Men Cross America Faster Than Women—The “Race Across America” From 1982 to 2012

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Purpose: The sex difference in ultraendurance performance has been investigated in swimmers, runners, and triathletes but not in cyclists. The purpose of this study was to examine the sex difference in the longest ultra-cycling race in the world, the Race Across America (RAAM). Methods: Cycling speed of female and male finishers in the RAAM between 1982 and 2012 was compared. Results: A total of 452 athletes including 404 men (89.4%) and 48 women (10.6%) finished. Mean cycling speed was 19.4 ± 2.0 km/h for men and 17.5 ± 2.0 km/h for women. Men were riding 1.9 ± 2.0 km/h (10.9%) faster than women. The fastest cycling speed ever was 24.77 km/h for men and 21.27 km/h for women, with a sex difference of 14.2%. Between 1982 and 2012, cycling speed was 22.7 ± 1.1 km/h for the annual fastest men and 18.4 ± 1.6 km/h for the annual fastest women, with an unchanged sex difference of 19.4% ± 7.3% (P > .05). For the annual top 3 men, cycling speed was 21.8 ± 0.9 km/h with no change across years (P > .05). The annual top 3 women achieved a cycling speed of 16.6 ± 1.0 km/h with no change over time (P > .05). The sex difference of 24.6% ± 3.0% showed no change across years (P > .05). Conclusions: In the last 30 y, men crossed America faster than women, and it seems unlikely that women will overtop men in the near future in the RAAM. However, the sex difference was only 14–15% among top competitors. Future studies need to analyze anthropometric, psychological, and physiological characteristics of successful female and male ultracyclists.

Keywords: ultraendurance, cycling, performance, female, male

In recent years, there has been an increased interest in investigating the sex difference in ultraendurance performances, defined as an endurance performance lasting for 6 hours or more.¹ Ultraendurance performances are mainly held in swimming,² cycling,³ running,⁴ and the combination of the 3 disciplines as triathlon.⁵ Over the last decades, the sex difference in ultraendurance performance such as ultrarunning has been of particular interest.⁶–⁸ Several studies addressed the question of whether the sex difference would decrease with increasing running distance.⁶–⁹ Some data suggested that women who were matched with men for performance at 42.2- or 56-km distances were able to run faster than men at longer distances such as 96 km.⁶,⁹

The sex difference in performance seemed to be influenced by the duration of an ultraendurance event¹⁰ and the locomotion mode.⁵ Coast et al.⁸ compared the world’s best running performances at distances from 100 m to 200 km. The running speeds were different, with the average difference being 12.4% faster for men and with a significant slope to the speed difference across distances where longer running distances were associated with greater sex differences. Knechtle et al.¹⁰ examined the performances in ultratriathlons, from the Double Iron ultratriathlon covering 7.6 km swimming, 360 km cycling, and 84.4 km running to the Deca Iron ultratriathlon covering 38 km swimming, 1800 km cycling, and 422 km running. The world’s best men were ~19% faster than the world’s best women in both a Double Iron ultratriathlon and a Triple Iron ultratriathlon, and they were ~30% faster in a Deca Iron ultratriathlon. With the increasing length of an ultratriathlon distance, the world’s best women became relatively slower than the world’s best men. These results may, however, be confounded by the reduced number of women participating in longer-distance events.²,⁴,¹⁰

The change in sex difference in ultraendurance performance across time has been examined for different disciplines. In swimming, women seemed to achieve a performance similar to that of men in both indoor pool swimming¹¹ and open-water ultraendurance swimming.¹² In the English Channel Swim, when 1533 swimmers—455 women (29.7%) and 1078 men (70.3%)—were investigated, the best annual performances did not differ between the sexes.¹² Similarly, in a 12-hour pool swim with 113 male (68.1%) and 53 female (31.9%) swimmers, the annual best performance was not different between women and men.¹¹ However, for shorter
open-water distances, the sex difference was ~11.5% in the 26.4-km open-water Ultra-swim Marathon Swim in Lake Zurich, where a total of 461 athletes—157 women (34.1%) and 304 men (65.9%)—competed. In running, finish times of women improved relative to men through the 1980s in 161-km ultramarathons held in North America but were then stable over the past 2 decades, with the fastest women running about 20% slower than the fastest men.14 In ultratriathlon performances, the sex difference in Triple Iron ultratriathlon covering 11.4 km swimming, 540 km cycling, and 126.6 km running was investigated across years.15 Overall race time decreased for men, while it increased for women over time. The sex difference in overall race time for winners increased from 10% in 1992 to 42% in 2011.15

