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A Descriptive Analysis of the Fastest Race Courses for Triathletes

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ABSTRACT

Background: For Ironman® triathlon, it has been reported that most of the finishers and the fastest women and men in Ironman® Hawaii originated from the United States of America (USA). We have, however, no knowledge of where the fastest race courses in the Ironman® 70.3 triathlon took place. We aim to analyse where the Ironman® 70.3 races were held and where the fastest split and overall race times were achieved.

Methods: The athletes' sex, age group, country of origin, and split times for swimming, running, cycling, and transitioning were obtained from the official Ironman® website. To investigate the locations of the fastest Ironman® 70.3 competitions between 2004 and 2020, a full sample of 852,721 qualifying records throughout 197 different event locations was processed. These race records were aggregated by location, and each location's split and full finish times were calculated. Data analysis was performed first for the full sample (all race records), and then for an elite sub-sample consisting of the top 100 males and top 100 females records in each location.

Results: For the full sample, the fastest overall race times were achieved in Ironman® 70.3 Zell am See (Austria). For the top 100 athletes sub-sample, the Ironman® 70.3 European Championship Elsinore and Ironman® 70.3 World Championship were the fastest courses.

Conclusion: These results are useful for athletes' strategic planning and inform event organisers about the strengths of different courses, aiding in the optimisation and promotion of future Ironman® 70.3 races worldwide.

Keywords: endurance, performance, half-distance Ironman®, multi-sport, running.

INTRODUCTION

Triathlon is a multi-sports discipline consisting of various distances of swimming, cycling, and running (e.g., Ironman® Hawaii, Olympic distance triathlon). Long-distance triathlon races such as the Ironman® Hawaii (3.8 km swimming, 180 km cycling, and 42.195 km running) are very popular among the practitioners (Lepers, 2008). Apart from the Ironman® Hawaii held annually as the World Championship in Ironman® triathlon, the Olympic distance triathlon (1.5 km swimming, 40 km cycling, and 10 km running) has been known to a broader audience since its inauguration in the Olympic Games. Similarly, the popularity of the half-Ironman® distance – also called Ironman® 70.3, has increased over time. The Ironman® 70.3 refers to the total distance in miles (113.0 km) covered in a race, being a 1.2-mile (1.9 km) swim, 56-mile (90 km) bike ride, and a 13.1-mile (21.1 km) run.

Among endurance sports disciplines, it is well-established that specific countries/cities dominate some race events, such as East Africa (*i.e.,* Ethiopia, Kenya) dominating long-distance running such as marathon running (World Athletics, 2022), and runners from Jamaica dominating sprint disciplines. Similarly, it has been shown that athletes from Russia were the fastest in specific ultra-marathon running races (*i.e.,* 100-km ultra-marathon and Comrades Marathon) and in certain cross-country skiing races (*i.e.,* Vasaloppet and Engadin Ski Marathon) (B Knechtle et al., 2020; B. Knechtle et al., 2020). For triathlon, there is some evidence regarding a greater rate of participation among athletes from the USA, as well as, some of the fastest triathletes in Ironman® Hawaii originated from the USA (Dähler et al., 2014; Rüst et al., 2015).

If the scientific literature has a body of information about the predominance of certain nations in sports disciplines, little data is available regarding the conditions of the event that could help athletes achieve the best results (Hermand et al., 2019). Since each triathlon discipline is centred on a specific natural element (i.e., water, air, and earth) triathletes constantly interact with the environment, changing behaviours to better address each challenge faced during training and competition (Verchère, 2017). For example, in the context of the marathon, the George Marathon, St. George, Utah, USA, and Mendoza Marathon, Argentina, are races known for being fast races as there are many downhill runs and favourable climatic conditions. Since each discipline in the triathlon is also dependent on weather conditions and the altitude of the race (Harnish et al., 2021), it is expected that in certain regions with advantageous topographic characteristics and environmental conditions, the race will be much faster than in others. The main purpose of this study is to analyse where the fastest split and overall race times were achieved for athletes competing in Ironman® 70.3.

METHODS

Ethical 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 (EKSG 01/06/2010). The study was conducted following recognised ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

DATA SET AND DATA PREPARATION

The athlete data was downloaded from the official Ironman® website (www.ironman.com) using a Python script. The athletes' sex, age group, country of origin, and times for swimming, running, cycling, and transitioning were thus obtained. Age group was available only for amateur (age group) athletes. We analysed both successful elite (professional) finishers and age group athletes of all Ironman® 70.3 races recorded on the Ironman® website between 2004 and 2020. Data considered for analysis were the time of each split discipline of Ironman® 70.3 distance, considering swimming, cycling, running, and transition times (represented by transition 1 - swimming for cycling, and transition 2 - cycling for running) and overall race time (all in seconds). Exclusion criteria were (i) athletes who did not start, (ii) disqualified athletes, (iii) athletes with at least one missing split time, (iv) inconsistent times (*i.e*., impossible split times or final times smaller than split times, etc.).

