**Oh How Times Change in a 100 Mile Ultramarathon (or don't)**

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## Introduction

In recent years, great improvements have been observed in running events. In 1954, the 4 minute mile was broken for the first time, during the 2019-2020 season 35 college athletes broke 4 minutes, and during the 2021-2022 season 75 college athletes broke 4 minutes in the mile. (Is The Sub-4-Minute Mile Still Special? 2022). The current thinking is that better technology and better understanding of beneficial training techniques are the driving force behind this improvement (David Epstein: Are athletes really getting faster, better, stronger? | TED Summaries n.d.). As people achieve greater feats of athleticism and events become more competitive, people have turned to new avenues in competitive running. Ultramarathons have skyrocketed in popularity, increasing 1696% from 1995-2020, as modern science has shown that humans evolved to have a high endurance threshold and can excel in such activities (Ultrarunning is Growing in Popularity n.d.). In addition to more participants, increased interest will also draw greater sponsorship for ultramarathoners, resulting in increased access to beneficial technologies and research into training and health outcomes. This could potentially result in improved performance as has been observed in the historically popular running events.

An ultramarathon is any foot-race longer than a marathon, but the most common ultramarathons are 50 mi, 100 mi, 50 km and 100 km races. Previous work by Rüst et al. at SciELO found that between 1998 and 2011, 100 mile ultramarathon times improved by 14.5% for male racers and 13.7% for females (Rüst et al. 2013). This suggests that over time, overall performance in 100 mile races is improving.

In this study, we used a dataset collected by the International Trail Running Association (ITRA) in order to examine how men's and women's ultramarathon finishing times have changed from 2012-2019 in the Leadville Trail 100 Run.

**Materials and Methods**

This dataset, containing 2846 men and 660 women, was compiled by ITRA using data collected in the results of the Leadville Trail 100 Run. The Leadville 100 mile is the highest elevation ultramarathon at 10,152 feet, with a total elevation gain of 15,600 feet (Dawson 2019). The brutal nature of this race typically leads to less than half of racers actually finishing the race (Dawson 2019). There are cut-off times at each of the 13 aide stations, reducing potential variation in time on the high end (Bailey n.d.).

Multiple variables were compiled in this dataset. For the purposes of this study, we used gender and race time data from the years 2012-2019 in order to address the research question. Race times were divided by year and all analysis was done on both men and women groups so that men would only be compared to men and women to women. The two groups were never combined in the analysis and the focus of this research was not to compare times between genders. We made a histogram of race times in order to view the spread of the data, which we analyzed using boxplots. We then gave each year from 2012-2019 a numerical race ID in the original dataset and then transferred this numerical variable to a categorical variable for analysis. We conducted an ANOVA test to find an F statistic in order to analyze the difference between the race time means across all 8 years. We found a p-value of the F statistic and determined if there was a significant difference in the times recorded between each of the years. When we found no

significant difference in the data, we found a 95% confidence interval to determine the difference between the average male and female times.

**Results**

In order to gain a better understanding of our data set, we found it necessary to plot a histogram of the race times for both women and men (Figure 1 and 2).