For cycling, little is known regarding the sex difference in performance.16 Schumacher et al16 studied the race results of the Track Cycling World Championships in 200-m, 1000-m, and individual and team pursuit races for elite and junior athletes and found a sex difference of 11% ± 1.8% in all disciplines and at all ages. The difference in cycling ultraendurance performance was mainly investigated in the 180-km cycling split in long-distance triathlon such as the Ironman World Championship in Ironman Hawaii.5,17 The sex difference in the 180-km cycling performance ranged between 12.7% ± 2.0%5 and 15.4% ± 0.7%,17 with men being faster than women. In the 150-km cycling split in the Powerman Long Distance Duathlon World Championship in Powerman Zofingen, the sex difference in performance was 17% ± 3%.18

To date, no study has investigated the sex difference in ultracycling performance. In particular, no study has investigated the change in sex difference in performance across time in ultracycling. The aim of the current study was to analyze the performance in Race Across America (RAAM) in female and male finishers from 1982 to 2012. This race, consisting of cycling approximately 4800 km, is considered the longest ultracycling race in the world. Regarding previous findings that the sex difference increased with increasing length of an ultraendurance distance,10,15 we hypothesized that the sex difference in ultracycling performance would be higher than existing reports on cycling split performances in Ironman triathlon5,17 and long-distance duathlon.18

Methods

The data set for this study was obtained from the race Web site www.raceacrossamerica.org. The study was approved by the institutional review board of St Gallen, Switzerland, with a waiver of the requirement for informed consent, given that the study involved the analysis of publicly available data.

The Race

Performance of all female and male cyclists who participated in the RAAM from 1982 to 2012 was analyzed. In the RAAM, the participants have to cover approximately 3000 miles (~4800 km). Over this distance, they have to climb a total altitude of approximately 25,000 m. The fastest finishers reach the finish after 8 days and a few hours; the slowest finishers need up to 11 to 12 days. The RAAM finishes 12 states, passing through 88 counties and 350 communities. The number of time stations changed over the years. The participants start in Oceanside, CA, and have to pass time stations to reach the finish line in Annapolis, MD. In recent years, the race passed through California, Arizona, Utah, Colorado, Kansas, Missouri, Illinois, Indiana, Ohio, West Virginia, and Maryland. The cyclists had to cross the Rocky Mountains and the Appalachians. In the Rocky Mountains, the Wolf Creek Pass (3309 m above sea level) is the highest point in the race, followed by the La Veta Pass (2860 m above sea level). In earlier years, the race started in San Diego, CA, and finished in Atlantic City, NJ. The cyclists passed through Guatay, CA (1219 m above sea level); Prescott, AZ (1636 m above sea level); Potato Patch, AZ (2112 m above sea level); Strawberry, AZ (1795 m above sea level); Forest Lakes, AZ (2300 m above sea level); Springerville, AZ (2124 m above sea level); Pie Town, NM (2395 m above sea level); and Mountaintain, NM (1987 m above sea level) and then crossed Texas, Oklahoma, Kansas, Missouri, Illinois, Indiana, Ohio, West Virginia, Maryland, Pennsylvania, and New Jersey.

Methodology

Data were available from 779 athletes, including 686 men and 93 women. Across years, 282 men and 45 women were not able to finish the race. Thus, a total of 48 female and 398 male finishers could be included in our data analysis. Since the race distance varied over years, all race times were converted to cycling speed before analysis by calculating race distance in miles divided by race time in hours and converted to kilometers per hour. To examine the changes in cycling speed across years, the performances of the annual top (ie, fastest race speed) and the annual top 3 men and women were analyzed. The sex difference in performance was calculated using the following equation: (cycling speed in men – cycling speed in women)/cycling speed in men × 100.

Statistical Analysis

To increase the reliability of the data analyses, each set of data was tested for normal distribution, as well as for homogeneity of variances, in advance of statistical analyses. Normal distribution was tested using a D’Agostino and Pearson omnibus normality test, and homogeneity of variances was tested using a Levene test. To find significant changes in the development of a variable across years, linear regression was used. To find significant differences between 2 groups a Student t test was used, with Welch correction in case of significantly
different variances between the 2 compared groups. Statistical analyses were performed using IBM SPSS Statistics (Version 19, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 5, GraphPad Software, La Jolla, CA, USA). Significance was accepted at $P < .05$ (2-sided for $t$ tests). Data in the text are given as mean ± standard deviation.

