Abstract
This study was conducted to test the statement that Berlin is the fastest marathon. Top ten and top three times were taken from the past five years and first place times were taken from the past ten years from the Berlin, Chicago, London, and Dubai marathons. Randomization tests were performed on these times to determine whether Berlin is significantly the fastest marathon. Results varied, but for the men, Berlin tends to become faster in comparison to the other marathons as the number of places observed decreases. First place Berlin men are significantly faster than the other first place marathons. Women followed a similar pattern, although Berlin was not significantly different from the other marathons for the first place times.

Introduction
Across the world, hundreds of marathons are run over the course of the year. Amongst all the marathons that are run each year, there are a few marathons that are known to produce much quicker times. These highly competitive marathons are run by the elite marathioners from different countries around the world. Runners across the word watch these marathons each year as world records are broken and history is made. Although each marathon course is 26.2 miles, the time that it takes a runner to complete the race can differ greatly from course to course. A generally agreed-upon thought in the running community is that the Berlin marathon is the fastest marathon. This research was conducted with the goal of exploring whether the statement stands true regarding the Berlin marathon being the fastest.

Methods
After exploring times from marathons around the world, I found that the Chicago, Dubai, and London marathons appeared to be comparable to Berlin for both men and women. I used randomization tests with 10,000 repetitions to compare the top ten, top three, and first place times from Berlin to each of the other three marathons. For the top ten group and top three times, I used data going back five years, and for the first place times, I went back ten years. I chose not to look at the times of runners who were not in the top ten, three, or one times. The reason for looking at such small groups from each race is that I only wanted to observe elite athletes, as they are the most consistent runners in each marathon.
Results

The randomization tests for the top ten men, as displayed in Table 2, show that Berlin is significantly faster than Chicago, significantly slower than Dubai, and there was no significant difference between Berlin and London. In addition, the average of the top 10 times for Dubai and London are both faster than the average top ten times for Berlin, as shown in Table 1 and Figure 1. These results are quite mixed, and do not show evidence to support the claim that Berlin is the fastest marathon.

After performing randomization tests for top three and first place times, the results begin to get more interesting. For the top three men, the p-values from the randomization tests, in Table 2, show that Berlin is significantly faster than Chicago, but not significantly faster or slower than Dubai or London. The average for the top three male times is faster in Berlin than in the other three marathons, as shown in Table 1 and Figure 2, but Berlin top three is still not fast enough to be significantly faster than Dubai and London top three. After conducting a randomization test on the first place male times, the results, as displayed in Table 2 and Figure 3, show that Berlin is significantly faster than the three other marathons.

The results for the female marathons are similar to those that were discovered for their male counterparts. When performing a randomization test on the top ten female performances, Berlin women were found to be significantly faster than Berlin, significantly slower than Dubai, and there was no significant difference between Berlin and London. The p-values for these tests can be found in Table 4, and a visualization of the spread is shown in Figure 4. Results for the top ten again were mixed, which led me to test the top three, as well at the first place times for the women.

Randomization for top three women resulted in Berlin being significantly faster than Chicago, while having no significant difference when being compared to London and Dubai. Referring to Figure 5 and Table 4 shows these results. Again, as observed in the men, the average of the top three times was the fastest for Berlin, which is worthy to note. When performing randomization tests on the first place females times, however, Berlin is not significantly faster than any of the other three marathons, as shown by the p-values in Table 4. By referring to Table 3, a noteworthy observation is that the average top three times for Berlin and Dubai are faster than the average first place times. This seemingly nonsensical observation is because top three times only came from the past 5 years, while first place times went back 10 years, and marathon times tend to get faster over the years.
Figure 1:

![Box plot showing Top 10 Men Time Comparison across Berlin, Chicago, Dubai, and London marathons.](image1)

Figure 2:

![Box plot showing Top Three Men Time Comparison across Berlin, Chicago, Dubai, and London marathons.](image2)
Figure 3:

First Place Men Time Comparison

Figure 4:

Top 10 Women Time Comparison
Figure 5:

Top Three Women Time Comparison

Figure 6:

First Place Women Time Comparison
Discussion

Regarding the original question of whether Berlin can be deemed the fastest marathon, the results from the tests conclude that this is too broad of a statement and does not stand true in all cases. For the men, the winner of Berlin is significantly faster than the other three marathons, but Berlin loses speed in comparison to Chicago, London, and Dubai as the number of runners observed increases. The results for the women support that original statement even less. The top ten and top three results were similar to the men, but when testing the first-place times, Berlin was not significantly faster than any of the other three marathons.

Some important factors that affect running were not considered in this study. These factors include the weather on race day for each marathon, the competition level in each race, and the nature of the course. These factors could likely be used to explain the results of this study, although one would likely experience much difficulty in judging competition and nature of the course, and in quantifying the
factors. Weather would also be difficult to consider, as weather affects all runners differently, and there are many different types of weather.

No other studies were found that are similar to this study. It would be interesting to repeat this study in ten years to see if the results differ over time. Another interesting study that could be conducted would be to measure how much faster marathons get over time.

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References

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