P_F = 59.30%	p = 0.0117
70 - 79	P_M = 37.93%	P_F = 58.33%	p = 0.2310
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 80 – 99 year old age group, there was not enough data to conduct a test of proportions. All other age groups used Pearson’s chi-square test to find the accurate p-value as a result of the large sample sizes.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups. The 60 – 69 year old age group result shows that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent. For the 50 – 59, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 145. New York City Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 5.56%	P_F = 6.52%	p = 1.0000
20 - 29	P_M = 3.72%	P_F = 3.73%	p = 0.9903
30 - 39	P_M = 5.64%	P_F = 4.61%	p = 0.0819
40 - 49	P_M = 2.85%	P_F = 4.61%	p = 0.0062
50 - 59	P_M = 1.77%	P_F = 2.73%	p = 0.2403
60 - 69	P_M = 1.93%	P_F = 1.16%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 60 – 69 year old age groups, there is at least one cell in each contingency table with an expected cell count of five or lower; to calculate the p-value for these age groups, we employed Fisher's exact test. There was not enough evidence to perform a test of proportions for the 70 – 79 and 80 – 99 year old age groups. All other age groups employed Pearson's chi-square test to determine the appropriate p-value.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. The 30 – 39 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or below forty percent is significantly larger than the proportion of female finishers with an age graded score at or below forty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 146. NYC Half Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 36	F: 46	M: 57.6	F: 53.2	M: 56.0	F: 54.4	M: 145.1	F: 79.2
20 - 29	M: 1262	F: 2465	M: 55.2	F: 53.8	M: 53.9	F: 53.4	M: 102.3	F: 70.5
30 - 39	M: 2678	F: 2905	M: 53.8	F: 53.1	M: 53.1	F: 52.7	M: 85.4	F: 69.5
40 - 49	M: 1860	F: 1585	M: 55.9	F: 54.5	M: 55.6	F: 54.1	M: 80.3	F: 73.2
50 - 59	M: 793	F: 513	M: 57.7	F: 58.1	M: 57.6	F: 57.4	M: 84.5	F: 86.7
60 - 69	M: 259	F: 86	M: 58.6	F: 61.2	M: 58.4	F: 61.6	M: 93.1	F: 90.3
70 - 79	M: 29	F: 12	M: 56.9	F: 65.5	M: 55.7	F: 61.7	M: 93.7	F: 126.2
80 - 99	M: 2	F: 0	M: 54.2	F: NA	M: 54.2	F: NA	M: 1.4	F: NA

For the 60 – 69 and the 70 – 79 year old age groups in this race, the mean and median age graded score for female finishers is larger than the mean and median age graded score for the male finishers but the variance for the female finishers is larger than the variance for the male finishers for the 70 – 79 age group and the variance for the male finishers is larger than the variance for the female finishers for the 60 – 69 age group. For the 50 – 59 year old age group, the median age graded score for the male finishers is larger than the median age graded score for the female finishers but the mean age graded score and the variance of the age graded scores for the female finishers are larger than the mean and variance for the male finishers. For all other age groups in this half marathon, the mean age graded scores, median age graded scores, and the variances of the age graded scores for the male finishers are larger than the scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 147. NYC Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0559	p = 0.0351	p = 0.0620	p = 0.1488	p = 0.1096
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p = 0.0014	p < 0.0001
30 - 39	p < 0.0001	p < 0.0001	p = 0.0035	p = 0.0141	p = 0.0003
40 - 49	p = 0.0572	p = 0.0634	p < 0.0001	p < 0.0001	p = 0.0002
50 - 59	p = 0.7443	p = 0.7507	p = 0.3598	p = 0.3715	p = 0.2502
60 - 69	p = 0.8857	p = 0.8046	p = 0.0295	p = 0.0300	p = 0.0306
70 - 79	p = 0.5030	p = 0.5913	p = 0.0174	p = 0.0284	p = 0.1613

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test does not hold for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups though the results were similar to the t-test results for these age groups. The pooled test statistic was used for the t-test for the 50 – 59, 60 – 69, and 70 – 79 year old age groups while the non-pooled test statistic was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 and the 30 – 39 year old age groups based on both the F and Levene's test results. The tests results for the 1 – 19 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are not statistically significant for the 1 – 19 and the 50 – 59 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores is not significant for the 70 – 79 year old age group but all other age groups follow the same trends as the difference between the mean age graded scores and the difference between the median age graded scores for the male and female race finishers.

6.6.2.8. Surf City USA Half Marathon

The Surf City USA Half Marathon was run on Sunday, February 3, 2013 in Huntington Beach, CA [Running USA 2014]. There were 14,698 total finishers, made up of 5,881 male finishers and 8,817 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 148. Proportion of Surf City Half Marathon Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 2.43%	P_F = 2.12%	p < 0.0001	p = 0.2182
20 - 29	P_M = 15.32%	P_F = 20.35%		p < 0.0001
30 - 39	P_M = 29.77%	P_F = 32.61%		p = 0.0027
40 - 49	P_M = 29.79%	P_F = 28.16%		p = 0.0714
50 - 59	P_M = 16.70%	P_F = 13.72%		p < 0.0001
60 - 69	P_M = 5.08%	P_F = 2.78%		p < 0.0001
70 - 79	P_M = 0.87%	P_F = 0.25%		p < 0.0001
80 - 99	P_M = 0.03%	P_F = 0.01%		p = 0.3460

The sample size for the 80 – 99 year old age group is very small so we employed Fisher's exact test to determine the p-value accurately. All other age groups have very large sample sizes so we used Pearson's chi-square test to calculate the p-value.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The p-value for the 40 – 49 year old age group gives weak statistical evidence of a significant difference between the proportions of male and female race finishers because the value is larger than the chosen level of significance but would be considered significant at a larger level of significance.

Table 149. Surf City Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 30.07%	P_F = 14.97%	p = 0.0009
20 - 29	P_M = 7.55%	P_F = 6.19%	p = 0.1811
30 - 39	P_M = 8.79%	P_F = 7.10%	p = 0.0359
40 - 49	P_M = 15.53%	P_F = 10.87%	p < 0.0001
50 - 59	P_M = 22.00%	P_F = 15.70%	p = 0.0002
60 - 69	P_M = 20.07%	P_F = 16.73%	p = 0.3200
70 - 79	P_M = 17.65%	P_F = 13.64%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 100%	p = 0.3333

The 70 – 79 and 80 – 99 year old age groups had at least one cell of the contingency table with an expected cell count of five or less; to determine the p-value for these age groups we employed Fisher’s exact test. Due to the large sample sizes of all other age groups, we used Pearson’s chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 1 – 19, 30 – 39, 40 – 49, and 50 – 59 year old age groups. For the 20 – 29, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 150. Surf City Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 18.88%	P_F = 17.11%	p = 0.6777
20 - 29	P_M = 26.86%	P_F = 26.37%	p = 0.7843
30 - 39	P_M = 24.73%	P_F = 28.49%	p = 0.0053
40 - 49	P_M = 18.04 %	P_F = 23.20%	p < 0.0001
50 - 59	P_M = 13.14%	P_F = 23.06%	p < 0.0001
60 - 69	P_M = 16.72%	P_F = 11.02%	p = 0.0577
70 - 79	P_M = 11.76%	P_F = 4.55%	p = 0.6670
80 - 99	P_M = 50.00%	P_F = 0.00%	p = 1.0000

For the 70 – 79 and 80 – 99 year old age groups, there is at least one cell of the contingency table with an expected cell frequency of five or smaller; to calculate the appropriate p-value for each age group, we used Fisher's exact test. For all other age groups, the sample sizes were sufficiently large so we used Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 30 – 39, 40 – 49, and 50 – 59 year old age groups. The 60 – 69 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or below forty percent is significantly larger than the proportion of female finishers with an age graded score at or below forty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 151. Surf City Half Marathon Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 143	F: 187	M: 52.5	F: 49.2	M: 53.1	F: 49.0	M: 146.9	F: 95.4
20 - 29	M: 901	F: 1794	M: 45.8	F: 46.1	M: 45.4	F: 45.6	M: 100.0	F: 81.1
30 - 39	M: 1751	F: 2875	M: 47.0	F: 45.8	M: 46.6	F: 45.5	M: 96.0	F: 88.4
40 - 49	M: 1752	F: 2483	M: 49.7	F: 47.7	M: 49.6	F: 47.7	M: 105.8	F: 93.2
50 - 59	M: 982	F: 1210	M: 52.0	F: 49.0	M: 51.4	F: 48.1	M: 110.2	F: 112.7
60 - 69	M: 299	F: 245	M: 50.7	F: 50.3	M: 49.4	F: 48.8	M: 119.8	F: 98.9
70 - 79	M: 51	F: 22	M: 51.8	F: 50.7	M: 51.0	F: 49.7	M: 131.5	F: 64.8
80 - 99	M: 2	F: 1	M: 44.9	F: 63.8	M: 44.9	F: 63.8	M: 100.8	F: 0.00

For the 20 – 29 year old age group in this race, the mean and median age graded score for female finishers is larger than the mean and median age graded score for the male finishers but the variance for the male finishers is larger than the variance for the female finishers. For all other age groups in this half marathon, the mean and median age graded scores for the male finishers are larger than the scores for the female finishers. The variances for the 50 – 59 old age group is larger for the female finishers than for the male finishers but the variances of all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the half marathon race finisher population.

Table 152. Surf City Half Marathon Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.0058$	$p = 0.0012$	$p = 0.0063$	$p = 0.0091$	$p = 0.0056$
20 - 29	$p = 0.0002$	$p = 0.0015$	$p = 0.5215$	$p = 0.4701$	$p = 0.3796$
30 - 39	$p = 0.0528$	$p = 0.0459$	$p < 0.0001$	$p < 0.0001$	$p = 0.0003$
40 - 49	$p = 0.0040$	$p = 0.0035$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.7041$	$p = 0.6875$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
60 - 69	$p = 0.1183$	$p = 0.1048$	$p = 0.6945$	$p = 0.5443$	$p = 0.3027$
70 - 79	$p = 0.0787$	$p = 0.1323$	$p = 0.6736$	$p = 0.8995$	$p = 0.4991$
80 - 99	NA	NA	$p = 0.3676$	$p = 0.5403$	$p = 0.5176$

The equal variances assumption of the Wilcoxon test is not met for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups but the results of the test are still similar to the results of the t-test. The pooled test statistic for the t-test was used for 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups while the non-pooled t-test statistic was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 50 – 59 and the 60 – 69 year old age groups based on both the F and Levene's test results. The tests results for the 30 – 39 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 1 – 19, the 30 – 39, the 40 – 49, and the 50 – 59 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.3. Ten K Race Results

To explore the differences that exist between the male and female ten kilometer race finishers, we employed several techniques, both statistical and visual. We first tested the proportion of male and female ten kilometer race finishers, then we visually inspect the descriptive statistics of the age graded scores, finally we ran several statistical tests to determine if the distribution of age graded scores was equal for the male and female ten kilometer race finishers. Each of these tests were conducted for the individual age groups, as we defined them previously, for each individual race we examined in this paper.

6.6.3.1. Cooper River Bridge Run

The Cooper River Bridge Run 10k was run on Saturday, April 6, 2013 in Charleston, SC [Running USA 2014]. There were 30,737 total finishers, made up of 12,625 male finishers and 18,112 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 153. Proportion of Cooper River Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	$P_M = 5.25\%$	$P_F = 4.84\%$	p < 0.0001	p = 0.1147
20 - 29	$P_M = 21.70\%$	$P_F = 27.82\%$		p < 0.0001
30 - 39	$P_M = 26.52\%$	$P_F = 27.80\%$		p = 0.0337
40 - 49	$P_M = 21.40\%$	$P_F = 20.75\%$		p = 0.2230
50 - 59	$P_M = 16.15\%$	$P_F = 13.73\%$		p < 0.0001
60 - 69	$P_M = 7.56\%$	$P_F = 4.55\%$		p < 0.0001
70 - 79	$P_M = 1.27\%$	$P_F = 0.46\%$		p < 0.0001
80 - 99	$P_M = 0.15\%$	$P_F = 0.04\%$		p = 0.0009

All age groups had large enough sample sizes to use Pearson's chi-square to determine the accurate p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups. For the 1 – 19 and 40 – 49 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 154. Cooper River Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 16.89%	P_F = 6.39%	$p < 0.0001$
20 - 29	P_M = 8.80%	P_F = 4.84%	$p < 0.0001$
30 - 39	P_M = 7.89%	P_F = 3.77%	$p < 0.0001$
40 - 49	P_M = 10.73%	P_F = 4.95%	$p < 0.0001$
50 - 59	P_M = 13.73%	P_F = 7.76%	$p < 0.0001$
60 - 69	P_M = 12.77%	P_F = 7.65%	$p = 0.0004$
70 - 79	P_M = 10.00%	P_F = 12.05%	$p = 0.6242$
80 - 99	P_M = 5.26%	P_F = 0.00%	$p = 1.0000$

The sample size of the 80 – 99 year old age group is very small so we used Fisher's exact test to determine the appropriate p-value for this age group. All other age groups had sufficiently large sample sizes so we were able to use Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 70 – 79 and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 155. Cooper River Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 28.05%	P_F = 45.38%	$p < 0.0001$
20 - 29	P_M = 25.70%	P_F = 34.01%	$p < 0.0001$
30 - 39	P_M = 31.66%	P_F = 41.00%	$p < 0.0001$
40 - 49	P_M = 30.61 %	P_F = 45.92%	$p < 0.0001$
50 - 59	P_M = 32.91%	P_F = 51.83%	$p < 0.0001$
60 - 69	P_M = 38.95%	P_F = 54.37%	$p < 0.0001$
70 - 79	P_M = 50.00%	P_F = 36.14%	$p = 0.0396$
80 - 99	P_M = 21.05%	P_F = 0.00%	$p = 0.5463$

There is at least one cell in the contingency table for the 80 – 99 year old age group that has an expected value of five or less; to calculate the p-value for this age group we used Fisher's exact test. The p-values for all other age groups were calculated using Pearson's chi-square test.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19. 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 70 – 79 year old age group. For the 80 – 99 year old age group, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 156. Cooper River Ten K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 663	F: 877	M: 47.3	F: 41.9	M: 47.1	F: 41.9	M: 180.0	F: 134.8
20 - 29	M: 2739	F: 5039	M: 45.9	F: 43.8	M: 46.0	F: 44.5	M: 120.4	F: 107.7
30 - 39	M: 3348	F: 5036	M: 44.7	F: 42.0	M: 45.0	F: 42.9	M: 130.3	F: 116.3
40 - 49	M: 2702	F: 3759	M: 45.9	F: 41.4	M: 46.7	F: 41.4	M: 146.2	F: 130.1
50 - 59	M: 2039	F: 2487	M: 46.2	F: 41.9	M: 47.3	F: 39.4	M: 160.8	F: 136.3
60 - 69	M: 955	F: 824	M: 45.1	F: 42.1	M: 45.2	F: 38.8	M: 162.0	F: 117.4
70 - 79	M: 160	F: 83	M: 43.2	F: 45.6	M: 40.1	F: 43.1	M: 150.1	F: 127.2
80 - 99	M: 19	F: 7	M: 46.9	F: 50.7	M: 46.2	F: 50.9	M: 95.4	F: 54.3

For the 70 – 79 and the 80 – 89 year old age groups in this race, the mean and median age graded scores for female finishers are larger than the mean and median age graded scores for the male finishers but the variances of the age graded scores for the male finishers are larger than the variances for the female finishers. For all other age groups in this ten kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances of the age graded scores for the 1 – 19 year old age group are larger for the female finishers than for the male finishers but the variances of age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 157. Cooper River Ten K Test Results by Age Group

Age Group	**F Test**	**Levene's Test**	**T Test**	**Wilcoxon**	**KS Test**
1 - 19	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
20 - 29	$p = 0.0008$	$p = 0.0043$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
30 - 39	$p = 0.0003$	$p = 0.0003$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
40 - 49	$p = 0.0010$	$p = 0.0005$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
60 - 69	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
70 - 79	$p = 0.4042$	$p = 0.3940$	$p = 0.1407$	$p = 0.0709$	$p = 0.0107$
80 - 99	$p = 0.5016$	$p = 0.5037$	$p = 0.3635$	$p = 0.4183$	$p = 0.7713$

The assumption of equal population variances of the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups but the test results were still very similar to the t-test results. The pooled test statistic for the t-test was used for the 70 – 79 and 80 – 99 year old age groups while all other age groups used the non-pooled test statistic for the t-test calculations.

The difference between the variances of the age graded scores for the male and female finishers is statistically non-significant for the 70 – 79 and the 80 – 89 year old age groups based on both the F and Levene's test results. All other age groups are highly significant for both tests. The difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores are highly non-significant for the 80 – 89 year old age group. The difference between the mean age graded scores and the difference between the median age graded scores are non-significant for the 70 – 79 year old age group but the test for equal distributions is significant for the 70 – 79 year old age group. All other age groups were highly statistically significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of the age graded scores.

6.6.3.2. Crescent City Classic 10k

The Crescent City Classic 10k was run on Saturday, March 30, 2013 in New Orleans, LA [Running USA 2014]. There were 17,016 total finishers, made up of 7,909 male finishers and 9,107 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 158. Proportion of Crescent City Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 6.88%	P_F = 5.89%	p < 0.0001	p = 0.0104
20 - 29	P_M = 22.70%	P_F = 27.53%		p < 0.0001
30 - 39	P_M = 26.40%	P_F = 28.30%		p = 0.0184
40 - 49	P_M = 20.69%	P_F = 20.72%		p = 0.9601
50 - 59	P_M = 15.31%	P_F = 12.87%		p < 0.0001
60 - 69	P_M = 6.80%	P_F = 4.15%		p < 0.0001
70 - 79	P_M = 1.15%	P_F = 0.53%		p < 0.0001
80 - 99	P_M = 0.08%	P_F = 0.02%		p = 0.1058

The 80 – 99 year old age group has at least one cell in the contingency table with an expected cell count of five or less so the appropriate p-value is calculated using Fisher's exact test. All other age groups had large enough sample sizes to use Pearson's chi-square test to find the appropriate p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 40 – 49 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 159. Crescent City Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 15.63%	P_F = 4.85%	p < 0.0001
20 - 29	P_M = 9.92%	P_F = 3.99%	p < 0.0001
30 - 39	P_M = 8.81%	P_F = 3.38%	p < 0.0001
40 - 49	P_M = 12.96%	P_F = 3.76%	p < 0.0001
50 - 59	P_M = 14.53%	P_F = 7.00%	p < 0.0001
60 - 69	P_M = 11.52%	P_F = 4.50%	p = 0.0002
70 - 79	P_M = 4.40%	P_F = 8.33%	p = 0.4472
80 - 99	P_M = 33.33%	P_F = 0.00%	p = 1.0000

The sample sizes for the 70 – 79 and 80 – 99 year old age groups are too small to accurate use Pearson's chi-square test so Fisher's exact test was used to calculate the p-value for each age group. All other age groups had sufficiently large sample sizes to make Pearson's chi-square test an appropriate choice to determine the p-values for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 70 – 79 and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 160. Crescent City Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 41.54%	P_F = 58.58%	$p < 0.0001$
20 - 29	P_M = 35.38%	P_F = 46.99%	$p < 0.0001$
30 - 39	P_M = 35.68%	P_F = 52.00%	$p < 0.0001$
40 - 49	P_M = 34.41 %	P_F = 56.12%	$p < 0.0001$
50 - 59	P_M = 36.75%	P_F = 58.96%	$p < 0.0001$
60 - 69	P_M = 42.94%	P_F = 56.61%	$p < 0.0001$
70 - 79	P_M = 49.45%	P_F = 37.50%	$p = 0.1784$
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

There was not enough information for the 80 – 99 year old age group to accurately perform a test of proportions. The sample sizes for all other age groups was large enough to use Pearson's chi-square test to determine the accurate p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 70 – 79 and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 161. Crescent City Ten K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 544	F: 536	M: 44.2	F: 38.7	M: 43.8	F: 36.8	M: 220.8	F: 124.7
20 - 29	M: 1795	F: 2507	M: 44.0	F: 40.6	M: 44.5	F: 41.0	M: 161.5	F: 125.9
30 - 39	M: 2088	F: 2577	M: 43.7	F: 39.4	M: 44.4	F: 39.4	M: 143.3	F: 121.5
40 - 49	M: 1636	F: 1887	M: 45.2	F: 39.1	M: 45.8	F: 37.1	M: 168.0	F: 125.5
50 - 59	M: 1211	F: 1172	M: 45.6	F: 40.4	M: 45.7	F: 37.5	M: 175.6	F: 122.8
60 - 69	M: 538	F: 378	M: 43.7	F: 40.5	M: 42.5	F: 38.3	M: 154.7	F: 90.5
70 - 79	M: 91	F: 48	M: 41.7	F: 44.0	M: 40.1	F: 41.0	M: 101.2	F: 104.1
80 - 99	M: 6	F: 2	M: 53.2	F: 49.6	M: 53.7	F: 49.6	M: 85.1	F: 80.5

For the 70 – 79 year old age group in this race, the mean age graded score, the median age graded score, and the variance of the age graded scores for the female finishers are larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers. For all other age groups in this ten kilometer race, the mean age graded score, the median age graded score, and the variance of the age graded scores for the male finishers are larger than the mean age graded score, the median age graded score, and the variance of the age graded scores for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 162. Crescent City Ten K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
40 - 49	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
60 - 69	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p = 0.0005$	$p < 0.0001$
70 - 79	$p = 0.8900$	$p = 0.9468$	$p = 0.2201$	$p = 0.2060$	$p = 0.3200$
80 - 99	$p = 1.0000$	NA	$p = 0.6505$	$p = 0.4047$	$p = 0.8475$

The assumption of equal variances for the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups but the results of the Wilcoxon test were still very similar to the results of the t-test. The pooled t-test statistic formula was used for the 70 – 79 and 80 – 99 year old age groups; all other age groups used the non-pooled test statistic formula for the t-test.

The difference between the variances of the age graded scores for the male and female finishers is statistically non-significant for the 70 – 79 and the 80 – 89 year old age groups based on both the F and Levene's test results. All other age groups are highly significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically non-significant for the 70 – 79 and the 80 – 89 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.3.3. Radio Fargo Moorhead 10k

The Radio Fargo Moorhead was run on Saturday, May 18, 2013 in Fargo, ND [Running USA 2014]. There were 3,479 total finishers, made up of 958 male finishers and 2,521 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 163. Proportion of Fargo Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 9.81%	P_F = 3.93%	p < 0.0001	p < 0.0001
20 - 29	P_M = 25.89%	P_F = 29.04%		p = 0.1180
30 - 39	P_M = 33.61%	P_F = 32.73%		p = 0.6841
40 - 49	P_M = 11.69%	P_F = 16.22%		p = 0.0020
50 - 59	P_M = 11.80%	P_F = 15.55%		p = 0.0094
60 - 69	P_M = 6.16%	P_F = 2.38%		p < 0.0001
70 - 79	P_M = 0.94%	P_F = 0.12%		p = 0.0002
80 - 99	P_M = 0.10%	P_F = 0.04%		p = 0.4770

There is at least one cell of the contingency table for the 80 – 99 year old age group that has an expected cell count of five or lower; to calculate the appropriate p-value for this age group Fisher's exact test was used. All other age groups had sufficiently large sample sizes for Pearson's chi-square test to be used for p-value calculations.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, the 40 – 49, and the 50 – 59 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 20 – 29, 30 – 39, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 164. Fargo Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 19.15%	P_F = 3.03%	p = 0.0003
20 - 29	P_M = 6.45%	P_F = 3.55%	p = 0.0513
30 - 39	P_M = 4.35%	P_F = 3.64%	p = 0.5729
40 - 49	P_M = 8.93%	P_F = 5.87%	p = 0.2453
50 - 59	P_M = 23.01%	P_F = 11.48%	p = 0.0019
60 - 69	P_M = 27.12%	P_F = 13.33%	p = 0.0610
70 - 79	P_M = 33.33%	P_F = 33.33%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The sample size of the 70 – 79 year old age group was too small to use Pearson's chi-square test to determine the accurate p-value so Fisher's exact test was used instead. There was not enough information for the 80 – 99 year old age group to perform the test of proportions accurately. All other age groups had satisfactorily large sample sizes to successfully use Pearson's chi-square test to determine the accurate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19 and 50 – 59 year old age group. The 20 – 29 and 60 – 69 year old age group results show weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 30 – 39, 40 – 49, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 165. Fargo Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 11.70%	P_F = 20.20%	p = 0.1080
20 - 29	P_M = 22.58%	P_F = 23.22%	p = 0.8353
30 - 39	P_M = 20.81%	P_F = 24.97%	p = 0.1369
40 - 49	P_M = 18.75 %	P_F = 26.65%	p = 0.0869
50 - 59	P_M = 15.93%	P_F = 26.79%	p = 0.0178
60 - 69	P_M = 27.12%	P_F = 28.33%	p = 0.8824
70 - 79	P_M = 11.11%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the contingency table of the 70 – 79 year old age group there is at least one cell with an expected frequency of five or smaller; to calculate the correct p-value for this age group we employed Fisher's exact test. The 80 – 99 year old age group does not have enough data to conduct a test of proportions correctly. All other age groups were large enough to use Pearson's chi-square test to determine the correct p-value.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 50 – 59 year old age group. The 40 – 49 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 30 – 39, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 166. Fargo Ten K Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 94	F: 99	M: 50.9	F: 47.2	M: 51.9	F: 48.0	M: 101.0	F: 62.8
20 - 29	M: 248	F: 732	M: 47.3	F: 45.7	M: 47.6	F: 46.1	M: 87.1	F: 64.3
30 - 39	M: 322	F: 825	M: 46.5	F: 45.3	M: 47.1	F: 45.4	M: 65.2	F: 69.3
40 - 49	M: 112	F: 409	M: 47.8	F: 46.4	M: 47.7	F: 46.9	M: 79.9	F: 82.0
50 - 59	M: 113	F: 392	M: 51.3	F: 48.1	M: 51.6	F: 47.6	M: 111.1	F: 107.4
60 - 69	M: 59	F: 60	M: 51.7	F: 47.4	M: 53.0	F: 48.0	M: 149.4	F: 89.2
70 - 79	M: 9	F: 3	M: 51.9	F: 54.0	M: 49.2	F: 54.7	M: 156.6	F: 89.6
80 - 99	M: 1	F: 1	M: 54.2	F: 57.2	M: 54.2	F: 57.2	M: 0.00	F: 0.00

For the 70 – 79 and the 80 – 89 year old age groups in this race, the mean and median age graded scores for female finishers are larger than the mean and median age graded score for the male finishers but the variance for the male finishers is larger than the variance for the female finishers for the 70 – 79 age group and the variance for the male finishers is equal to the variance for the female finishers for the 80 – 89 age group. For all other age groups in this ten kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 30 – 39 and the 40 – 49 year old age groups are larger for the female finishers than for the male finishers but the variances of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 167. Fargo Ten K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0208	p = 0.0225	p = 0.0047	p = 0.0071	p = 0.0125
20 - 29	p = 0.0027	p = 0.0065	p = 0.0124	p = 0.0074	p = 0.0006
30 - 39	p = 0.5242	p = 0.5389	p = 0.0288	p = 0.0176	p = 0.0066
40 - 49	p = 0.8868	p = 0.8193	p = 0.1303	p = 0.1803	p = 0.1544
50 - 59	p = 0.8013	p = 0.8490	p = 0.0050	p = 0.0050	p = 0.0204
60 - 69	p = 0.0504	p = 0.0088	p = 0.0362	p = 0.0799	p = 0.0363
70 - 79	p = 0.8282	p = 0.3634	p = 0.7966	p = 0.8533	p = 0.9639

The equal variance assumption of the Mann-Whitney-Wilcoxon test was not met for the 1 – 19, 20 – 29, and 60 – 69 year old age groups but the test results are still similar to the results of the t-test. The pooled test statistic formula for the t-test was used for the 30 – 39, 40 – 49, 50 – 59, and 70 – 79 year old age groups; all other age groups was the non-pooled test statistic formula for the t-test.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 1 – 19, the 20 – 29, and the 60 – 69 year old age groups based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded scores, the difference between the median age graded scores, and the test for equal distributions of age graded scores between male and female race finishers are statistically non-significant for the 40 – 49 and the 70 – 79 year old age groups. The 60 – 69 year old age group is significant for the difference between the mean age graded scores for male and female race finishers and for the test of equal distributions of the age graded scores for the male and female race finishers but is not significant for the difference between the median age graded scores for the male and female race finishers. All other age groups were highly significant for the difference between the means, the difference between the medians, and the test for equal distributions of the age graded scores between male and female finishers.

