



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

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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 to 2018 were collected including Double Iron, Triple Iron, Quintuple Iron, and Deca Iron ultra-triathlons. Different pacing patterns by event and sex were observed ($P < .05$); 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.

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

3
4 **Running head: Ultra-triathlon performance analysis**

5
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38 **ABSTRACT**

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

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

61 INTRODUCTION

62

63 The most popular distance in triathlon has been the traditional Ironman format that
64 comprehends 3.8km of swimming, 180km of cycling and 42km of running¹. Triathlons
65 with greater distances than Ironman were usually called ultra-triathlons, in that regard,
66 races that comprehended two, three or even ten times the distance of an Ironman has
67 being held since 1985². Since the beginning, ultra-triathlons increased their number of
68 men and women participants becoming more popular every year². Ultra-triathlons were
69 one of the most challenge endurance events that an athlete could be part of. Even very
70 good and experienced athletes that undertook this kind of races had a great risk to quit
71 the race (*i.e.* non-finishers). Research showed that gastrointestinal issues was the main
72 reason for dropouts in an Ironman race³, but there were no scientific evidences to
73 support athletes and coaches in their race strategy to an ultra-triathlon to avoid
74 becoming a non-finisher.

75

76 Much has changed in exercise training in the past decades due to the advances in sports
77 sciences, which could help coaches and athletes to achieve better performances than 10
78 or 15 years ago. For instance, the number of women participants has been increased in
79 several sports decreasing the men-to-women ratio⁴⁻⁶. Moreover, women seemed to
80 close the performance gap with men in several endurance sports, such as open-water
81 swimming⁴, running⁵ or even Ironman triathlon⁶. But there were no such records in
82 ultra-triathlons; instead, it was shown that the best women were actually increasing the
83 gap to the best men². In addition, pacing has been recognized as an important aspect of
84 performance in ultra-endurance^{7,8}; however, no study has compared the relative
85 contribution of each discipline to the overall race time in ultra-triathlons of different

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

89

90 Furthermore, nationality may play its role through the climatic and cultural differences
91 in each nation which may ease or difficult triathlon practice. The nationality impact in
92 performance and number of participants could be of assistance to event organizers in
93 order to set races in the most preferred locations for each nation, and where may be the
94 fastest athletes. Some previous analysis demonstrated that no nation had a particular
95 dominance in open-water swimming⁴, whereas regarding to running East-Africans (*i.e.*
96 Ethiopia and Kenya) were the fastest marathoners and ultra-marathoners⁹. Moreover, an
97 analysis of Ironman triathlon demonstrated that nationality played an important role in
98 pacing in all three disciplines and overall race time¹⁰.

99

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

105 **MATERIALS AND METHODS**

106

107 **Ethics approval**

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

111

112 **Sample**

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

126

127 **Data analysis**

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

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

135

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

137

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

146 **RESULTS**

147

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

156

157 The overall performance trend results revealed an increase in the average race time in
158 all four events from 1985 to 2018 for both men and women, with an exception for the
159 Deca Iron ultra-triathlon in females, which had a negative slope (Figure 1-A to 1-D).

160 The performance trends with only the top-3 race times in each annual race showed a
161 positive slope in overall race time for both women and men in all three events of
162 Double Iron, Triple Iron, Quintuple Iron and Deca Iron ultra-triathlon (Figure 1-E to 1-
163 H).

164

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

166

167 For the performance trends of split race speed in females, negative slopes for the all
168 three disciplines (swim, cycle, run) were identified in Double, Triple and Quintuple
169 events, whereas the Deca Iron ultra-triathlon showed a positive slope (Figure 2-A to 2-
170 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

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

201

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

203

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

209

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

211

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

217

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

219

220 **DISCUSSION**

221

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

235

236 With the regards to pacing, the differences in the relative contribution of each discipline
237 to the overall race time indicated that triathletes redistributed their energy among the
238 three disciplines depending on the distance of the races. Moreover, the findings
239 suggested that triathletes became relatively faster in swimming and cycling, and
240 relatively slower in running as the distance increased. In turn, this observation might be
241 attributed to an increased exercise-induced fatigue in running compared to the other two
242 exercise modes. It has been previously suggested that exercise economy was also
243 important for performance in addition to maximal oxygen uptake¹¹. In events of longer
244 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 swimming¹³, marathons¹⁴ 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 2009². 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, Hawaii¹⁷, 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 USA¹⁹. However, this scenario has been

271 changing in the last two decades¹⁰. Furthermore, some previous analysis of Double and
272 Triple Iron ultra-triathlon also showed a dominance of Europeans in these events²⁰.

