# Ultra-triathlon—Pacing, performance trends, the role of nationality, and sex differences in finishers and non-finishers

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# Ultra-triathlon - pacing, performance trends, the role of nationality and sex differences in finishers and non-finishers

**Running head: Ultra-triathlon performance analysis**

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# ABSTRACT

Ultra-triathlons are defined as triathlons longer than the traditional Ironman distance and became more popular in the last two decades; however, scarce scientific evidence of these events are available. Therefore, we aimed to investigate the trends of performance, pacing, nationality, sex differences and rate of non-finishers in ultra-triathlons. Data from 1985-2018 were collected including Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlons. Different pacing patterns by event and sex were observed ($p$<0.05); athletes spent less %time in swimming and cycling, and more %time in running as the distance of event was longer; women spent more %time in cycling and less% time in running in Double and Triple. Performance analysis showed a negative trend over time for men and women since 1985. Switzerland, France and Germany were the fastest nations in ultra-triathlons. The frequency of North Americans competing in Europe was very low (<5%), whereas Europeans often competed in North-America (~25%). The rate of non-finishers between sexes was similar in all races with the exception of Deca Iron ultra-triathlon, which was much greater (~20%) for women. Non-finishers had slower race times in swimming and cycling splits than finishers. In conclusion, ultra-triathletes should redistribute their energy among swimming, cycling and running depending on their sex and distance of race. Performance in ultra-triathlons has been decreasing in men and women over the years, but sex difference in performance remained. Europeans were the fastest ultra-triathletes and compete in Europe and North America. Additionally, non-finishers were slower swimmers and cyclists than finishers.



**Keywords:** ultra-endurance; swimming; cycling; running; athlete.

# INTRODUCTION

The most popular distance in triathlon has been the traditional Ironman format that comprehends 3.8km of swimming, 180km of cycling and 42km of running[1]**.** Triathlons with greater distances than Ironman were usually called ultra-triathlons, in that regard, races that comprehended two, three or even ten times the distance of an Ironman has being held since 1985[2]. Since the beginning, ultra-triathlons increased their number of men and women participants becoming more popular every year[2]. Ultra-triathlons were one of the most challenge endurance events that an athlete could be part of. Even very good and experienced athletes that undertook this kind of races had a great risk to quit the race (*i.e.* non-finishers). Research showed that gastrointestinal issues was the main reason for dropouts in an Ironman race[3], but there were no scientific evidences to support athletes and coaches in their race strategy to an ultra-triathlon to avoid becoming a non-finisher.

Much has changed in exercise training in the past decades due to the advances in sports sciences, which could help coaches and athletes to achieve better performances than 10 or 15 years ago. For instance, the number of women participants has been increased in several sports decreasing the men-to-women ratio[4-6]. Moreover, women seemed to close the performance gap with men in several endurance sports, such as open-water swimming[4], running[5] or even Ironman triathlon[6]. But there were no such records in ultra-triathlons; instead, it was shown that the best women were actually increasing the gap to the best men[2]. In addition, pacing has been recognized as an important aspect of performance in ultra-endurance[7,8]; however, no study has compared the relative contribution of each discipline to the overall race time in ultra-triathlons of different

distances. Such information would be of great practical value for ultra-triathletes as they might compete in races of different distances, and likely should re-distribute their energy among the disciplines.

Furthermore, nationality may play its role through the climatic and cultural differences in each nation which may ease or difficult triathlon practice. The nationality impact in performance and number of participants could be of assistance to event organizers in order to set races in the most preferred locations for each nation, and where may be the fastest athletes. Some previous analysis demonstrated that no nation had a particular dominance in open-water swimming[4], whereas regarding to running East-Africans (*i.e.* Ethiopia and Kenya) were the fastest marathoners and ultra-marathoners[9]. Moreover, an analysis of Ironman triathlon demonstrated that nationality played an important role in pacing in all three disciplines and overall race time[10].

However, for the best of our knowledge the role of nationality, finisher/non-finisher, sex and performance trends such as pacing in ultra-triathlon has not yet been investigated. Therefore, the aim of the study was to investigate the trends of performance, pacing, nationality role, sex differences and rate of non-finishers in Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlons held from 1985 to 2018.

# MATERIALS AND METHODS

## Ethics approval

This study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland, with a waiver of the requirement for informed consent of the participants as the study involved the analysis of publicly available data.