6.6.3.4. NYRR Joe Kleinerman 10k Classic

The NYRR Joe Kleinerman 10k Classic was run on Saturday, January 5, 2013 in New York City, NY [Running USA 2014]. There were 3,137 total finishers, made up of 1,714 male finishers and 1,423 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 168. Proportion of Joe Kleinerman Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.82%	P_F = 1.34%	p < 0.0001	p = 0.1587
20 - 29	P_M = 14.35%	P_F = 29.80%		p < 0.0001
30 - 39	P_M = 36.06%	P_F = 36.05%		p = 0.9980
40 - 49	P_M = 28.24%	P_F = 20.66%		p < 0.0001
50 - 59	P_M = 15.05%	P_F = 9.35%		p < 0.0001
60 - 69	P_M = 4.14%	P_F = 2.18%		p = 0.0024
70 - 79	P_M = 1.28%	P_F = 0.56%		p = 0.0397
80 - 99	P_M = 0.06%	P_F = 0.07%		p = 0.8952

The contingency table for the 80 – 99 year old age group has at least one cell with an expected frequency of five or lower; to accurately determine the p-value for this age group, Fisher’s exact test was used. The sample sizes for all other age groups were sufficiently large so Pearson’s chi-square test was used to calculate the p-values.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19 and the 20 – 29 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 30 – 39, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 169. Joe Kleinerman Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 50.00%	P_F = 31.58%	p = 0.2845
20 - 29	P_M = 24.39%	P_F = 21.70%	p = 0.4225
30 - 39	P_M = 24.27%	P_F = 16.57%	p = 0.0015
40 - 49	P_M = 36.98%	P_F = 23.47%	p < 0.0001
50 - 59	P_M = 39.15%	P_F = 42.86%	p = 0.4788
60 - 69	P_M = 42.25%	P_F = 54.84%	p = 0.2409
70 - 79	P_M = 54.55%	P_F = 87.50%	p = 0.1987
80 - 99	P_M = 0.00%	P_F = 100%	p = 1.0000

The sample sizes for the 70 – 79 and 80 – 99 year old age groups were too small to use Pearson's chi-square test to determine the p-value, Fisher's exact test was used to accurately calculate the p-value for these age groups. All other age groups employed Pearson's chi-square test to determine the p-values.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 30 – 39 and 40 – 49 year old age groups. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 170. Joe Kleinerman Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 7.14%	P_F = 5.26%	p = 1.0000
20 - 29	P_M = 3.66%	P_F = 3.30%	p = 0.8069
30 - 39	P_M = 4.05%	P_F = 4.09%	p = 0.9674
40 - 49	P_M = 2.69 %	P_F = 4.42%	p = 0.1915
50 - 59	P_M = 3.49%	P_F = 2.26%	p = 0.7582
60 - 69	P_M = 1.41%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19, 50 – 59, and 60 – 69 year old age groups, there is at least one cell of the contingency tables with an expected cell count of five or less; to determine the correct p-value for each age group, Fisher's exact test was employed. There was not enough data for the 70 – 79 and 80 – 99 year old age groups to conduct a proper test of proportions. All other age groups were large enough to use Pearson's chi-square test to determine the appropriate p-value for each age group.

For the all age groups in this race, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 171. Joe Kleinerman Ten K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 14	F: 19	M: 58.2	F: 55.4	M: 59.7	F: 54.4	M: 138.4	F: 104.9
20 - 29	M: 246	F: 424	M: 54.3	F: 53.8	M: 53.8	F: 52.9	M: 88.0	F: 68.8
30 - 39	M: 618	F: 513	M: 54.4	F: 52.4	M: 54.2	F: 52.0	M: 75.3	F: 66.6
40 - 49	M: 484	F: 294	M: 57.2	F: 53.7	M: 56.7	F: 52.8	M: 82.0	F: 76.5
50 - 59	M: 258	F: 133	M: 57.5	F: 58.4	M: 57.6	F: 58.9	M: 100.4	F: 96.3
60 - 69	M: 71	F: 31	M: 58.8	F: 60.1	M: 58.5	F: 60.9	M: 75.6	F: 89.9
70 - 79	M: 22	F: 8	M: 60.3	F: 69.3	M: 60.8	F: 65.4	M: 86.0	F: 128.3
80 - 99	M: 1	F: 1	M: 56.3	F: 70.3	M: 56.3	F: 70.3	M: 0.00	F: 0.00

For half of the age groups in this race, the mean and median age graded scores for male finishers are larger than the mean and median age graded score for the female finishers but the mean and median age graded scores for female finishers are larger than the mean and median age graded scores for the male finishers for the other half of the age groups. The variances for the 60 – 69 and the 70 – 79 year old age groups are larger for the female finishers than for the female finishers but the variance of all other age groups in this ten kilometer follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 172. Joe Kleinerman Ten K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.5754	p = 0.6209	p = 0.4661	p = 0.4335	p = 0.1621
20 - 29	p = 0.0284	p = 0.0517	p = 0.4958	p = 0.5942	p = 0.1465
30 - 39	p = 0.1510	p = 0.1754	p < 0.0001	p < 0.0001	p = 0.0002
40 - 49	p = 0.5182	p = 0.5133	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.7942	p = 0.7428	p = 0.3758	p = 0.4417	p = 0.5934
60 - 69	p = 0.5462	p = 0.5878	p = 0.4926	p = 0.5126	p = 0.6854
70 - 79	p = 0.4473	p = 0.4977	p = 0.0345	p = 0.0710	p = 0.3452

The 20 – 29 year old age group does not meet the assumption of equal variances for the Mann-Whitney-Wilcoxon test but the test results were still similar to the results of the t-test. The non-pooled test statistic formula for the t-test was used for the 20 – 29 year old age group and the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 30 – 39 and the 40 – 49 year old age groups. The 70 – 79 year old age group is statistically significant for the difference between the mean age graded scores for the male and female race finishers but not significant for the difference between the median age graded scores or the test for equal distributions of age graded scores between male and female race finishers. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.3.5. Manhattan Beach 10k

The Manhattan Beach 10k was run on Sunday, October 6, 2013 in Manhattan Beach, CA [Running USA 2014]. There were 3,455 total finishers, made up of 1,716 male finishers and 1,739 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 173. Proportion of Manhattan Beach Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	$P_M = 7.11\%$	$P_F = 6.96\%$	$p < 0.0001$	$p = 0.8666$
20 - 29	$P_M = 12.06\%$	$P_F = 18.75\%$		$p < 0.0001$
30 - 39	$P_M = 23.72\%$	$P_F = 28.18\%$		$p = 0.0101$
40 - 49	$P_M = 27.51\%$	$P_F = 24.78\%$		$p = 0.1177$
50 - 59	$P_M = 16.61\%$	$P_F = 14.32\%$		$p = 0.0869$
60 - 69	$P_M = 8.57\%$	$P_F = 5.29\%$		$p = 0.0003$
70 - 79	$P_M = 3.96\%$	$P_F = 1.55\%$		$p < 0.0001$
80 - 99	$P_M = 0.47\%$	$P_F = 0.17\%$		$p = 0.1261$

All age groups have sufficiently large sample sizes for Pearson's chi-square test to calculate the appropriate p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, and the 30 – 39 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 30 – 39, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 40 – 49, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. For the 50 – 59 year old age group there is weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 174. Manhattan Beach Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 38.52%	P_F = 20.66%	p = 0.0023
20 - 29	P_M = 20.77%	P_F = 11.35%	p = 0.0030
30 - 39	P_M = 16.95%	P_F = 13.27%	p = 0.1229
40 - 49	P_M = 25.85%	P_F = 17.17%	p = 0.0016
50 - 59	P_M = 33.33%	P_F = 28.92%	p = 0.2720
60 - 69	P_M = 23.13%	P_F = 23.91%	p = 0.8893
70 - 79	P_M = 20.59%	P_F = 22.22%	p = 0.8601
80 - 99	P_M = 37.50%	P_F = 66.67%	p = 0.5455

There is at least one cell in the contingency table for the 80 – 99 year old age group has an expected frequency of five or smaller; to determine the appropriate p-value for this age group Fisher's exact test was utilized. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, and 40 – 49 year old age groups. For the 30 – 39, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 175. Manhattan Beach Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 4.10%	P_F = 12.40%	p = 0.0186
20 - 29	P_M = 13.04%	P_F = 12.88%	p = 0.9572
30 - 39	P_M = 8.35%	P_F = 11.43%	p = 0.1270
40 - 49	P_M = 7.84%	P_F = 16.71%	p < 0.0001
50 - 59	P_M = 10.88%	P_F = 19.68%	p = 0.0045
60 - 69	P_M = 14.29%	P_F = 17.39%	p = 0.5184
70 - 79	P_M = 30.88%	P_F = 11.11%	p = 0.0455
80 - 99	P_M = 12.50%	P_F = 0.00%	p = 1.0000

There is at least one cell in the contingency table for the 80 – 99 year old age group has an expected cell count of five or lower; to determine the appropriate p-value for this age group Fisher's exact test was used for calculation. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19, 40 – 49, and 50 – 59 year old age group. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 70 – 79 year old age group. For the 20 – 29, 30 – 39, 60 – 69, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 176. Manhattan Beach Ten K Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 122	F: 121	M: 56.9	F: 53.1	M: 56.7	F: 53.8	M: 119.4	F: 105.5
20 - 29	M: 207	F: 326	M: 51.9	F: 49.9	M: 51.7	F: 50.1	M: 126.7	F: 75.3
30 - 39	M: 407	F: 490	M: 52.4	F: 50.4	M: 52.2	F: 50.8	M: 86.8	F: 80.4
40 - 49	M: 472	F: 431	M: 53.8	F: 50.5	M: 54.1	F: 50.5	M: 92.0	F: 106.7
50 - 59	M: 285	F: 249	M: 55.0	F: 52.5	M: 56.0	F: 53.9	M: 121.9	F: 140.7
60 - 69	M: 147	F: 92	M: 51.4	F: 52.0	M: 50.7	F: 51.4	M: 120.1	F: 133.8
70 - 79	M: 68	F: 27	M: 49.0	F: 51.7	M: 45.8	F: 48.5	M: 143.8	F: 107.4
80 - 99	M: 8	F: 3	M: 57.5	F: 60.5	M: 59.6	F: 63.6	M: 70.8	F: 38.4

For the 60 – 69, the 70 – 79, and the 80 – 89 year old age groups in this race, the mean and median age graded scores for the female finishers are larger than the mean and median age graded scores for the male finishers. For all other age groups in this ten kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 40 – 49, the 50 – 59, and the 60 – 69 year old age groups are larger for the female finishers than for the male finishers but the variances of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 177. Manhattan Beach Ten K Test Results by Age Group

Age Group	**F Test**	**Levene's Test**	**T Test**	**Wilcoxon**	**KS Test**
1 - 19	$p = 0.4988$	$p = 0.4909$	$p = 0.0048$	$p = 0.0097$	$p = 0.0414$
20 - 29	$p < 0.0001$	$p = 0.0002$	$p = 0.0326$	$p = 0.0570$	$p = 0.0167$
30 - 39	$p = 0.4169$	$p = 0.4743$	$p = 0.0012$	$p = 0.0107$	$p = 0.0716$
40 - 49	$p = 0.1169$	$p = 0.1259$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.2428$	$p = 0.1685$	$p = 0.0138$	$p = 0.0200$	$p = 0.0124$
60 - 69	$p = 0.5585$	$p = 0.5535$	$p = 0.6966$	$p = 0.9104$	$p = 0.5856$
70 - 79	$p = 0.4125$	$p = 0.2254$	$p = 0.3050$	$p = 0.2205$	$p = 0.2349$
80 - 99	$p = 0.7924$	$p = 0.5908$	$p = 0.5983$	$p = 0.4750$	$p = 0.5440$

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test for the 20 – 29 year old but the test results are still similar to the t-test results. The non-pooled test statistic formula for the t-test was used for the 20 – 29 year old age group and the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score, the difference between the median age graded score, and the test for equal distributions are highly non-significant for the 60 – 69, the 70 – 79, and the 80 – 89 year old age groups. The 20 – 29 year old age group is statistically non-significant for the difference in median age graded score between the male and female race finishers and the 30 – 39 year old age group is non-significant for the test for equal distributions between the male and female race finishers. All other age groups were highly non-significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the tests for equal distributions between the male and female race finishers.

6.6.3.6. NYRR 5-Borough Series: Queens 10k

The NYRR five-borough series: Queens 10k was run on Saturday, July 21, 2013 around Flushing Meadow in New York City, NY [Running USA 2014]. There were 6,479 total finishers, made up of 3,663 male finishers and 2,816 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 178. Proportion of Queens Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.74%	P_F = 1.03%	p < 0.0001	p = 0.2090
20 - 29	P_M = 19.27%	P_F = 30.89%		p < 0.0001
30 - 39	P_M = 42.70%	P_F = 42.15%		p = 0.7385
40 - 49	P_M = 23.94%	P_F = 18.61%		p < 0.0001
50 - 59	P_M = 10.10%	P_F = 6.14%		p < 0.0001
60 - 69	P_M = 2.78%	P_F = 0.96%		p < 0.0001
70 - 79	P_M = 0.46%	P_F = 0.21%		p = 0.0927

All age groups have sufficiently large sample sizes for Pearson's chi-square test to correctly determine the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19 and the 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 1 – 19 and 30 – 39 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The 70 – 79 year old age group there has weak statistical evidence to show that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 179. Queens Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 33.33%	P_F = 6.90%	p = 0.0128
20 - 29	P_M = 15.86%	P_F = 10.92%	p = 0.0039
30 - 39	P_M = 17.01%	P_F = 9.18%	p < 0.0001
40 - 49	P_M = 24.52%	P_F = 13.17%	p < 0.0001
50 - 59	P_M = 34.86%	P_F = 27.75%	p = 0.0991
60 - 69	P_M = 33.33%	P_F = 40.74%	p = 0.4727
70 - 79	P_M = 29.41%	P_F = 83.33%	p = 0.0515

There is at least one cell in the contingency table for the 70 – 79 year old age group has an expected cell count of five or smaller; to determine the appropriate p-value for this age group Fisher's exact test was utilized. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age group. The 50 – 59 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. The 70 – 79 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 60 – 69 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 180. Queens Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 3.70%	P_F = 10.34%	p = 0.6120
20 - 29	P_M = 10.48%	P_F = 6.78%	p = 0.0086
30 - 39	P_M = 6.46%	P_F = 7.83%	p = 0.1623
40 - 49	P_M = 2.85%	P_F = 5.34%	p = 0.0180
50 - 59	P_M = 1.62%	P_F = 0.00%	p = 0.1839
60 - 69	P_M = 0.00%	P_F = 0.00%	NA
70 - 79	P_M = 0.00%	P_F = 0.00%	NA

There is at least one cell in the contingency table for the 1 – 19 and 50 – 59 year old age group has an expected frequency of five or fewer; to determine the appropriate p-value for this age group Fisher's exact test was utilized. There is not enough data for the 60 – 69 and 70 – 79 year old age groups to conduct a test of proportions. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 20 – 29 year old age group. For the 1 – 19, 30 – 39, 50 –549, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 181. Queens Ten K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 27	F: 29	M: 55.2	F: 49.3	M: 53.8	F: 47.9	M: 136.4	F: 52.2
20 - 29	M: 706	F: 870	M: 51.3	F: 50.5	M: 50.5	F: 50.2	M: 78.6	F: 56.5
30 - 39	M: 1564	F: 1187	M: 51.7	F: 50.1	M: 51.1	F: 49.7	M: 69.2	F: 50.2
40 - 49	M: 877	F: 524	M: 54.5	F: 51.5	M: 54.6	F: 50.9	M: 65.3	F: 57.9
50 - 59	M: 370	F: 173	M: 56.8	F: 55.4	M: 57.0	F: 54.7	M: 70.6	F: 58.7
60 - 69	M: 102	F: 27	M: 57.7	F: 59.8	M: 56.1	F: 59.3	M: 88.8	F: 42.3
70 - 79	M: 17	F: 6	M: 57.6	F: 69.0	M: 54.3	F: 68.7	M: 114.7	F: 100.6

For the 60 – 69 and the 70 – 79 year old age group in this race, the mean and median age graded scores for the female finishers are larger than the mean and median age graded scores for the male finishers. For all other age groups in this ten kilometer race, the mean and median age graded scores for the male finishers are larger than the scores for the female finishers. The variances for all of the age groups in this race are larger for the male finishers than for the female finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 182. Queens Ten K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0145	p = 0.0142	p = 0.0285	p = 0.0793	p = 0.1156
20 - 29	p < 0.0001	p < 0.0001	p = 0.0642	p = 0.1017	p = 0.1814
30 - 39	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
40 - 49	p = 0.1233	p = 0.1145	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.1685	p = 0.1326	p = 0.0580	p = 0.0399	p = 0.1660
60 - 69	p = 0.0328	p = 0.0755	p = 0.1981	p = 0.1243	p = 0.2847
70 - 79	p = 0.9638	p = 0.7628	p = 0.0328	p = 0.0274	p = 0.0488

The equal variance assumption for the Mann-Whitney-Wilcoxon test is not met for the 1 – 19, 20 – 29, 30 – 39, and 60 – 69 year old age groups but the test results are similar to the t-test results. The pooled test statistic formula for the t-test was used for the 40 – 49, 50 – 59, and 70 – 79 year old age groups; the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 1 – 19, the 20 – 29, and the 30 – 39 year old age group based on both the F and Levene's test results. The tests results for the 60 – 69 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on the F test but the difference is not statistically significant based on Levene's test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score, the difference between the median age graded score and the test for equal distributions are statistically significant for the 30 – 39, the 40 – 49, and the 70 – 79 year old age groups. The 1 – 19 year old age group is statistically significant for the difference in mean age graded score between the male and female race finishers and the 50 – 59 year old age group is significant for the difference in median age graded score between the male and female race finishers. All other age groups were highly non-significant for the difference between the mean age graded scores, the difference between the median age graded scores, and the tests for equal distributions between the male and female race finishers.

6.6.3.7. NYRR Scotland Run 10k

The Scotland Run 10k was run on Saturday, April 6, 2013 around Central Park in New York City, NY [Running USA 2014]. There were 7,255 total finishers, made up of 3,936 male finishers and 3,319 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 183. Proportion of Scotland Run Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.46%	P_F = 0.21%	$p < 0.0001$	$p = 0.0749$
20 - 29	P_M = 20.25%	P_F = 36.52%		$p < 0.0001$
30 - 39	P_M = 41.13%	P_F = 39.89%		$p = 0.4081$
40 - 49	P_M = 23.55%	P_F = 15.46%		$p < 0.0001$
50 - 59	P_M = 10.54%	P_F = 5.85%		$p < 0.0001$
60 - 69	P_M = 3.33%	P_F = 1.72%		$p < 0.0001$
70 - 79	P_M = 0.69%	P_F = 0.33%		$p = 0.0376$
80 - 99	P_M = 0.05%	P_F = 0.03%		$p = 0.6660$

There is at least one cell in the contingency table for the 80 – 99 year old age group has an expected frequency of five or smaller; to determine the appropriate p-value for this age group

Fisher's exact test was utilized. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 30 – 39 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. For the 1 – 19 year old age group there is weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 184. Scotland Run Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 38.89%	P_F = 28.57%	p = 1.0000
20 - 29	P_M = 26.10%	P_F = 15.51%	p < 0.0001
30 - 39	P_M = 24.15%	P_F = 16.39%	p < 0.0001
40 - 49	P_M = 36.35%	P_F = 23.39%	p < 0.0001
50 - 59	P_M = 46.51%	P_F = 42.27%	p = 0.3275
60 - 69	P_M = 61.83%	P_F = 61.40%	p = 0.9557
70 - 79	P_M = 51.85%	P_F = 72.73%	p = 0.2960
80 - 99	P_M = 0.00%	P_F = 100%	p = 0.3333

For the 1 – 19, 70 – 79, and 80 – 99 year old age groups there is at least one cell in the contingency tables with an expected cell count of five or smaller; to determine the accurate p-value for these age groups, we used Fisher's exact test for the calculation. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 20 – 29, 30 – 39, and 40 – 49 year old age groups. For the 1 – 19, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 185. Scotland Run Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 0.00%	P_F = 14.29%	p = 0.2800
20 - 29	P_M = 2.63%	P_F = 2.56%	p = 0.9152
30 - 39	P_M = 1.85%	P_F = 4.83%	p < 0.0001
40 - 49	P_M = 2.05%	P_F = 8.97%	p < 0.0001
50 - 59	P_M = 1.69%	P_F = 1.55%	p = 1.0000
60 - 69	P_M = 0.76%	P_F = 0.00%	p = 1.0000
70 - 79	P_M = 3.70%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 19, 50 – 59, 60 – 69, and 70 – 79 year old age groups have at least one cell in the contingency table with an expected cell frequency of five or less; to determine the appropriate p-value for this age group Fisher's exact test was utilized. There is not enough data for the 80 – 99 year old age group to perform a test of proportions. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 30 – 39 and 40 – 49 year old age groups. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 186. Scotland Run Ten K Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 18	F: 7	M: 57.6	F: 52.0	M: 55.3	F: 53.9	M: 103.4	F: 80.8
20 - 29	M: 797	F: 1212	M: 54.9	F: 53.6	M: 53.2	F: 52.5	M: 99.5	F: 58.9
30 - 39	M: 1619	F: 1324	M: 54.4	F: 53.1	M: 53.8	F: 52.4	M: 74.6	F: 62.0
40 - 49	M: 927	F: 513	M: 57.8	F: 53.9	M: 57.2	F: 53.4	M: 84.0	F: 80.0
50 - 59	M: 415	F: 194	M: 60.0	F: 60.1	M: 59.2	F: 58.8	M: 85.2	F: 85.3
60 - 69	M: 131	F: 57	M: 63.2	F: 62.4	M: 62.8	F: 63.8	M: 94.9	F: 162.7
70 - 79	M: 27	F: 11	M: 63.3	F: 67.5	M: 63.1	F: 68.3	M: 128.1	F: 142.9
80 - 99	M: 2	F: 1	M: 53.6	F: 69.2	M: 53.6	F: 69.2	M: 22.9	F: 0.00

For the 50 – 59, the 70 – 79, and the 80 – 89 year old age groups in this race, the mean age graded scores for the female finishers are larger than the mean age graded scores for the male finishers. For the 60 – 69, the 70 – 79 and the 80 – 89 year old age groups, the median age graded scores for the female finishers are larger than the median age graded scores for the male finishers. For all other age groups in this marathon, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 50 – 59, the 60 – 69, and the 70 – 79 year old age groups are larger for the female finishers than for the male finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 187. Scotland Run Ten K Test Results by Age Group

Scotland Run	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.8077	p = 0.5520	p = 0.2175	p = 0.4493	p = 0.8316
20 - 29	p < 0.0001	p < 0.0001	p = 0.0016	p = 0.0314	p < 0.0001
30 - 39	p = 0.0004	p = 0.0036	p < 0.0001	p = 0.0002	p < 0.0001
40 - 49	p = 0.5365	p = 0.5699	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.9856	p = 0.9852	p = 0.9855	p = 0.8446	p = 0.5602
60 - 69	p = 0.0130	p = 0.0081	p = 0.6843	p = 0.7046	p = 0.0469
70 - 79	p = 0.7757	p = 0.9079	p = 0.3132	p = 0.2738	p = 0.8072
80 - 99	NA	NA	p = 0.2282	p = 0.5403	p = 0.5176

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test is not met for the 20 – 29, 30 – 39, and 60 – 69 year old age groups but the test results are still similar to the results of the t-test. The non-pooled test statistic formula for the t-test was used for the 20 – 29, 30 – 39, and 60 – 69 year old age groups while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29, the 30 – 39, and the 60 – 69 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded scores and the difference between the median age graded scores for male and female race finishers are statistically significant for the 20 – 29, the 30 – 39, and the 40 – 49 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores of the male and female race finishers follows the same trend for the means and medians.