**Results**

**Participation Trends**

From 1982 to 2012, a total of 779 ultracyclists—686 men (88.1%) and 93 women (11.9%)—started in the RAAM. Of these 779 starters, 452 (58%) athletes finished successfully, among them 404 men (89.4%) and 48 women (10.6%). Per year, $25.1 ± 8.2$ cyclists started, with $22.1 ± 6.8$ men and $3.0 ± 2.0$ women. Among the starters, $13.0 ± 5.2$ men and $1.5 ± 1.2$ women finished annually. The annual number of male starters increased ($r^2 = .15$, $P = .03$), whereas the annual number of female starters remained unchanged ($r^2 = .02$, $P > .05$). For men, the annual number of finishers increased, but it did not for women (Figure 1). For both women and men, the annual number of nonfinishers showed no changes across years ($P > .05$). During years, the percentage for finishers was $59.5% ± 14.6%$, and it was $40.5% ± 14.5%$ for nonfinishers. Regarding sex, the percentage of finishers was $89.3% ± 9.2%$ in men and $10.7% ± 9.1%$ in women. Considering the nonfinishers, $86.7% ± 12.5%$ were men and $13.3% ± 12.4%$ were women.

**Performance Trends**

The 404 successful men rode at a mean speed of $19.4 ± 2.0$ km/h, and the 48 successful women, at $17.5 ± 2.0$ km/h. Men were riding on average $1.9 ± 2.0$ km/h (10.9%) faster than women. The mean cycling speed of the annual fastest men was $22.7 ± 1.1$ km/h, and it was $18.4 ± 1.6$ km/h for the annual fastest women, with no change in cycling speed across years ($P > .05$; Figure 2). The sex difference in cycling speed remained unchanged at $19.4% ± 7.3%$ over time ($P > .05$; Figure 2).

For men, the fastest cycling speed ever was achieved in 1986 by Pete Penseyres (USA) with $24.77$ km/h, followed by Daniel Wyss (Switzerland) with $24.52$ km/h in 2009 and Reto Schoch (Switzerland) with $24.26$ km/h in 2012. For women, the fastest cycling speed of $21.27$ km/h was obtained by Seana Hogan (USA) in 1995, followed by $20.80$ km/h of Susan Notarangelo (USA) in 1989 and $20.65$ km/h by Elaine Mariolle (USA) in 1986 (Table 1). For the annual top 3 men, mean cycling speed was $21.8 ± 0.9$ km/h, with no change across years ($P > .05$; Figure 3). In 1984, 1985, 1987, 1988, 1990, 1991, 1994, 2009, 2010, and 2011, at least 3 women were able to finish and they achieved a mean cycling speed of $16.6 ± 1.0$ km/h with no change across years ($P > .05$; Figure 3). The sex difference in cycling speed was $24.6% ± 3.0%$ with no change across years ($P > .05$; Figure 3). For the overall fastest cyclists ever (ie, the record holder, the top 3 ever, and the top 10 ever for each sex), the sex differences were only $14%$ to $15%$ (Table 1). These athletes competed in different editions of the race.

![Figure 1](image_url) — Number of annual female, male, and overall finishers in the Race Across America from 1982 to 2012.
Table 1 Cycling Speeds (km/h) and Sex Difference (%) in the Race Across America, 1982–2012

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record cycling speed for men (1986)</td>
<td>24.77</td>
</tr>
<tr>
<td>Record cycling speed for women (1995)</td>
<td>21.27</td>
</tr>
<tr>
<td>Sex difference in cycling speed</td>
<td>14.2</td>
</tr>
<tr>
<td>Top 3 cycling speed, men, mean ± SD</td>
<td>24.5 ± 0.3</td>
</tr>
<tr>
<td>Top 3 cycling speed, women, mean ± SD</td>
<td>21.1 ± 0.2</td>
</tr>
<tr>
<td>Sex difference in cycling speed, mean ± SD</td>
<td>14.2 ± 0.1</td>
</tr>
<tr>
<td>Top 10 cycling speed, men, mean ± SD</td>
<td>24.0 ± 0.4</td>
</tr>
<tr>
<td>Top 10 cycling speed, women, mean ± SD</td>
<td>20.4 ± 0.6</td>
</tr>
<tr>
<td>Sex difference in cycling speed, mean ± SD</td>
<td>15.3 ± 1.1</td>
</tr>
</tbody>
</table>