## Sample

All data were the official results from Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlons held from 1985 to 2018. One of the authors collected all split and overall race times from race websites and organizers. The standard and traditional Ironman distance was 3.8km swim / 180km cycle / 42km run, thus the ultra-triathlon distance was as follow: Double Iron (7.6km swim / 360km cycle / 84km run) with 2,988 entries/athletes; Triple Iron (11.8km swim / 540km cycle / 126km run) with 1,724 entries/athletes; Quintuple Iron (19km swim / 900km cycle / 210km run) with 117 entries/athletes; and Deca Iron ultra-triathlon (38km swim / 1800km cycle / 420km run) with 220 entries/athletes; totalizing 5,049 athletes/entries. Competitors needed to perform a distance equal to Ironman distance per day in consecutive days. Data from both women and men were analyzed including overall and split race times, nationality, finisher/non-finisher status, event year and event host nation. Overall and split race times by event and sex were displayed in Table 1.

## Data analysis

Continuous data had normality and homogeneity assessed with Kolmogorov-Smirnov's and Levene's test, respectively. Since all continuous variables presented parametric

distribution, data were expressed and mean and standard deviation (±). Categorial variables were analyzed as frequency rates, Chi square and Cramer's Phi. The percentages of split race times to overall race times were calculated individually for each athlete and the mean and SD displayed in Table 1 (reason why the sum of %R in each event does not equals 100%).

**** Table 1 about here ****

Linear regressions were applied for performance trends. Performance trends with just the top-3 of each race in year were also performed. A one-way ANOVA was applied to compare to race times (overall and splits) between the nations in each event. A student *t*-test for independent samples was applied to compare the speed in splits (*i.e.* swimming and cycling) between finishers and non-finishers in each event. The significance level was 5% ($p < 0.05$). All procedures were performed using Statistical Software for the Social Sciences (SPSS v21.0, Chicago, IL, USA) and GraphPad Prism (Prism v6.0, San Diego, CA, USA).

# RESULTS

The percentage of spent in each discipline differed among the events ($p < 0.001$). In the swim split, significant differences among all events were identified ($p < 0.001$) with the longer the race, the smaller the percentage (*i.e.,* less relative time). For cycling, Double Iron had significantly larger % time than Triple and Deca Iron ($p < 0.001$), whereas in the running split, the longer the race higher the percentage, with statistical significant among all comparisons ($p < 0.001$). Additionally, women spent significantly more % time cycling than men, whereas men spent significantly more % time running in Double and Triple Iron. No sex differences were identified for Quintuple and Deca Iron.

The overall performance trend results revealed an increase in the average race time in all four events from 1985 to 2018 for both men and women, with an exception for the Deca Iron ultra-triathlon in females, which had a negative slope (Figure 1-A to 1-D). The performance trends with only the top-3 race times in each annual race showed a positive slope in overall race time for both women and men in all three events of Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlon (Figure 1-E to 1-H).

**** Figure 1 about here ****

For the performance trends of split race speed in females, negative slopes for the all three disciplines (swim, cycle, run) were identified in Double, Triple and Quintuple events, whereas the Deca Iron ultra-triathlon showed a positive slope (Figure 2-A to 2-D). Likewise, performance trends of split race speed in males showed negative slopes

171 for the all three disciplines (*i.e.* swim, cycle, and run) in Double, Triple and
172 Quintuple events, whereas Deca Iron ultra-triathlon showed a positive slope for the
173 cycling split but negative for swimming and running (Figure 2-E to 2-H)
174
175 ** **Figure 2 about here** **
176
177 The comparison of overall race times showed that Switzerland was the fastest in Double
178 Iron ($p < 0.001$), whereas France was the fastest in Triple ($p < 0.001$), Quintuple ($p =$
179 0.014), and Deca Iron ultra-triathlon ($p < 0.001$). Furthermore, the nation with a higher
180 participation in Double Iron and Quintuple Iron was the United States (USA), in Triple
181 Iron Germany, and Deca Iron ultra-triathlon France (Figure 3).
182
183 ** **Figure 3 about here** **
184
185 The comparison of split race times between nations were statistical significant for all
186 three disciplines in Double, Triple and Deca Iron ultra-triathlon, but only in running for
187 the Quintuple Iron (Figure 4). In the Double Iron and Triple Iron, Switzerland had
188 fastest swimmers and cyclists whereas Austria and France had the fastest runners
189 (Figure 4-A and 4-B). In Quintuple and Deca Iron ultra-triathlon, France and Germany
190 were the fastest in all three disciplines, being France the first in cycling and running
191 (Figure 4-C and 4-D).
192
193 ** **Figure 4 about here** **
194

Regarding the participation of Europeans and athletes living in North America (*i.e.* USA, Canada and Mexico) in events, Europeans presented the majority of participants in races taking place in Europe in all four events (*i.e.* Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlons). Moreover, Europeans also showed a massive participation in races taking place in North America, being more than 25% in Double and Triple and the majority in Deca Iron ultra-triathlon (Figure 5).