6.6.3.8. UAE Healthy Kidney 10k

The UAE Healthy Kidney 10k was run on Saturday, May 11, 2013 around Manhattan in New York City, NY [Running USA 2014]. There were 5,854 total finishers, made up of 3,156 male finishers and 2,698 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 188. Proportion of UAE Ten K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 0.86%	P_F = 0.44%	p < 0.0001	p = 0.0550
20 - 29	P_M = 19.74%	P_F = 33.84%		p < 0.0001
30 - 39	P_M = 41.57%	P_F = 40.47%		p = 0.5138
40 - 49	P_M = 23.29%	P_F = 16.35%		p < 0.0001
50 - 59	P_M = 10.49%	P_F = 7.01%		p < 0.0001
60 - 69	P_M = 3.39%	P_F = 1.67%		p < 0.0001
70 - 79	P_M = 0.60%	P_F = 0.22%		p = 0.0267
80 - 99	P_M = 0.06%	P_F = 0.00%		p = 0.1910

There is at least one cell in the contingency table for the 80 – 99 year old age group has an expected frequency of five or smaller; to determine the appropriate p-value for this age group Fisher's exact test was utilized. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 30 –

39 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. For the 1 – 19 year old age group there is weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 189. UAE Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 25.93%	P_F = 8.33%	p = 0.3938
20 - 29	P_M = 21.51%	P_F = 11.72%	p < 0.0001
30 - 39	P_M = 18.29%	P_F = 9.80%	p < 0.0001
40 - 49	P_M = 28.57%	P_F = 14.97%	p < 0.0001
50 - 59	P_M = 35.05%	P_F = 25.93%	p = 0.0316
60 - 69	P_M = 38.32%	P_F = 33.33%	p = 0.5609
70 - 79	P_M = 36.84%	P_F = 83.33%	p = 0.0730
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 70 – 79 year old age groups, there is at least one cell in the contingency table has an expected cell frequency of five or smaller; Fisher's exact test was used to determine the appropriate p-value for each age group. There is not enough information for the 80 – 99 year old age group to conduct a test of proportions. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups. The 70 – 79 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance.

For the 1 – 19, 60 – 69, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 190. UAE Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 7.41%	P_F = 16.67%	p = 0.5733
20 - 29	P_M = 5.78%	P_F = 5.37%	p = 0.7290
30 - 39	P_M = 5.64%	P_F = 5.68%	p = 0.9685
40 - 49	P_M = 3.81 %	P_F = 7.03%	p = 0.0143
50 - 59	P_M = 5.44%	P_F = 5.29%	p = 0.9430
60 - 69	P_M = 1.87%	P_F = 2.22%	p = 1.0000
70 - 79	P_M = 0.00%	P_F = 0.00%	NA
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

The 1 – 19 and 60 – 69 year old age groups have at least one cell in the contingency table with an expected cell count of five or fewer; to calculate the appropriate p-value for these age groups Fisher's exact test was utilized. The 70 – 79 and 80 – 99 year old age groups do not have enough data to conduct a test of proportions. All other age groups had sufficiently large sample sizes to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 191. UAE Healthy Kidney Ten K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 27	F: 12	M: 54.8	F: 47.2	M: 55.6	F: 47.7	M: 185.4	F: 89.8
20 - 29	M: 623	F: 913	M: 53.6	F: 51.8	M: 52.4	F: 51.7	M: 109.9	F: 61.8
30 - 39	M: 1312	F: 1092	M: 52.7	F: 51.0	M: 52.5	F: 50.8	M: 77.2	F: 50.8
40 - 49	M: 735	F: 441	M: 55.4	F: 51.9	M: 55.5	F: 52.1	M: 76.4	F: 64.6
50 - 59	M: 331	F: 189	M: 56.8	F: 54.8	M: 57.0	F: 54.5	M: 93.8	F: 80.7
60 - 69	M: 107	F: 45	M: 58.0	F: 57.4	M: 57.2	F: 56.1	M: 96.4	F: 102.7
70 - 79	M: 19	F: 6	M: 59.4	F: 66.2	M: 53.3	F: 67.2	M: 164.2	F: 34.9
80 - 99	M: 2	F: 0	M: 52.7	F: NA	M: 52.7	F: NA	M: 47.3	F: NA

For the 70 – 79 year old age group in this race, the mean and median age graded scores for the female finishers are larger than the mean and median age graded scores for the male finishers. For all other age groups in this ten kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances of the age graded scores for the 60 – 69 year old age groups are larger for the female finishers than for the male finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the ten kilometer race finisher population.

Table 192. UAE Healthy Kidney Ten K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.2078$	$p = 0.3245$	$p = 0.0870$	$p = 0.0972$	$p = 0.0982$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.0003$	$p = 0.0185$	$p = 0.0011$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
40 - 49	$p = 0.0526$	$p = 0.0722$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.2559$	$p = 0.2884$	$p = 0.0215$	$p = 0.0093$	$p = 0.0046$
60 - 69	$p = 0.7741$	$p = 0.8361$	$p = 0.7173$	$p = 0.7074$	$p = 0.8813$
70 - 79	$p = 0.0945$	$p = 0.0424$	$p = 0.2259$	$p = 0.1921$	$p = 0.1598$

The 20 – 29, 30 – 39, and 40 – 49 year old age groups do not meet the equal variances assumption for the Mann-Whitney-Wilcoxon test but the test results are still similar to the t-test results. The non-pooled test statistic formula for the t-test was used for the 20 – 29, 30 – 39, and 40 – 49 year old age groups while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29, and the 30 – 39 year old age groups based on both the F and Levene's test results. The tests results for the 40 – 49, and the 70 – 79 year old age group are split; for the 70 – 79 year old age group, the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test, the 40 – 49 year old age group follows the opposite trend. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically non-significant for the 1 – 19, the 60 – 69, and the 70 – 79 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.4. Five K Race Results

To explore the differences that exist between the male and female five kilometer race finishers, we employed several techniques, both statistical and visual. We first tested the proportion of male and female five kilometer race finishers, then we visually inspect the descriptive statistics of the age graded scores, finally we ran several statistical tests to determine if the distribution of age graded scores was equal for the male and female five kilometer race finishers. Each of these tests were conducted for the individual age groups, as we defined them previously, for each individual race we have considered in this paper.

6.6.4.1. Boston Athletic Association 5k

The Boston 5k was run on Sunday, April 14, 2013 in Boston, MA [Running USA 2014]. There were 5,477 total finishers, made up of 2,422 male finishers and 3,055 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 193. Proportion of Boston Five K Finishers by Age Group

Boston	**Proportion of Finishers**		**P-value**	**Age Group P**
1 - 19	$P_M = 4.29\%$	$P_F = 3.18\%$	$p < 0.0001$	$p = 0.0318$
20 - 29	$P_M = 18.08\%$	$P_F = 27.86\%$		$p < 0.0001$
30 - 39	$P_M = 31.67\%$	$P_F = 31.06\%$		$p = 0.6915$
40 - 49	$P_M = 24.11\%$	$P_F = 22.23\%$		$p = 0.1488$
50 - 59	$P_M = 14.57\%$	$P_F = 12.21\%$		$p = 0.0169$
60 - 69	$P_M = 6.36\%$	$P_F = 3.24\%$		$p < 0.0001$
70 - 79	$P_M = 0.87\%$	$P_F = 0.23\%$		$p = 0.0001$
80 - 99	$P_M = 0.04\%$	$P_F = 0.00\%$		$p = 0.2614$

The sample size for the 80 – 99 year old age group was too small to use Pearson's chi-square test so we used Fisher's exact test to calculate the p-value for this age group. All other age groups had sufficiently large sample sizes so we used Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 30 – 39, 40 – 49, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 194. Boston Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 38.46%	P_F = 24.74%	p = 0.0369
20 - 29	P_M = 29.91%	P_F = 16.10%	p < 0.0001
30 - 39	P_M = 27.25%	P_F = 16.54%	p < 0.0001
40 - 49	P_M = 33.90%	P_F = 23.27%	p < 0.0001
50 - 59	P_M = 33.14%	P_F = 38.61%	p = 0.1253
60 - 69	P_M = 35.06%	P_F = 34.34%	p = 0.9064
70 - 79	P_M = 42.86%	P_F = 42.86%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 70 – 79 year old age group the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. There is not enough information for the 80 – 99 year old age group to perform a test of proportions. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age group. For the 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 195. Boston Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 7.69%	P_F = 6.19%	p = 0.6750
20 - 29	P_M = 8.68%	P_F = 8.46%	p = 0.8958
30 - 39	P_M = 10.04%	P_F = 9.06%	p = 0.4926
40 - 49	P_M = 6.34 %	P_F = 8.25%	p = 0.1946
50 - 59	P_M = 6.23%	P_F = 6.43%	p = 0.9111
60 - 69	P_M = 15.58%	P_F = 3.03%	p = 0.0016
70 - 79	P_M = 4.76%	P_F = 14.29%	p = 0.4444
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 70 – 79 year old age group the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. There is not enough information for the 80 – 99 year old age group to perform a test of proportions. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 60 – 69 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 196. Boston Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 104	F: 97	M: 57.0	F: 54.9	M: 55.1	F: 53.1	M: 171.1	F: 140.2
20 - 29	M: 438	F: 851	M: 55.0	F: 51.8	M: 53.5	F: 51.1	M: 160.3	F: 96.5
30 - 39	M: 767	F: 949	M: 53.4	F: 51.7	M: 52.3	F: 51.2	M: 123.2	F: 86.8
40 - 49	M: 584	F: 679	M: 55.5	F: 53.4	M: 55.0	F: 53.3	M: 112.7	F: 90.1
50 - 59	M: 353	F: 373	M: 55.3	F: 57.0	M: 54.4	F: 57.1	M: 115.4	F: 103.4
60 - 69	M: 154	F: 99	M: 55.2	F: 56.1	M: 55.6	F: 55.0	M: 147.7	F: 94.4
70 - 79	M: 21	F: 7	M: 59.4	F: 58.1	M: 57.5	F: 51.9	M: 121.2	F: 280.2
80 - 99	M: 1	F: 0	M: 45.0	F: NA	M: 45.0	F: NA	M: 0.00	F: NA

For the 50 – 59 and the 60 – 69 year old age groups in this race, the mean age graded score for the female finishers is larger than the mean age graded score for the male finishers. For the 50 – 59 year old age group, the median age graded score for the female finishers is larger than the median age graded score for the male finishers. For all other age groups in this marathon, the mean and median age graded scores for the male finishers are larger than the scores for the female finishers. The variances for the 70 – 79 year old age group are larger for the female finishers than for the male finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 197. Boston Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.3246	p = 0.3028	p = 0.2485	p = 0.2031	p = 0.1469
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p = 0.0001	p < 0.0001
30 - 39	p < 0.0001	p < 0.0001	p = 0.0008	p = 0.0057	p < 0.0001
40 - 49	p = 0.0050	p = 0.0047	p = 0.0003	p = 0.0009	p = 0.0003
50 - 59	p = 0.2977	p = 0.2712	p = 0.0308	p = 0.0333	p = 0.0154
60 - 69	p = 0.0172	p = 0.0124	p = 0.5513	p = 0.6901	p = 0.2387
70 - 79	p = 0.1476	p = 0.0749	p = 0.8166	p = 0.7103	p = 0.4313

The assumption of equal population variances was not met for the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups but the test results were still similar to the results of the t-test. The pooled test statistic formula for the t-test was used for the 1 – 19, 50 – 59, and 70 – 79 year old age groups while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly non-significant for the 1 – 19, the 50 – 59, and the 70 – 79 year old age groups based on both the F and Levene's test results. All other age groups are highly statistically significant for both tests. The difference between the mean age graded scores and the difference between the median age graded scores for the male and female race finishers are statistically non-significant for the 1 – 19, the 60 – 69, and the 70 – 79 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.4.2. Finish Chelsea's Run 5k

The Finish Chelsea's Run 5k was run on Sunday, March 2, 2013 in San Diego, CA [Running USA 2014]. There were 1,626 total finishers, made up of 646 male finishers and 980 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 198. Proportion of Chelsea's Run Five K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 20.43%	P_F = 15.92%	$p < 0.0001$	$p = 0.0343$
20 - 29	P_M = 14.24%	P_F = 19.90%		$p = 0.0079$
30 - 39	P_M = 20.59%	P_F = 26.22%		$p = 0.0328$
40 - 49	P_M = 27.55%	P_F = 23.37%		$p = 0.0987$
50 - 59	P_M = 11.15%	P_F = 11.63%		$p = 0.7763$
60 - 69	P_M = 4.95%	P_F = 2.55%		$p = 0.0113$
70 - 79	P_M = 1.08%	P_F = 0.41%		$p = 0.1052$

The 70 – 79 year old age group has at least one cell in the contingency table with an expected value of five or fewer, to determine the appropriate p-value we used Fisher's exact test. All other age groups had adequate sample sizes to use Pearson's chi-square test to calculate the p-value of each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29, the 30 – 39, and the 50 – 59 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 30 – 39, and 60 – 69 year old age groups. For the 50 – 59 and 70 – 79 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. The 40 – 49 year old age group there shows weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 199. Chelsea's Run Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 21.21%	P_F = 12.82%	p = 0.0569
20 - 29	P_M = 19.57%	P_F = 8.21%	p = 0.0054
30 - 39	P_M = 14.29%	P_F = 6.61%	p = 0.0131
40 - 49	P_M = 11.80%	P_F = 8.30%	p = 0.2392
50 - 59	P_M = 36.11%	P_F = 28.95%	p = 0.3065
60 - 69	P_M = 31.25%	P_F = 24.00%	p = 0.5455
70 - 79	P_M = 57.14%	P_F = 25.00%	p = 0.5455

For the 70 – 79 year old age group the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 20 – 29 and 30 – 39 year old age group. The 1 – 19 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 200. Chelsea's Run Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 24.24%	P_F = 26.92%	p = 0.6039
20 - 29	P_M = 23.91%	P_F = 27.69%	p = 0.4983
30 - 39	P_M = 29.32%	P_F = 33.85%	p = 0.3646
40 - 49	P_M = 23.60%	P_F = 29.69%	p = 0.1693
50 - 59	P_M = 8.33%	P_F = 23.68%	p = 0.0076
60 - 69	P_M = 31.25%	P_F = 36.00%	p = 0.7058
70 - 79	P_M = 14.29%	P_F = 25.00%	p = 1.0000

For the 70 – 79 year old age group the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 50 – 59 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 201. Finish Chelsea's Run Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 132	F: 156	M: 49.4	F: 46.7	M: 51.3	F: 47.3	M: 172.5	F: 147.0
20 - 29	M: 92	F: 195	M: 49.0	F: 45.8	M: 50.2	F: 45.5	M: 153.1	F: 104.0
30 - 39	M: 133	F: 157	M: 46.9	F: 44.4	M: 46.4	F: 44.7	M: 145.3	F: 117.3
40 - 49	M: 178	F: 229	M: 47.0	F: 46.6	M: 46.7	F: 47.0	M: 130.2	F: 113.4
50 - 59	M: 72	F: 114	M: 55.4	F: 50.6	M: 56.7	F: 49.7	M: 109.3	F: 165.4
60 - 69	M: 32	F: 25	M: 50.6	F: 47.8	M: 49.6	F: 46.4	M: 261.8	F: 173.6
70 - 79	M: 7	F: 4	M: 57.4	F: 48.9	M: 65.8	F: 47.6	M: 182.1	F: 195.6

For the 40 – 49 year old age group in this race, the median age graded score for the female finishers is larger than the mean and median age graded score for the male finishers. For all other age groups in this five kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 50 – 59 and the 70 – 79 year old age groups are larger for the female finishers than for the male finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 202. Finish Chelsea's Run Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.3370	p = 0.2740	p = 0.0705	p = 0.0486	p = 0.0398
20 - 29	p = 0.0267	p = 0.0161	p = 0.0311	p = 0.0119	p = 0.0127
30 - 39	p = 0.1488	p = 0.1386	p = 0.0461	p = 0.0911	p = 0.1237
40 - 49	p = 0.3266	p = 0.3352	p = 0.7348	p = 0.7581	p = 0.7561
50 - 59	p = 0.0603	p = 0.0458	p = 0.0083	p = 0.0036	p = 0.0015
60 - 69	p = 0.3033	p = 0.1033	p = 0.4860	p = 0.5572	p = 0.5659
70 - 79	p = 0.8563	p = 0.9109	p = 0.3478	p = 0.2193	p = 0.3768

The assumption of equal population variances was not met for the 20 – 29 year old age group but the test results were still similar to the results of the t-test. The non-pooled test statistic formula for the t-test was used for the 20 – 29 year old age group while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. The tests results for the 50 – 59 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded scores is significant for the 20 – 29, the 30 – 39, and the 50 – 59 year old age groups but statistically non-significant for all other age groups. The difference between the median age graded scores and the test for distributions are statistically significant for the 1 – 19, the 20 – 29, and the 50 – 59 year old age groups. All other age groups were highly non-significant for the difference between the medians and the test for distributions.

6.6.4.3. Publix Gasparilla Distance Classic 5k

The Publix Super Markets Gasparilla Distance Classic 5k was run on Saturday, February 23, 2013 in Tampa, FL [Running USA 2014]. There were 9,915 total finishers, made up of 3,961 male finishers and 5,951 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 203. Proportion of Gasparilla Five K Finishers by Age Group

Age Group	**Proportion of Finishers**		**P-value**	**Age Group P**
1 - 19	P_M = 7.22%	P_F = 5.33%	p < 0.0001	p = 0.0002
20 - 29	P_M = 17.34%	P_F = 22.53%		p < 0.0001
30 - 39	P_M = 25.30%	P_F = 27.68%		p = 0.0256
40 - 49	P_M = 23.96%	P_F = 23.07%		p = 0.3652
50 - 59	P_M = 15.80%	P_F = 14.74%		p = 0.1783
60 - 69	P_M = 8.15%	P_F = 5.73%		p < 0.0001
70 - 79	P_M = 1.84%	P_F = 0.74%		p < 0.0001
80 - 99	P_M = 0.38%	P_F = 0.18%		p = 0.0647

All age groups had sufficiently large sample sizes allowing us to use Pearson's chi-square test to calculate the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 and the 30 – 39 year old age group but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 30 – 39, 60 – 69, and 70 – 79 year old age groups. For the 40 – 49 and 50 – 59 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. For the 80 – 99 year old age group there is weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 204. Gasparilla Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 12.24%	P_F = 7.57%	p = 0.0541
20 - 29	P_M = 4.51%	P_F = 2.31%	p = 0.0064
30 - 39	P_M = 2.69%	P_F = 1.34%	p = 0.0118
40 - 49	P_M = 4.64%	P_F = 2.33%	p = 0.0021
50 - 59	P_M = 9.27%	P_F = 3.88%	p < 0.0001
60 - 69	P_M = 8.36%	P_F = 6.47%	p = 0.4308
70 - 79	P_M = 8.22%	P_F = 15.91%	p = 0.2325
80 - 99	P_M = 6.67%	P_F = 18.18%	p = 0.5558

The 70 – 79 and 80 – 99 year old age groups have at least one cell in the contingency tables with an expected cell count of five or lower, to determine the appropriate p-value for the age groups we used Fisher's exact test for the calculations. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups. The 1 – 19 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 205. Gasparilla Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 31.47%	P_F = 45.74%	$p = 0.0003$
20 - 29	P_M = 46.14%	P_F = 50.48%	$p = 0.0641$
30 - 39	P_M = 52.89%	P_F = 55.68%	$p = 0.1630$
40 - 49	P_M = 43.84%	P_F = 57.61%	$p < 0.0001$
50 - 59	P_M = 37.86%	P_F = 52.91%	$p < 0.0001$
60 - 69	P_M = 38.39%	P_F = 49.56%	$p = 0.0038$
70 - 79	P_M = 45.21%	P_F = 38.64%	$p = 0.4866$
80 - 99	P_M = 33.33%	P_F = 9.09%	$p = 0.1973$

For the 80 – 99 year old age group the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19, 40 – 49, 50 – 59, and 60 – 69 year old age groups. The 20 – 29 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or below forty percent is significantly larger than the proportion of male finishers with an age graded score at or below forty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 30 – 39, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 206. Gasparilla Five K Descriptive Statistics by Age Group

Age Group	**Total**		**Mean**		**Median**		**Variance**	
1 - 19	M: 286	F: 317	M: 46.4	F: 41.9	M: 45.6	F: 41.4	M: 155.6	F: 132.5
20 - 29	M: 687	F: 1341	M: 41.3	F: 39.6	M: 41.1	F: 39.9	M: 117.1	F: 95.2
30 - 39	M: 1002	F: 1647	M: 39.4	F: 38.1	M: 39.3	F: 38.5	M: 112.9	F: 90.3
40 - 49	M: 949	F: 1373	M: 41.6	F: 38.7	M: 41.5	F: 38.0	M: 115.5	F: 102.5
50 - 59	M: 626	F: 877	M: 43.8	F: 40.5	M: 43.7	F: 38.8	M: 140.9	F: 100.9
60 - 69	M: 323	F: 341	M: 44.0	F: 42.3	M: 44.2	F: 40.1	M: 150.5	F: 102.1
70 - 79	M: 73	F: 44	M: 42.5	F: 45.6	M: 42.8	F: 42.5	M: 147.3	F: 153.8
80 - 99	M: 15	F: 11	M: 45.3	F: 54.7	M: 44.5	F: 52.6	M: 54.7	F: 176.5

For the 70 – 79 and the 80 – 89 year old age groups in this race, the mean age graded scores and the variance of the age graded scores for female finishers are larger than the mean age graded scores and the variance of the age graded scores for the male finishers but the median age graded score for the female finishers is larger than the variance for the male finishers for the 80 – 89 year old age group and the median age graded score for the male finishers is larger than the variance for the female finishers for the 70 – 79 year old age group. For all other age groups in this five kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 70 – 79 and the 80 – 89 year old age groups are larger for the female finishers than for the male finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 207. Gasparilla Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.1638	p = 0.2267	p < 0.0001	p < 0.0001	p < 0.0001
20 - 29	p = 0.0016	p = 0.0136	p = 0.0006	p = 0.0007	p = 0.0022
30 - 39	p < 0.0001	p = 0.0006	p = 0.0010	p = 0.0026	p = 0.0180
40 - 49	p = 0.0458	p = 0.0653	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
60 - 69	p = 0.0004	p = 0.0022	p = 0.0451	p = 0.0558	p = 0.0008
70 - 79	p = 0.8570	p = 0.8913	p = 0.1839	p = 0.1851	p = 0.1563
80 - 99	p = 0.0454	p = 0.1790	p = 0.0509	p = 0.0333	p = 0.1353

The assumption of equal population variances was not met for the 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69 and 80 – 99 year old age groups but the test results were still similar to the results of the t-test. The pooled test statistic formula for the t-test was used for the 1 – 19 and 70 – 79 year old age group while the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly non-significant for the 1 – 19 and the 70 – 79 year old age groups based on both the F and Levene's test results. The tests results for the 40 – 49 and the 80 – 89 year old age groups are split; the difference between the variances for the male and female finishers is statistically significant based on the F test but the difference is not statistically significant based on Levene's test. All other age groups are highly significant for both tests. The difference between the mean age graded score and the median age graded score for the male and female finishers is highly non-significant for the 70 – 79 year old age group. The tests results for the 60 – 69 and the 80 – 89 year old age groups are split; for the 60 – 69 year old age group the difference between the mean age graded scores for the male and female finishers is statistically significant but the difference between the median age graded scores is not significant, the 80 – 89 year old age group follows the opposite trend. All other age groups are highly significant for both tests. The test for equal distributions of the age graded scores is highly non-significant for the 70 – 79 and 80 – 89 year old age groups but all other age groups are highly significant.

