Gender gap between elite runners continues to shrink in the 21st century

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Data and code accessibility statement

All data and R code underpinning the results of this study are publicly available on Zenodo: https://doi.org/10.5281/zenodo.16612750.

Abstract

In 1992 a provocative paper extrapolated from historical trends in world record performances to predict that women would soon run faster than men across a whole range of distances[1]. Since then, however, the consensus has been that the gap between male and female runners stabilised towards the end of the 20th century and has since remained unchanged[2,3]. Here I analyse running performances by elite athletes since 2001 to show that contrary to this widely held belief, women have in fact continued to close the gap on men across all distances from 60 m to the marathon. Women made the biggest gains relative to men in middle and long-distance running disciplines, and this occurred despite the fact that men too have continued to improve significantly in these events over the past 25 years. The jury is still out there as to whether women will one day run faster than men, but what does appear more certain is that many of the most memorable races of the coming decades will be run by women.

Introduction

The limits of human running have long fascinated physiologists, biomechanical engineers, evolutionary biologists, statisticians and sports fans alike. In the 1990s and early 2000s, analyses of changes in running times by men and women during the 20th century led to the bold prediction that women would outrun men in the not-too-distant future[1,4]. These controversial studies were heavily scrutinised, with others arguing that the gender gap in running performance would never be bridged due to aerobic, biomechanic, musculoskeletal and hormonal differences between men and women[5–8]. Since then, the general consensus has been that the gap between elite male and female runners is around 10%[7,9,10] and has remained fixed at this value since the 1980s when women's running professionalised and access to the sport increased[2,3,6,11].

Here I question this assumption using a comprehensive dataset of 13,098 running performances recorded between 2001 and 2025 by elite male and female athletes across running events ranging in distance from 60 m to the marathon. I show that contrary to conventional wisdom, the gender gap in athletic performance has shrunk markedly since the turn of this century, as female athletes have continued to improve faster than men across all running disciplines.

Results

The data show that the gender gap between elite male and female runners has shrunk significantly during the 21st century across all running distances (Fig. 1 and Table S1). When averaged over the past 25 years, elite women's running times were 12.6 % slower than men's across disciplines. The size of the performance gap varied considerably among disciplines depending on their distance (Fig. 1 a–b), increasing progressively from short-distance sprint races such as the 60 m (9.2 %) until it reached a peak in middle and long-distance events such as the 10 km (14.2 %).

Across all events, women significantly reduced the gender gap by an average of 1.3 % over the past 25 years – from 13.2 % in 2001 to 11.9 % in 2025 (Fig. 1 c–d). This shrinking gender gap was particularly pronounced in running events longer than 800 m, where women gained an average of 3.5 s km^{-1} against men's times between 2001 and 2025 (equivalent to a 1.9 % reduction in the gender gap across these middle and long-distance events). As a result, the variability in gender gap across running events has visibly decreased since the start of the century, from 5.6 % in 2001 to 4.4 % in 2025.

