

## Running Mechanics of the 2016 US Marathon Olympic Team

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A very deep field in the men's race at the 2016 US Marathon Olympic Trials made predictions of a top 3 challenging. Less uncertainty existed in the women's race. Race day temperatures were relatively high for the races that began at 10:06 and 10:22am. Some top competitors in the men's race, notably Dathan Ritzenhein and Diego Estrada did not finish due to muscle cramping. On the women's side, Shalane Flanagan appeared to suffer the effects of dehydration, but managed to maintain a top 3 finish by a strong early pace.

The top 3 men and women followed different race strategies with Galen Rupp running a conservative race until Tyler Pennell put in a surge around mile 17. After matching this move, Galen Rupp and Meb Keflezighi maintained a solid pace until Rupp gradually pulled away in the last couple of miles. Jared Ward ran a more conservative race when Pennell made his move to the lead and was able to close on Pennell and stay ahead of Luke Puskedra by more than a minute.

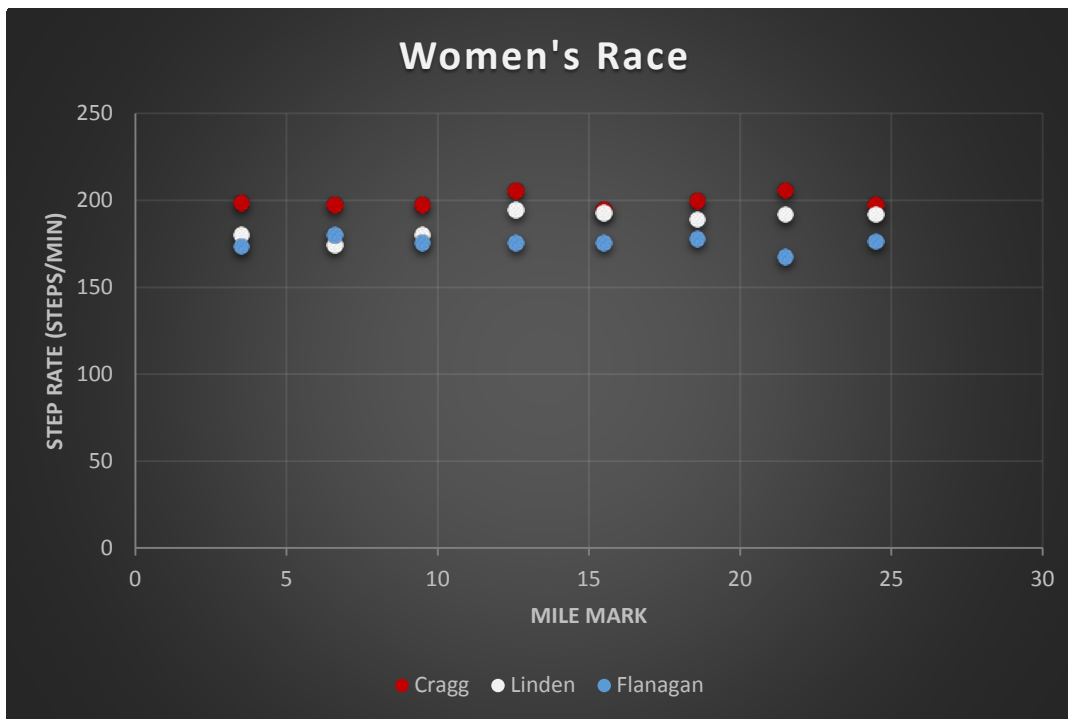
On the women's side, training partners Amy Kragg and Shalane Flanagan made a strong move early in the race, running a less consistent pace than on the men's side. Through well beyond halfway, it appeared to be a two-woman race for top two spots. Desi Linden stayed in the main pack much longer and it was unclear whether Kara Goucher, Desi Linden, or another athlete would take the final spot on the Olympic team. Late in the race, Shalane's pace slowed dramatically and Desi was able to pass putting her in second. Shalane courageously maintained her position to claim 3<sup>rd</sup> place.