6.6.4.4. McGuire's St. Patrick's Day Run 5k

The McGuire's St. Patrick's Day Run 5k was run on Saturday, March 9, 2013 in Pensacola, FL [Running USA 2014]. There were 11,979 total finishers, made up of 5,237 male finishers and 6,740 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 208. Proportion of McGuire's Five K Finishers by Age Group

Age Group	**Proportion of Finishers**		**P-value**	**Age Group P**
1 - 19	P_M = 5.42%	P_F = 5.71%	p < 0.0001	p = 0.5065
20 - 29	P_M = 39.81%	P_F = 38.99%		p = 0.4770
30 - 39	P_M = 24.94%	P_F = 25.16%		p = 0.8070
40 - 49	P_M = 15.91%	P_F = 18.04%		p = 0.0051
50 - 59	P_M = 9.24%	P_F = 9.15%		p = 0.8753
60 - 69	P_M = 3.86%	P_F = 2.55%		p = 0.0001
70 - 79	P_M = 0.76%	P_F = 0.31%		p = 0.0006
80 - 99	P_M = 0.06%	P_F = 0.07%		p = 0.7226

The contingency table for the 80 – 99 year old age group contains at least one cell with an expected cell count of five or less, so we used Fisher's exact test to calculate the p-value. All other age groups had large enough sample sizes to use Pearson's chi-square test to calculate the p-values.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 30 – 39, and the 40 – 49 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 40 – 49, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 20 – 29, 30 – 39, 50 – 59, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 209. McGuire's Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 9.86%	P_F = 2.86%	p = 0.0001
20 - 29	P_M = 2.88%	P_F = 1.71%	p = 0.0071
30 - 39	P_M = 3.22%	P_F = 2.18%	p = 0.0792
40 - 49	P_M = 5.40%	P_F = 3.13%	p = 0.0102
50 - 59	P_M = 6.82%	P_F = 4.38%	p = 0.0764
60 - 69	P_M = 10.40%	P_F = 6.98%	p = 0.2453
70 - 79	P_M = 10.00%	P_F = 14.29%	p = 0.6833
80 - 99	P_M = 0.00%	P_F = 20.00%	p = 1.0000

For the 70 – 79 and 80 – 99 year old age groups the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, and 40 – 49 year old age groups. The 30 – 39 and 50 – 59 year old age group results show weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 210. McGuire's Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 32.75%	P_F = 62.86%	$p < 0.0001$
20 - 29	P_M = 53.09%	P_F = 61.15%	$p < 0.0001$
30 - 39	P_M = 55.59%	P_F = 64.62%	$p < 0.0001$
40 - 49	P_M = 49.94%	P_F = 62.01%	$p < 0.0001$
50 - 59	P_M = 50.62%	P_F = 59.64%	$p = 0.0028$
60 - 69	P_M = 52.48%	P_F = 58.14%	$p = 0.2724$
70 - 79	P_M = 47.50%	P_F = 28.57%	$p = 0.1532$
80 - 99	P_M = 33.33%	P_F = 0.00%	$p = 0.3750$

The 80 – 99 year old age group has at least one cell of the contingency table with an expected cell frequency of five or lower; to determine the correct p-value, Fisher's exact test was used for the calculations. All other age groups have sufficiently large sample sizes for Pearson's chi-square test to be appropriate for the p-value calculations.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, and 50 – 59 year old age groups. For the 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 211. McGuire's St. Patrick's Day Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 284	F: 385	M: 44.3	F: 38.3	M: 43.9	F: 37.7	M: 141.0	F: 99.5
20 - 29	M: 2085	F: 2628	M: 38.8	F: 37.3	M: 39.1	F: 36.4	M: 130.1	F: 101.0
30 - 39	M: 1306	F: 1696	M: 38.6	F: 36.7	M: 38.6	F: 35.3	M: 124.3	F: 102.9
40 - 49	M: 833	F: 1216	M: 40.2	F: 38.0	M: 40.1	F: 36.4	M: 124.9	F: 114.5
50 - 59	M: 484	F: 617	M: 41.2	F: 39.6	M: 39.6	F: 37.0	M: 149.5	F: 109.5
60 - 69	M: 202	F: 172	M: 41.8	F: 41.0	M: 39.3	F: 38.3	M: 164.9	F: 96.1
70 - 79	M: 40	F: 21	M: 42.7	F: 47.3	M: 40.6	F: 44.8	M: 184.8	F: 118.6
80 - 99	M: 3	F: 5	M: 41.5	F: 55.1	M: 40.0	F: 55.3	M: 112.0	F: 50.6

For the 70 – 79 and the 80 – 89 year old age groups in this race, the mean and median age graded scores for the female finishers are larger than the mean and median age graded scores for the male finishers but the variances of the age graded scores for the male finishers are larger than the variances of the age graded scores for the female finishers. For all other age groups in this five kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances of the age graded scores for all age groups are larger for the male race finishers than for the female race finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 212. McGuire’s St. Patrick’s Day Five K Test Results by Age Group

Age Group	F Test	Levene’s Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0015	p = 0.0014	p < 0.0001	p < 0.0001	p < 0.0001
20 - 29	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001	p < 0.0001
30 - 39	p = 0.0003	p = 0.0013	p < 0.0001	p < 0.0001	p < 0.0001
40 - 49	p = 0.1700	p = 0.2809	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.0003	p = 0.0037	p = 0.0214	p = 0.0681	p = 0.0004
60 - 69	p = 0.0003	p = 0.0010	p = 0.4995	p = 0.7915	p = 0.0075
70 - 79	p = 0.2898	p = 0.4384	p = 0.1929	p = 0.0568	p = 0.0625
80 - 99	p = 0.4508	p = 0.4286	p = 0.0690	p = 0.0736	p = 0.1813

The assumption of equal population variances was not met for the 1 – 19, 20 – 29, 30 – 39, 50 – 59, and 60 – 69 year old age groups but the test results were still similar to the results of the t-test. The pooled test statistic formula for the t-test was used for the 40 – 49, 70 – 79, and 80 – 99 year old age groups while the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly non-significant for the 40 – 49, the 70 – 79, and the 80 – 89 year old age groups based on both the F and Levene’s test results. All other age groups are highly significant for both tests with p-values less than 0.002. The difference between the mean age graded score and the difference between the median age graded score are statistically non-significant for the 60 – 69, the 70 – 79, and the 80 – 89 year old age groups. All other age groups were highly significant for the difference between the means and the difference between the medians with less than 0.025. The test for equal distributions of the age graded scores follows the same trend for the means and medians with the exception of the 60 – 69 year old age group which has a highly significant p-value.

6.6.4.5. MLB All-Star Run Benefitting Sandy Relief 5k

The MLB All-Star 5k Benefiting Sandy Relief was run on Saturday, July 13, 2013 around Prospect Park in Brooklyn, NY [Running USA 2014]. There were 4,722 total finishers, made up of 2,469 male finishers and 2,253 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 213. Proportion of MLB All-Star Five K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 1.78%	P_F = 1.51%	$p < 0.0001$	$p = 0.4660$
20 - 29	P_M = 29.38%	P_F = 37.73%		$p < 0.0001$
30 - 39	P_M = 40.91%	P_F = 40.48%		$p = 0.0846$
40 - 49	P_M = 17.70%	P_F = 14.43%		$p = 0.0051$
50 - 59	P_M = 7.61%	P_F = 4.57%		$p < 0.0001$
60 - 69	P_M = 2.35%	P_F = 1.11%		$p = 0.0013$
70 - 79	P_M = 0.32%	P_F = 0.18%		$p = 0.3186$
80 - 99	P_M = 0.04%	P_F = 0.00%		$p = 0.3394$

The 80 – 99 year old age group has at least one cell of the contingency table with an expected cell frequency of five or less so Fisher’s exact test was used to calculate the p-value. All other age groups had sufficiently large sample sizes so Pearson’s chi-square test was used to calculate the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, and 60 – 69 year old age groups. For the 1 – 19, 70 – 79, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers. For the 30 – 39 year old age group there is weak statistical evidence that the proportion of male finishers is significantly different from proportion of female finishers as the p-value is larger than our chosen level of significance but would be considered significant at a higher level of significance.

Table 214. MLB All-Star Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 15.91%	P_F = 35.29%	p = 0.0480
20 - 29	P_M = 18.95%	P_F = 15.65%	p = 0.0835
30 - 39	P_M = 16.04%	P_F = 18.64%	p = 0.1320
40 - 49	P_M = 13.73%	P_F = 20.31%	p = 0.0156
50 - 59	P_M = 9.57%	P_F = 17.48%	p = 0.0503
60 - 69	P_M = 13.79%	P_F = 4.00%	p = 0.2660
70 - 79	P_M = 12.50%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 1 – 19 and 70 – 79 year old age groups, there was at least one cell in the contingency tables with an expected cell count of five or fewer; Fisher's exact test was used to determine the correct p-value for each age group. There is not enough information for the 80 – 99 year old age group to perform a test of proportions. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the 1 – 19 and 40 – 49 year old age groups. The 20 – 29 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. The 50 – 59 year old age group result shows weak statistical evidence that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 30 – 39, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 215. MLB All-Star Finishers – 40% or lower by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	P_M = 11.36%	P_F = 11.76%	p = 1.0000
20 - 29	P_M = 10.37%	P_F = 9.06%	p = 0.3791
30 - 39	P_M = 13.07%	P_F = 9.65%	p = 0.0187
40 - 49	P_M = 17.16%	P_F = 8.31%	p = 0.0004
50 - 59	P_M = 21.81%	P_F = 20.39%	p = 0.7772
60 - 69	P_M = 27.59%	P_F = 40.00%	p = 0.2633
70 - 79	P_M = 50.00%	P_F = 25.00%	p = 0.5758
80 - 99	P_M = 0.00%	P_F = 0.00%	NA

For the 60 – 69 and 70 – 79 year old age groups the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. There is not enough information for the 80 – 99 year old age group to perform a test of proportions. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male race finishers with an age graded score at or below forty percent is significantly larger than the proportion of female race finishers at or below forty percent for the 30 – 39 and 40 – 49 year old age groups. For the 1 – 19, 20 – 29, 50 – 59, 60 – 69, 70 – 79, and 80 –

99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 216. MLB All-Star Run Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 44	F: 34	M: 48.6	F: 46.8	M: 48.6	F: 47.0	M: 110.7	F: 141.3
20 - 29	M: 723	F: 850	M: 48.0	F: 48.5	M: 47.7	F: 48.7	M: 98.0	F: 79.0
30 - 39	M: 1010	F: 912	M: 48.8	F: 48.2	M: 48.9	F: 48.4	M: 92.3	F: 82.9
40 - 49	M: 437	F: 325	M: 50.7	F: 47.4	M: 50.6	F: 47.8	M: 96.4	F: 80.8
50 - 59	M: 188	F: 103	M: 52.4	F: 50.7	M: 51.3	F: 51.2	M: 102.6	F: 110.2
60 - 69	M: 58	F: 25	M: 53.2	F: 57.2	M: 51.7	F: 59.4	M: 112.6	F: 69.9
70 - 79	M: 8	F: 4	M: 60.2	F: 57.7	M: 58.5	F: 54.8	M: 272.9	F: 114.1
80 - 99	M: 1	F: 0	M: 71.0	F: NA	M: 71.0	F: NA	M: 0.00	F: NA

For the 20 – 29 and the 60 – 69 year old age groups in this race, the mean and median age graded scores for female finishers are larger than the mean and median age graded scores for the male finishers. For all other age groups in this five kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variances for the 1 – 19 and the 50 – 59 year old age groups are larger for the female finishers than for the male finishers but the variances of the age graded scores for the other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 217. MLB All-Star Run Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p = 0.4488$	$p = 0.4279$	$p = 0.4737$	$p = 0.4775$	$p = 0.2946$
20 - 29	$p = 0.0025$	$p = 0.0062$	$p = 0.3323$	$p = 0.1803$	$p = 0.0688$
30 - 39	$p = 0.0994$	$p = 0.1290$	$p = 0.1545$	$p = 0.1565$	$p = 0.2870$
40 - 49	$p = 0.0929$	$p = 0.0959$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
50 - 59	$p = 0.6679$	$p = 0.7001$	$p = 0.1916$	$p = 0.3825$	$p = 0.6182$
60 - 69	$p = 0.2002$	$p = 0.2226$	$p = 0.1011$	$p = 0.0511$	$p = 0.0456$
70 - 79	$p = 0.5086$	$p = 0.2589$	$p = 0.7953$	$p = 0.6711$	$p = 0.8475$

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the 20 – 29 year old age group but the test results were still similar to the results of the t-test. The non-pooled test statistic formula for the t-test was used for the 20 – 29 year old age group while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 20 – 29 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are highly statistically significant the 40 – 49 year old age group. All other age groups were non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.4.6. NYRR Dash to the Finish Line 5k

The NYRR Dash to the Finish Line 5k was run on Saturday, November 2, 2013 around Central Park in New York City, NY [Running USA 2014]. There were 7,993 total finishers, made up of 3,598 male finishers and 4,395 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 218. Proportion of NY Dash Five K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 3.14%	P_F = 2.64%	p < 0.0001	p = 0.1878
20 - 29	P_M = 16.79%	P_F = 24.91%		p < 0.0001
30 - 39	P_M = 33.96%	P_F = 35.84%		p = 0.1591
40 - 49	P_M = 25.54%	P_F = 22.78%		p = 0.0121
50 - 59	P_M = 14.95%	P_F = 10.56%		p < 0.0001
60 - 69	P_M = 4.84%	P_F = 3.05%		p = 0.0001
70 - 79	P_M = 0.72%	P_F = 0.20%		p = 0.0005
80 - 99	P_M = 0.06%	P_F = 0.02%		p = 0.4510

Fisher's exact test was used to determine the p-value for the 80 – 99 year old age group as the sample size is too small for Pearson's chi-square test to be appropriate. All other age groups had sufficiently large sample sizes so Pearson's chi-square test was the appropriate choice for calculating the p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 20 – 29 and the 30 – 39 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 1 – 19, 30 – 39, and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 219. New York Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 27.43%	P_F = 10.34%	p = 0.0009
20 - 29	P_M = 19.70%	P_F = 11.78%	p < 0.0001
30 - 39	P_M = 13.26%	P_F = 7.43%	p < 0.0001
40 - 49	P_M = 12.51%	P_F = 7.59%	p = 0.0003
50 - 59	P_M = 13.57%	P_F = 16.16%	p = 0.2483
60 - 69	P_M = 14.37%	P_F = 27.61%	p = 0.0041
70 - 79	P_M = 19.23%	P_F = 33.33%	p = 0.3963
80 - 99	P_M = 0.00%	P_F = 100%	p = 0.3333

For the 70 – 79 and 80 – 99 year old age groups the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 20 – 29, 30 – 39, and 40 – 49 year old age groups. The 60 – 69 year old age group result shows that the proportion of female finishers with an age graded score at or above sixty percent is significantly larger than the proportion of male finishers with an age graded score at or above sixty percent. For the 50 – 59, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 220. New York Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 26.55%	P_F = 18.97%	p = 0.1709
20 - 29	P_M = 14.90%	P_F = 12.69%	p = 0.2024
30 - 39	P_M = 17.27%	P_F = 14.92%	p = 0.0928
40 - 49	P_M = 15.08 %	P_F = 15.45%	p = 0.8234
50 - 59	P_M = 15.43%	P_F = 9.70%	p = 0.0067
60 - 69	P_M = 12.07%	P_F = 18.66%	p = 0.1078
70 - 79	P_M = 7.69%	P_F = 0.00%	p = 1.0000
80 - 99	P_M = 50.00%	P_F = 0.00%	p = 1.0000

For the 70 – 79 and 80 – 99 year old age groups, there is at least one cell of the contingency tables that has an expected cell count of five or lower and Fisher's exact test was used to calculate the appropriate p-values. All other age groups had large enough sample sizes for Pearson's chi-square test to be appropriate for p-value calculations.

The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower for the 50 – 59 year old age group. The 30 – 39 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or below forty percent is significantly larger than the proportion of female finishers with an age graded score at or below forty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 1 – 19, 20 – 29, 40 – 49, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 221. NY Dash Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 113	F: 116	M: 51.0	F: 47.8	M: 48.9	F: 47.6	M: 169.0	F: 80.2
20 - 29	M: 604	F: 1095	M: 51.7	F: 50.3	M: 49.4	F: 49.6	M: 166.1	F: 108.2
30 - 39	M: 1222	F: 1575	M: 49.1	F: 48.4	M: 48.1	F: 48.2	M: 95.5	F: 72.4
40 - 49	M: 919	F: 1001	M: 49.1	F: 48.5	M: 48.1	F: 48.8	M: 96.4	F: 71.4
50 - 59	M: 538	F: 464	M: 49.3	F: 51.8	M: 48.7	F: 52.3	M: 101.1	F: 80.6
60 - 69	M: 174	F: 134	M: 50.7	F: 52.6	M: 50.2	F: 53.9	M: 78.8	F: 148.5
70 - 79	M: 26	F: 9	M: 52.7	F: 55.9	M: 51.8	F: 57.3	M: 100.0	F: 126.6
80 - 99	M: 2	F: 1	M: 46.4	F: 83.3	M: 46.4	F: 83.3	M: 89.2	F: 0.00

For half of the age groups in this race, the mean age graded scores for male finishers are larger than the mean age graded scores for the female finishers but the other four age groups, the mean age graded scores for the female finishers are larger than the mean age graded scores for the male finishers. For the 1 – 19 year old age group, the median age graded score for the male finishers is larger than the median age graded score for the female finishers. For all other age groups in this race, the median age graded scores are larger for the female race finishers then for the male race finishers. The variances for the 60 – 69 and the 70 – 79 year old age groups are larger for the female race finishers than for the male race finishers but the variance of the age graded scores for all other age groups follow the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 222. NY Dash Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	$p < 0.0001$	$p < 0.0001$	$p = 0.0297$	$p = 0.1647$	$p = 0.0348$
20 - 29	$p < 0.0001$	$p < 0.0001$	$p = 0.0263$	$p = 0.3456$	$p = 0.0019$
30 - 39	$p < 0.0001$	$p < 0.0001$	$p = 0.0777$	$p = 0.4478$	$p = 0.0005$
40 - 49	$p < 0.0001$	$p = 0.0002$	$p = 0.1939$	$p = 0.7845$	$p = 0.0129$
50 - 59	$p = 0.0118$	$p = 0.0389$	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
60 - 69	$p < 0.0001$	$p = 0.0011$	$p = 0.1247$	$p = 0.0864$	$p = 0.0034$
70 - 79	$p = 0.6098$	$p = 0.7476$	$p = 0.4241$	$p = 0.4617$	$p = 0.6434$
80 - 99	NA	NA	$p = 0.1933$	$p = 0.5403$	$p = 0.5176$

The assumption of equal population variances was not met for the 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, and 60 – 69 year old age groups and the test results were not similar to the results of the t-test for most of these age groups. The pooled test statistic formula for the t-test was used for the 70 – 79 and 80 – 99 year old age groups while the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is highly non-significant for the 70 – 79 year old age group based on both the F and Levene’s test results. All other age groups are highly significant for both tests. The difference between the mean age graded score for the male and female finishers is statistically significant for the 1 – 19, the 20 – 29, and the 50 – 59 year old age groups. All other age groups were highly non-significant for the difference between the means for the male and female race finishers. The difference between the median age graded score for the male and female finishers is statistically significant for the 50 – 59 year old age group. All other age groups were highly non-significant for the difference between the means for the male and female race finishers. The test for equal distributions of the age graded scores between the male and female finishers is highly non-significant for the 70 – 79 and the 80 – 89 year old age groups. All other age groups were highly significant for the test for equal distributions of the age graded scores between the male and female race finishers.

6.6.4.7. Wahoo’s OC 5k

The Wahoo’s OC 5k was run on Sunday, May 5, 2013 around the OC Fair and Event Center in Costa Mesa, CA [Running USA 2014]. There were 1,881 total finishers, made up of 644 male finishers and 1,236 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 223. Proportion of OC Marathon Five K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 9.01%	P_F = 10.11%	p = 0.5124	p = 0.4684
20 - 29	P_M = 22.52%	P_F = 20.31%		p = 0.3184
30 - 39	P_M = 28.88%	P_F = 27.91%		p = 0.7008
40 - 49	P_M = 21.89%	P_F = 23.54%		p = 0.4839
50 - 59	P_M = 11.18%	P_F = 13.11%		p = 0.2636
60 - 69	P_M = 5.43%	P_F = 4.29%		p = 0.2738
70 - 79	P_M = 1.09%	P_F = 0.73%		p = 0.4226

All age groups have adequately large sample sizes so Pearson's chi-square was used to determine the appropriate p-value for each age group.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19, the 30 – 39, the 40 – 49, and the 50 – 59 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at there is no statistical evidence that the differences between the proportion of male and female race finishers were significant. We conducted chi-square tests of independence for each age group and found that there is no statistical evidence that the proportion of male race finishers is significantly different than the proportion of female race finishers for any of the age groups.

Table 224. OC Finishers – 60% or higher by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 27.59%	P_F = 7.20%	p = 0.0002
20 - 29	P_M = 6.21%	P_F = 2.79%	p = 0.0961
30 - 39	P_M = 4.30%	P_F = 2.32%	p = 0.2024
40 - 49	P_M = 12.06%	P_F = 3.44%	p = 0.0005
50 - 59	P_M = 9.72%	P_F = 10.49%	p = 0.8575
60 - 69	P_M = 8.57%	P_F = 3.77%	p = 0.3826
70 - 79	P_M = 28.57%	P_F = 33.33%	p = 1.0000

For the 60 – 69 and 70 – 79 year old age groups the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19 and 40 – 49 year old age groups. The 20 – 29 year old age group result shows weak statistical evidence that the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score at or above sixty percent; the p-value is not significant at our current level of significance but would be considered significant at a higher level of significance. For the 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 225. OC Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 27.59%	P_F = 43.20%	p = 0.0432
20 - 29	P_M = 40.00%	P_F = 47.41%	p = 0.1530
30 - 39	P_M = 50.54%	P_F = 52.75%	p = 0.6258
40 - 49	P_M = 39.01%	P_F = 54.30%	p = 0.0029
50 - 59	P_M = 40.28%	P_F = 48.77%	p = 0.2293
60 - 69	P_M = 60.00%	P_F = 64.15%	p = 0.6938
70 - 79	P_M = 57.14%	P_F = 11.11%	p = 0.1058

The 70 – 79 year old age group had at least one cell of the contingency table with an expected cell count of five or less and we used Fisher's exact test to determine the appropriate p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 1 – 19 and 40 – 49 year old age groups. For the 20 – 29, 30 – 39, 50 – 59, 60 – 69, and 70 – 79 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 226. OC Marathon Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 58	F: 125	M: 49.3	F: 43.9	M: 50.3	F: 41.5	M: 255.4	F: 126.5
20 - 29	M: 145	F: 251	M: 41.8	F: 41.1	M: 41.9	F: 40.7	M: 135.0	F: 101.6
30 - 39	M: 186	F: 345	M: 40.0	F: 39.4	M: 39.9	F: 39.4	M: 123.0	F: 101.7
40 - 49	M: 141	F: 291	M: 43.3	F: 40.0	M: 42.4	F: 38.5	M: 170.7	F: 102.4
50 - 59	M: 72	F: 162	M: 43.2	F: 42.8	M: 44.0	F: 40.9	M: 185.5	F: 150.9
60 - 69	M: 35	F: 53	M: 40.9	F: 39.6	M: 37.4	F: 37.8	M: 173.8	F: 42.3
70 - 79	M: 7	F: 9	M: 43.1	F: 54.7	M: 39.4	F: 49.6	M: 211.7	F: 188.1

For the 70 – 79 year old age group in this race, the mean and median age graded scores for female finishers are larger than the mean and median age graded scores for the male finishers. For the 60 – 69 year old age group, the mean age graded score for the male finishers is larger than the mean age graded score for the female finishers, but the median age graded scores are larger for the female finishers than for male finishers. For all other age groups in this marathon, the mean age graded scores, the median age graded scores, and the variances of the age graded scores for the male race finishers are larger than the mean age graded scores, the median age graded scores, and the variances of the age graded scores for the female race finishers. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 227. OC Marathon Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.0012	p < 0.0001	p = 0.0247	p = 0.0238	p = 0.0222
20 - 29	p = 0.0503	p = 0.0478	p = 0.4953	p = 0.5305	p = 0.5352
30 - 39	p = 0.1350	p = 0.1634	p = 0.4890	p = 0.4481	p = 0.3484
40 - 49	p = 0.0003	p = 0.0010	p = 0.0085	p = 0.0125	p = 0.0068
50 - 59	p = 0.2884	p = 0.3182	p = 0.8390	p = 0.7592	p = 0.1320
60 - 69	p < 0.0001	p = 0.0051	p = 0.6050	p = 0.6514	p = 0.3033
70 - 79	p = 0.8520	p = 0.8601	p = 0.1234	p = 0.0903	p = 0.2962

The Mann-Whitney-Wilcoxon test assumption of equal population variances was not met for the 1 – 19, 20 – 29, 40 – 49, and 60 – 69 year old age groups but the test results were still similar to the results of the t-test. The pooled test statistic formula for the t-test was used for the 30 – 39, 50 – 59, and 70 – 79 year old age groups while the non-pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 1 – 19, the 40 – 49, and the 60 – 69 year old age groups based on both the F and Levene's test results. The tests results for the 20 – 29 year old age group are split; the difference between the variances for the male and female finishers is statistically significant based on Levene's test but the difference is not statistically significant based on the F test. All other age groups are highly non-significant for both tests. The difference between the mean age graded score and the difference between the median age graded score are statistically significant for the 1 – 19 and the 40 – 49 year old age groups. All other age groups were highly non-significant for the difference between the means and the difference between the medians. The test for equal distributions of the age graded scores follows the same trend for the means and medians.

6.6.4.8. Percy Sutton Harlem 5k

The Percy Sutton Harlem 5k Run was run on Saturday, August 24, 2013 around Harlem in New York City, NY [Running USA 2014]. There were 3,464 total finishers, made up of 1,711 male finishers and 1,753 female finishers, that were fourteen years of age and older. We divided these finishers into age groups, as defined above, in order to determine where the differences in the populations existed. We examined the proportion of male and female finishers by age group, then we visually inspected the measures of distribution and tested the differences statistically.

Table 228. Proportion of Percy Sutton Five K Finishers by Age Group

Age Group	Proportion of Finishers		P-value	Age Group P
1 - 19	P_M = 2.10%	P_F = 3.65%	p < 0.0001	p = 0.0074
20 - 29	P_M = 21.92%	P_F = 30.52%		p < 0.0001
30 - 39	P_M = 40.62%	P_F = 40.27%		p = 0.8729
40 - 49	P_M = 21.20%	P_F = 16.60%		p = 0.0023
50 - 59	P_M = 9.64%	P_F = 6.50%		p = 0.0011
60 - 69	P_M = 3.10%	P_F = 1.83%		p = 0.0169
70 - 79	P_M = 1.34%	P_F = 0.51%		p = 0.0110
80 - 99	P_M = 0.18%	P_F = 0.11%		p = 0.6352

The contingency table for the 80 – 99 year old age group has at least one cell with an expected cell count of five or smaller so the p-value was determined by Fisher's exact test. All other age groups have sufficiently large sample sizes so the p-values were determined by Pearson's chi-square test.

The proportion of female finishers is larger than the proportion of male finishers for the 1 – 19 and the 20 – 29 year old age groups but the proportion of male finishers is larger than the proportion of female finishers for all other age groups. We used a chi square test of proportions to determine if the proportion of race finishers were the same for all age groups. We found that in at least one age group the differences between the proportion of male and female race finishers were statistically significant with a p-value of less than 0.0001. To determine which age groups had significant differences we conducted chi-square tests of independence for each age group and found that the proportion of male race finishers is significantly different than the proportion of female race finishers for the 1 – 19, 20 – 29, 40 – 49, 50 – 59, 60 – 69, and 70 – 79 year old age groups. For the 30 – 39 and 80 – 99 year old age groups there is no statistical evidence of a significant difference between the male and female proportions of race finishers.