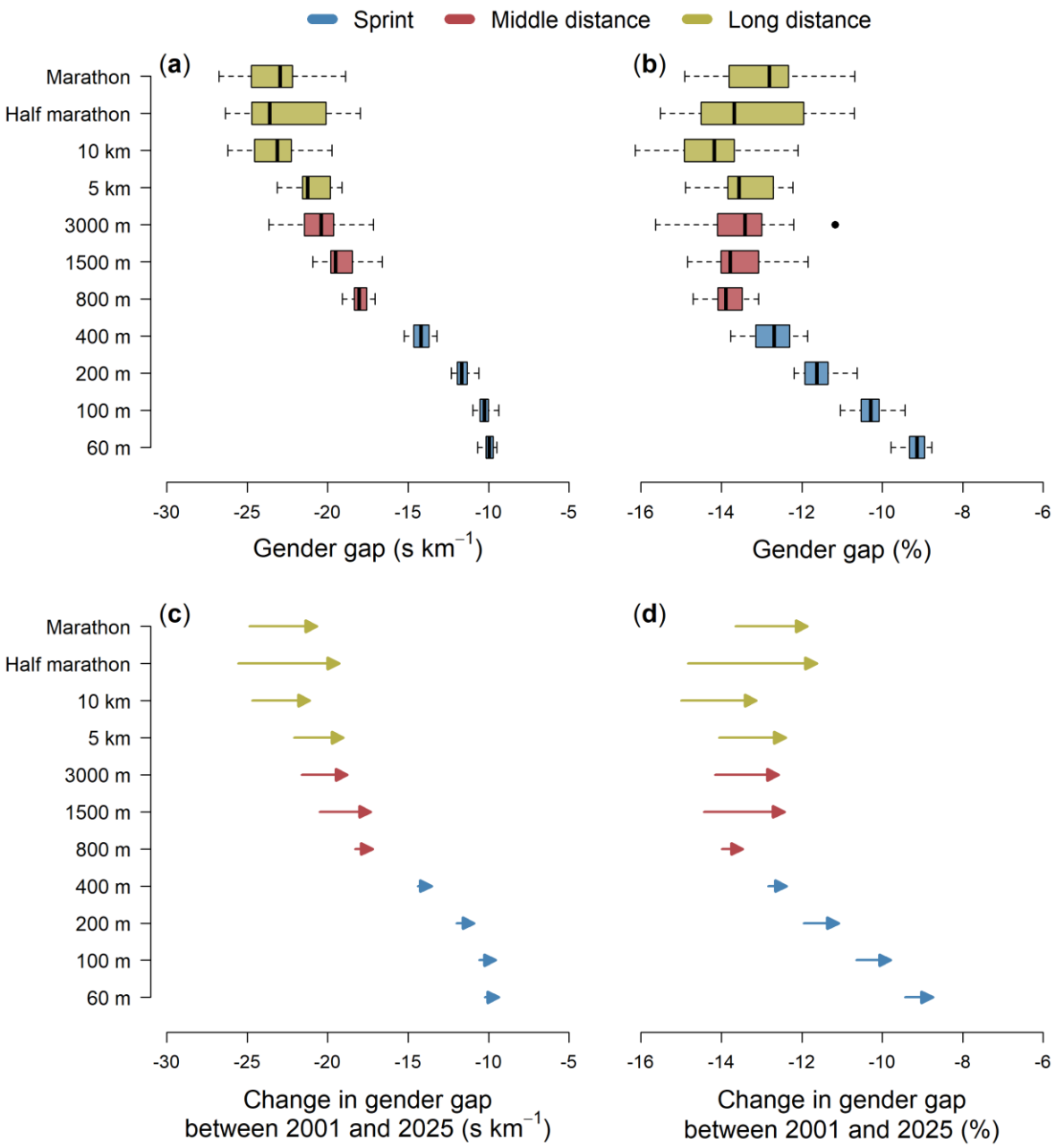

***Fig. 1*: Shrinking gender gap among elite runners during the 21st century**. *Top panels depict variation in the gender gap – expressed as both a difference in pace between men and women (**a**) and as a % (**b**) – across the 11 events considered in this analysis for the period between 2001 and 2025. The more negative the values, the greater the gender gap. Bottom panels (**c–d**) show changes in the gender gap between 2001 (start of the arrow) and 2025 (arrow head) for each running event, as estimated from linear mixed effects models. Arrows pointing to the right indicate a shrinking gender gap over time, with the length of the arrow reflecting the magnitude of this change. Running events are colour-coded into sprint (blue), middle-distance (red) and long-distance races (yellow).*

Women reduced the gender gap even though elite male athletes have also continued to significantly improve their performances across all disciplines (Fig. 2). Since 2001, male athletes have increased their running pace by an average of 2.1 s km^{-1} across disciplines, with the greatest gains coming in the half marathon and marathon (5.8–6.0 s km^{-1}). But over the same period, women increased their average running pace by twice as much (4.3 s km^{-1} across disciplines), making gains relative to men in all running events.