**** Figure 5 about here ****

The rate of participants who did not finish (DNF) a race was similar between women and men in Double Iron (~7.0%), Triple Iron (~5.1%), and Quintuple Iron (~8.8%), but the differences were larger in Deca Iron ultra-triathlon, being of approximately 22% more DNF in women. Deca Iron ultra-triathlon was the event with less DNF for men, whereas Triple Iron was the event with less DNF for women (Table 2).

**** Table 2 about here ****

Split times (*i.e.* swimming and cycling) of DNF were higher for both men and women in Double and Triple Iron ultra-triathlon, with an exception for cycling in women in the Triple Iron ultra-triathlon (Figure 6-A and 6-B). DNF men swimmers were slower than finishers in Quintuple Iron ultra-triathlon (Figure 6-C). No statistical significances were identified for Deca Iron ultra-triathlon (Figure 6-D).

**** Figure 6 about here ****

# DISCUSSION

The main findings of the present study were that the athletes spent less % time in swimming and cycling, and more % time in running as the distance of event was longer; women spent more % time in cycling and less % time in running in Double and Triple Iron ultra-triathlon. In addition, the overall race time became slower across calendar years for all events. We hypothesized that this would be a result of increasing number of participants, but even when only including the top three the race time slope remained positive. Furthermore, Switzerland and France were the fastest nations in ultra-triathlons, where swimming and cycling were the best disciplines for Switzerland and cycling and running for France. Additionally, North-Americans competed mostly in events held in North-America, whereas Europeans competed in both Europe and North-America. The rate of non-finishers was similar for women and men in all events except the Deca Iron which was higher for women, and non-finishers swim and cycle was slower than in finishers in all events for both men and women.

With the regards to pacing, the differences in the relative contribution of each discipline to the overall race time indicated that triathletes redistributed their energy among the three disciplines depending on the distance of the races. Moreover, the findings suggested that triathletes became relatively faster in swimming and cycling, and relatively slower in running as the distance increased. In turn, this observation might be attributed to an increased exercise-induced fatigue in running compared to the other two exercise modes. It has been previously suggested that exercise economy was also important for performance in addition to maximal oxygen uptake[11]. In events of longer distance, running became more an “intermediate” discipline - a discipline that would be

245 followed by the discipline of the next day (swimming) - rather than a “last” discipline.
246 Instead, when running was the “last” discipline - as it happened more often in the
247 shorter distances, the triathletes could perform it at a higher exercise intensity (*i.e.* less
248 economical)[12].
249
250 The performance trends results were opposite from what has been observed in open-
251 water swimming[13], marathons[14] or Ironman triathlon[6,15] showing an improvement in
252 performance over the years. A previous analysis from ultra-triathlons also showed a
253 positive slope for race winners from 1985 to 2009[2]. We hypothesized that the reduced
254 mean performance would be a reflection of an increased number of participants, but
255 when analyzing only the top three athletes in each race performance continued in a
256 positive slope for overall race time for both men and women in all four events for
257 Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlon. Since there is
258 evidence that elite triathletes were becoming faster every year[15,16], it is possible that
259 ultra-triathlons were becoming less popular among the fastest triathletes that may be
260 focusing on different challenges, such as a classification to the Ironman World
261 Championship in Kona-Kailua, Hawaii[17], and are now attracting older and experienced
262 athletes not so focused on the race time performance.
263
264 Regarding the nationality analysis, Europeans were racing in both Europe and North
265 America, whereas athletes living in North America (*i.e.* Mexico, USA and Canada)
266 have only participated in events taking place in North America. This result may
267 reverberate in performance, since Switzerland, France and Germany were the fastest
268 nations in the present analysis. This is a novelty, since triathlon was originated in the
269 USA[17,18] and the World Championship and qualifying races of Ironman have been
270 dominated by women and men from the USA[19]. However, this scenario has been

changing in the last two decades[10]. Furthermore, some previous analysis of Double and Triple Iron ultra-triathlon also showed a dominance of Europeans in these events[20].

The rate of non-finishers was similar between men and women in Double Iron, Triple Iron, Quintuple Iron, but much higher in Deca Iron ultra-triathlon with an increased rate of non-finisher women. It was previously described that an ultra-triathlon leads to a loss skeletal muscle mass[21]. Although women possibly lose less muscle mass than men due to their reduced initial values, it may be enough to cause greater impact in their performance than men[22]. Thus, body composition may be a limiting factor for the discrepant performance and the ability to finish such a race. On the other hand, it is noteworthy that women have being closing the performance gap with men in several endurance sports including Ironman triathlon[6], but the sex difference does not seem to reduce over time in ultra-triathlons.