273

274 The rate of non-finishers was similar between men and women in Double Iron, Triple
275 Iron, Quintuple Iron, but much higher in Deca Iron ultra-triathlon with an increased rate
276 of non-finisher women. It was previously described that an ultra-triathlon leads to a loss
277 skeletal muscle mass²¹. Although women possibly lose less muscle mass than men due
278 to their reduced initial values, it may be enough to cause greater impact in their
279 performance than men²². Thus, body composition may be a limiting factor for the
280 discrepant performance and the ability to finish such a race. On the other hand, it is
281 noteworthy that women have been closing the performance gap with men in several
282 endurance sports including Ironman triathlon⁶, but the sex difference does not seem to
283 reduce over time in ultra-triathlons.

284

285 The average split race times of men and women non-finishers were higher than in
286 finishers. Although a slower pace may save more energy, may be a reflect of less
287 experience and physical fitness to the race, and it also exposes that athlete to an
288 increased time over exercise stress, which means more hydration, food and also a
289 possible gastrointestinal discomfort^{23,24}, a main cause for dropouts in Ironman races³.

290 Some previous analysis in pacing of ultra-triathletes showed that best overall athletes
291 were slower in swimming and cycling but fastest in running¹². In sum, ultra-triathletes
292 should account their experience and limitations to set the best individual strategy to
293 which discipline to go faster.

294

295 **PERSPECTIVE**

296

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

304

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

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377 **Table 1** Overall and split race time (minutes) of women and men in ultra-triathlons
 378 from 1985 to 2018
 379

	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

380 %R: percentage of total race time; ^a: different from Double Iron; ^b: different from Triple
 381 Iron; ^d: different from Deca Iron; ^e: different from all other events; *: different from
 382 males.
 383

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		<i>p</i> -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