Table 229. Percy Sutton Finishers – 60% or higher by Age Group

Age Group	**Proportion of Finishers**		**P-value**
1 - 19	$P_M = 50.00\%$	$P_F = 18.75\%$	$p = 0.0011$
20 - 29	$P_M = 21.87\%$	$P_F = 18.69\%$	$p = 0.2386$
30 - 39	$P_M = 26.62\%$	$P_F = 14.45\%$	$p < 0.0001$
40 - 49	$P_M = 31.30\%$	$P_F = 12.03\%$	$p < 0.0001$
50 - 59	$P_M = 39.39\%$	$P_F = 25.44\%$	$p = 0.0153$
60 - 69	$P_M = 39.62\%$	$P_F = 46.88\%$	$p = 0.5121$
70 - 79	$P_M = 39.13\%$	$P_F = 66.67\%$	$p = 0.2433$
80 - 99	$P_M = 66.67\%$	$P_F = 100\%$	$p = 1.0000$

For the 70 – 79 and 80 – 99 year old age groups the sample size is too small for Pearson's chi-square test to work correctly so we used Fisher's exact test to determine the p-value. All other age groups had sufficiently large sample sizes so Pearson's chi-square test to determine the appropriate p-value for each age group.

The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the 1 – 19, 30 – 39, 40 – 49, and 50 – 59 year old age group. For the 20 – 29, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence that the proportion of finishers with an age graded score of sixty percent or higher is significantly different between the male and female race populations.

Table 230. Percy Sutton Finishers – 40% or lower by Age Group

Age Group	Proportion of Finishers		P-value
1 - 19	P_M = 0.00%	P_F = 7.81%	p = 0.1564
20 - 29	P_M = 9.07%	P_F = 11.03%	p = 0.3363
30 - 39	P_M = 9.35%	P_F = 11.61%	p = 0.1671
40 - 49	P_M = 5.54 %	P_F = 19.59%	p < 0.0001
50 - 59	P_M = 4.85%	P_F = 8.77%	p = 0.1898
60 - 69	P_M = 3.77%	P_F = 3.13%	p = 1.0000
70 - 79	P_M = 13.04%	P_F = 0.00%	p = 0.5409
80 - 99	P_M = 33.33%	P_F = 0.00%	p = 1.0000

For the 1 – 19, 60 – 69, 70 – 79, and 80 – 99 year old age groups there is at least one cell of the contingency table with an expected value of five or smaller, Fisher's exact test was used to determine the appropriate p-value. All other age groups, the sample size was large enough for Pearson's chi-square test to be used for the p-value calculations.

The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower for the 40 – 49 year old age group. For the 1 – 19, 20 – 29, 30 – 39, 50 – 59, 60 – 69, 70 – 79, and 80 – 99 year old age groups, there is no statistical evidence of a significant difference between the male and female finishers with an age graded score of forty percent or lower.

Table 231. Percy Sutton Five K Descriptive Statistics by Age Group

Age Group	Total		Mean		Median		Variance	
1 - 19	M: 36	F: 64	M: 62.0	F: 51.2	M: 60.1	F: 49.6	M: 125.8	F: 90.7
20 - 29	M: 375	F: 535	M: 53.0	F: 51.9	M: 52.9	F: 51.4	M: 102.1	F: 100.1
30 - 39	M: 695	F: 706	M: 53.5	F: 50.4	M: 53.5	F: 50.2	M: 96.2	F: 82.3
40 - 49	M: 361	F: 291	M: 55.2	F: 49.1	M: 55.2	F: 49.2	M: 103.3	F: 90.5
50 - 59	M: 165	F: 114	M: 57.6	F: 54.1	M: 58.0	F: 54.1	M: 112.3	F: 103.4
60 - 69	M: 53	F: 32	M: 58.4	F: 59.7	M: 57.7	F: 56.2	M: 113.4	F: 142.7
70 - 79	M: 23	F: 9	M: 58.4	F: 62.1	M: 58.9	F: 62.6	M: 227.9	F: 98.1
80 - 99	M: 3	F: 2	M: 57.4	F: 75.0	M: 60.5	F: 75.0	M: 297.8	F: 1.3

For the 60 – 69, 70 – 79, and the 80 – 89 year old age groups in this race, the mean age graded scores for female finishers are larger than the mean age graded scores for the male finishers, the median age graded scores for the 70 – 79 and 80 – 89 year old age groups are larger for the female race finishers than for the male race finishers. For all other age groups in this five kilometer race, the mean and median age graded scores for the male finishers are larger than the mean and median age graded scores for the female finishers. The variance of the age graded scores for the 60 – 69 year old age group is larger for the female finishers than for the male finishers but the variances of the age graded scores for the 60 – 69 year old age group follows the opposite trend. The findings above reflect only this sample, we conducted several statistical tests to determine if these trends are significant for the five kilometer race finisher population.

Table 232. Percy Sutton Five K Test Results by Age Group

Age Group	F Test	Levene's Test	T Test	Wilcoxon	KS Test
1 - 19	p = 0.2566	p = 0.2244	p < 0.0001	p < 0.0001	p < 0.0001
20 - 29	p = 0.8273	p = 0.8576	p = 0.0916	p = 0.0538	p = 0.1546
30 - 39	p = 0.0388	p = 0.0463	p < 0.0001	p < 0.0001	p < 0.0001
40 - 49	p = 0.2400	p = 0.2277	p < 0.0001	p < 0.0001	p < 0.0001
50 - 59	p = 0.6398	p = 0.6129	p = 0.0070	p = 0.0051	p = 0.0040
60 - 69	p = 0.4561	p = 0.4521	p = 0.6041	p = 0.5770	p = 0.6750
70 - 79	p = 0.2196	p = 0.1236	p = 0.5001	p = 0.4506	p = 0.3637
80 - 99	p = 0.0918	NA	p = 0.2637	p = 0.1489	p = 0.1813

The assumption of equal population variances for the Mann-Whitney-Wilcoxon test was not met for the 30 – 39 year old age group but the test results were still similar to the results of the t-test. The non-pooled test statistic formula for the t-test was used for the 30 – 39 year old age group while the pooled test statistic formula was used for all other age groups.

The difference between the variances of the age graded scores for the male and female finishers is statistically significant for the 30 – 39 year old age group based on both the F and Levene's test results. All other age groups are highly non-significant for both tests with all p-values larger than 0.09. The difference between the mean age graded scores, the difference between the median age graded scores, and the difference between the distributions of the age graded scores are statistically significant for the 1 – 19, the 30 – 39, the 40 – 49, and the 50 – 59 year old age groups. All other age groups were not statistically significant for the difference between the means, the difference between the medians, and the difference between the distributions of the age graded scores.

6.6.5. Age Group Meta-Analysis

Having performed statistical tests to find differences between male and female race finishers for each race individually, we wanted to combine the results in order to draw conclusions for each race distance. We used meta-analytic tests to combine the p-values for each test and each distance by age group, defined to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99, specifically we used the Stouffer's weighted Z score method for combining the p-values.

6.6.5.1. Marathon Age Group Results

To further examine the differences between the populations of male and female marathon runners, we chose to look at the distribution of male and female marathon finishers grouped by age using meta-analytic techniques. To accomplish this, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results for every statistical test except the test of distributions which has a two-sided alternative hypothesis. After the p-values were converted, we performed a meta-analysis to combine the p-values of the non-qualifying marathons using Stouffer's Z-score method and defined our age groups to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99. For ease of computation, we used a p-value of 0.00009 for all p-values less than 0.0001 and a p-value of 0.99999 for all p-values equal to 1.000 that appeared in the test results; these values were chosen for convenience of calculation and to keep the calculation for breaking down as we were using computer programs to calculate the final Z value. There were not enough races with results in the 80 – 99 age group for the age group to be included in this section.

Table 233. Meta-Analysis: Marathon – Ages 1 – 19

Variable	Z value	P value: M > F	P value: F > M
Proportions	-2.259	p = 0.9881	p = 0.0119
		Age Graded Scores	
Proportions			
60%	4.142	p < 0.0001	p = 1.0000
40%	3.915	p = 1.0000	p < 0.0001
Variances			
F Test	4.045	p < 0.0001	p = 1.0000
Levene's Test	4.071	p < 0.0001	p = 1.0000
Means	4.121	p < 0.0001	p = 1.0000
Medians	4.104	p < 0.0001	p = 1.0000
Distributions	-1.268	p = 0.8975	p = 0.1025

The result of the meta-analysis for the combined marathon race finishers in the 1 – 19 age group for the test of proportions shows that the proportion of female marathon finishers is significantly larger than the proportion of male marathon finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male marathon finishers are significantly larger than the mean, median, and variance of the age graded scores for the female marathon finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. There is no statistical evidence that the distribution of age graded scores for the male and female marathon finishers are significantly different.

Table 234. Meta-Analysis: Marathon – Ages 20 – 29

Variable	Z value	P value: M > F	P value: F > M
Proportions	-8.719	$p = 1.0000$	$p < 0.0001$
		Age Graded Scores	
Proportions			
60%	7.095	$p < 0.0001$	$p = 1.0000$
40%	-3.071	$p = 0.0011$	$p = 0.9989$
Variances			
F Test	8.257	$p < 0.0001$	$p = 1.0000$
Levene's Test	8.252	$p < 0.0001$	$p = 1.0000$
Means	4.878	$p < 0.0001$	$p = 1.0000$
Medians	2.929	$p = 0.0017$	$p = 0.9983$
Distributions	1.839	$p = 0.0330$	$p = 0.9670$

The result of the meta-analysis for the combined marathon race finishers in the 20 – 29 age group for the test of proportions shows that the proportion of female marathon finishers is significantly larger than the proportion of male marathon finishers. The proportion of male finishers with an age graded score of sixty percent or higher and the proportion of male racers with an age graded score of forty percent of lower are significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher and the proportion of female racers with an age graded score of forty percent or below. All other results are highly significant with p-values less than 0.002; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male marathon finishers are significantly larger than the mean, median, and variance of the age graded scores for the female marathon finishers. We can also see that the distribution of age graded scores for the male and female marathon finishers are significantly different and that the distribution of male finishers is significantly larger than the distribution of female finishers.

Table 235. Meta-Analysis: Marathon – Age 30 – 39

Variable	Z value	P value: M > F	P value: F > M
Proportions	-6.794	p = 1.0000	p < 0.0001
		Age Graded Score	
Proportions			
60%	4.560	p < 0.0001	p = 1.0000
40%	-3.730	p = 0.0001	p = 0.9999
Variances			
F Test	8.117	p < 0.0001	p = 1.0000
Levene's Test	8.143	p < 0.0001	p = 1.0000
Means	1.946	p = 0.0258	p = 0.9742
Medians	0.431	p = 0.3332	p = 0.6668
Distributions	3.244	p = 0.0006	p = 0.9994

The results of the meta-analysis for the combined marathon race finishers in the 30 – 39 age group show that the proportion of female marathon finishers is significantly larger than the proportion of male marathon finishers. We can also see that the mean age graded score and the variance of the age graded scores for the male finishers are significantly larger than the mean age graded score and the variance of the age graded scores for the female finishers; also the distribution of the age graded scores for the male finishers is significantly different from the distribution of the age graded scores for the female finishers. Specifically, the distribution of age graded scores for the male race finishers is significantly larger than the distribution of age graded scores for the female race finishers. The proportion of male marathon finishers with an age graded score of sixty percent or higher and the proportion of male finishers with an age graded score of forty percent or lower are significantly larger than the proportion of female marathon finishers with an age graded score of sixty percent or larger and the proportion of female finishers with an age graded score of forty percent or lower. There is no statistical evidence that the median age graded score for the male finishers is significantly different from the median age graded score for the female finishers.

Table 236. Meta-Analysis: Marathon – Ages 40 – 49

Variable	Z value	P value: M > F	P value: F > M
Proportions	7.228	$p < 0.0001$	$p = 1.0000$
		Age Graded Score	
Proportion			
60%	-2.126	$p = 0.9832$	$p = 0.0168$
40%	-2.677	$p = 0.0037$	$p = 0.9963$
Variances			
F Test	3.478	$p = 0.0003$	$p = 0.9997$
Levene's Test	3.384	$p = 0.0004$	$p = 0.9996$
Means	-4.271	$p = 1.0000$	$p < 0.0001$
Medians	-4.089	$p = 1.0000$	$p < 0.0001$
Distributions	3.851	$p = 0.0001$	$p = 0.9999$

The results of the meta-analysis for the combined marathon race finishers in the 40 – 49 age group show that the proportion of marathon finishers and the variance of age graded scores for the male finishers are significantly larger than the proportion of marathon finishers and the variance of age graded scores for the female finishers. The proportion of female race finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male race finishers with an age graded score of sixty percent or higher. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower. The mean and median age graded scores for the female race finishers are significantly larger than the mean and median age graded scores for the male race finishers. The distribution of the age graded scores for the male marathon finishers is significantly different, and significantly larger, from the distribution of the age graded scores for the female marathon finishers.

Table 237. Meta-Analysis: Marathon – Ages 50 – 59

Variable	Z value	P value: M > F	P value: F > M
Proportions	8.678	$p < 0.0001$	$p = 1.0000$
		Age Graded Score	
Proportions			
60%	-2.351	$p = 0.9906$	$p = 0.0094$
40%	-2.355	$p = 0.0093$	$p = 0.9907$
Variances			
F Test	-0.298	$p = 0.6172$	$p = 0.3828$
Levene's Test	-1.133	$p = 0.8714$	$p = 0.1286$
Means	-6.835	$p = 1.0000$	$p < 0.0001$
Medians	-6.065	$p = 1.0000$	$p < 0.0001$
Distributions	4.754	$p < 0.0001$	$p = 1.0000$

The results of the meta-analysis for the combined marathon race finishers in the 50 – 59 age group for both tests of variance, F and Levene's, are highly non-significant which shows that there is no statistical evidence that the variance of the age graded scores for the male finishers is significantly larger than the variance of the age graded scores for the female finishers. The proportion of marathon finishers for the male runners is significantly larger than the proportion of marathon finishers for the female runners; also, the distribution of age graded scores for the male finishers is significantly different from, and significantly larger than, the distribution of age graded scores for the female finishers. The mean and median age graded scores for the female marathon finishers are significantly larger than the mean and median age graded scores for the male marathon finishers. The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower.

Table 238. Meta-Analysis: Marathon – Ages 60 – 69

Variable	Z value	P value: M > F	P value: F > M
Proportions	8.249	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-3.743	p = 0.9999	p = 0.0001
40%	0.032	p = 0.5127	p = 0.4873
Variances			
F Test	0.247	p = 0.4025	p = 0.5975
Levene's Test	0.242	p = 0.4044	p = 0.5956
Means	-7.970	p = 1.0000	p < 0.0001
Medians	-7.672	p = 1.0000	p < 0.0001
Distributions	6.191	p < 0.0001	p = 1.0000

The results of the meta-analysis for the combined marathon race finishers in the 60 – 69 age group for both tests of variance, F and Levene's, are highly non-significant showing that there is no statistical evidence that the variance of the age graded scores for the male runners is significantly larger than the variance of the age graded scores for the female runners. For the test of proportions, there is strong statistical evidence that the proportion of marathon finishers for the male runners is significantly larger than the proportion of marathon finishers for the female runners. The proportion of female marathon finishers of sixty percent or higher is significantly larger than the proportion of male marathon finishers of sixty percent or higher. There is no statistical evidence that the proportion of marathon finishers with an age graded score of forty percent or lower is significantly different between the male and female populations. The mean and median age graded scores for the female race finishers are significantly larger than the mean and median age graded scores for the male race finishers. Finally, the distribution of the age graded scores for the male runners is significantly different from, and significantly larger than, the distribution of the age graded scores for the female runners.

Table 239. Meta-Analysis: Marathon – Ages 70 – 79

Variable	Z value	P value: M > F	P value: F > M
Proportions	5.576	p < 0.0001	p = 1.0000
		Age Graded Score	
Proportions			
60%	-3.214	p = 0.9993	p = 0.0007
40%	-3.036	p = 0.0012	p = 0.9988
Variances			
F Test	-0.544	p = 0.7068	p = 0.2932
Levene's Test	0.140	p = 0.4443	p = 0.5557
Means	-5.497	p = 1.0000	p < 0.0001
Medians	-5.237	p = 1.0000	p < 0.0001
Distributions	4.512	p < 0.0001	p = 1.0000

The results of the meta-analysis for the combined marathon race finishers in the 70 – 79 age group for both tests of variance, F and Levene's, are highly non-significant which shows that there is no statistical evidence that the variance of the age graded scores for the male runners is significantly larger than the variance of the age graded scores for the female runners. For the test of proportions, there is strong statistical evidence that the proportion of marathon finishers in the 70 – 79 year old age group for the male runners is significantly larger than the proportion of marathon finishers for the female runners in the 70 – 79 year old age group. The mean and median age graded scores for the female race finishers are significantly larger than the mean and median age graded scores for the male race finishers. The proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower. Finally, the distribution of the age graded scores for the male runners is significantly different from, and significantly larger than, the distribution of the age graded scores for the female runners.

While there is not enough information available to include the 80 – 99 year old age group in the meta-analysis for the test of means, the test of medians, the tests of variances, and the test of distributions, we were able to conduct a meta-analysis for the test of proportions. The result of this analysis was a z-value equal to 2.790 and a p-value equal to 0.0026; this shows that there is strong evidence that the proportion of male marathon finishers is significantly larger than the proportion of female marathon finishers.

6.6.5.2. Half Marathon Age Group Results

To further examine the differences between the populations of male and female half marathon runners, we chose to look at the distribution of male and female half marathon finishers grouped by age using meta-analytic techniques. To accomplish this, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results. These conversions were performed for every statistical test except the test of distributions which has a two-sided alternative hypothesis. After the p-values were converted, we performed a meta-analysis to combine the p-values of the half marathons using Stouffer's Z-score method and defined our age groups to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99. For ease of computation, we used a p-value of 0.00009 for all p-values less than 0.0001 and a p-value of 0.99999 for all p-values equal to 1.000 that appeared in the test results; these values were chosen for convenience of calculation and to keep the calculation for breaking down as we were using computer programs to calculate the final Z value. There were not enough races with results in the 80 – 99 age group for the age group to be included in this section.

Table 240. Meta-Analysis: Half Marathon – Ages 1 – 19

Variable	Z value	P value: M > F	P value: F > M
Proportions	-3.060	p = 0.9989	p = 0.0011
		Age Graded Scores	
Proportions			
60%	5.148	p < 0.0001	p = 1.0000
40%	-0.592	p = 0.2770	p = 0.7230
Variances			
F Test	4.684	p < 0.0001	p = 1.0000
Levene's Test	4.758	p < 0.0001	p = 1.0000
Means	0.610	p = 0.2709	p = 0.7291
Medians	0.677	p = 0.2492	p = 0.7508
Distributions	-3.383	p = 0.9996	p = 0.0004

The results of the meta-analysis for the combined half marathon race finishers in the 1 – 19 age group for both tests of variance, F and Levene's, are highly significant which shows that there is strong statistical evidence that the variance of the age graded scores for the male runners is significantly larger than the variance of the age graded scores for the female runners. For the test of proportions the result shows that the proportion of half marathon finishers for the female runners is significantly larger than the proportion of half marathon finishers for the male runners. The proportion of male half marathon finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female half marathon finishers with an age graded score of sixty percent or higher. There is no statistical evidence that the mean and median age graded scores for the male finishers are significantly larger than the mean and median age graded scores for the female finishers; there is also no statistical evidence of a significant difference between the proportion of male and female race finishers with an age graded score of forty percent or lower. The distribution of age graded score for the female half marathon finishers is significantly larger than the distribution of age graded score for the male half marathon finishers.

Table 241. Meta-Analysis: Half Marathon – Ages 20 – 29

Variable	Z value	P value: M > F	P value: F > M
Proportions	-10.070	p = 1.0000	p < 0.0001
		Age Graded Scores	
Proportions			
60%	5.224	p < 0.0001	p = 1.0000
40%	-1.063	p = 0.1438	p = 0.8562
Variances			
F Test	9.166	p < 0.0001	p = 1.0000
Levene's Test	9.003	p < 0.0001	p = 1.0000
Means	6.987	p < 0.0001	p = 1.0000
Medians	6.155	p < 0.0001	p = 1.0000
Distributions	-0.226	p = 0.5894	p = 0.4106

The result of the meta-analysis for the combined half marathon race finishers in the 20 – 29 age group for the test of proportions shows that the proportion of female half marathon finishers is significantly larger than the proportion of male half marathon finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male half marathon finishers are significantly larger than the mean, median, and variance of the age graded scores for the female half marathon finishers. The proportion of male race finishers with an age graded score of sixty percent or larger are significantly larger than the proportion of female race finishers with an age graded score of sixty percent or higher. We can also see that there is no statistical evidence that the distribution of age graded scores for the male and female half marathon finishers are significantly different; there is also no statistical evidence that the proportions of finishers with an age graded score of forty percent or lower for the male and female race finishers are significantly different.

Table 242. Meta-Analysis: Half Marathon – Ages 30 – 39

Variable	Z value	P value: M > F	P value: F > M
Proportions	0.130	p = 0.4483	p = 0.5517
		Age Graded Scores	
Proportions			
60%	7.081	p < 0.0001	p = 1.0000
40%	3.097	p = 0.9990	p = 0.0010
Variances			
F Test	6.696	p < 0.0001	p = 1.0000
Levene's Test	6.675	p < 0.0001	p = 1.0000
Means	8.016	p < 0.0001	p = 1.0000
Medians	7.454	p < 0.0001	p = 1.0000
Distributions	-2.838	p = 0.9977	p = 0.0023

The result of the meta-analysis for the combined half marathon race finishers in the 30 – 39 age group for the test of proportions shows that there is no statistical evidence to show that the proportion of male half marathon finishers is significantly larger than the proportion of female half marathon finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male half marathon finishers are significantly larger than the mean, median, and variance of the age graded scores for the female half marathon finishers. We can also see that the distribution of age graded scores for the male and female half marathon finishers are significantly different; specifically, the distribution of age graded scores of the female runners is significantly larger than the distribution of age graded scores of the male runners.

Table 243. Meta-Analysis: Half Marathon – Ages 40 – 49

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.998	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	8.685	p < 0.0001	p = 1.0000
40%	6.833	p = 1.0000	p < 0.0001
Variances			
F Test	3.861	p = 0.0001	p = 0.9999
Levene's Test	3.658	p = 0.0001	p = 0.9999
Means	9.322	p < 0.0001	p = 1.0000
Medians	9.289	p < 0.0001	p = 1.0000
Distributions	-4.793	p = 1.0000	p < 0.0001

The results of the meta-analysis for the combined half marathon race finishers in the 40 – 49 age group are all highly significant with p-values less than or equal to 0.0001. The proportion of half marathon finishers for the male runners is significantly larger than the proportion of half marathon finishers for the female runners. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. Finally, the distributions of the age graded scores are significantly different between the male and female running populations; specifically the distribution of age graded scores for the female half marathon finishers is significantly larger than the distribution of age graded scores for the male finishers.

Table 244. Meta-Analysis: Half Marathon – Ages 50 – 59

Variable	Z value	P value: M > F	P value: F > M
Proportions	9.195	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	3.838	p = 0.0001	p = 0.9999
40%	3.902	p = 1.0000	p < 0.0001
Variances			
F Test	-1.114	p = 0.8674	p = 0.1326
Levene's Test	-1.274	p = 0.8987	p = 0.1013
Means	5.290	p < 0.0001	p = 1.0000
Medians	5.988	p < 0.0001	p = 1.0000
Distributions	-2.289	p = 0.9889	p = 0.0111

The results of the meta-analysis for the combined half marathon race finishers in the 50 – 59 age group for both tests of variance, F and Levene's, are highly non-significant which shows that there is no statistical evidence that the variance of the age graded scores for the male runners is significantly larger than the variance of the age graded scores for the female runners. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The results of all other tests are all highly significant with p-values less than 0.0001. This means that the mean age graded score, the median age graded score, and the variance for the age graded scores for the male race finishers are significantly larger than the mean age graded score, the median age graded score, and the variance of age graded scores for the female race finishers. As a result of these differences, the distribution of the age graded scores for the male runners is significantly different from the distribution of the age graded scores for the female runners; specifically, the distribution of age graded scores for the female half marathon finishers is significantly larger than the distribution of the age graded scores for the male half marathon finishers.

Table 245. Meta-Analysis: Half Marathon – Ages 60 – 69

Variable	Z value	P value: M > F	P value: F > M
Proportions	9.391	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-0.894	p = 0.8143	p = 0.1857
40%	-2.821	p = 0.0024	p = 0.9976
Variances			
F Test	1.141	p = 0.1269	p = 0.8731
Levene's Test	1.282	p = 0.1000	p = 0.9000
Means	-2.863	p = 0.9979	p = 0.0021
Medians	-2.470	p = 0.9932	p = 0.0068
Distributions	2.697	p = 0.0035	p = 0.9965

The results of the meta-analysis for the combined half marathon race finishers in the 60 – 69 age group for the test of proportions and the test for distributions are both highly significant with p-values less than 0.004; the proportion of half marathon finishers for the male runners is significantly larger than the proportion of half marathon finishers for the female runners and the distributions of age graded scores for the male and female populations are significantly different from one another. The results for both tests of variance, F and Levene's, are non-significant with p-values larger than 0.10 giving no statistical evidence that the variance of age graded scores for the male finishers is significantly larger than the variance of age graded scores for the female finishers. The mean and median age graded scores for the female runners are significantly larger than the mean and median age graded scores for the male runners. The proportion of male half marathon finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female half marathon finishers with an age graded score of forty percent or below. There is no statistical evidence of a significant difference between the proportions of half marathon finishers with an age graded score of sixty percent or higher between the male and female running populations.