Statistical analysis. To investigate the locations of the fastest Ironman® 70.3 competitions between 2004 and 2020, a full sample of 852,721 qualifying records throughout 197 different Ironman® 70.3 event locations were processed. The race records were aggregated by location and then the statistical values (mean, std, max, and min) of split and full finish times were calculated for each location. Results are presented using strip plots that show graphically the distribution of full and split times in each location by gender, along with detailed tables displaying the descriptive statistical values. Both tables and charts are sorted by mean time for easy identification of the fastest locations. This analysis was then repeated with an elite sub-sample of the top 100 males and top 100 females (when available) in each of the 197 unique locations, resulting in a sample size of 38,252 records. The statistical significance of the differences observed is proven in each case using two-way or three-way analysis of variance (ANOVA) tests. The significance level was set at 0.05% in all cases. All data processing and analysis were performed using Python and a Google Colab notebook.

RESULTS

Table 1 presents descriptive information (*i.e.,* general weather conditions, the topography of swimming, cycling, and running course) regarding the environmental conditions over the race courses with most of the successful Ironman® 70.3 finishers. **Figure 1** summarises the 10 fastest locations sorted by overall race times and split times. The fastest Ironman® 70.3 overall race times were achieved in Ironman® 70.3 Zell am See (Austria). Descriptive information for the race courses indicates a temperature of 19 ºC, covering swimming in a lake, a difference of 1270 m on overall altitude in cycling. For running, the athletes cover 2 laps of 21.1 km, in a course with an altitude difference of 26 m per lap. For swimming, cycling, and running split disciplines, the fastest times were achieved in Ironman® 70.3 Connecticut, Ironman® 70.3 Zell am See (Austria), and Ironman® 70.3 Costa Navarino (Greece), respectively (**Figure 2, Figure 3,** and **Figure 4**). Significant differences were showed between race courses.

Table 1. **Descriptive information of the Ironman® 70.3 race courses.**

Race	Month	Average temperature (°C)	Swimming course characteristics	Cycling course characteristics	Running course characteristics
IRONMAN® 70.3 Zell am See	August	19°C	1 lap of 1.9 km in a lake	1 lap of 90 km, altitude difference of 1270 m per lap, overall altitude difference of 1270 m	2 laps of 21.1 km, altitude difference of 26 m per lap, at an overall altitude difference of 52 m
IRONMAN® 70.3 European Championship Elsinore	June	21°C	1 lap of 1.9 km in a bay	1 lap of 90 km, altitude difference of 600 m per lap, overall altitude difference of 600 m	3,5 laps of 21.1 km, altitude difference of 28.6 m per lap, at an overall altitude difference 100 m
IRONMAN® 70.3 Greece Costa Navarino	October	23°C	1 lap of 1.9 km in the ocean	2 laps of 90 km, altitude difference of 540 m per lap, overall altitude difference of 1080 m	3 laps of 21.1 km, altitude difference of 66.7 m per lap, at an overall altitude difference 200 m
IRONMAN® 70.3 Indian Wells La Quinta	December	18°C	1 lap of 1.9 km in a lake	1 lap of 90 km, altitude difference of 161 m per lap, overall altitude difference of 161 m	2 laps of 21.1 km, altitude difference of 57.7 m per lap, at an overall altitude difference of 115 m
IRONMAN® 70.3 Middle East Championship Bahrain	December	22°C	1 lap of 1.9 km in a bay	1 lap of 90 km, altitude difference of 300 m per lap, overall altitude difference of 300 m	3 laps of 21.1 km, altitude difference of 24.3 m per lap, at an overall altitude difference 73 m
IRONMAN® 70.3 Texas	April	21°C	1 lap of 1.9 km in a bay	1 lap of 90 km, altitude difference of 45 m per lap, overall altitude difference of 45 m	3 laps of 21.1 km, altitude difference of 10.7 m per lap, at an overall altitude difference 32 m
IRONMAN® 70.3 Tallinn	August	17°C	1 lap of 1.9 km in a lake	1 lap of 90 km, altitude difference of 300 m per lap, overall altitude difference of 300 m	2 laps of 21.1 km, altitude difference of 57.7 m per lap, at an overall altitude difference of 115 m
IRONMAN® 70.3 Western Sydney	September	23°C	1 lap of 1.9 km in a lake	2 laps of 90 km, altitude difference of 165 m per lap, overall altitude difference of 330 m	1 lap of 21.1 km, altitude difference of 25 m per lap, at an overall altitude difference of 25 m
IRONMAN® 70.3 Maceio	August	28°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude difference of 200 m per lap, overall altitude difference of 200 m	3 laps of 21.1 km, altitude difference of 23.3 m per lap, at an overall altitude difference 70 m
IIRONMAN® 70.3 Liuzhou	September	28°C	1 lap of 1.9 km in a river	2 laps of 90 km, altitude difference of 168,5 m per lap, overall altitude difference of 337 m	2 laps of 21.1 km, altitude difference of 171 m per lap, at an overall altitude difference of 342 m
IRONMAN® 70.3 Luxembourg	June	18°C	1 lap of 1.9 km in a river	1 lap of 90 km, altitude difference of 580 m per lap, overall altitude difference of 580 m	2,5 laps of 21.1 km, altitude difference of 40 m per lap, at an overall altitude difference of 100 m