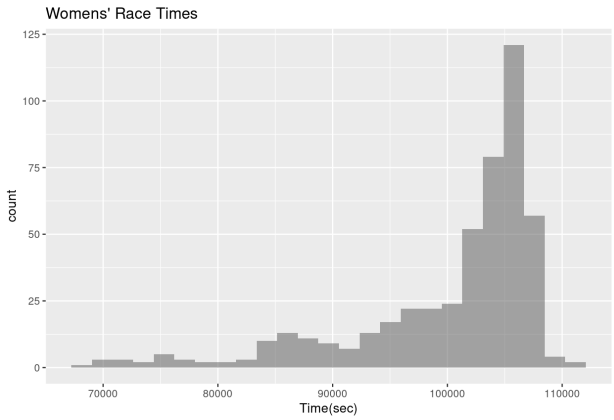


**Figure 1**. Distribution of women's race times.

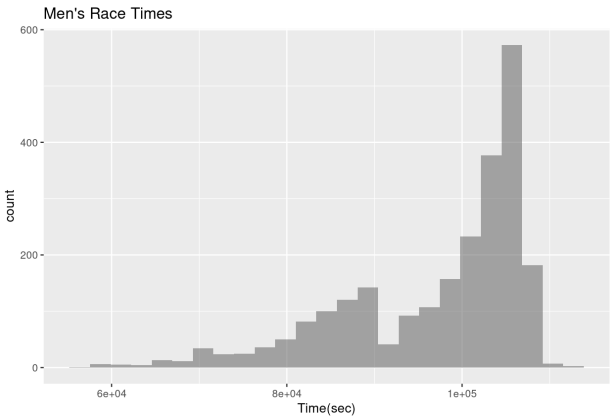


**Figure 2.** Distribution of men's race times.

The histogram for the women's race times is unimodal and skewed left, showing that the majority of women had slower times. The histogram for the men's race times is skewed left and bimodal, showing that while the majority of men's times are also slower, there is another peak around 90,000 seconds. This peak indicates to us that there is also a large number of men who finished in around 90,000 seconds. The mean of the men's race times was found to be 97153.04 seconds with a 95% confidence interval of 96723 to 97580 seconds. The mean of the women's race times was found to be 100309.5 seconds with a 95% confidence interval of 99527 to 101047 seconds.

After analyzing the distribution of all of the races combined, we found it necessary to explore the difference in race times between each year. To do this we plotted side by side boxplots of the race times between the women (Figure 3), and the men (Figure 4).

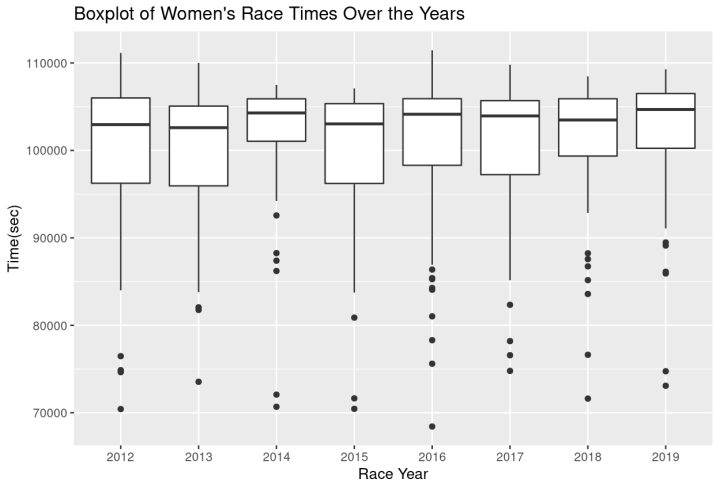


**Figure 3.** Side by side boxplot of women's race times separated by year.

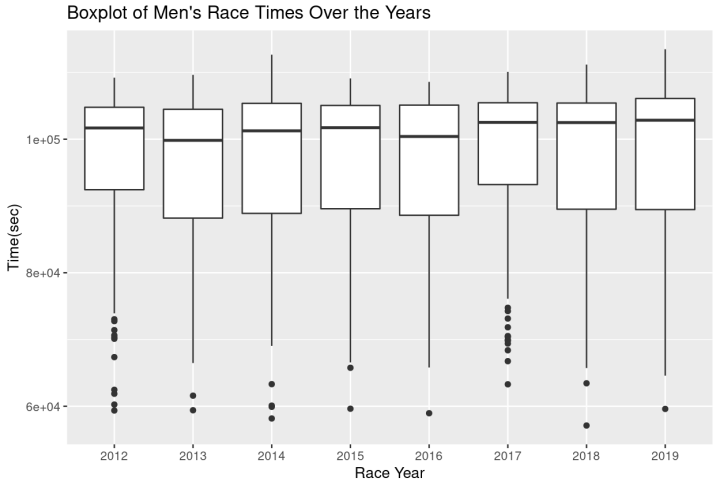


**Figure 4.** Side by side boxplot of men's race times separated by year.

The boxplots for the women's race times all have similar medians, around 10,4000 seconds. For every race year there are outliers in the lower end, meaning that there were a few women who finished in much less time than the majority of the group. In Figure 3, the 2014 race has a smaller variance than the other boxplots, with all the values falling within half the range of the

other years. The boxplots of the men's race times also have similar medians, all falling around 10,1000 seconds. The men's races also have outliers on the lower end, meaning that a few men each year finish with a much lower time than the majority of participants.

| Race Year | Min | Q1 | Median | Q3 | Max | Mean | sd | n | Missing |
|---|---|---|---|---|---|---|---|---|---|
| 2012 | 704223 | 96246.0 | 102954 | 106002 | 111150 | 98948.09 | 9433.536 | 56 | 0 |
| 2013 | 73544 | 95948.0 | 102603 | 105072 | 110001 | 99799.53 | 7349.056 | 81 | 0 |
| 2014 | 70684 | 101049.0 | 104287 | 105900 | 107495 | 101116.25 | 8077.906 | 51 | 0 |
| 2015 | 70449 | 96219.5 | 103035 | 105350 | 107096 | 99309.80 | 8710.995 | 59 | 0 |
| 2016 | 68427 | 98302.0 | 104136 | 105916 | 111459 | 100077.09 | 9454.094 | 65 | 0 |
| 2017 | 74789 | 97233.0 | 103946 | 105697 | 109802 | 99855.31 | 8845.775 | 45 | 0 |
| 2018 | 71620 | 99359.5 | 103482 | 105908 | 108464 | 101177.25 | 7911.871 | 59 | 0 |
| 2019 | 73087 | 100245.0 | 104863 | 106506 | 109290 | 101996.01 | 7220.482 | 71 | 129 |