Table 246. Meta-Analysis: Half Marathon – Ages 70 – 79

Variable		Z value	P value: M > F	P value: F > M
Proportions		7.857	p < 0.0001	p = 1.0000
			Age Graded Scores	
Proportions				
	60%	-0.354	p = 0.6383	p = 0.3617
	40%	-0.779	p = 0.2181	p = 0.7819
Variances				
	F Test	1.164	p = 0.1222	p = 0.8778
	Levene's Test	1.476	p = 0.0700	p = 0.9300
Means		-2.267	p = 0.9883	p = 0.0117
Medians		-2.232	p = 0.9872	p = 0.0128
Distributions		2.123	p = 0.0169	p = 0.9831

The results of the meta-analysis for the combined half marathon race finishers in the 70 – 79 age group for the test of proportions are highly significant with a p-value less than 0.0001 showing that the proportion of half marathon finishers for the male runners is significantly larger than the proportion of half marathon finishers for the female runners. The F test of variances shows no statistical evidence and the Levene's test of variances shows weak statistical evidence that the variance of age graded scores for male finishers is larger than the variance of age graded scores for female finishers. The mean and median age graded score for the female race finishers is significantly larger than the mean and median age graded score for the male race finishers. The distribution of age graded scores for the male half marathon finishers is significantly larger than the distribution of age graded scores for the female half marathon finishers. There is no statistical evidence that the proportion of finishers with an age graded score at or above sixty percent and the proportion of finishers at or below forty percent are significantly different between the male and female running populations.

While there is not enough information available to include the 80 – 99 year old age group in the meta-analysis for the test of means, the test of medians, the tests of variances, and the test of distributions, we were able to conduct a meta-analysis for the test of proportions. The result of this analysis was a z-value equal to 3.348 and a p-value equal to 0.0004; this shows that there is strong evidence that the proportion of male half marathon finishers is significantly larger than the proportion of female half marathon finishers.

6.6.5.3. Ten K Age Group Results

To further examine the differences between the populations of male and female ten kilometer race runners, we chose to look at the distribution of male and female ten kilometer finishers grouped by age using meta-analytic techniques. To accomplish this, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results. These conversions were performed for every statistical test except the test of distributions which has a two-sided alternative hypothesis. After the p-values were converted, we performed a meta-analysis to combine the p-values of the ten kilometer races using Stouffer's *Z*-score method and defined our age groups to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99. For ease of computation, we used a p-value of 0.00009 for all $p < 0.0001$ and a p-value of 0.99999 for all $p = 1.000$ that appeared in the test results; these values were chosen for convenience of calculation and to keep the calculation for breaking down as we were using computer programs to calculate the final Z value.

Table 247. Meta-Analysis: Ten K – Ages 1 – 19

Variable	Z value	P value: M > F	P value: F > M
Proportions	3.125	p = 0.0009	p = 0.9991
		Age Graded Scores	
Proportions			
60%	5.997	p < 0.0001	p = 1.0000
40%: F > M	5.646	p < 0.0001	p = 1.0000
Variances			
F Test	5.573	p < 0.0001	p = 1.0000
Levene's Test	5.570	p < 0.0001	p = 1.0000
Means	5.916	p < 0.0001	p = 1.0000
Medians	5.863	p < 0.0001	p = 1.0000
Distributions	-1.058	p = 0.8549	p = 0.1451

The results of the meta-analysis for the combined ten kilometer race finishers in the 1 – 19 age group are all highly significant with p-values less than 0.0009 except for the test of distributions; there is no statistical evidence that there is a significant difference between the distributions of age graded scores for the male and female race finishers. The proportion of ten kilometer race finishers for the male runners in the 1 – 19 year old age group is significantly larger than the proportion of ten kilometer race finishers for the female runners in the 1 – 19 year old age group. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower.

Table 248. Meta-Analysis: Ten K – Ages 20 – 29

Variable	Z value	P value: M > F	P value: F > M
Proportions	-8.455	p = 1.0000	p < 0.0001
		Age Graded Scores	
Proportions			
60%	7.088	p < 0.0001	p = 1.0000
40%	4.265	p = 1.0000	p < 0.0001
Variances			
F Test	7.160	p < 0.0001	p = 1.0000
Levene's Test	6.698	p < 0.0001	p = 1.0000
Means	6.758	p < 0.0001	p = 1.0000
Medians	6.314	p < 0.0001	p = 1.0000
Distributions	0.179	p = 0.4289	p = 0.5711

The results of the meta-analysis for the combined ten kilometer race finishers in the 20 – 29 age group for the test of proportions shows that the proportion of female ten kilometer race finishers is significantly larger than the proportion of male ten kilometer race finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male ten kilometer finishers are significantly larger than the mean, median, and variance of the age graded scores for the female ten kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that there is no statistical evidence that the distribution of age graded scores for the male and female race finishers are significantly different.

Table 249. Meta-Analysis: Ten K – Ages 30 – 39

Variable	Z value	P value: M > F	P value: F > M
Proportions	-2.374	p = 0.9912	p = 0.0088
		Age Graded Scores	
Proportions			
60%	7.825	p < 0.0001	p = 1.0000
40%	6.178	p = 1.0000	p < 0.0001
Variances			
F Test	7.243	p < 0.0001	p = 1.0000
Levene's Test	7.058	p < 0.0001	p = 1.0000
Means	8.199	p < 0.0001	p = 1.0000
Medians	8.154	p < 0.0001	p = 1.0000
Distributions	-0.988	p = 0.8385	p = 0.1615

The results of the meta-analysis for the combined ten kilometer race finishers in the 30 – 39 age group for the test of proportions shows that the proportion of female ten kilometer race finishers is significantly larger than the proportion of male ten kilometer race finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male ten kilometer finishers are significantly larger than the mean, median, and variance of the age graded scores for the female ten kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that there is no statistical evidence that the distribution of age graded scores for the male and female race finishers are significantly different from one another.

Table 250. Meta-Analysis: Ten K – Ages 40 – 49

Variable	Z value	P value: M > F	P value: F > M
Proportions	3.253	p = 0.0006	p = 0.9994
		Age Graded Scores	
Proportions			
60%	7.513	p < 0.0001	p = 1.0000
40%	6.934	p = 1.0000	p < 0.0001
Variances			
F Test	4.956	p < 0.0001	p = 1.0000
Levene's Test	5.049	p < 0.0001	p = 1.0000
Means	7.605	p < 0.0001	p = 1.0000
Medians	7.593	p < 0.0001	p = 1.0000
Distributions	-2.957	p = 0.9984	p = 0.0016

The results of the meta-analysis for the combined ten kilometer race finishers in the 40 – 49 year age group are all highly significant with p-values less than 0.002. The proportion of ten kilometer race finishers in the 40 – 49 year age group for the male runners is significantly larger than the proportion of ten kilometer race finishers for the female runners in the 40 – 49 year age group. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. As a result of this statistical difference, the distributions of the age graded scores are significantly different between the male and female running populations; specifically, the distribution of age graded scores for the female ten kilometer race finishers is significantly larger than the distribution of age graded scores for the male ten kilometer race finishers.

Table 251. Meta-Analysis: Ten K – Ages 50 – 59

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.299	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	5.419	p < 0.0001	p = 1.0000
40%	5.256	p = 1.0000	p < 0.0001
Variances			
F Test	5.086	p < 0.0001	p = 1.0000
Levene's Test	5.069	p < 0.0001	p = 1.0000
Means	5.781	p < 0.0001	p = 1.0000
Medians	5.847	p < 0.0001	p = 1.0000
Distributions	-0.581	p = 0.7194	p = 0.2806

The results of the meta-analysis for the combined ten kilometer race finishers in the 50 – 59 age group are all highly significant with p-values less than 0.0001. The proportion of ten kilometer race finishers in the 50 – 59 year old age group for the male runners is significantly larger than the proportion of ten kilometer race finishers in the 50 – 59 year old age group for the female runners. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. As a result of this statistical difference, the distributions of the age graded scores are significantly different between the male and female running populations.

Table 252. Meta-Analysis: Ten K – Ages 60 – 69

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.595	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	4.795	p < 0.0001	p = 1.0000
40%: F > M	5.043	p = 1.0000	p < 0.0001
Variances			
F Test	4.849	p < 0.0001	p = 1.0000
Levene's Test	4.858	p < 0.0001	p = 1.0000
Means	4.974	p < 0.0001	p = 1.0000
Medians	4.760	p < 0.0001	p = 1.0000
Distributions	3.579	p = 0.0002	p = 0.9998

The results of the meta-analysis for the combined ten kilometer race finishers in the 60 – 69 age group are all highly significant with p-values less than 0.0001. The proportion of ten kilometer race finishers in the 60 – 69 year old age group for the male runners is significantly larger than the proportion of ten kilometer race finishers in the 60 – 69 year old age group for the female runners. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. As a result of this statistical difference, the distributions of the age graded scores are significantly different between the male and female running populations; specifically, the distribution of male ten kilometer race finishers is significantly larger than the distribution of female ten kilometer race finishers.

Table 253. Meta-Analysis: Ten K – Ages 70 – 79

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.847	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-1.357	p = 0.9126	p = 0.0874
40%	-2.941	p = 0.0016	p = 0.9984
Variances			
F Test	0.905	p = 0.1827	p = 0.8173
Levene's Test	1.183	p = 0.1184	p = 0.8816
Means	-2.684	p = 0.9964	p = 0.0036
Medians	-3.023	p = 0.9987	p = 0.0013
Distributions	3.257	p = 0.0006	p = 0.9994

The results of the meta-analysis for the combined ten kilometer race finishers in the 70 – 79 age group for the test of proportions and the test for distributions are both highly significant with p-values less than 0.02; the proportion of ten kilometer race finishers for the male runners is significantly larger than the proportion of ten kilometer finishers for the female runners and the distributions of age graded scores for the male and female populations are significantly different from one another. Specifically, the distribution of male race finishers is significantly larger than the distribution of female race finishers. The results for both tests of variance, F and Levene's, are non-significant with p-values larger than 0.11 giving no statistical evidence that the variance of age graded scores for the male finishers is significantly larger than the variance of age graded scores for the female finishers. The mean and median age graded scores for the female ten kilometer finishers are significantly larger than the mean and median age graded scores for the male ten kilometer finishers. There is weak statistical evidence that the proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher; the p-value is larger than our chosen level of significance but would be considered significant at a larger significance level. The proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower.

Table 254. Meta-Analysis: Ten K – Ages 80 – 99

Variable	Z value	P value: M > F	P value: F > M
Proportions	4.054	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-0.854	p = 0.8034	p = 0.1966
40%	-0.556	p = 0.2892	p = 0.7208
Variances			
F Test	0.694	p = 0.2438	p = 0.7562
Levene's Test	0.825	p = 0.2047	p = 0.7953
Means	-0.997	p = 0.8406	p = 0.1594
Medians	-0.816	p = 0.7928	p = 0.2072
Distributions	-0.683	p = 0.7528	p = 0.2472

The results of the meta-analysis for the combined ten kilometer race finishers in the 80 – 99 age group for the test of proportions is highly significant with p-values less than 0.02; the proportion of ten kilometer race finishers for the male runners is significantly larger than the proportion of ten kilometer finishers for the female runners. The results for both tests of variance, F and Levene's, are non-significant with p-values larger than 0.20 giving no statistical evidence that the variance of age graded scores for the male finishers is significantly larger than the variance of age graded scores for the female finishers. The results for the mean and median age graded scores are also non-significant with p-values larger than 0.15 giving no statistical evidence that the mean and median age graded scores for the female ten kilometer finishers are significantly larger than the mean and median age graded scores for the male ten kilometer finishers. There is also no statistical evidence of a significant difference for the proportion of race finishers with an age graded score at or above sixty percent and the proportion of race finishers with an age graded score at or below forty percent between the male and female running populations.

6.6.5.4. Five K Age Group Results

To further examine the differences between the populations of male and female five kilometer race runners, we chose to look at the distribution of male and female five kilometer finishers grouped by age using meta-analytic techniques. To accomplish this, we converted the two-sided p-values into one-sided p-values that answer the alternative hypothesis of male results larger than female results. These conversions were performed for every statistical test except the test of distributions which has a two-sided alternative hypothesis. After the p-values were converted, we performed a meta-analysis to combine the p-values of the five kilometer races using Stouffer's Z-score method and defined our age groups to be ages 1 – 19, 20 – 29, 30 – 39, 40 – 49, 50 – 59, 60 – 69, 70 – 79, and 80 – 99. For ease of computation, we used a p-value of 0.00009 for all p-values less than 0.0001 and a p-value of 0.99999 for all p-values equal to 1.000 that appeared in the test results; these values were chosen for convenience of calculation and to keep the calculation for breaking down as we were using computer programs to calculate the final Z value.

Table 255. Meta-Analysis: Five K – Ages 1 – 19

Variable	Z value	P value: M > F	P value: F > M
Proportions	2.747	p = 0.0030	p = 0.9970
		Age Graded Scores	
Proportions			
60%	3.915	p < 0.0001	p = 1.0000
40%	6.090	p = 1.0000	p < 0.0001
Variances			
F Test	4.843	p < 0.0001	p = 1.0000
Levene's Test	4.902	p < 0.0001	p = 1.0000
Means	6.734	p < 0.0001	p = 1.0000
Medians	6.630	p < 0.0001	p = 1.0000
Distributions	-3.090	p = 0.9990	p = 0.0010

The results of the meta-analysis for the combined five kilometer race finishers in the 1 – 19 age group are all highly significant with p-values less than 0.003. The proportion of five kilometer race finishers in the 1 – 19 year old age group for the male runners is significantly larger than the proportion of five kilometer race finishers in the 1 – 19 year old age group for the female runners. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The mean, median, and variance of the age graded scores for the male race finishers are significantly larger than the mean, median, and variance of the age graded scores for the female race finishers. As a result of this statistical difference, the distributions of the age graded scores are significantly different between the male and female running populations; specifically, the distribution of age graded scores for the female five kilometer race finishers is significantly larger than the distribution of age graded scores for the male five kilometer race finishers.

Table 256. Meta-Analysis: Five K – Ages 20 – 29

Variable	Z value	P value: M > F	P value: F > M
Proportions	-4.927	p = 1.0000	p < 0.0001
		Age Graded Scores	
Proportions			
60%	5.676	p < 0.0001	p = 1.0000
40%	3.016	p = 0.9987	p = 0.0013
Variances			
F Test	7.090	p < 0.0001	p = 1.0000
Levene's Test	6.783	p < 0.0001	p = 1.0000
Means	5.815	p < 0.0001	p = 1.0000
Medians	4.817	p < 0.0001	p = 1.0000
Distributions	3.042	p = 0.0012	p = 0.9988

The results of the meta-analysis for the combined five kilometer race finishers in the 20 – 29 age group for the test of proportions shows that the proportion of female five kilometer race finishers is significantly larger than the proportion of male five kilometer race finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male five kilometer finishers are significantly larger than the mean, median, and variance of the age graded scores for the female five kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that the distribution of age graded scores for the male and female race finishers are significantly different; specifically, the distribution of the age graded scores for the male runners is significantly larger than the distribution of the age graded scores for the female runners.

Table 257. Meta-Analysis: Five K – Ages 30 – 39

Variable	Z value	P value: M > F	P value: F > M
Proportions	-1.158	p = 0.8766	p = 0.1234
		Age Graded Scores	
Proportions			
60%	6.983	p < 0.0001	p = 1.0000
40%	2.516	p = 0.9941	p = 0.0059
Variances			
F Test	7.807	p < 0.0001	p = 1.0000
Levene's Test	7.412	p < 0.0001	p = 1.0000
Means	6.908	p < 0.0001	p = 1.0000
Medians	5.286	p < 0.0001	p = 1.0000
Distributions	1.375	p = 0.0845	p = 0.9155

The results of the meta-analysis for the combined five kilometer race finishers in the 30 – 39 age group for the test of proportions shows no statistical evidence that the proportion of female five kilometer race finishers is significantly larger than the proportion of male five kilometer race finishers. All other results are highly significant with p-values; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male five kilometer finishers are significantly larger than the mean, median, and variance of the age graded scores for the female five kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that there is weak evidence that the distribution of age graded scores for the male and female race finishers are significantly different; specifically, that the distribution of age graded scores for the male runners is significantly different from the distribution of age graded scores for the female runners.

Table 258. Meta-Analysis: Five K – Ages 40 – 49

Variable	Z value	P value: M > F	P value: F > M
Proportions	1.853	p = 0.0320	p = 0.9680
		Age Graded Scores	
Proportions			
60%	7.696	p < 0.0001	p = 1.0000
40%	6.098	p = 1.0000	p < 0.0001
Variances			
F Test	5.501	p < 0.0001	p = 1.0000
Levene's Test	5.227	p < 0.0001	p = 1.0000
Means	7.423	p < 0.0001	p = 1.0000
Medians	6.516	p < 0.0001	p = 1.0000
Distributions	-0.695	p = 0.7564	p = 0.2436

The results of the meta-analysis for the combined five kilometer race finishers in the 40 – 49 age group for the test of proportions show that the proportion of male five kilometer race finishers is significantly larger than the proportion of female five kilometer race finishers. All other results are highly significant with p-values less than 0.0001; this means that the mean age graded score, the median age graded score, the variance of the age graded scores for the male five kilometer finishers are significantly larger than the mean, median, and variance of the age graded scores for the female five kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that there is no statistical evidence that the distribution of age graded scores for the male and female race finishers are significantly different.

Table 259. Meta-Analysis: Five K – Ages 50 – 59

Variable	Z value	P value: M > F	P value: F > M
Proportions	4.084	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	2.712	p = 0.0033	p = 0.9967
40%	3.323	p = 0.9996	p = 0.0004
Variances			
F Test	5.545	p < 0.0001	p = 1.0000
Levene's Test	5.050	p < 0.0001	p = 1.0000
Means	1.741	p = 0.0408	p = 0.9592
Medians	1.512	p = 0.0652	p = 0.9348
Distributions	3.771	p = 0.0001	p = 0.9999

The results of the meta-analysis for the combined five kilometer race finishers in the 50 – 59 age group for the test of medians are weakly significant with a p-value larger than our chosen level of significance but would be considered significant at a larger level of significance; this shows weak statistical evidence that the median age graded scores for the male race finishers are significantly larger than the median age graded scores for the female race finishers. The results of all other tests are all significant with p-values less than 0.0001; this means that the variance of the age graded scores and the proportion of race finishers for the male five kilometer finishers are significantly larger than the variance of the age graded scores and the proportion of race finishers for the female five kilometer finishers. The proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. We can also see that the distribution of age graded scores for the male and female race finishers are significantly different; specifically, the distribution of age graded scores for the male five kilometer race finishers is significantly larger than the distribution of age graded score for the female five kilometer race finishers.

Table 260. Meta-Analysis: Five K – Ages 60 – 69

Variable	Z value	P value: M > F	P value: F > M
Proportions	7.659	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	0.073	p = 0.4711	p = 0.5289
40%	2.279	p = 0.9887	p = 0.0113
Variances			
F Test	3.882	p = 0.0001	p = 0.9999
Levene's Test	3.727	p = 0.0001	p = 0.9999
Means	0.988	p = 0.1616	p = 0.8384
Medians	0.939	p = 0.1739	p = 0.8261
Distributions	3.908	p < 0.0001	p = 1.0000

The results of the meta-analysis for the combined five kilometer race finishers in the 60 – 69 age group for the test of means and the test of medians are non-significant with p-values larger than 0.16; this shows no statistical evidence that the mean and median age graded scores for the female race finishers are significantly larger than the mean and median age graded scores for the male race finishers. There is no statistical evidence that proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. The proportion of female race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male race finishers with an age graded score of forty percent or lower. The results of all other tests are all significant with p-values less than or equal to 0.0001; this means that the variance of the age graded scores and the proportion of race finishers for the male five kilometer finishers are significantly larger than the variance of the age graded scores and the proportion of race finishers for the female five kilometer finishers. We can also see that the distribution of age graded scores for the male and female race finishers are significantly different; specifically, the distribution of age graded scores for the male five kilometer finishers is significantly larger than the distribution of the age graded scores for the female five kilometer finishers.

Table 261. Meta-Analysis: Five K – Ages 70 – 79

Variable	Z value	P value: M > F	P value: F > M
Proportions	6.883	p < 0.0001	p = 1.0000
		Age Graded Scores	
Proportions			
60%	-1.508	p = 0.9342	p = 0.0658
40%	-1.330	p = 0.0918	p = 0.9082
Variances			
F Test	0.230	p = 0.4091	p = 0.5909
Levene's Test	-0.737	p = 0.7694	p = 0.2306
Means	-2.095	p = 0.9819	p = 0.0181
Medians	-0.063	p = 0.5251	p = 0.4749
Distributions	2.073	p = 0.0191	p = 0.9809

The results of the meta-analysis for the combined five kilometer race finishers in the 70 – 79 age group for the test of proportions are highly significant with a p-value less than 0.0001; the proportion of male five kilometer race finishers is significantly larger than the proportion of female five kilometer race finishers for the 70 – 79 year old age group. There is weak statistical evidence that the proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. There is also weak statistical evidence that the proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower. The mean age graded score for the female race finishers is significantly larger than the mean age graded score for the male race finishers. The results for all other tests are highly non-significant with p-values larger than 0.13. There is no statistical evidence that the median age graded score and the variance of the age graded scores for the male finishers are significantly larger than the median age graded score and the variance of the age graded scores for the female finishers. As a result of this non-significant result, there is no statistical evidence that the distribution of age graded scores for the male and female race finishers are significantly different; specifically, the distribution of age graded scores for the male five kilometer finishers is significantly larger than the female five kilometer finishers.

Table 262. Meta-Analysis: Five K – Ages 80 – 99

Variable	Z value	P value: M > F	P value: F > M
Proportions	1.863	p = 0.0312	p = 0.9688
		Age Graded Scores	
Proportions			
60%	-0.655	p = 0.7437	p = 0.2563
40%	-1.460	p = 0.0721	p = 0.9279
Variances			
F Test	-1.358	p = 0.9128	p = 0.0872
Levene's Test	-1.052	p = 0.8536	p = 0.1464
Means	-2.688	p = 0.9964	p = 0.0036
Medians	-2.828	p = 0.9977	p = 0.0023
Distributions	2.088	p = 0.0184	p = 0.9816

The results of the meta-analysis for the combined five kilometer race finishers in the 80 – 99 age group for the test of proportions are highly significant with a p-value less than 0.032; the proportion of male five kilometer race finishers is significantly larger than the proportion of female five kilometer race finishers for the 80 – 99 year old age group. There is no statistical evidence that the proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher. There is weak statistical evidence that the proportion of male race finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female race finishers with an age graded score of forty percent or lower; the p-value is larger than our chosen level of significance but would be considered significant at a higher level of proof. The mean and median age graded scores for the female race finishers are significantly larger than the mean and median age graded scores for the male race finishers. The results for the tests of variance are split with the result for Levene's test non-significant and the result for the F test weakly significant with a p-value larger than the level of significance chosen for this paper but that would be considered significant at a larger level of significance. There is weak statistical evidence that the variance of the age graded scores for the female finishers are significantly larger than the variance of the age graded scores for the male finishers. As a result of these mixed results, there is no statistical evidence that the distribution of age graded scores for the male and female race finishers are significantly different.

CHAPTER 7. CONCLUSIONS

The goal of this paper was to examine the differences between the male and female running populations in order to determine if these differences corroborate the theory that men are more competitive than women. If this theory is true we would expect to see certain trends throughout our data; specifically, we would see the age grades for men to be higher and closer together than the age grades for women; specifically, we would expect men to have, overall, higher age graded scores with few low age graded scores. Translated into numbers, we would expect to see a larger proportion of male finishers with an age graded score at or above sixty percent as well as a larger proportion of female finishers with an age graded score at or below forty percent. The mean and median age graded score for men should be larger than the scores for women while the variance of the age graded scores for women should be larger than the variance of the male finishers, if the male finishers are indeed more competitive.

To determine if these trends appear in the populations of male and female runners, we conducted several statistical tests for the variables of age graded score and age of the runners; we preformed this analysis for three marathons that require qualification to participate and thirty-two races that did not require qualification to participate, eight races at each of the four popular race distances: marathon, half marathon, ten kilometer, and five kilometer. Specifically, we tested the significance of the differences between the male and female running populations for the proportion of race finishers with an age graded score of sixty percent or higher, the proportion of race finishers with an age graded score of forty percent or lower, the mean and median age graded scores, the variance of the age graded scores, the distribution of the age graded scores, the mean and median ages, the variance of the ages, and the distribution of ages; the results from these tests were very interesting.

7.1. Overall Age Graded Score Conclusions

Overall, we found that across all distances the mean age graded score for male race finishers was significantly larger than the mean age graded score for female race finishers; this shows that on average, the male runners finished their chosen race distance faster than the female runners in the same race. This finding is echoed in the median age graded score which is significantly larger for the male runners than for the female runners. These findings agree with what we would expect to see if men were more competitive than women; our next result does not agree with what we would expect.

We found that, for all distances examined, the variance of the age graded scores for the male runners is significantly larger than the variance of the age graded scores for the female runners; this is for the races and distances overall, some specific races may have a larger variance for the female population than for the male population but using meta-analysis we can say that, overall, the variance of the age graded scores for the male population is larger than the variance of the age graded scores for the female population. Based on what we expected to see for the variance findings if men were more competitive than women, this finding suggests that the male runners are not more competitive than the female runners, as it is opposite of what we would expect if men were more competitive, but the previous findings suggest that the male runners are more competitive than the female runners.

To further examine which gender was more competitive, we looked at the proportion of finishers at certain levels of the age graded scores to determine which gender had a larger proportion of race finishers at that level. For all distances that we examined, we found that the proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher.

This result shows that, for all distances, the male running population finished faster than the female running population which suggests that the male runners are more competitive than the female runners. The results for the proportion of race finishers at or below forty percent are less straight forward. For all marathons studied, we found that the proportion of male runners with an age graded score of forty percent or lower is significantly larger than the proportion of female runners with an age graded score of forty percent and any race that had a larger proportion of female finishers than male finishers had a highly non-significant result. For all other race distances studied, the proportion of female finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male finishers with an age graded score of forty percent or lower. These findings show that more men finish faster than women and more women finish slower than men for half marathon, ten kilometer, and five kilometer races which suggest that men are more competitive than women for these race distances, when we define competitiveness as how quickly a person finishes a specific race. The marathon race distance results show that more men finish faster than women but more men also finish slower than women which suggests that men are more competitive at the higher age graded scores but men are less competitive at lower age graded scores.