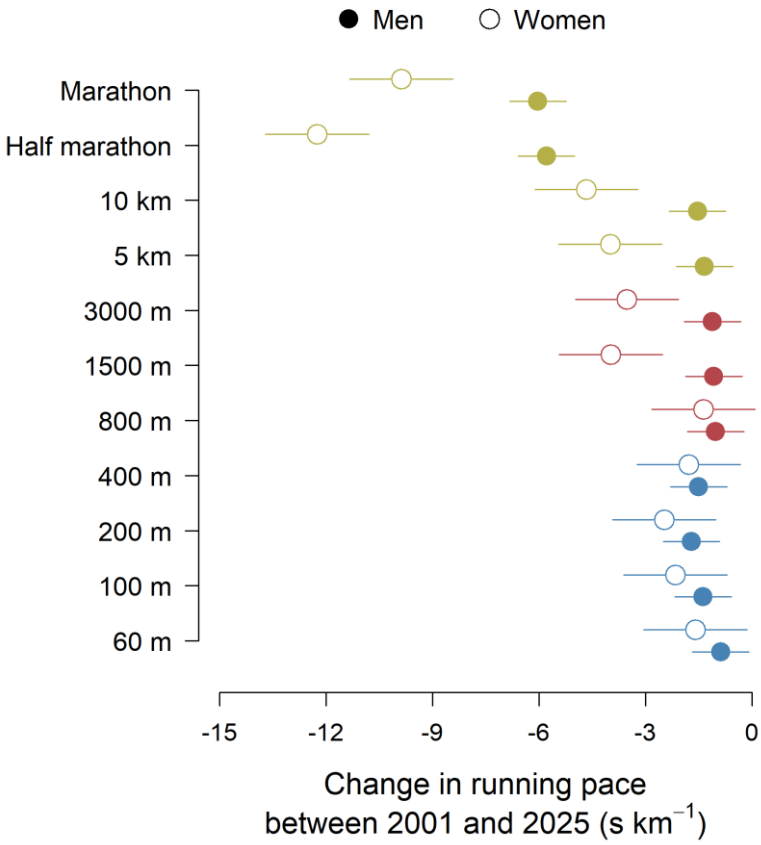

Fig. 2: Increased running performance among elite athletes during the 21st century*. Change in running pace for male (filled circles) and female (open circles) athletes across the 11 events considered in this analysis for the period between 2001 and 2025. The more negative the values, the greater the increase in pace over the past 25 years. Values are estimates from linear mixed effects models, with error bars denoting 95% confidence intervals. Running events are colour-coded into sprint (blue), middle-distance (red) and long-distance races (yellow).*

Discussion

Both men and women have continued to push the frontiers of athletic performance during the 21st century. Many people will remember Usain Bolt obliterating the 100 m world record in 2009, or when Eliud Kipchoge ran a marathon in under 2 hours in 2019. But progress by elite female

athletes over this period has simply been much greater (Figs 1–2). Since the turn of the century, women have substantially improved almost all middle and long-distance world records (2.8% improvement on average compared to 1.3% for men; Table S2), running below 14 minutes in the 5 km and 29 minutes in the 10 km for the first time. Women have also improved the marathon world record by nearly 11 minutes since 2000 (7.7% improvement), with Ruth Chepngetich's time of 2:09:56 being fast enough to win the men's Olympic marathon as recently as 2004 (and at almost every other Olympics before then).

As previous studies have shown, the gender gap in running performance varies considerably with distance (Fig. 1 a–b), being narrowest in short sprint events[10,12]. This likely reflects advantages of having shorter limbs and faster leg turnover rates when accelerating at the start of a race[10]. A perfect example of this are the 2024 Olympic 100 m finals, during which Noah Lyles and Julien Alfred – who won their respective races – reached the 10 m mark at almost the exact same time (1.95 s and 1.96 s) but where then separated by nearly a full second at the end of the race (9.79 s and 10.72 s). However, the data also clearly show that these differences in gender gap across disciplines are at least in part a legacy of the different opportunities that men and women have historically had to participate in sport – especially over longer endurance events. Kathrine Switzer is famously the first woman to have officially run a marathon in 1967 (despite Jock Semple's 'best' efforts), and women only began competing in the 5 km and 10 km at the Olympics as recently as 1996 and 1988.