388 **FIGURES LEGENDS**

389

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

393

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

396

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

399

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

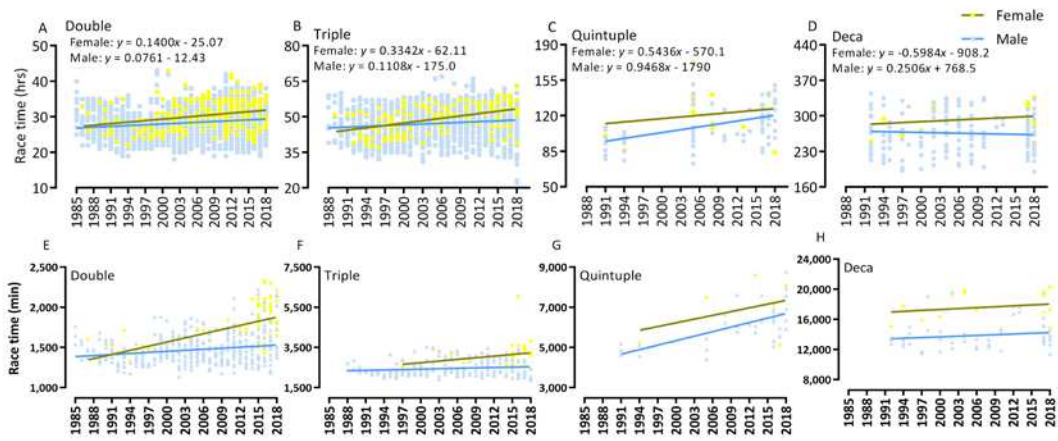
403

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

406

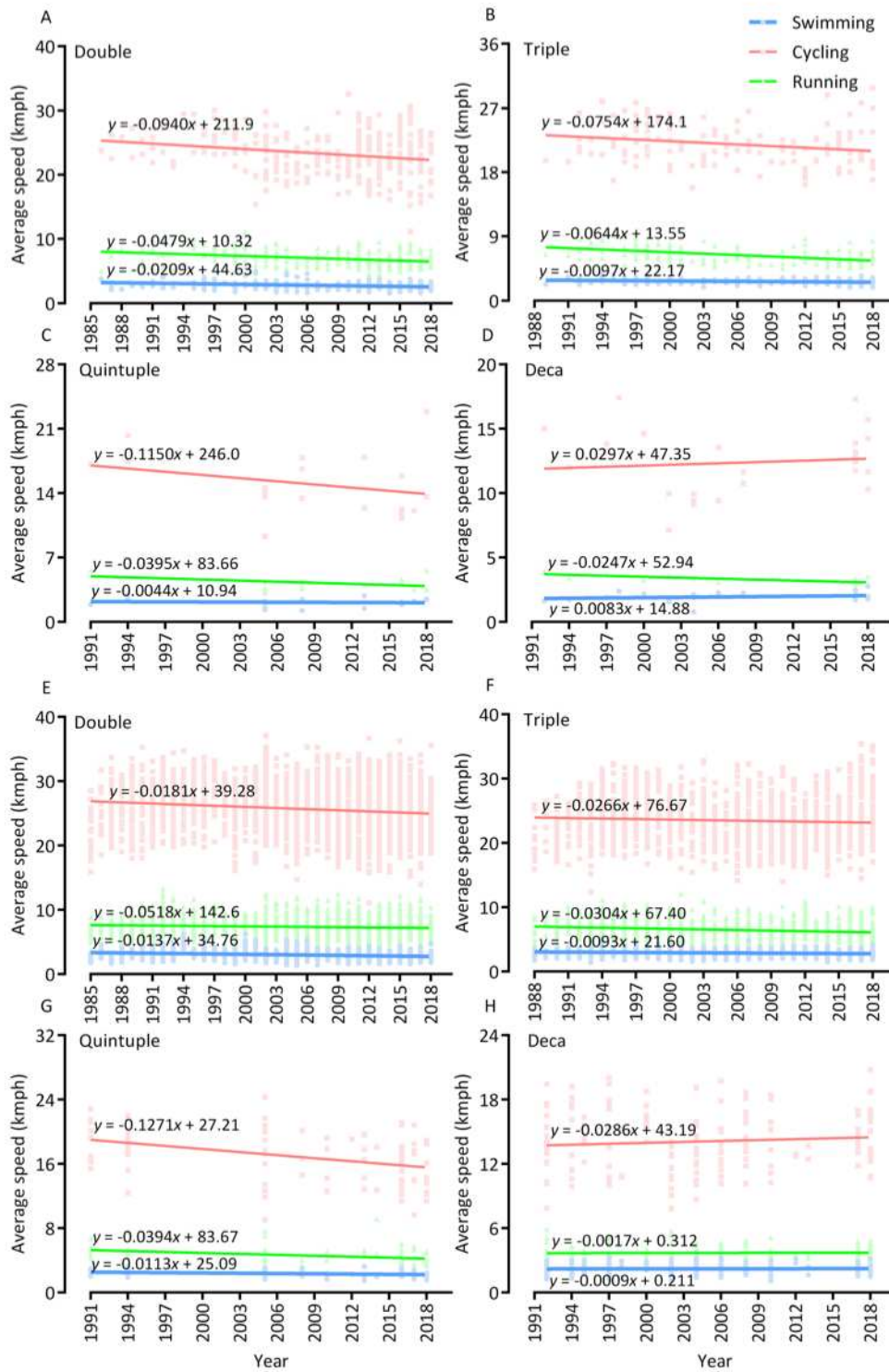
407 **Figure 6.** Split race times of finishers and athletes that do not finished (DNF) ultra-
408 triathlons. Data from men (blue) and women (red) from 1985 to 2018. *: statistical
409 difference between the groups ($p < 0.05$).