7.2. Age Group Age Graded Score Conclusions

We wished to explore the relationship between the male and female running populations with respect to the age graded scores in further detail by looking at the mean age graded score, the median age graded score, the variance of the age graded scores, the proportion of finishers with an age graded score of sixty percent or above, and the proportion of finishers with an age graded score of forty percent or below for the individual age groups of the races studied. For all race distances studied, the variance of age graded scores for the male race finishers is significantly larger than the variance of age graded scores for the female race finishers for the race finishers in all age groups; there are a few age groups that have a larger variance for women than for men throughout the four race distances but overall the male variance is larger than the female variance. For every race distance that we studied, the mean and median age graded scores followed the same pattern as the proportion of finishers with an age graded score of sixty percent or larger; the gender that has significantly more finishers with an age graded score at or above sixty percent also has a significantly larger mean and median age graded score.

When we examined the proportion of finishers with an age graded score of sixty percent or larger we found that for all race finishers at the marathon distance, the proportion of male finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the race finishers between the ages of fourteen and thirty-nine years old; the proportion of female finishers with an age graded score of sixty percent or higher is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the marathon finishers with an age of forty years old or older. For the finishers of the half marathon races, the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score of sixty percent or higher for the runners between the ages of fourteen and fifty-nine years old; for the half marathon finishers with ages greater than or equal to sixty years old, the proportion of female racers with an age graded score at or above sixty percent is significantly larger than the proportion of male racers with an age graded score of sixty percent or higher. The results for the ten kilometer race finishers and the five kilometer race finishers were the same; the proportion of male finishers with an age graded score at or above sixty percent is significantly larger than the proportion of female finishers with an age graded score of sixty percent or larger for the race finishers between the ages of fourteen and sixty-nine years old. The proportion of female finishers with an age graded score of sixty percent and above is significantly larger than the proportion of male finishers with an age graded score of sixty percent or higher for the race finishers with ages greater than or equal to seventy years old. The split in the age groups for the proportion of finishers with age graded scores at or above sixty percent are much clearer than the breakdown of the proportion of finishers with age graded scores of forty percent or lower.

The findings for the proportion of finishers with an age graded score at or below forty percent were quite different from the proportion of finishers with an age graded score at or above sixty percent; this is the case for all race distances that were reviewed. For the marathon finishers that participated in races that required prequalification, the proportion of female finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male finishers with an age graded score of forty percent or lower for the marathon finishers with ages between fourteen and twenty-nine; the proportion of male finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female finishers with an age graded score of forty percent or lower for the marathon finishers aged thirty years old and older. For the marathon finishers that participated in races that did not require prequalification, the proportion of female finishers with an age graded score at or below forty percent is significantly larger than the proportion of male finishers with an age graded score of forty percent or lower for the race finishers with ages between fourteen and nineteen years old and ages between sixty and sixty-nine years old; the proportion of male finishers with an age graded score at or below forty percent is significantly larger than the proportion of female finishers for the race finishers with ages between twenty and fifty-nine years and ages greater than or equal to seventy years old. For the half marathon finishers with an age graded score at or below forty percent, the proportion of male finishers is significantly larger than the proportion of female finishers for the race finishers with ages between fourteen and twenty-nine years old and between sixty and seventy-nine years old; the proportion of female race finishers is significant larger than the proportion of male race finishers for the runners between the ages of thirty and fifty-nine years old. The only set of races that have a clear split between the age groups that have a larger proportion of men and the age groups that have a larger proportion of women are the ten kilometer and five kilometer race distances; the five and ten kilometer race distances have the same distribution of proportions through the age groups. The proportion of female finishers with an age graded score of forty percent or lower is significantly larger than the proportion of male finishers with an age graded score of forty percent or lower for the runners between the ages of fourteen and sixty-nine years; the proportion of male finishers with an age graded score of forty percent or lower is significantly larger than the proportion of female finishers with an age graded score at or below forty percent for the runners with an age greater than or equal to seventy years.

7.3. Overall Age Conclusions

Investigating the differences between the male and female running populations based on the age graded scores of the race finishers was not the only objective we wished to explore using our data; we also wanted to determine if the populations of male and female runners differ in terms of the ages of the race finishers. The results for the ages of the race finishers were similar to the results for the age graded scores; the mean and median age for male runners are significantly larger than the mean and median ages for the female runners for all race distances that were studied. Which show that the male running population is significantly older than the female running population; age does not provide a reliable measure for competitiveness so we can only use it to make conclusions about the distribution of the ages for the male and female running populations. The variance of the ages was also significantly larger for the male race finishers than for the female race finishers. Based on these findings we can see that the male runners are older than the female runners but the female runners are grouped closer together than the male runners.

To investigate the ages of the racing populations in depth, we examined the distributions of the ages of the running populations by testing if the proportion of race finishers is different between male and female runners for each age group included in this paper. We found that, overall, for the runners between the ages of fourteen and thirty-nine years the proportion of female finishers is significantly than the proportion of male finishers; for the runners between the ages of forty and ninety-nine years the proportion of male finishers is significantly larger than the proportion of female finishers. The exact direction of the test for the fourteen to nineteen year old age group is split between the four race distances; there are some discrepancies among the individual races for each of the race distances but through the use of meta-analysis for these distances we can see the following trends very clearly. For the racers competing in the marathon and half marathon races distances in the fourteen to nineteen year old age group, the proportion of female finishers is significantly larger than the proportion of male finishers; for the racers competing in the ten kilometer and five kilometer race distances in the fourteen to nineteen year old age group, the proportion of male finishers is significantly larger than the proportion of female finishers.

7.4. Distance Comparison Conclusions

As a final examination of the data we wished to understand the relationship between race distances for each gender, separately; looking at both age graded score and age of the race finishers. To determine how the distributions of the race finishers differed in terms of race distances we combined the data from all eight races and compared the mean, median, and variances of the ages and age graded scores of the race finishers. We expected that the distribution of age graded scores and ages for the female and male, individually, to be largest for the marathon followed by the half marathon then the ten kilometer and smallest for the five kilometer race distances. What we found was something different than we expected for all four sets of data that we studied.

For the distribution of age graded scores, the male and female runners have the same distributions of races with the mean and median age graded scores and the variance of the age graded scores having two separate distributions; for the age graded scores, the half marathon had the largest values for the mean and median age graded scores, followed by the marathon, then the ten kilometer, and the five kilometer with the smallest values for the mean and median age graded scores but the five kilometer has the largest value for the variance of the age graded scores followed by the ten kilometer, then the marathon, and the half marathon with the smallest value for the variance of the age graded scores. These findings are much different than what we expected to find and it is very interesting that the male and female runners have the same distributions and that the mean age graded score and variance of the age graded scores have different distributions. From the results we can see that the half marathon racers finish the fastest, on average, while the five kilometer finish the slowest, on average, across the four race distances, and the variance of the age graded scores are distributed in the opposite direction from the distribution of the mean and median age graded scores.

For the distribution of ages, the male and female runners have completely different distributions of the race distances but both genders have different distributions for the mean and median ages and the variance of the ages. For female runners, the mean and median ages of the ten kilometer are the largest followed by the five kilometer values which are larger than the values for the half marathon and the mean and median ages for the marathon are the smallest values; the variance of the ages has a similar distribution to the mean and median ages with the largest value falling in the ten kilometer race followed by the five kilometer race distance which is larger than the marathon value and the variance of the ages for the half marathon is the smallest value. For the male runners, the mean and median ages of the race finishers are largest for the ten kilometer race followed by the marathon values which are larger than the half marathon values and the five kilometer mean and median ages are the smallest values; the variance of the ages is largest for the ten kilometer race followed by the five kilometer variance which is larger than the marathon value and the half marathon variance of the ages of the race finishers is the smallest value of the four. The mean and median ages of the female race finishers are not significantly different between the marathon and half marathon race distances and the variance of the ages for the female race finishers is not significantly different between the five and ten kilometer race distances. The mean and median age of the male race finishers are not significantly different between the marathon and half marathon race distances. These results show that both male and female race finishers are oldest, on average, for the ten kilometer race distances and female race finishers are youngest, on average, for the marathon and half marathon while male race finishers are youngest, on average, for the five kilometer race.

7.5. Final Conclusions

Based on our overall age graded score results, men finish faster than women while women finish closer to one another, based on the finisher's respective world record time. In other words, male runners finish with times closer to their respective world record times, resulting in higher age graded scores, while female runners finish with times, and age graded scores, grouped closely together near the average finishing time. Our overall age results show that men are older than women but the ages of the male runners are more variable than female runners. Once broken down in to age groups, the overall results break down as we saw clear separations between age groups. In general, we saw a higher proportion of overall finishers for women for racers under the age of forty years but men had higher age graded scores for these age groups; for the racers over the age of forty years there is a higher proportion of overall finishers for men but women had higher age graded scores for these age groups. These results back up the finding from the overall age results since there is a higher proportion of men in the older age groups; the results agree with the finding of a larger variance for men, which is true for all races and all age groups, but the findings for the mean and median do not agree as older racers have a larger mean and median age graded score for women.

For years the media have portrayed the gap between male and female athletes as something so large that it could never be overcome. Previous research has shown that although men finish faster than women the actual performance gap is not as large as the media would like the public to imagine. This gap has become easier to visualize with the increased use of age graded scoring among races in the United States. Using these age graded scores, our research has uncovered further differences between the male and female running populations. After reviewing all of our findings, we are able to conclude that male runners finish races faster overall and women finish closer together meaning that men may be more competitive in the whole race but women are more competitive within small groups. In other words, men race all other runners while women cluster around the fiftieth percentile.

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APPENDIX A. SAS CODE

```
/* Major Marathon - SAS Code */
/* Import the data from excel and the totals text file */
proc import datafile = "E:\STAT 899\Running Data\Major Marathons.xlsx"
   dbms = xlsx replace out = work.boston;
   sheet = 'Boston';
proc import datafile = "E:\STAT 899\Running Data\Major Marathons.xlsx"
   dbms = xlsx replace out = work.chicago;
   sheet = 'Chicago';
proc import datafile = "E:\STAT 899\Running Data\Major Marathons.xlsx"
   dbms = xlsx replace out = work.newyork;
   sheet = 'New York';
run;

data major;
  set newyork chicago boston;

  if ag_percent >= 60 then over60 = '1: Yes'; *proportion 60% and above;
  else if ag_percent <60 then over60 = '2: No';

  if ag_percent >=70 then over70 = '1: Yes'; *proportion 70% and above;
  else if ag_percent <70 then over70 = '2: No';

  if ag_percent <= 40 then under40 = '1: Yes'; *proportion 40% and below;
  else if ag_percent >40 then under40 = '2: No';
run;

proc sort data = major;
  by race;
run;

/* Frequency Tables */
proc freq data = major;
  by race;
  tables sex*over60 / nocol nopercent chisq; *60% and above;
  tables sex*over70 / nocol nopercent chisq; *70% and above;
  tables sex*under40 / nocol nopercent chisq; *40% and below;
run;

/* Test for Equal Variances and Test for Equal Means */
proc ttest data = major plots = none;
  by race;
  class sex;
  var ag_percent;
run;

/* Levene's Test for Equal Variances */
proc anova data = major plots = none;
  by race;
  class sex;
  model ag_percent = sex;
  means sex / hovtest;
run; quit;
```

```
/* Test for Equal Medians and Test for Equal Distributions */
proc npar1way data = major wilcoxon d;
  by race;
  class sex;
  var ag_percent;
run; quit;

/* Sort by race and age group */
proc sort data = major;
  by race age_group;
run;

/* Tests for Frequencies, Means, Medians, Variances, and Distributions */
proc freq data = major;
  by race age_group;
  tables sex*over60 / nocol nopercent chisq; *60% and above;
  tables sex*under40 / nocol nopercent chisq; *40% and below;
proc ttest data = major plots = none;
  by race age_group;
  class sex;
  var ag_percent;
proc anova data = major plots = none;
  by race age_group;
  class sex;
  model ag_percent = sex;
  means sex / hovtest;
proc npar1way data = major wilcoxon d;
  by race age_group;
  class sex;
  var ag_percent;
run; quit;

/* Test of Proportions */
proc freq data = major;
  by race;
  table sex * age_group / nocol nopercent chisq;
run;

/* Descriptive Statistics */
proc sort data = major;
  by race;
run;

proc means data = major n mean median var;
  by race;
  class sex;
  var ag_percent;
run;

proc sort data = major;
  by race age_group;
run;

proc means data = major n mean median var;
  by race age_group;
  class sex;
  var ag_percent;
```

```
run;

data hist;
  set work.major;

  if sex = "F" then sex1 = "Female";
  else if sex = "M" then sex1 = "Male";

  label sex1 = 'Gender';
  label age = "Age (in years)";
run;

proc sort data = hist;
  by race;
run;

/* Histograms for Age Distribution by Race */
title "Major Marathon Age Graded Score Distribution";
proc univariate data = hist noprint;
  class race sex1;
  histogram ag_percent / nrows = 3 ncols = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
run; title;

/* Non-Major Marathon, Half Marathon, 10K, and 5K - SAS Code */
/* Import both marathon files from excel and merge into one dataset */
proc import datafile = "E:\STAT 899\Running Data\Male Data.xlsx"
   dbms = xlsx replace out = work.m_marathon;
   sheet = "Marathon";
proc import datafile = "E:\STAT 899\Running Data\Female Data.xlsx"
   dbms = xlsx replace out = work.f_marathon;
   sheet = "Marathon";
run;

proc sort data = work.m_marathon;
  by race;
proc sort data = work.f_marathon;
  by race;
run;

data marathon;
  set work.m_marathon (in=ina) work.f_marathon (in=inb);
  by race;

  if (ina = 1) then sex = 'M';
  else if (inb = 1) then sex = 'F';

  if ag_perc >= 60 then over60 = '1: Yes'; *proportion 60% and above;
  else if ag_perc <60 then over60 = '2: No';

  if ag_perc >=70 then over70 = '1: Yes'; *proportion 70% and above;
  else if ag_perc <70 then over70 = '2: No';

  if ag_perc <= 40 then under40 = '1: Yes'; *proportion 40% and below;
  else if ag_perc >40 then under40 = '2: No';

  if sex = 'F' then sex1 = 'Female';
```

```
  else if sex = 'M' then sex1 = 'Male';

  label sex1 = 'Gender';
  label ag_perc = 'AG Scores (percent)';
run;

/* Import both half marathon files from excel and merge into one dataset */
proc import datafile = "E:\STAT 899\Running Data\Male Data.xlsx"
   dbms = xlsx replace out = work.m_half;
   sheet = "Half";
proc import datafile = "E:\STAT 899\Running Data\Female Data.xlsx"
   dbms = xlsx replace out = work.f_half;
   sheet = "Half";
run;

proc sort data = work.m_half;
  by race;
proc sort data = work.f_half;
  by race;
run;

data half;
  set work.m_half (in=ina) work.f_half (in=inb);
  by race;

  if (ina = 1) then sex = 'M';
  else if (inb = 1) then sex = 'F';

  if ag_perc >= 60 then over60 = '1: Yes'; *proportion 60% and above;
  else if ag_perc <60 then over60 = '2: No';

  if ag_perc >= 70 then over70 = '1: Yes'; *proportion 70% and above;
  else if ag_perc <70 then over70 = '2: No';

  if ag_perc <= 40 then under40 = '1: Yes'; *proportion 40% and below;
  else if ag_perc >40 then under40 = '2: No';

  if sex = 'F' then sex1 = 'Female';
  else if sex = 'M' then sex1 = 'Male';

  label sex1 = 'Gender';
  label ag_perc = 'AG Scores (percent)';
run;

/* Import both 10k files from excel and merge into one dataset */
proc import datafile = "E:\STAT 899\Running Data\Male Data.xlsx"
   dbms = xlsx replace out = work.m_tenk;
   sheet = "Ten K";
proc import datafile = "E:\STAT 899\Running Data\Female Data.xlsx"
   dbms = xlsx replace out = work.f_tenk;
   sheet = "Ten K";
run;

proc sort data = work.m_tenk;
  by race;
proc sort data = work.f_tenk;
  by race;
```

```
run;

data tenk;
  set work.m_tenk (in=ina) work.f_tenk (in=inb);
  by race;

  if (ina = 1) then sex = 'M';
  else if (inb = 1) then sex = 'F';

  if ag_perc >= 60 then over60 = '1: Yes'; *proportion 60% and above;
  else if ag_perc <60 then over60 = '2: No';

  if ag_perc >= 70 then over70 = '1: Yes'; *proportion 70% and above;
  else if ag_perc <70 then over70 = '2: No';

  if ag_perc <= 40 then under40 = '1: Yes'; *proportion 40% and under;
  else if ag_perc >40 then under40 = '2: No';

  if sex = 'F' then sex1 = 'Female';
  else if sex = 'M' then sex1 = 'Male';

  label sex1 = 'Gender';
  label ag_perc = 'AG Scores (percent)';
run;

/* Import both 5k files from excel and merge into one dataset */
proc import datafile = "E:\STAT 899\Running Data\Male Data.xlsx"
   dbms = xlsx replace out = work.m_fivek;
   sheet = "Five K";
proc import datafile = "E:\STAT 899\Running Data\Female Data.xlsx"
   dbms = xlsx replace out = work.f_fivek;
   sheet = "Five K";
run;

proc sort data = work.m_fivek;
  by race;
proc sort data = work.f_fivek;
  by race;
run;

data fivek;
  set work.m_fivek (in=ina) work.f_fivek (in=inb);
  by race;

  if (ina = 1) then sex = 'M';
  else if (inb = 1) then sex = 'F';

  if ag_perc >= 60 then over60 = '1: Yes'; *proportion 60% and above;
  else if ag_perc <60 then over60 = '2: No';

  if ag_perc >=70 then over70 = '1: Yes'; *proportion 70% and above;
  else if ag_perc <70 then over70 = '2: No';

  if ag_perc <= 40 then under40 = '1: Yes'; *proportion 40% and below;
  else if ag_perc >40 then under40 = '2: No';

  if sex = 'F' then sex1 = 'Female';
```

```
  else if sex = 'M' then sex1 = 'Male';

  label sex1 = 'Gender';
  label ag_perc = 'AG Scores (percent)';
run;

/* Test of Proportions: test equality 60% and above, 70% and above,
   and 40% and below between Men and Women for each race individually */
proc freq data = marathon;
  title 'Marathon';
  by race;
  table sex * over60 / nocol nopercent chisq;
  table sex * over70 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = half;
  title 'Half Marathon';
  by race;
  table sex * over60 / nocol nopercent chisq;
  table sex * over70 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = tenk;
  title 'Ten K';
  by race;
  table sex * over60 / nocol nopercent chisq;
  table sex * over70 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = fivek;
  title 'Five K';
  by race;
  table sex * over60 / nocol nopercent chisq;
  table sex * over70 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
run; title;

/* Histograms of distributions of AG Scores */
proc univariate data = marathon noprint;
  title 'AG Scores Distribution - Marathon';
  class sex1 race;
  histogram ag_perc / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = half noprint;
  title 'AG Scores Distribution -  Half Marathon';
  class sex1 race;
  histogram ag_perc / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = tenk noprint;
  title 'AG Scores Distribution - Ten K';
  class sex1 race;
  histogram ag_perc / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = fivek noprint;
  title 'AG Scores Distribution - Five K';
  class sex1 race;
  histogram ag_perc / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
run; title;
```

```
/* Histograms of distributions of Age */
proc univariate data = marathon noprint;
  title 'Age Distribution - Marathon';
  class sex1 race;
  histogram age / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = half noprint;
  title 'Age Distribution -  Half Marathon';
  class sex1 race;
  histogram age / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = tenk noprint;
  title 'Age Distribution - Ten K';
  class sex1 race;
  histogram age / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
proc univariate data = fivek noprint;
  title 'Age Distribution - Five K';
  class sex1 race;
  histogram age / ncol = 1 nrows = 2 endpoints = 0 to 100 by 10;
  inset N (5.0) mean (3.1) median (3.1) / noframe position = NE height = 4;
run; title;

/* Test for Equal Variances and Test for Equal Means:
   AG Scores Variance and Means between genders */
proc ttest data = marathon plots = none;
  title 'Marathon';
  by race;
  class sex;
  var ag_perc;
proc ttest data = half plots = none;
  title 'Half Marathon';
  by race;
  class sex;
  var ag_perc;
proc ttest data = tenk plots = none;
  title 'Ten K';
  by race;
  class sex;
  var ag_perc;
proc ttest data = fivek plots = none;
  title 'Five K';
  by race;
  class sex;
  var ag_perc;
run; title;

/* Test for Equal Variances and Test for Equal Means:
   Age Variance and Means between genders */
proc ttest data = marathon plots = none;
  title 'Marathon';
  by race;
  class sex;
  var age;
proc ttest data = half plots = none;
  title 'Half Marathon';
  by race;
```

```
  class sex;
  var age;
proc ttest data = tenk plots = none;
  title 'Ten K';
  by race;
  class sex;
  var age;
proc ttest data = fivek plots = none;
  title 'Five K';
  by race;
  class sex;
  var age;
run; title;

* AG Scores - Levene's Test Results for Equal Variances;
proc anova data = marathon plots = none;
  title 'Marathon';
  by race;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = half plots = none;
  title 'Half Marathon';
  by race;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = tenk plots = none;
  title 'Ten K';
  by race;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = fivek plots = none;
  title 'Five K';
  by race;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
run; title;

* Age - Levene's Test Results for Equal Variances;
proc anova data = marathon plots = none;
  title 'Marathon';
  by race;
  class sex;
  model age = sex;
  means sex / hovtest;
proc anova data = half plots = none;
  title 'Half Marathon';
  by race;
  class sex;
  model age = sex;
  means sex / hovtest;
proc anova data = tenk plots = none;
  title 'Ten K';
  by race;
```

```
  class sex;
  model age = sex;
  means sex / hovtest;
proc anova data = fivek plots = none;
  title 'Five K';
  by race;
  class sex;
  model age = sex;
  means sex / hovtest;
run; title;

/* AG Scores - Test for Equal Medians: Wilcoxon-Mann-Whitney Test*/
/* AG Scores - Test for Equal Distributions: Kolmogorov-Smirnov Test*/
proc npar1way data = marathon wilcoxon d;
  title 'Marathon';
  by race;
  class sex;
  var ag_perc;
proc npar1way data = half wilcoxon d;
  title 'Half Marathon';
  by race;
  class sex;
  var ag_perc;
proc npar1way data = tenk wilcoxon d;
  title 'Ten K';
  by race;
  class sex;
  var ag_perc;
proc npar1way data = fivek wilcoxon d;
  title 'Five K';
  by race;
  class sex;
  var ag_perc;
run; title;

/* Age - Test for Equal Medians: Wilcoxon-Mann-Whitney Test*/
/* Age - Test for Equal Distributions: Kolmogorov-Smirnov Test*/
proc npar1way data = marathon wilcoxon d;
  title 'Marathon';
  by race;
  class sex;
  var age;
proc npar1way data = half wilcoxon d;
  title 'Half Marathon';
  by race;
  class sex;
  var age;
proc npar1way data = tenk wilcoxon d;
  title 'Ten K';
  by race;
  class sex;
  var age;
proc npar1way data = fivek wilcoxon d;
  title 'Five K';
  by race;
  class sex;
  var age;
```

```
run; title;

/* Sort the data by race and age group*/
proc sort data = marathon;
  by race age_group;
proc sort data = half;
  by race age_group;
proc sort data = tenk;
  by race age_group;
proc sort data = fivek;
  by race age_group;
run;

/* Test of Proportions: test equality 60% and above, and 40% and below by age
group and between genders */
proc freq data = marathon;
  title 'Marathon';
  by race age_group;
  table sex * over60 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = half;
  title 'Half Marathon';
  by race age_group;
  table sex * over60 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = tenk;
  title 'Ten K';
  by race age_group;
  table sex * over60 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
proc freq data = fivek;
  title 'Five K';
  by race age_group;
  table sex * over60 / nocol nopercent chisq;
  table sex * under40 / nocol nopercent chisq;
run; title;

/* Test for Equal Variances and Test for Equal Means:
   AG Score Variance and Means, by age group and between genders */
proc ttest data = marathon plots = none;
  title 'Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc ttest data = half plots = none;
  title 'Half Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc ttest data = tenk plots = none;
  title 'Ten K';
  by race age_group;
  class sex;
  var ag_perc;
proc ttest data = fivek plots = none;
  title 'Five K';
  by race age_group;
```

```
  class sex;
  var ag_perc;
run; title;

* AG Score by age group - Levene's Test Results for Equal Variances;
proc anova data = marathon plots = none;
  title 'Marathon';
  by race age_group;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = half plots = none;
  title 'Half Marathon';
  by race age_group;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = tenk plots = none;
  title 'Ten K';
  by race age_group;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
proc anova data = fivek plots = none;
  title 'Five K';
  by race age_group;
  class sex;
  model ag_perc = sex;
  means sex / hovtest;
run; title;

/* AG Score by age group - Test for Equal Medians: Wilcoxon-Mann-Whitney
Test*/
/* AG Score by age group - Test for Equal Distributions: Kolmogorov-Smirnov
Test*/
proc npar1way data = marathon wilcoxon d;
  title 'Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc npar1way data = half wilcoxon d;
  title 'Half Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc npar1way data = tenk wilcoxon d;
  title 'Ten K';
  by race age_group;
  class sex;
  var ag_perc;
proc npar1way data = fivek wilcoxon d;
  title 'Five K';
  by race age_group;
  class sex;
  var ag_perc;
run; title;
```

```
/* Test of Proportions: test proportion in each age group
   between Men and Women for each race individually */
proc freq data = marathon;
  title 'Marathon';
  by race;
  table sex * age_group / nocol nopercent chisq;
proc freq data = half;
  title 'Half Marathon';
  by race;
  table sex * age_group / nocol nopercent chisq;
proc freq data = tenk;
  title 'Ten K';
  by race;
  table sex * age_group / nocol nopercent chisq;
proc freq data = fivek;
  title 'Five K';
  by race;
  table sex * age_group / nocol nopercent chisq;
run; title;

/* Combine datasets by Gender: comparing distributions by distance for
individual genders*/
proc format;
    value distfmt 1 = "Marathon"
                  2 = "Half Marathon"
                  3 = "Ten K"
                  4 = "Five K";
run;

data allf;
  set f_marathon (in=ina) f_half (in=inb) f_tenk (in=inc) f_fivek (in=ind);

  if (ina = 1) then dist = 1;
  else if (inb = 1) then dist = 2;
  else if (inc = 1) then dist = 3;
  else if (ind = 1) then dist = 4;

  format dist distfmt.;
  label dist = 'Distance';
  label ag_perc = 'AG Score (percent)';
data allm;
  set m_marathon (in=ina) m_half (in=inb) m_tenk (in=inc) m_fivek (in=ind);

  if (ina = 1) then dist = 1;
  else if (inb = 1) then dist = 2;
  else if (inc = 1) then dist = 3;
  else if (ind = 1) then dist = 4;

  format dist distfmt.;
  label dist = 'Distance';
  label ag_perc = 'AG Score (percent)';
run;

proc sort data = allf;
  by dist;
proc sort data = allm;
  by dist;
```

```
run;

/* Compare Distribution of AG Scores for Distance: Marathon vs Half, Marathon
vs 10k, Marathon vs 5k, Half vs 10k, Half vs 5k, and 10k vs 5k. Individually
by Gender */
/* AG Score Comparisons for Females */
/* Female Tests for Means: AG Score */
proc ttest data = allf;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var ag_perc;
proc ttest data = allf;
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var ag_perc;
proc ttest data = allf;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var ag_perc;
proc ttest data = allf;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var ag_perc;
proc ttest data = allf;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var ag_perc;
proc ttest data = allf;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var ag_perc;
run; title;

/* Female Tests for Variance: AG Score */
proc anova data = allf plots = none;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  model ag_perc = dist;
```

```
  means dist/ hovtest;
proc anova data = allf plots = none;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
run; title;

/* Female Nonparametric Tests: AG Scores */
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var ag_perc;
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var ag_perc;
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var ag_perc;
proc npar1way data = allf wilcoxon d;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var ag_perc;
proc npar1way data = allf wilcoxon d;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var ag_perc;
proc npar1way data = allf wilcoxon d;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var ag_perc;
run; title;

/* AG Score Comparisons for Males */
/* Male Tests for Mean: AG Score */
proc ttest data = allm;
```

```
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var ag_perc;
proc ttest data = allm;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var ag_perc;
proc ttest data = allm;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var ag_perc;
proc ttest data = allm;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var ag_perc;
proc ttest data = allm;
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var ag_perc;
proc ttest data = allm;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var ag_perc;
run; title;

/* Male Tests for Variance: AG Score */
proc anova data = allm plots = none;
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist/ hovtest;
proc anova data = allm plots = none;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
```

```
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist / hovtest;
run; title;

/* Male Nonparametric Tests: AG Score*/
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var ag_perc;
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var ag_perc;
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var ag_perc;
proc npar1way data = allm wilcoxon d;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var ag_perc;
proc npar1way data = allm wilcoxon d;
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var ag_perc;
proc npar1way data = allm wilcoxon d;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var ag_perc;
run; title;

/* Compare Distribution of Age for Distance: Marathon vs Half, Marathon vs
10k, Marathon vs 5k, Half vs 10k, Half vs 5k, and 10k vs 5k. Individually by
Gender */
/* Age Comparisons for Females */
/* Female Test for Mean: Age */
proc ttest data = allf;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var age;
proc ttest data = allf;
```

```
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var age;
proc ttest data = allf;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var age;
proc ttest data = allf;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var age;
proc ttest data = allf;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var age;
proc ttest data = allf;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var age;
run; title;

/* Female Test for Variance: Age */
proc anova data = allf plots = none;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  model age = dist;
  means dist/ hovtest;
proc anova data = allf plots = none;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allf plots = none;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  model age = dist;
  means dist / hovtest;
```

```
proc anova data = allf plots = none;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  model age = dist;
  means dist / hovtest;
run; title;

/* Female Nonparametric Tests: Age */
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var age;
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var age;
proc npar1way data = allf wilcoxon d;
  title 'Females: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var age;
proc npar1way data = allf wilcoxon d;
  title 'Females: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var age;
proc npar1way data = allf wilcoxon d;
  title 'Females: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var age;
proc npar1way data = allf wilcoxon d;
  title 'Females: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var age;
run; title;

/* Age Comparisons for Males */
/* Male Test for Mean: Age */
proc ttest data = allm;
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var age;
proc ttest data = allm;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var age;
proc ttest data = allm;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
```

```
  var age;
proc ttest data = allm;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var age;
proc ttest data = allm;
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var age;
proc ttest data = allm;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var age;
run; title;

/* Male Test for Variance: Age */
proc anova data = allm plots = none;
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  model ag_perc = dist;
  means dist/ hovtest;
proc anova data = allm plots = none;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  model age = dist;
  means dist / hovtest;
proc anova data = allm plots = none;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  model age = dist;
  means dist / hovtest;
run; title;
```

```
/* Male Nonparametric Tests: Age */
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs Half';
  where dist = 1 or dist = 2;
  class dist;
  var age;
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs 10k';
  where dist = 1 or dist = 3;
  class dist;
  var age;
proc npar1way data = allm wilcoxon d;
  title 'Males: Full vs 5k';
  where dist = 1 or dist = 4;
  class dist;
  var age;
proc npar1way data = allm wilcoxon d;
  title 'Males: Half vs 10k';
  where dist = 2 or dist = 3;
  class dist;
  var age;
proc npar1way data = allm wilcoxon d;
  title 'Males: Half vs 5k';
  where dist = 2 or dist = 4;
  class dist;
  var age;
proc npar1way data = allm wilcoxon d;
  title 'Males: 10k vs 5k';
  where dist = 3 or dist = 4;
  class dist;
  var age;
run; title;

/* Histograms of distributions of AG Scores by distance*/
title 'Female AG Score Distribution';
proc univariate data = allf noprint;
  class dist;
  histogram ag_perc / nrows = 4 endpoints = 0 to 100 by 10;
  inset mean (3.1) var (3.1) / noframe position = NE height = 4;
run;title;

title 'Male AG Score Distribution';
proc univariate data = allm noprint;
  class dist;
  histogram ag_perc / nrows = 4 endpoints = 0 to 100 by 10;
  inset mean (3.1) var (3.1) / noframe position = NE height = 4;
run;title;

/* Histograms of distributions of Age by distance*/
title 'Female Age Distribution';
proc univariate data = allf noprint;
  class dist;
  histogram age / nrows = 4 endpoints = 0 to 100 by 10;
  inset mean (3.1) var (3.1) / noframe position = NE height = 4;
run;title;

title 'Male Age Distribution';
```

```
proc univariate data = allm noprint;
  class dist;
  histogram age / nrows = 4 endpoints = 0 to 100 by 10;
  inset mean (3.1) var (3.1) / noframe position = NE height = 4;
run; title;

/* Mean AG Scores for each race and distance */
proc means data = marathon n mean median var;
  title 'Marathon';
  by race;
  class sex;
  var ag_perc;
proc means data = half  n mean median var;
  title 'Half Marathon';
  by race;
  class sex;
  var ag_perc;
proc means data = tenk n mean median var;
  title 'Ten K';
  by race;
  class sex;
  var ag_perc;
proc means data = fivek n mean median var;
  title 'Five K';
  by race;
  class sex;
  var ag_perc;
run; title;

/* Mean Age for each race and distance */
proc means data = marathon n mean median var;
  title 'Marathon';
  by race;
  class sex;
  var age;
proc means data = half  n mean median var;
  title 'Half Marathon';
  by race;
  class sex;
  var age;
proc means data = tenk n mean median var;
  title 'Ten K';
  by race;
  class sex;
  var age;
proc means data = fivek n mean median var;
  title 'Five K';
  by race;
  class sex;
  var age;
run; title;

proc sort data = marathon;
  by race age_group;
proc sort data = half;
  by race age_group;
proc sort data = tenk;
```

```
  by race age_group;
proc sort data = fivek;
  by race age_group;
run;

/* Mean AG Score for race and distance by age group */
proc means data = marathon n mean median var;
  title 'Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc means data = half  n mean median var;
  title 'Half Marathon';
  by race age_group;
  class sex;
  var ag_perc;
proc means data = tenk n mean median var;
  title 'Ten K';
  by race age_group;
  class sex;
  var ag_perc;
proc means data = fivek n mean median var;
  title 'Five K';
  by race age_group;
  class sex;
  var ag_perc;
run; title;

proc sort data = allf;
  by dist;
proc sort data = allm;
  by dist;
run;

/* Mean AG Scores by gender and distance */
proc means data = allf n mean median var;
  title 'Female Means';
  by dist;
  var ag_perc;
proc means data = allm n mean median var;
  title 'Male Means';
  by dist;
  var ag_perc;
run; title;

/* Mean Age by gender and distance */
proc means data = allf n mean median var;
  title 'Female Means';
  by dist;
  var age;
proc means data = allm n mean median var;
  title 'Male Means';
  by dist;
  var age;
run; title;
```