The average split race times of men and women non-finishers were higher than in finishers. Although a slower pace may save more energy, may be a reflect of less experience and physical fitness to the race, and it also exposes that athlete to an increased time over exercise stress, which means more hydration, food and also a possible gastrointestinal discomfort[23,24], a main cause for dropouts in Ironman races[3]. Some previous analysis in pacing of ultra-triathletes showed that best overall athletes were slower in swimming and cycling but fastest in running[12]. In sum, ultra-triathletes should account their experience and limitations to set the best individual strategy to which discipline to go faster.

## PERSPECTIVE

This is an update analysis of ultra-triathlons with all available data from races that have taken place from 1985 to 2018. The limitations of the present study may be accountable for some unavailable information that could help explain some results, such as the years of experience in triathlons (and/or ultra-triathlons). Furthermore, scientific literature lacks information regarding physiological responses before (preparation), during and after an ultra-triathlon, such information would for a great assistance to understand both great performances and physiological factors for dropouts.

In conclusion, ultra-triathletes should redistribute their energy among swimming, cycling and running depending on their sex and distance of a race. Also, the average performance in ultra-triathlons decreased in both men and women over the years, but the number of participants increased. Europeans, more specifically Swiss, French and Germans, were the fastest ultra-triathletes, especially Switzerland's swimmers, France's cyclists and Germany's runners when considering performance by discipline. Europeans seemed to compete in races in Europe and North America, whereas North Americans competed mostly in North America. The performance gap between men and women remained unchanged in ultra-triathlons. Additionally, non-finishers were slower swimmers and cyclists than finishers, and women had more dropouts than men in Deca Iron ultra-triathlon.

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**Table 1** Overall and split race time (minutes) of women and men in ultra-triathlons from 1985 to 2018

| | Double | Triple | Quintuple | Deca |
|---|---|---|---|---|
| Overall | | | | |
| Female | 1,862.1 ± 255.6 | 3,004.8 ± 440.8 | 7,338.9 ± 1,390.3 | 17,667.3 ± 1,858.4 |
| Male | 1,734.0 ± 250.8 | 2,875.8 ± 413.6 | 6,698.0 ± 1,210.0 | 15,983.3 ± 2,479.6 |
| Swimming | | | | |
| Female | 172.6 ± 33.9 | 255.9 ± 35.5 | 564.0 ± 143.6 | 1,221.3 ± 368.6 |
| %R | 9.1 ± 1.6[e] | 8.5 ± 1.3[e] | 7.7 ± 1.8[e] | 6.7 ± 1.0[e] |
| Male | 159.9 ± 33.0 | 243.9 ± 43.2 | 495.5 ± 87.8 | 1,088.9 ± 267.6 |
| %R | 9.1 ± 1.6[e] | 8.4 ± 1.2[e] | 7.4 ± 1.3[e] | 6.7 ± 1.5[e] |
| Cycling | | | | |
| Female | 947.9 ± 142.7 | 1,511.3 ± 224.9 | 3,778.3 ± 841.2 | 9,129 ± 2,092.4 |
| %R | 50.1 ± 3.5[d*] | 50.1 ± 3.5[*] | 49.7 ± 3.4 | 48.5 ± 5.0 |
| Male | 860.3 ± 136.2 | 1,412.7 ± 225.3 | 3.323.9 ± 720.7 | 7,951.7 ± 1,603 |
| %R | 49.3 ± 3.6[bd] | 48.8 ± 4.2 | 48.5 ± 4.3 | 48.4 ± 4.6 |
| Running | | | | |
| Female | 752.1 ± 143.7 | 1,235.5 ± 257.9 | 3.068.8 ± 575.9 | 7,794.2 ± 835.3 |
| %R | 40.2 ± 3.7[e*] | 40.9 ± 3.9[d*] | 41.9 ± 3.6 | 44.4 ± 4.7 |
| Male | 715.9 ± 139.6 | 1,225.7 ± 247.5 | 2,911.2 ± 669.6 | 7,148.6 ± 1,464.8 |
| %R | 41.1 ± 4.1[e] | 42.4 ± 4.5[d] | 43.4 ± 5.4 | 44.6 ± 4.9 |

%R: percentage of total race time; [a]: different from Double Iron; [b]: different from Triple Iron; [d]: different from Deca Iron; [e]: different from all other events; *: different from males.