410 **Figure 1.**



411

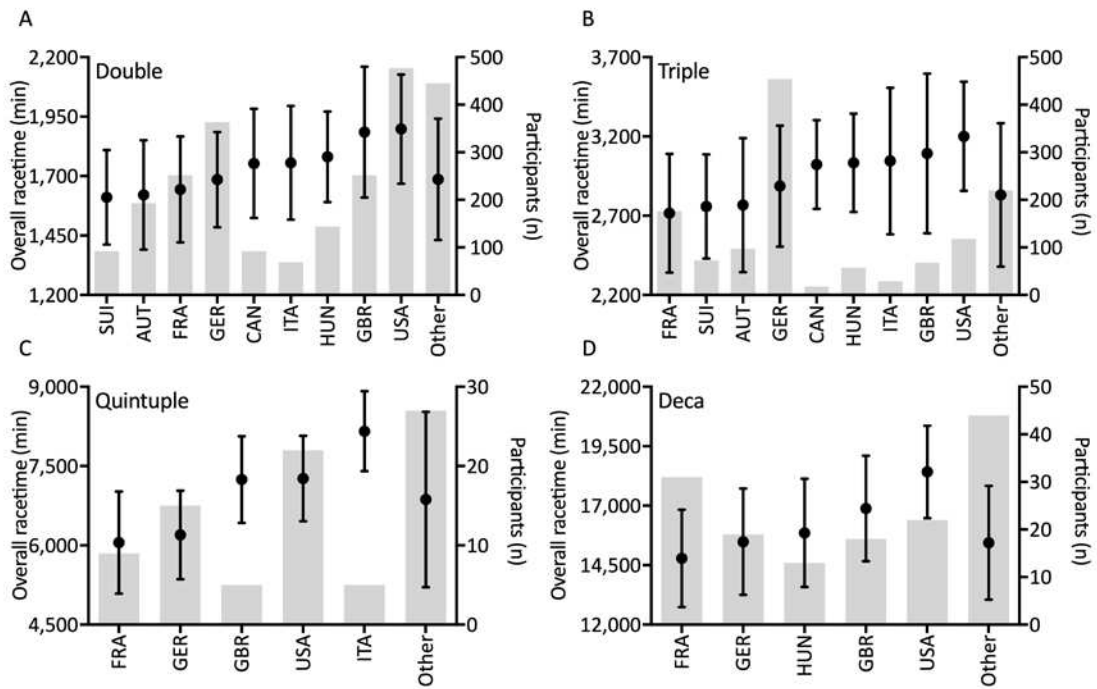
412 **Figure 2.**



413

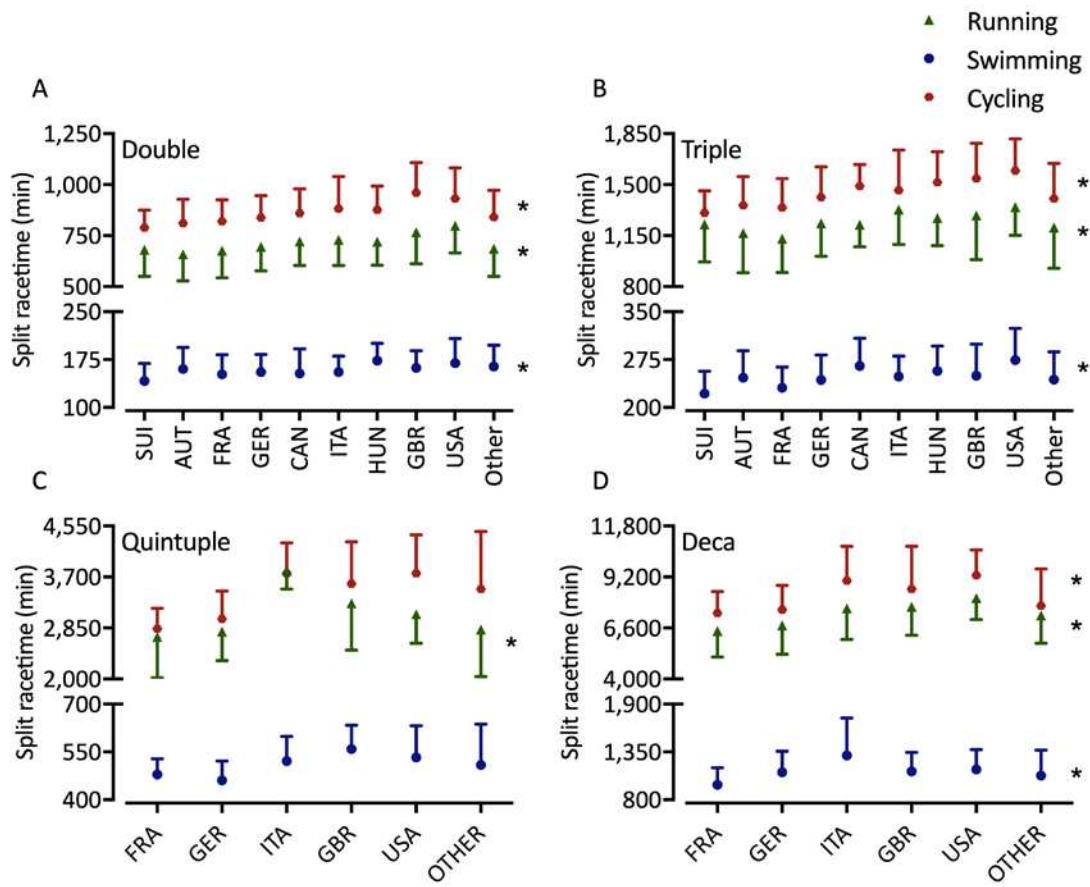
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415 **Figure 3.**