APPENDIX B. R CODE

```
## Program to calculate the Age Grade percentages or Scores from Excel ##

# Input the excel data #
options(java.parameters = "-Xmx1024m") #Expand Memory in 32-bit R
library(XLConnect)

fdata <- loadWorkbook("E:/STAT 899/Running Data/Female.xlsx")
mdata <- loadWorkbook("E:/STAT 899/Running Data/Male.xlsx")

F.Mar <- readWorksheet(fdata , sheet = "Marathon")
F.Half <- readWorksheet(fdata, sheet = "Half")
F.10k <- readWorksheet(fdata, sheet = "Ten K")
F.5k <- readWorksheet(fdata, sheet = "Five K")

M.Mar <- readWorksheet(mdata, sheet = "Marathon")
M.Half <- readWorksheet(mdata, sheet = "Half")
M.10k <- readWorksheet(mdata, sheet = "Ten K")
M.5k <- readWorksheet(mdata, sheet = "Five K")

# Entering the WMA AG Factors (2010 Factors) #
WMA.FM <-
c(0.615,0.6559,0.6946,0.7311,0.7654,0.7975,0.8274,0.8551,0.8806,0.9039,0.925,0.945,0.965,0.
9821,0.9936,0.9993,1,1,1,1,1,1,1,1,1,0.9996,0.9983,0.9962,0.9933,0.9895,0.9849,0.9795,0.9732,
0.966,0.9581,0.9493,0.9396,0.9292,0.9183,0.9074,0.8965,0.8856,0.8747,0.8638,0.8529,0.842,0.
8311,0.8202,0.8093,0.7984,0.7875,0.7766,0.7657,0.7548,0.7439,0.733,0.7221,0.7112,0.7003,0.6
894,0.6785,0.6676,0.6567,0.6458,0.6349,0.624,0.6131,0.6022,0.5913,0.5803,0.5686,0.5561,0.54
29,0.5289,0.5141,0.4985,0.4821,0.465,0.4471,0.4284,0.4089,0.3886,0.3676,0.3458,0.3232,0.299
8,0.2756,0.2507,0.225,0.1985,0.1712,0.1431,0.1143,0.0847,0.0543,0.0231)
WMA.FH <-
c(0.6563,0.6942,0.7299,0.7634,0.7947,0.8238,0.8507,0.8754,0.8979,0.9182,0.9363,0.9533,0.97
03,0.9848,0.9945,0.9994,1,1,1,1,1,1,1,1,1,0.9997,0.9989,0.9976,0.9957,0.9934,0.9904,0.987,0.9
83,0.9785,0.9734,0.9678,0.9617,0.9551,0.9479,0.9402,0.9319,0.9232,0.9139,0.904,0.8937,0.882
8,0.8719,0.861,0.8501,0.8392,0.8283,0.8174,0.8065,0.7956,0.7847,0.7738,0.7629,0.752,0.7411,
0.7302,0.7193,0.7084,0.6975,0.6866,0.6757,0.6648,0.6539,0.643,0.6321,0.6212,0.6103,0.5994,0
.5885,0.5776,0.5667,0.5552,0.5425,0.5286,0.5135,0.4972,0.4797,0.461,0.4411,0.42,0.3977,0.37
42,0.3495,0.3236,0.2965,0.2682,0.2387,0.208,0.1761,0.143,0.1087,0.0732)
WMA.FT <-
c(0.7236,0.7566,0.7874,0.816,0.8424,0.8666,0.8886,0.9084,0.926,0.9414,0.9546,0.9667,0.9788,
0.9892,0.9961,0.9996,1,1,1,1,1,1,1,1,1,0.9997,0.9989,0.9976,0.9957,0.9934,0.9904,0.987,0.983,
0.9785,0.9734,0.9678,0.9617,0.9551,0.9479,0.9402,0.9319,0.9232,0.9139,0.904,0.8937,0.8828,0
.8719,0.861,0.8501,0.8392,0.8283,0.8174,0.8065,0.7956,0.7847,0.7738,0.7629,0.752,0.7411,0.7
302,0.7193,0.7084,0.6975,0.6866,0.6757,0.6648,0.6539,0.643,0.6321,0.6212,0.6103,0.5994,0.58
85,0.5776,0.5667,0.5552,0.5425,0.5286,0.5135,0.4972,0.4797,0.461,0.4411,0.42,0.3977,0.3742,
0.3495,0.3236,0.2965,0.2682,0.2387,0.208,0.1761,0.143,0.1087,0.0732)
```

```
WMA.FF <-
c(0.725,0.7579,0.7886,0.8171,0.8434,0.8675,0.8894,0.9091,0.9266,0.9419,0.955,0.967,0.979,0.
9893,0.9961,0.9996,1,1,1,1,1,1,1,1,1,0.9997,0.9989,0.9976,0.9957,0.9934,0.9904,0.987,0.983,0.
9785,0.9734,0.9678,0.9617,0.9551,0.9479,0.9402,0.9319,0.9232,0.9139,0.904,0.8937,0.8828,0.8
719,0.861,0.8501,0.8392,0.8283,0.8174,0.8065,0.7956,0.7847,0.7738,0.7629,0.752,0.7411,0.730
2,0.7193,0.7084,0.6975,0.6866,0.6757,0.6648,0.6539,0.643,0.6321,0.6212,0.6103,0.5994,0.5885
,0.5776,0.5667,0.5552,0.5425,0.5286,0.5135,0.4972,0.4797,0.461,0.4411,0.42,0.3977,0.3742,0.3
495,0.3236,0.2965,0.2682,0.2387,0.208,0.1761,0.143,0.1087,0.0732)
WMA.MM <-
c(0.6211,0.6604,0.6975,0.7324,0.7651,0.7956,0.8239,0.85,0.8739,0.8956,0.9151,0.9324,0.9475,
0.9615,0.9755,0.9875,0.9955,0.9995,1,1,1,1,1,1,1,1,1,1,1,1,0.999,0.996,0.991,0.984,0.9759,0.9
679,0.9599,0.9519,0.9439,0.9358,0.9278,0.9198,0.9118,0.9038,0.8957,0.8877,0.8797,0.8717,0.8
637,0.8556,0.8476,0.8396,0.8316,0.8236,0.8155,0.8075,0.7995,0.7915,0.7835,0.7754,0.7674,0.7
594,0.7514,0.7434,0.7353,0.7272,0.7185,0.7091,0.699,0.6882,0.6766,0.6644,0.6515,0.6379,0.62
36,0.6085,0.5928,0.5764,0.5593,0.5415,0.5229,0.5037,0.4838,0.4632,0.4419,0.4198,0.3971,0.37
37,0.3496,0.3248,0.2992,0.273,0.2461,0.2185,0.1902)
WMA.MH <-
c(0.6369,0.6752,0.7113,0.7452,0.7769,0.8064,0.8337,0.8588,0.8817,0.9024,0.9209,0.9372,0.95
13,0.9643,0.9773,0.9884,0.9958,0.9995,1,1,1,1,1,1,1,1,0.9998,0.9984,0.996,0.9925,0.9878,0.9
82,0.975,0.9675,0.9599,0.9524,0.9448,0.9373,0.9297,0.9222,0.9146,0.9071,0.8995,0.892,0.8844
,0.8769,0.8693,0.8618,0.8542,0.8467,0.8392,0.8316,0.8241,0.8165,0.809,0.8014,0.7939,0.7863,
0.7788,0.7712,0.7637,0.7561,0.7486,0.741,0.7334,0.7253,0.7166,0.7071,0.6969,0.686,0.6744,0.
6622,0.6492,0.6356,0.6212,0.6062,0.5905,0.574,0.5569,0.5391,0.5206,0.5014,0.4815,0.4609,0.4
396,0.4177,0.395,0.3717,0.3476,0.3229,0.2974,0.2713,0.2445,0.2169,0.1887)
WMA.MT <-
c(0.6526,0.6899,0.725,0.7579,0.7886,0.8171,0.8434,0.8675,0.8894,0.9091,0.9266,0.9419,0.955,
0.967,0.979,0.9893,0.9961,0.9996,1,1,1,1,1,0.9999,0.9991,0.9975,0.9952,0.9922,0.9885,0.984,0.
9788,0.9729,0.9662,0.9592,0.9521,0.9451,0.938,0.931,0.924,0.9169,0.9099,0.9028,0.8958,0.888
8,0.8817,0.8747,0.8676,0.8606,0.8536,0.8465,0.8395,0.8324,0.8254,0.8184,0.8113,0.8043,0.797
2,0.7902,0.7832,0.7761,0.7691,0.762,0.755,0.7479,0.7402,0.7319,0.723,0.7134,0.7031,0.6923,0.
6808,0.6687,0.6559,0.6425,0.6285,0.6138,0.5985,0.5825,0.566,0.5488,0.5309,0.5124,0.4933,0.4
735,0.4531,0.4321,0.4104,0.3881,0.3652,0.3416,0.3174,0.2926,0.2671,0.2409,0.2142,0.1868)
WMA.MF <-
c(0.6526,0.6899,0.725,0.7579,0.7886,0.8171,0.8434,0.8675,0.8894,0.9091,0.9266,0.9419,0.955,
0.967,0.979,0.9893,0.9961,0.9996,1,1,1,1,1,0.9999,0.9991,0.9975,0.9952,0.9922,0.9885,0.984,0.
9788,0.9729,0.9662,0.9592,0.9521,0.9451,0.938,0.931,0.924,0.9169,0.9099,0.9028,0.8958,0.888
8,0.8817,0.8747,0.8676,0.8606,0.8536,0.8465,0.8395,0.8324,0.8254,0.8184,0.8113,0.8043,0.797
2,0.7902,0.7832,0.7761,0.7691,0.762,0.755,0.7479,0.7402,0.7319,0.723,0.7134,0.7031,0.6923,0.
6808,0.6687,0.6559,0.6425,0.6285,0.6138,0.5985,0.5825,0.566,0.5488,0.5309,0.5124,0.4933,0.4
735,0.4531,0.4321,0.4104,0.3881,0.3652,0.3416,0.3174,0.2926,0.2671,0.2409,0.2142,0.1868)

# DFs for Open Standard and for Factors #
F.OS <- data.frame(Race = c("Marathon","Half","Ten K","Five K"), Std =
c(8125,3950,1820,888))
M.OS <- data.frame(Race = c("Marathon","Half","Ten K","Five K"), Std =
c(7495,3553,1611,774))
```

```
FM.Age <- F.Mar["Age"]- 4; FH.Age <- F.Half["Age"]- 4
FT.Age <- F.10k["Age"]- 4; FF.Age <- F.5k["Age"] - 4

MM.Age <- M.Mar["Age"]- 4; MH.Age <- M.Half["Age"]- 4
MT.Age <- M.10k["Age"]- 4; MF.Age <- M.5k["Age"] - 4

# Computing the AG Percentages for each race #
FM.AGP <- 100 * (F.OS[1,2] / WMA.FM[FM.Age[,1]]) / F.Mar["Result"]
FH.AGP <- 100 * (F.OS[2,2] / WMA.FH[FH.Age[,1]]) / F.Half["Result"]
FT.AGP <- 100 * (F.OS[3,2] / WMA.FT[FT.Age[,1]]) / F.10k["Result"]
FF.AGP <- 100 * (F.OS[4,2] / WMA.FF[FF.Age[,1]]) / F.5k["Result"]

MM.AGP <- 100 * (M.OS[1,2] / WMA.MM[MM.Age[,1]]) / M.Mar["Result"]
MH.AGP <- 100 * (M.OS[2,2] / WMA.MH[MH.Age[,1]]) / M.Half["Result"]
MT.AGP <- 100 * (M.OS[3,2] / WMA.MT[MT.Age[,1]]) / M.10k["Result"]
MF.AGP <- 100 * (M.OS[4,2] / WMA.MF[MF.Age[,1]]) / M.5k["Result"]

# Save Female and Male as DataFrame then export #
F.Mar["AG.Perc"] <- FM.AGP; F.Half["AG.Perc"] <- FH.AGP
F.10k["AG.Perc"] <- FT.AGP; F.5k["AG.Perc"] <- FF.AGP

M.Mar["AG.Perc"] <- MM.AGP; M.Half["AG.Perc"] <- MH.AGP
M.10k["AG.Perc"] <- MT.AGP; M.5k["AG.Perc"] <- MF.AGP

fnew <-loadWorkbook("E:/STAT 899/Running Data/NewF.xlsx", create = TRUE)
mnew <-loadWorkbook("E:/STAT 899/Running Data/NewM.xlsx", create = TRUE)

createSheet(fnew, name = "Marathon"); createSheet(fnew, name = "Half")
createSheet(fnew, name = "Ten K"); createSheet(fnew, name = "Five K")

createSheet(mnew, name = "Marathon"); createSheet(mnew, name = "Half")
createSheet(mnew, name = "Ten K"); createSheet(mnew, name = "Five K")

writeWorksheet(fnew, F.Mar, sheet = "Marathon")
writeWorksheet(fnew, F.Half, sheet = "Half")
writeWorksheet(fnew, F.10k, sheet = "Ten K"); writeWorksheet(fnew, F.5k, sheet = "Five K")

writeWorksheet(mnew, M.Mar, sheet = "Marathon")
writeWorksheet(mnew, M.Half, sheet = "Half")
writeWorksheet(mnew, M.10k, sheet = "Ten K")
writeWorksheet(mnew, M.5k, sheet = "Five K")

saveWorkbook(fnew); saveWorkbook(mnew)
```

APPENDIX C. RACE REFERENCES

Marathons

2012 Boston Marathon – The Boston Marathon.

http://www.baa.org/races/boston-marathon.aspx

2013 Chicago Marathon – Bank of America Chicago Marathon.

http://www.chicagomarathon.com/

2013 New York Marathon – The 2013 ING New York City Marathon.

http://www.nyrr.org/races-and-events/2013/the-2013-ing-new-york-city-marathon

2013 Air Force Marathon – United States Air Force Marathon.

http://www.usafmarathon.com/

2013 Duluth Marathon – Grandma's Marathon.

http://www.grandmasmarathon.com/racesevents/grandmas-marathon/register/

2013 Los Angeles Marathon – ASICS LA Marathon.

http://www.lamarathon.com/

2013 Ogden Marathon – Zions Bank Ogden Marathon.

http://getoutandlive.org/participate/ogden-marathon

2013 Philadelphia Marathon – GORE-TEX Philadelphia Marathon.

http://philadelphiamarathon.com/

2013 San Francisco Marathon – Wipro San Francisco Marathon.

https://www.thesfmarathon.com/

2013 Surf City Marathon – Surf City USA Marathon.

http://www.runsurfcity.com/

2013 Twin Cities Marathon – Medtronic Twin Cities Marathon.
https://www.tcmevents.org/events/medtronic_twin_cities_marathon_weekend_-_october_2-4_2015/marathon/

Half Marathons

2013 Berkeley Half – Berkeley Half Marathon.
http://berkeleyhalf.com/

2013 Brooklyn Half – NYRR Brooklyn Half Marathon.
http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30518&result.year=2013

2013 Capital City Half – The Capital City Half Marathon.
http://www.capitalcityhalfmarathon.com/

2013 Columbus Half – Nationwide Children's Hospital Columbus Half Marathon.
http://www.columbusmarathon.com/

2013 Duluth Half – Garry Bjorkland Half Marathon.
http://www.grandmasmarathon.com/racesevents/garry-bjorklund-half-marathon/register-garry-bjorklund-half-marathon/

2013 Manhattan Half – Manhattan Half-Marathon.
http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30127&result.year=2013

2013 NYC Half – New York City Half Marathon.
http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30317&result.year=2013

2013 Surf City Half – Surf City USA Half Marathon.

http://www.runsurfcity.com/

Ten Kilometer Races

2013 Cooper River 10k – Cooper River Bridge Run.

http://bridgerun.com/

2013 Crescent City 10k – Crescent City Classic.

http://www.ccc10k.com/

2013 Fargo 10k – Radio Fargo Moorhead 10k.

http://www.fargomarathon.com/

2013 Joe K 10k – Joe Kleinerman 10k Classic.

http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30105&result.year=2013

2013 Manhattan Beach 10k – Manhattan Beach 10k Run.

http://mb10k.com/

2013 Queens 10k – NYRR 5-Borough Series: Queens 10k.

http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30721&result.year=2013

2013 Scotland Run 10k – NYRR Scotland Run.

http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30406&result.year=2013

2013 UAE 10k – UAE Healthy Kidney 10k.

http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30511&result.year=2013

Five Kilometer Races

2013 Boston 5k – Boston Athletic Association 5k.
http://www.baa.org/races/5k.aspx

2013 Chelsea's Run 5k – Finish Chelsea's Run 5k.
https://chelseaslight.org/programs/finish-chelseas-run/

2013 Gasparilla 5k – Publix Super Markets Gasparilla Distance Classic.
http://www.tampabayrun.com/5k-general-information

2013 McGuire's 5k – McGuire's St. Patrick's Day 5k Run.
http://www.mcguiresirishpub.com/race-results.php

2013 MLB All Star 5k – MLB All-Star 5k Benefiting Sandy Relief.
http://web2.nyrrc.org/cgi-bin/start.cgi/aes-programs/results/startup.html?result.id=b30713&result.year=2013

2013 NY Dash 5k – NYRR Dash to the Finish Line 5k.
http://www.nyrr.org/races-and-events/2015/nyrr-dash-to-the-finish-line-5k

2013 OC 5k – Wahoo's OC 5k.
http://www.ocmarathon.com/races/oc-5k/wahoos-oc-5k.aspx

2013 Percy Sutton 5k – Percy Sutton Harlem 5k Run.
http://web2.nyrrc.org/cgi-bin/htmlos.cgi/2147.1.215572612383251676