This suggests that as women's professional running continues to grow, we may well see the gender gap shift towards a new equilibrium that has more to do with biology than opportunity[6,13]. In this regard, it is interesting to note that the difference in running pace between men and women stabilises in events longer that 5 km (Fig. 1a), meaning that in relative terms the gender gap shrinks in the half marathon and marathon. This is consistent with the idea that women have certain advantages over men in endurance races that can bridge and possibly even reverse the gender gap in ultramarathon endurances races[5,14–16] – something that Jasmine Paris's heroic finish at the 2024 Barkley Marathon certainly suggests is possible.

Regardless of whether women will one day outrun men, what the data do strongly suggest is that many of the most memorable and exciting races of the coming decades will be run by women. Currently Faith Kipyegon is bidding to become the first woman to run under 4 minutes for the mile, emulating what Sir Roger Bannister did in 1954 in what is surely the most iconic moment in modern running history to date. I would not bet against her.

Methods

All data formatting, analysis and visualisation were conducted in R (version 4.2.2) using the *rvest*, *xml2*, *tidyverse*, *lme4*, *lmerTest*, *plotrix* and *shape* packages. Data and R code to reproduce the results of this study are publicly available on Zenodo: https://doi.org/10.5281/zenodo.16612750.

Athletic performance data

Results of all officially ratified races for running events that took place between 2001 and 2025 were downloaded from the World Athletics website (https://worldathletics.org). For the purposes of this analysis, I included 11 running events ranging in distance from 60 m to the marathon, which I categorized into sprint races (60 m, 100 m, 200 m and 400 m), middle-distance races (800 m, 1500 m and 3000 m), and long-distance races run on track (5 km and 10 km) and road surfaces (half marathon and marathon). Except for the 60 m, which are run indoors, for all other running distances I only included results from outdoor races. I excluded the mile, which is run less frequently and not contested at the Olympics or World Championships, as well any running events that include hurdles or barriers (as these events vary in distance and hurdle height between men and women). I also excluded all races run in 2020, as most were cancelled due to the Covid-19 pandemic.

For each running event, I first compiled the top 100 performances recorded in each year for both men and women. For short and middle-distance races, which are run most frequently, it is not uncommon for a handful of athletes to record many of the top performances in any given season. To avoid a small number of athletes having an undue influence on the trends, for each year I therefore only retained an athlete's top performance in any given event. To ensure a similar number of performances were compared across running events, for each year I then subset the data to keep only the top 25 performing athletes in each event for both men and women. This resulted in a total of 13,098 running performance recorded across 971 sporting events by 3614 elite athletes.

Gender gap calculation and data analysis

For each year between 2001 and 2025, I calculate the mean time (in seconds) that the top 25 elite male and female athletes took to complete each running event. I then used these mean values to quantify the gender gap between men and women for each event and each year, both in terms of differences in pace (expressed in s km^{-1}) and as a percentage.

To determine if differences in athletic performance between men and women are similar across running disciplines, I pooled all data from 2001 and 2025 and used ANOVAs to compare gender gaps among the 11 running events considered in this analysis.

To then test if differences in athletic performance between men and women have remained stable over the past 25 years, I used linear mixed effects models to characterise changes in gender gaps over time for each running event. Specifically, I modelled the gender gap as a function of calendar year, and allowed this relationship to vary among disciplines by including running event as a random intercept and slope term in the models (factor with 11 levels).

Finally, I used a similar mixed effects model to test how the mean running pace of elite men and women has changed between 2001 and 2025. This allowed me to determine if changes in the gender gap over time have arisen due to women making greater gains than men, or simply because men have stopped improving or slowed down in recent decades. As before, I allowed the relationship between running pace and calendar year to vary among disciplines by including running event as a random intercept and slope term in the models.

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