Discussion

The aim of the current study was to analyze the RAAM performance of female and male finishers from 1982 to 2012. We hypothesized that the sex difference in ultracycling performance would be higher than existing reports on cycling split performances in Ironman triathlon and long-distance duathlon. However, when we compared the fastest cycling speeds for women and men in the RAAM, the sex difference was 14.2% for the fastest speeds ever, 14.2% ± 0.1% for the 3 fastest finishers ever, and 15.3% ± 1.1% for the 10 fastest finishers ever.

These findings are in line with previous results reported for cycling split times in Ironman triathlon and long-distance duathlon races. However, only a few studies investigated the change in sex difference in cycling performance across years. Lepers reported for the top 10 finishers in the Ironman Hawaii between 1988 and 2007 an unchanged sex difference of 12.7% ± 2.0% in the cycling split. In the current ultracyclists, however, the sex difference in cycling speed for the annual top 3 women and the annual top 3 men was 24.6% ± 3.0%, considerably higher than the 180-km cycling split in Ironman Hawaii. The higher sex difference in performance across years in the RAAM than in the cycling split in Ironman Hawaii might also be due to the lower number of women competing and finishing in ultraendurance races. Coast et al compared the world’s best running performances at distances from 100 m to 200 km. The running speeds were different, with the average difference being 12.4% faster for men, with a significant slope to the speed difference across distances in that longer distances were associated with greater differences. The authors assumed that the results might be confounded by the reduced number of women in longer distance events. In addition, in the RAAM, women accounted for only ~12% of the participants and ~11% of the finishers.

The sex difference in endurance performance appears to be biological in origin. Success in endurance
performance is determined mainly by aerobic capacity and muscle strength. Since men have a larger aerobic capacity and greater muscle strength, the gap in endurance performances between men and women is unlikely to narrow naturally. In several studies, the sex difference in performance amounted to 11% to 12%,\textsuperscript{6,16,21,22} In marathon running, men were 11.6% ± 1.8% faster than women when the world's fastest marathon times from 1983 to 2009 were analyzed.\textsuperscript{21} In the Track Cycling World Championships from 1979 to 1999, the sex difference in performance was 11% ± 1.8% for all disciplines and at all ages.\textsuperscript{16} Sparling et al\textsuperscript{22} analyzed the annual world rankings from 1980 to 1996 for 1500-m running and the marathon. In the 1500-m, the sex difference of 11.1% ± 1.1% in the world's best times was consistent from 1980 to 1996. In the marathon, the sex difference in the world's best times of 11.2% ± 0.9% was the same as for the 1500-m distance. For swimming, the sex difference in ultraendurance performance was 12.5% ± 9.6% in the English Channel Swim.\textsuperscript{2}

Figure 3 — Changes in cycling speed of the annual top 3 women and men in the Race Across America from 1982 to 2012.

A few studies investigated the change in sex difference in performance across years in ultraendurance races.\textsuperscript{4,10–13} The sex difference of 19.4% ± 7.3% for the annual fastest cyclists and 24.6% ± 3.0% for the annual 3 fastest cyclists was higher compared with other ultraendurance performances such as ultrarunning\textsuperscript{2,12,13} and ultrarunning.\textsuperscript{4} In the English Channel Swim, the sex difference for the annual 3 fastest swimmers was 12.5% ± 9.6% from 1975 to 2011.\textsuperscript{2} In the Lake Zurich Swim, the sex difference in swimming time for winners during the 1987–2011 period was 11.5% ± 11.6%.\textsuperscript{13} In the Western States 100-Mile Endurance Run from 1974 to 2007, the sex difference in performance decreased across years to reach 14% in 2007.\textsuperscript{4}