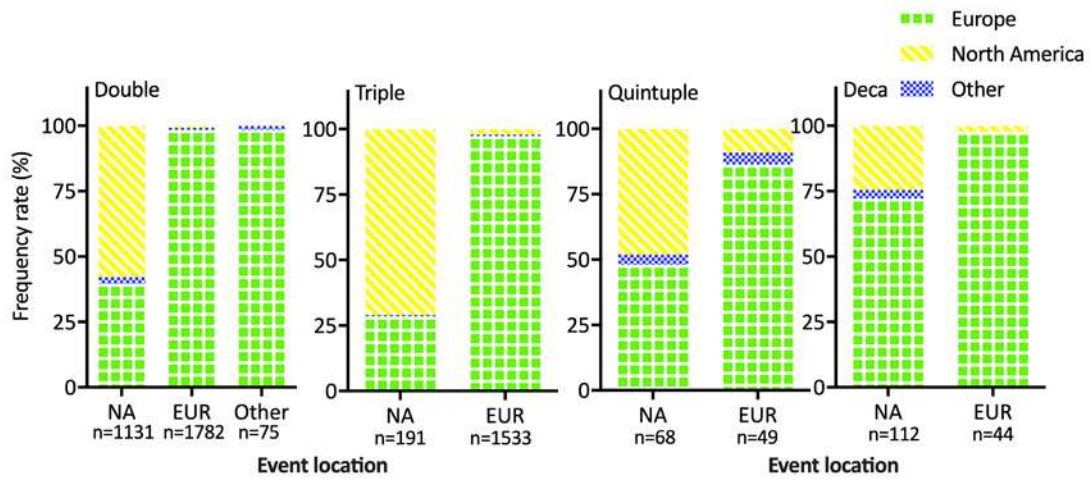
416

417 **Figure 4.**



418

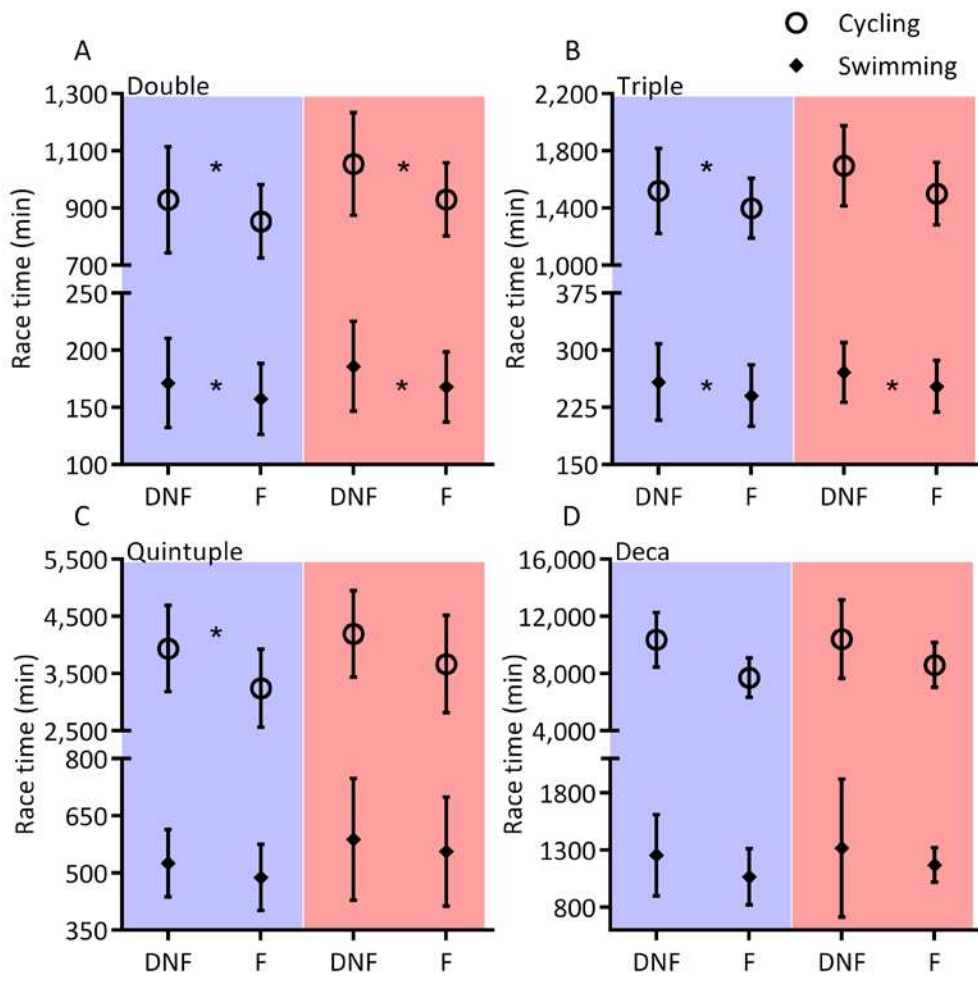
419 **Figure 5.**



420

421

422 **Figure 6.**



423