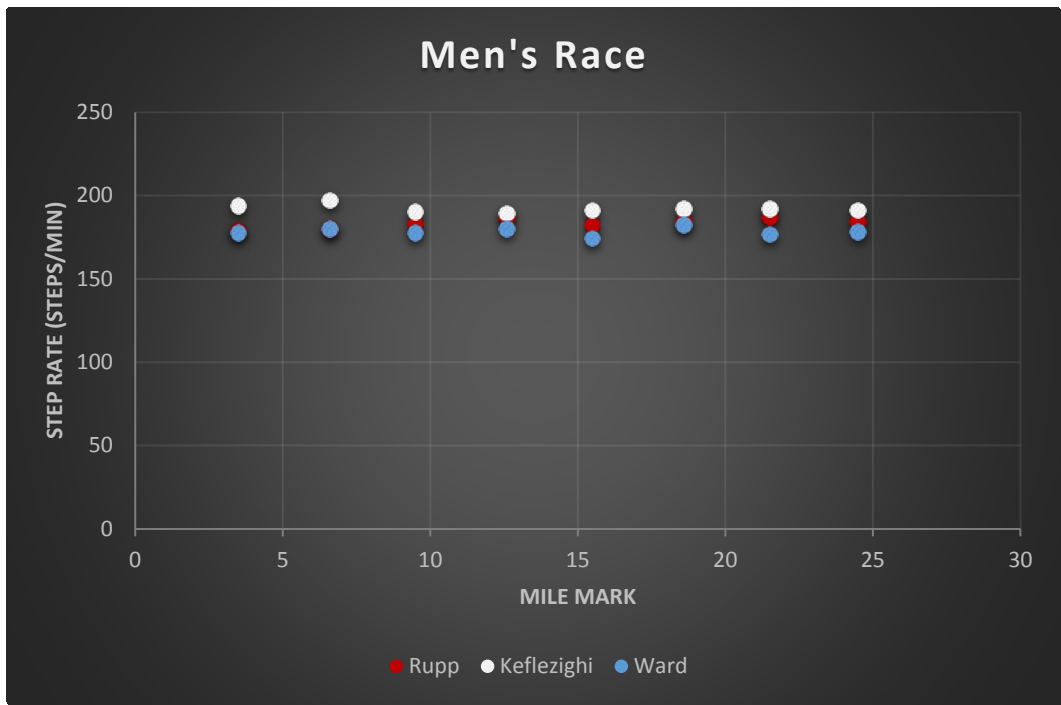
The different race strategies completed by each athlete led us to an interest in how their running mechanics varied throughout the race. We set up high speed (120Hz) Sony A7s cameras on the side of Figueroa Road to capture a few aspects of running mechanics at 8 locations of the race. Step rate and time on the ground for the top 3 men and women were recorded at these 8 locations.

|                       | Amy Cragg | Desi Linden | Shalane Flanagan | Galen Rupp | Meb Keflezighi | Jared Ward |
|-----------------------|-----------|-------------|------------------|------------|----------------|------------|
| Step Rate (steps/min) | 199       | 187         | 175              | 183        | 192            | 178        |
| Ground Time (s)       | 0.180     | 0.186       | 0.191            | 0.172      | 0.195          | 0.211      |

## Step Rate

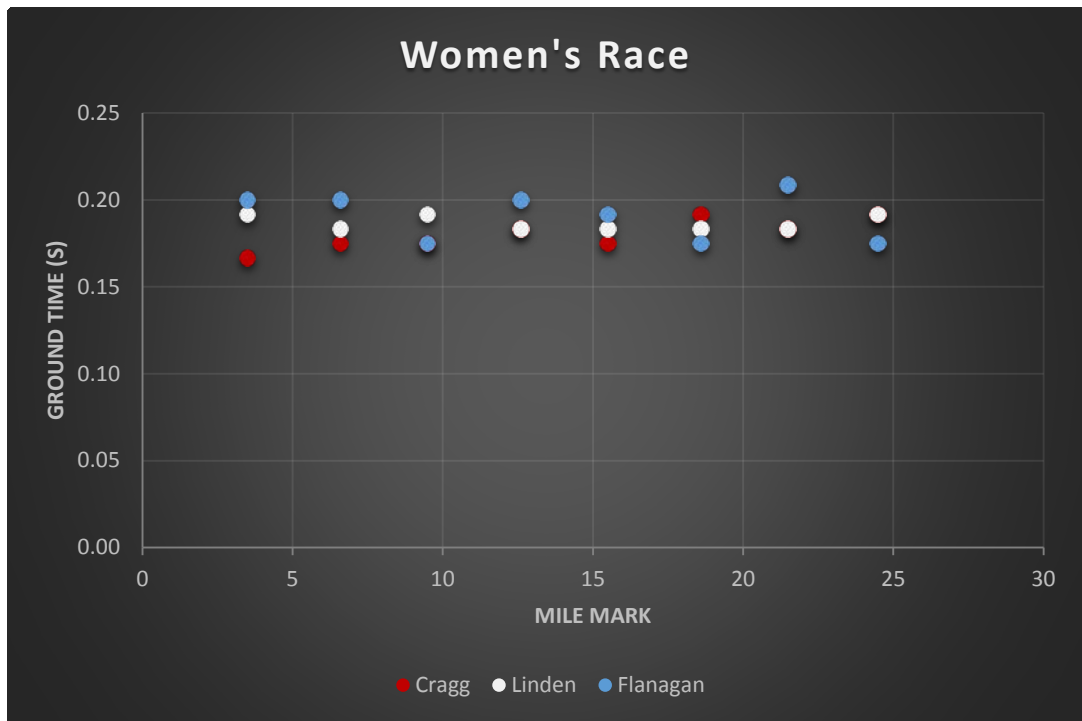
Averages for each athlete show Desi Linden and Meb Keflezighi with the highest step rates. For years, claims have been made that runners should maintain a 180 step per minute rate. While this may be the average rate for elite runners at a certain pace, there are many factors that will cause runners to prefer rates other than 180 including pace, leg length, foot strike position, leg strength and power, and other yet undetermined factors. Amy averaged 199 steps per minute through the measurement zones while Shalane running at the same pace during every measurement averaged 175 steps per minute. The men also had a relatively large range of step rates between each other. The variability of someone's step rate is more important than the specific step rate. Runners that have the ability to keep their technique consistent step-by-step use less energy to maintain a given pace. The following graphs show the step rates for each measurement location. After considering the differences in pace as they came through each measurement location, all six runners were very consistent in their movements. However, Shalane had a noticeable decrease in step rate at mile 21.5 while running at her overall average pace. This could be an indication of where she was starting to struggle with fatigue and dehydration.