384 **Table 2** Number and rate of women and men finishers and non-finishers in ultra-
385 triathlons from 1985 to 2018
386

| | | Female | | Male | | *p*-value (Cramer's ϕ) |
|---|---|---|---|---|---|---|
| Double | | F | DNF | F | DNF | |
| | N | 246 | 89 | 2,133 | 520 | 0.004 |
| | % | 73.4 | 26.6 | 80.4 | 19.6 | (0.003) |
| Triple | | | | | | |
| | N | 136 | 33 | 1172 | 383 | 0.156 |
| | % | 80.5 | 19.5 | 75.4 | 24.6 | (0.141) |
| Quintuple | | | | | | |
| | N | 15 | 6 | 77 | 19 | 0.386 |
| | % | 71.4 | 28.6 | 80.2 | 19.8 | (0.374) |
| Deca | | | | | | |
| | N | 17 | 10 | 164 | 29 | 0.012 |
| | % | 63.0 | 37.0 | 85.0 | 15.0 | (0.005) |

387 F: finishers; DNF: non-finishers

## FIGURES LEGENDS

**Figure 1.** Performance trends of overall race time of men and women competing in ultra-triathlons from 1985 to 2018. Panels E, F, G and H included only top-3 athletes in each race.

**Figure 2.** Performance trends of split race time of women (panels A, B, C and D) and men (panels E, F, G and H) competing in ultra-triathlons from 1985 to 2018.

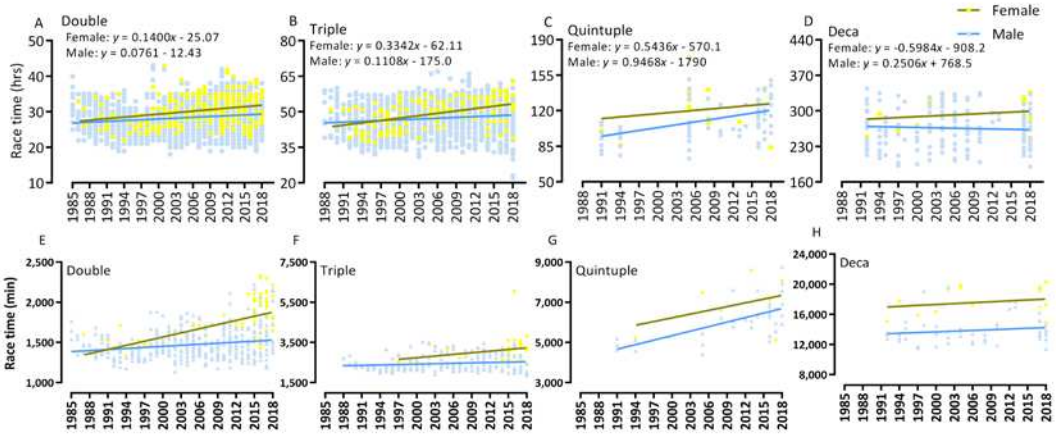
**Figure 3.** Overall race times (solid black circles) and participation (gray bars) in ultra-triathlons of different nations from 1985 to 2018.

**Figure 4.** Split race times (swimming, cycling and running) of different nations competing in ultra-triathlons from 1985 to 2018. *: statistical significance, between-nation effect.

**Figure 5.** Frequency rate of participation of Europeans, people born in North America (US, Canada and Mexico) in events that takes place in Europe or North America.

**Figure 6.** Split race times of finishers and athletes that do not finished (DNF) ultra-triathlons. Data from men (blue) and women (red) from 1985 to 2018. *: statistical difference between the groups ($p < 0.05$).