The sex difference in performance between female and male endurance athletes might be explained by anthropometric differences between female and male endurance athletes, such as skeletal-muscle mass and body fat. Knechtle et al\textsuperscript{10} argued that the increase in sex difference with increasing length of an ultraendurance performance such as an ultratriathlon was most probably due to the lower skeletal-muscle mass in women. It has been shown that male ultraendurance athletes had a higher skeletal-muscle mass than female ultraendurance athletes.\textsuperscript{23–26} Male Ironman triathletes with 41 kg of skeletal-muscle mass had 46% higher skeletal-muscle mass than female Ironman triathletes with 28 kg of skeletal-muscle mass.\textsuperscript{23} For ultrarunners, male ultrarunners with 38 kg of skeletal-muscle mass\textsuperscript{24} had 38% higher muscle mass than female ultrarunners with 27.4 kg.\textsuperscript{25} For ultrawimmers, the sex difference in skeletal-muscle mass was considerably higher than in runners.\textsuperscript{26} Male open-water ultrawimmers with 42 kg of skeletal-muscle mass had 45% more skeletal-muscle mass than female open-water ultrawimmers with 29 kg of skeletal-muscle mass.\textsuperscript{26} These differences in skeletal-muscle mass between female and male ultraendurance athletes might explain why the sex difference in performance was lower for swimmers than for cyclists. Another major predictor variable for a successful outcome in endurance competitions is percent body fat. It has been shown that lower body fat was associated with faster...
race times in men.\textsuperscript{27,28} The average percentage body fat for male Ironman triathletes was 14.4\% ± 4.8\%, and it was 22.8\% ± 4.8\% for female Ironman triathletes.\textsuperscript{27} The higher skeletal-muscle mass and the lower percentage body fat in men may support the theory of a biology-based performance difference between men and women ultraendurance athletes.

Another explanation for the sex difference in participation and performance in ultraendurance could be a difference in the motivation between men and women to participate in such an ultraendurance race. Personality, motivation, and goal orientation have been investigated in endurance athletes such as runners\textsuperscript{29} and participants in different sport disciplines.\textsuperscript{30,31} Female athletes were motivated to exercise regularly to reduce their body fat, to increase their physical fitness, or to improve their social interactions.\textsuperscript{26–33} The aspect of competing and winning in a race seemed to be of lower importance for women than for men. For example, for female marathoners, social affiliation and improving physical fitness were more important than achievement and personal accomplishment.\textsuperscript{34,35} Krouse et al\textsuperscript{36} investigated the influence of motivation, goal orientation, and training for female ultramarathoners. They reported that general health orientation and psychological coping were the strongest motivational factors for women ultramarathoners.

A limitation to our study is the fact that very few women have ever finished the RAAM. Of the 31 years in the study, there were no female finishers in 9 years, 1 female finisher in 6 years, 2 in 6 years, and 3 in 10 years. There have never been 4 or more female finishers in a given year. The sex difference in performance of 14.2\% for the fastest woman and man ever in the RAAM is in line with the 12.4\% sex difference reported by Coast et al\textsuperscript{8} for the world’s best running performances at distances from 100 m to 200 km. The sex difference of 24.6\% ± 3.0\% for the annual top 3 finishers from 1982 to 2012 is, however, likely due to the lack of participation in the event by elite female athletes. Generally, men are over-represented in sports,\textsuperscript{37} and the faster performance in men than in women is most probably due to men’s greater training motivation.\textsuperscript{35} Popular modern male sports require the skills needed for success in male–male physical competition,\textsuperscript{38} whereas as female ultraendurance athletes are task-oriented, internally motivated, health, and financially conscious individuals.\textsuperscript{36}

**Practical Applications**

The sex difference in performance in the RAAM was 14.2\% for the fastest cyclists ever, 14.2\% ± 0.1\% for the fastest 3 cyclists ever, and 15.3\% ± 1.1\% for the 10 fastest cyclists ever. From 1982 to 2012, the sex difference in performance remained unchanged at 19.4\% ± 7.3\% for the annual winners and 24.6\% ± 3.0\% for the annual top 3 finishers. Men have crossed America faster than women for the last 30 years, and it seems unlikely that women will overtop them in the near future in the RAAM. Future studies need to compare anthropometric, psychological, and physiological characteristics of female and male ultracyclists. In addition to physiological variables, using performance variables and quantifying physiological requirements during the competition—such as percent maximum oxygen uptake, percent maximum heart rate, and training impulse—would be well advised to begin describing this race.

**Conclusions**

Men have crossed America faster than women for the last 30 years, with an unchanged sex difference in cycling speed of 24.6\% ± 3.0\%. However, the sex difference was only 14\% to 15\% among top competitors. It seems unlikely that women will overtop men in the near future in the RAAM.

**References**