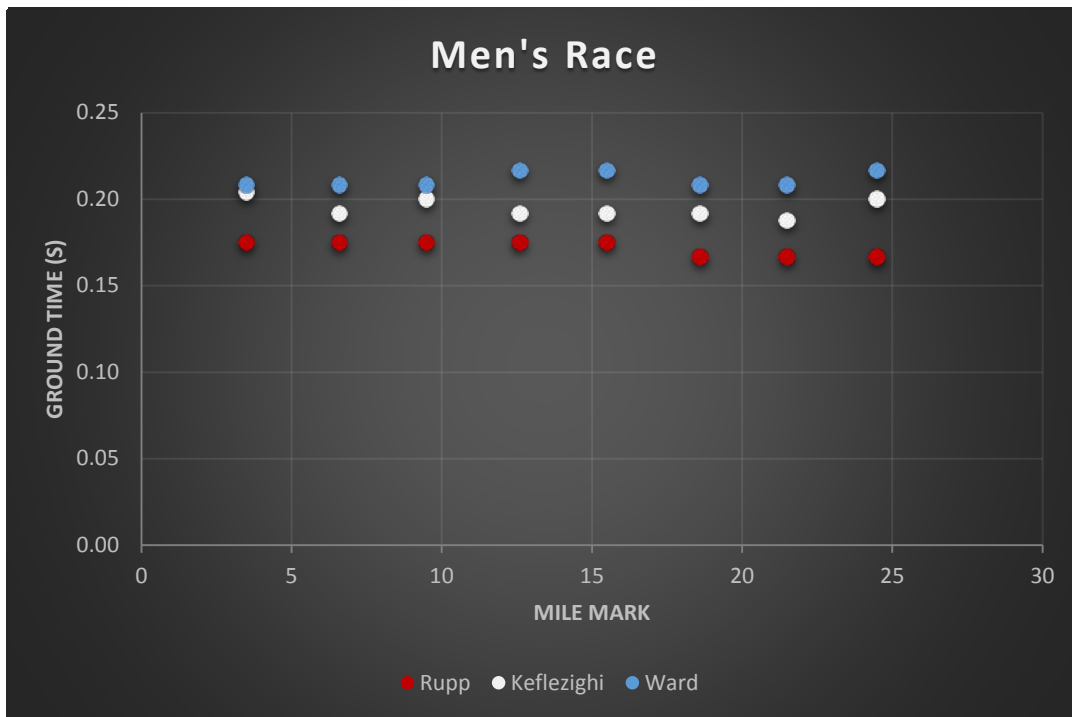




### Ground Time

A connection between ground time and running economy seems to exist where runners with shorter ground times use less energy. There could be a temptation to assume the differences in ground time between runners explains the finish order. However, there are many more factors much more important than time on the ground. Ground time is another factor that runners should keep consistent between steps. The men had minimal variability throughout the race. In the women's race, Desi kept a steadier pace and had smaller changes in ground time. Shalane and Amy could likely have run a faster race by keeping more consistency in their paces and technique. However, race strategy during a race where place is the most important outcome can override desires for a steady pace with a better time.





#### 2016 Rio

Going into the Olympic marathon, Amy, Desi, Shalane, Galen, Meb, and Jared will be an excellent team for the US. Their training over the years has already allowed them to run very consistently. The warm humid environment expected in Rio will likely lead to higher variability among performances. Since the current US team was selected in warm conditions, these athletes have an advantage over many other countries. All of their coaches have excellent experiences that have them in a perfect state to consider these results and help their athletes prepare for Rio.