410 **Figure 1.**




411

412 **Figure 2.**

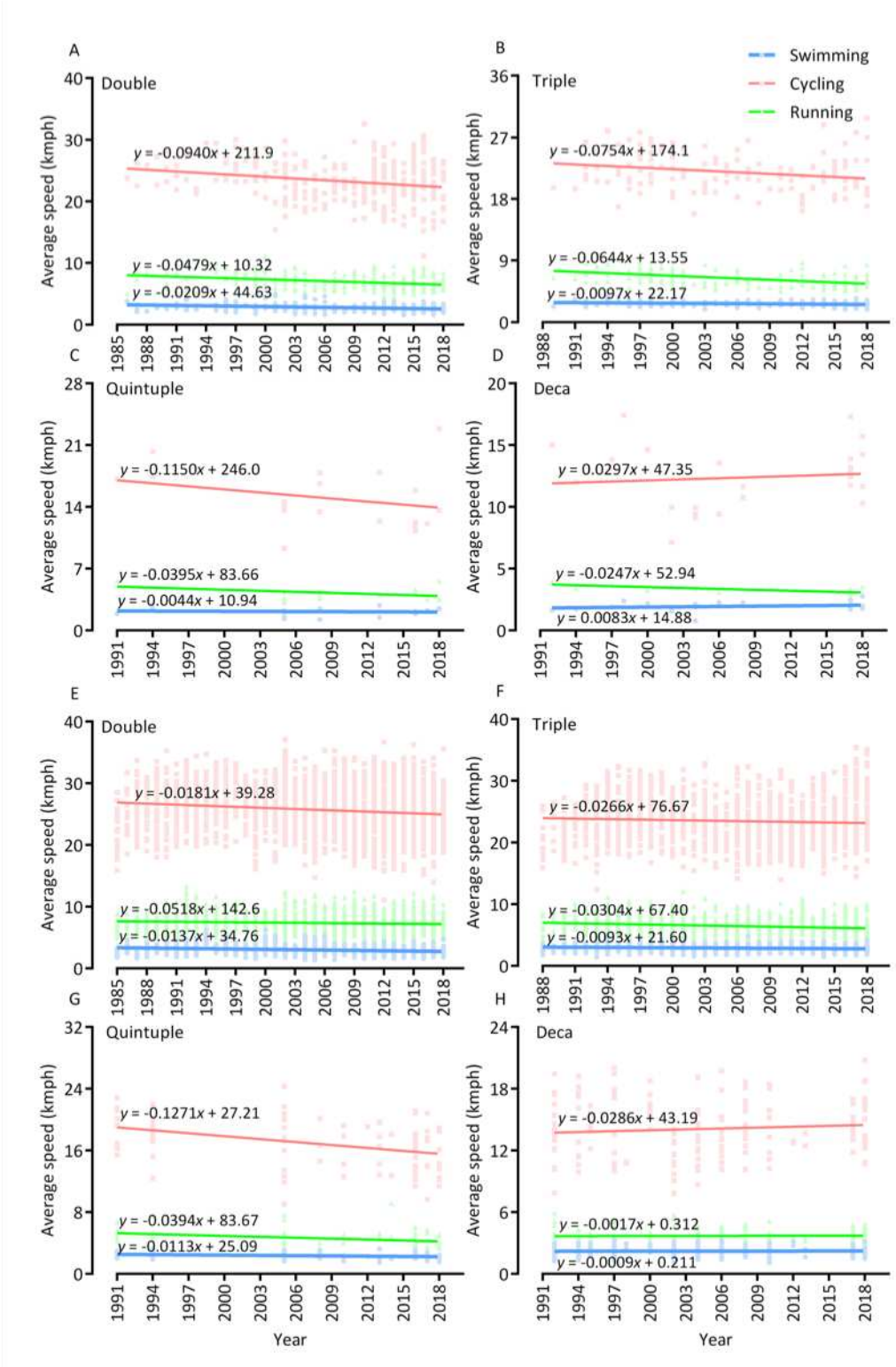



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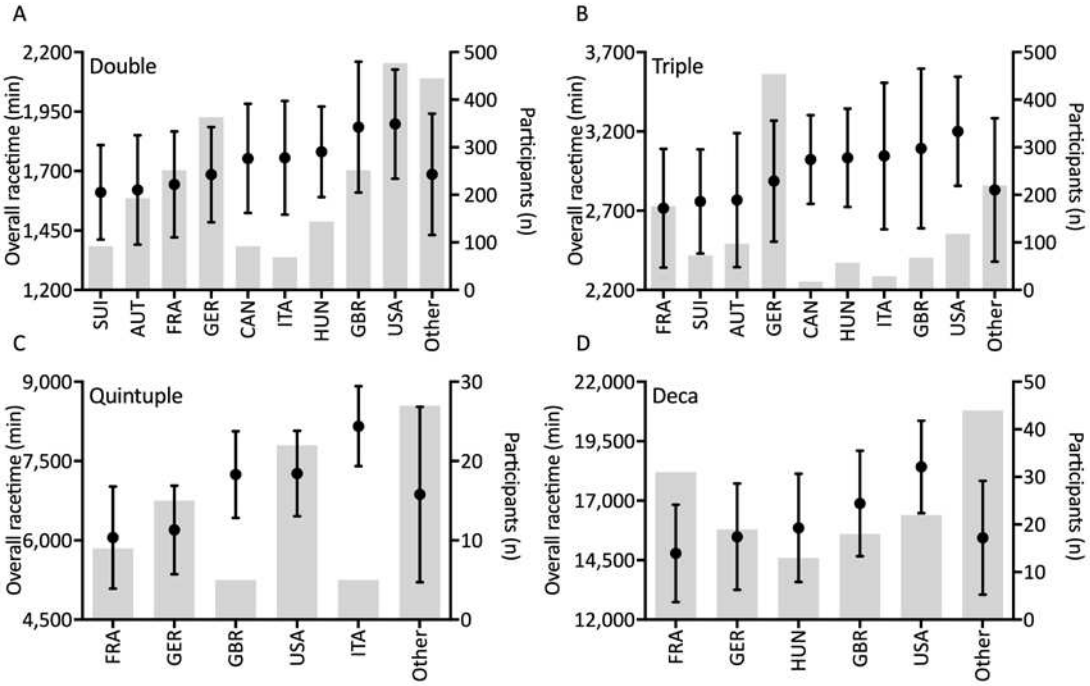
**Figure 3.**