**Table 1.** Statistics on women's race times by year (Figure 3).

| Race Year | Min | Q1 | Median | Q3 | Max | Mean | sd | n | Missing |
|---|---|---|---|---|---|---|---|---|---|
| 2012 | 59367 | 92437.00 | 101683.0 | 104783.0 | 109212 | 97556.86 | 10011.65 | 307 | 0 |
| 2013 | 59403 | 88184.50 | 99827.5 | 104480.2 | 109638 | 96160.42 | 10223.86 | 416 | 0 |
| 2014 | 58172 | 88894.00 | 101254.0 | 105370.0 | 112661 | 97194.83 | 10695.87 | 305 | 0 |
| 2015 | 59634 | 89583.00 | 101727.5 | 105058.0 | 109106 | 97097.75 | 10229.95 | 254 | 0 |
| 2016 | 58959 | 88608.75 | 100409.0 | 105108.2 | 108588 | 96619.07 | 10510.83 | 276 | 0 |
| 2017 | 63291 | 93209.75 | 102520.5 | 105459.5 | 110090 | 98100.85 | 10003.19 | 242 | 0 |
| 2018 | 57117 | 89516.00 | 102494.0 | 105416.5 | 111181 | 97299.98 | 10771.85 | 319 | 0 |
| 2019 | 59604 | 89456.75 | 102844.0 | 106103.5 | 113478 | 97770.14 | 10683.40 | 306 | 421 |

**Table 2.** Statistics on men's race times by year (Figure 4).

As we can see from Tables 1 and 2, the sample sizes (n) of the men running the Leadville Trail 100 for every year are much larger than the sample sizes for the women running the race. The men average around 303 participants in the race per year, whereas the women average only 60 participants per year. The difference in variance in the boxplots can, at least in part, be attributed to the difference in sample size—because the men running the Leadville Trail 100 have more participants, they have a smaller variance than the women do. The men also tend to have a smaller median time in seconds than the women do.

In Table 1 and 2, we see that the means between each race time do not seem to differ much. To confirm that the difference is not statistically discernible, we ran a one-way ANOVA test which yielded a p-value of .449 for the difference of means in the women's race times over the years, and a p-value of .317 for the difference in means in the men's race times over the years. These p-values confirm that there is very little evidence supporting the assertion that the mean race times for women or men in the Leadville 100 differ from 2012 to 2017.

**Discussion**

Our calculated p-value was .449 for women and .317 for men, reflecting the differences in race times per year. Therefore we can conclude that the difference in race times between years is not large enough to show a statistically discernible difference for either the men or the women. However, our data only includes times from races from 2012-2019, which is not a large time frame. It is possible that if we were to have data from the past 50 years of the Leadville Trail 100 race that there would be a more significant trend in the data. We found that the 95% confidence interval of the average race time for men does not overlap with that of the women, indicating that there is a statistically discernible difference in the performance between men and women. The

interval was found to be lower for men suggesting that men performed better in the Leadville 100 from 2012-2019.

A major confounding variable in this study was the elevation at which the Leadville 100 is run. The capacity that humans have for improvement in athletics may vary by altitude, and different genders may respond to changes in altitude differently. This would likely influence times in the Leadville 100 as it is the highest altitude ultramarathon. Another confounding variable is increased interest and participation. As popularity increases, more novices will likely be drawn to this challenging sport, potentially causing slower average race times. This influence could dilute the potential positive effects of increased participation on performance. The final confounding variable is age. It is known that age is a significant factor in race performance and it is possible that some age groups would be more likely to improve over the years. Additionally, the number of people in each age group may vary by year which could further impact results if some age groups are increasing faster than others.

One area for future research would be taking a closer look at what ages are present in the data set and how race times differ amongst the ages in addition to gender. Another area of possible future research would be looking more closely at the race times of women ultra runners in the Leadville 100, because the sample size is much smaller than the men's sample size. More women are getting involved with ultra trail running, and within the next ten years, the results for women could look drastically different than they do currently, and therefore, analysis should be continued in the future.

## References


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