A
Double
Overall racetime (min)
2,200
1,950
1,700
1,450
1,200
Participants (n)
500
400
300
200
100
0
SUI
AUT
FRA
GER
CAN
ITA
HUN
GBR
USA
Other
B
Triple
Overall racetime (min)
3,700
3,200
2,700
2,200
Participants (n)
500
400
300
200
100
0
FRA
SUI
AUT
GER
CAN
HUN
ITA
GBR
USA
Other
C
Quintuple
Overall racetime (min)
9,000
7,500
6,000
4,500
Participants (n)
30
20
10
0
FRA
GER
GBR
USA
ITA
Other
D
Deca
Overall racetime (min)
22,000
19,500
17,000
14,500
12,000
Participants (n)
50
40
30
20
10
0
FRA
GER
HUN
GBR
USA
Other

417 **Figure 4.**

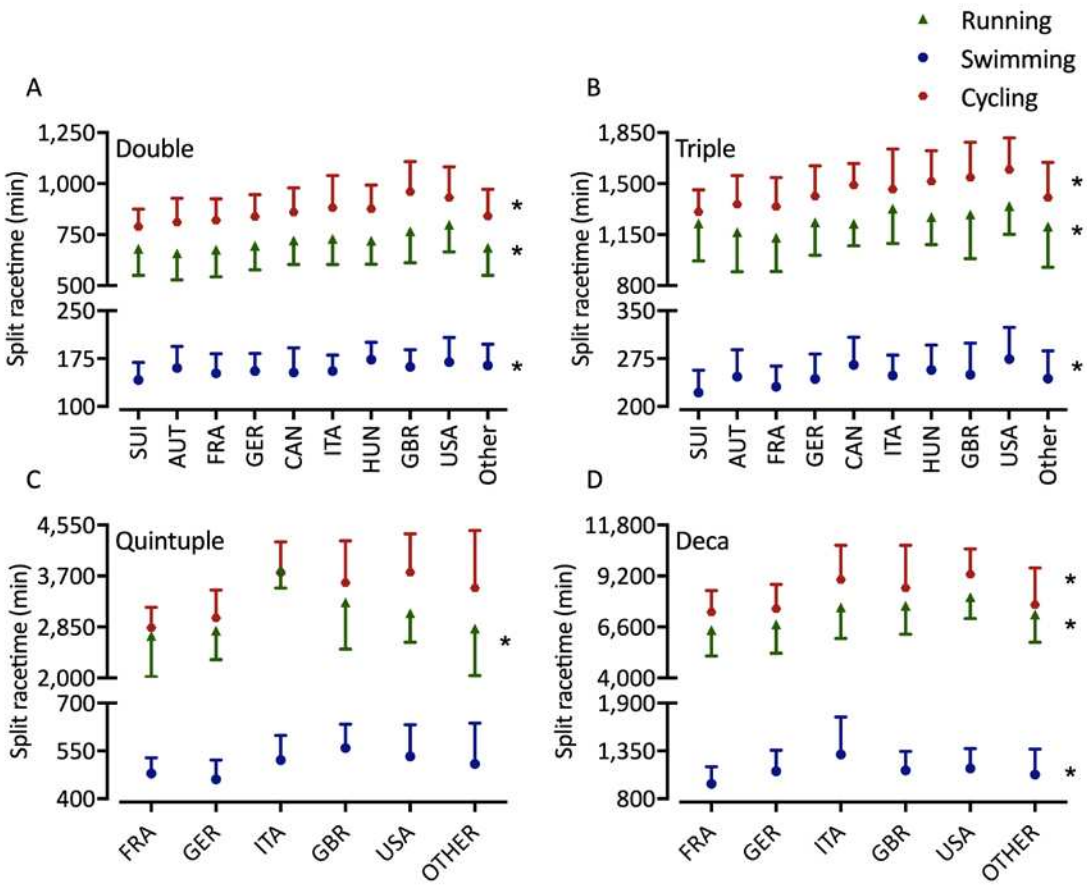



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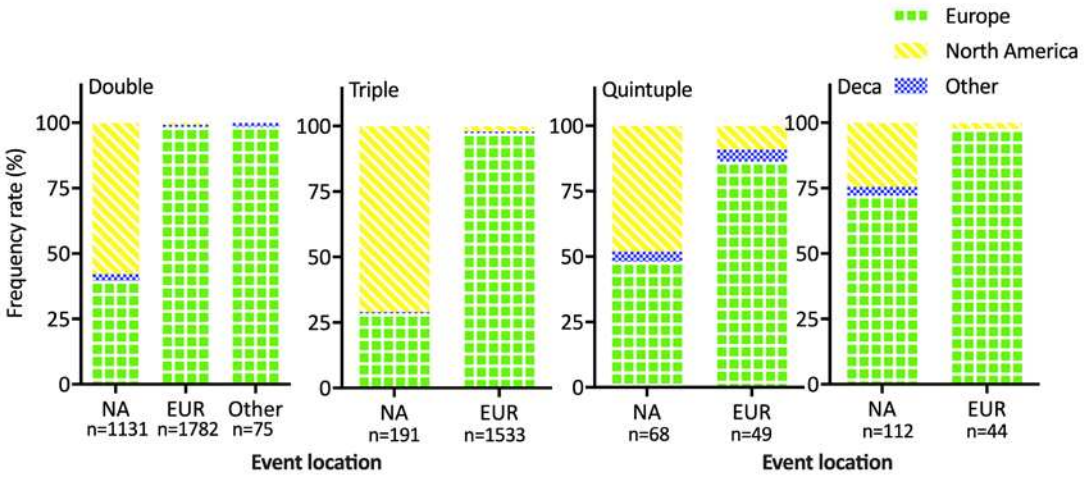
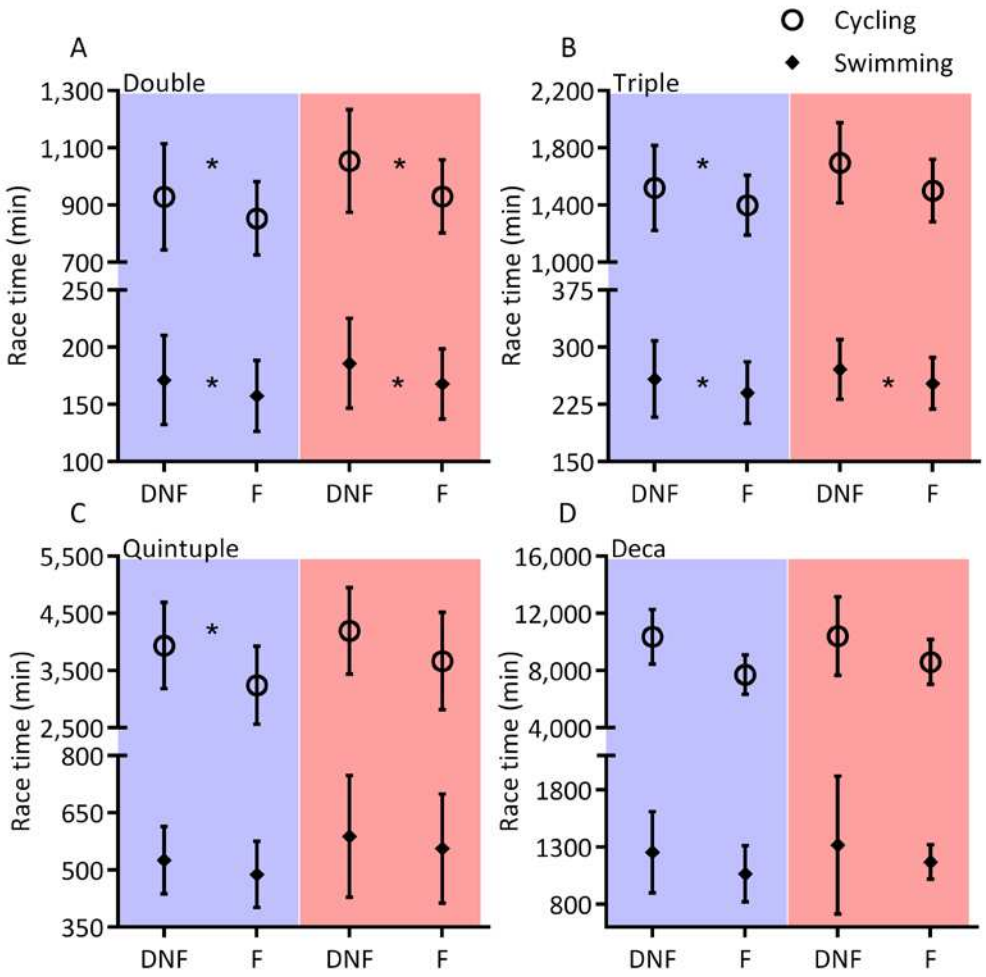
**Figure 5.**


Europe
North America
Other
Double
Triple
Quintuple
Deca
Frequency rate (%)
100
75
50
25
0
NA
n=1131
EUR
n=1782
Other
n=75
NA
n=191
EUR
n=1533
NA
n=68
EUR
n=49
NA
n=112
EUR
n=44
Event location
Event location

422 **Figure 6.**

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