IRONMAN® 70.3 Marbella	May	21°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude diffe-rence of 1400 m per lap, overall altitude difference of 1400 m	2 laps of 21.1 km, altitude difference of 25 m per lap, at an overall altitude difference of 50 m
IRONMAN® 70.3 Vichy	August	28°C	1 lap of 1.9 km in a lake	1 lap of 90 km, altitude diffe-rence of 1000 m per lap, overall altitude difference of 1000 m	2 laps of 21.1 km, altitude difference of 50 m per lap, at an overall altitude difference of 100 m
IRONMAN® 70.3 Gdynia	August	25°C	1 lap of 1.9 km in a bay	1 lap of 90 km, altitude diffe-rence of 1860 m per lap, overall altitude difference of 1860 m	2 laps of 21.1 km, altitude difference of 70 m per lap, at an overall altitude difference of 340 m
IRONMAN® 70.3 Mallorca	May	25°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude diffe-rence of 850 m per lap, overall altitude difference of 850 m	3 laps of 21.1 km, altitude dif-ference of 20 m per lap, at an overall altitude difference 60 m
IRONMAN 70.3 Panama	March	30°C	1 lap of 1.9 km in the ocean	3 laps of 90 km	3 laps of 21.1 km
IRONMAN 70.3 Augusta	September	27°C	1 lap of 1.9 km in the river	1 lap of 90 km	2 laps of 21.1 km
IRONMAN 70.3 North Carolina	October	18°C	1 lap of 1.9 km in the ocean	1 lap of 90 km	1 lap of 21.1 km
IRONMAN 70.3 Dubai	March	24°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude diffe-rence of 87 m per lap, overall altitude difference of 87 m	1.5 laps of 21.1 km, altitude difference of 5 m per lap, at an overall altitude difference 7,5 m
IRONMAN 70.3 Sao Paolo	September	25°C	1 lap of 1.9 km in a reservoir	2 laps of 90 km, altitude differ-ence of 20 m per lap, overall altitude difference of 40 m	3 laps of 21.1 km, altitude dif-ference of 15 m per lap, at an overall altitude difference 45 m
IRONMAN 70.3 Alagolas	August	28°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude differ-ence of 100 m per lap, overall altitude difference of 100 m	3 laps of 21.1 km, altitude dif-ference of 20 m per lap, at an overall altitude difference 60 m
IRONMAN 70.3 Emilia Romagna	September	25°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude differ-ence of 185 m per lap, overall altitude difference of 185 m	3 laps of 21.1 km, altitude difference of 5 m per lap, at an overall altitude difference 15 m
IRONMAN 70.3 Pays D'Aix	May	20°C	1 lap of 1.9 km in a lake	1 lap of 90 km, altitude differ-ence of 390 m per lap, overall altitude difference of 390 m	3 laps of 21.1 km, altitude dif-ference of 15 m per lap, at an overall altitude difference 45 m
IRONMAN 70.3 Sunshine Coast	September	26°C	1 lap of 1.9 km in the ocean	2 laps of 90 km, altitude differ-ence of 35 m per lap, overall altitude difference of 70 m	2 laps of 21.1 km, altitude dif-ference of 20 m per lap, at an overall altitude difference 40 m
IRONMAN 70.3 Geelong	March	19°C	1 lap of 1.9 km in a bay	2 laps of 90 km, altitude differ-ence of 75 m per lap, overall altitude difference of 150 m	2.5 laps of 21.1 km, altitude difference of 25 m per lap, at an overall altitude difference 67 m
IRONMAN 70.3 Steelhead	Juna	20°C	1 lap of 1.9 km in a lake	1 lap of 90 km	2 laps of 21.1 km
IRONMAN 70.3 Turkey	November	24°C	2 laps of 1.9 km in the ocean	2 laps of 90 km, altitude differ-ence of 20 m per lap, overall altitude difference of 40 m	3 laps of 21.1 km, altitude difference of 5 m per lap, at an overall altitude difference 15 m
IRONMAN 70.3 California	April	17°C	1 lap of 1.9 km in the ocean	1 lap of 90 km, altitude differ-ence of 220 m per lap, overall altitude difference of 220 m	2 laps of 21.1 km, altitude dif-ference of 10 m per lap, at an overall altitude difference 20 m
IRONMAN 70.3 Astana	June	25°C	1 lap of 1.9 km in a river	1 lap of 90 km, altitude differ-ence of 20 m per lap, overall altitude difference of 20 m	2 laps of 21.1 km, altitude difference of 5 m per lap, at an overall altitude difference 10 m
IRONMAN 70.3 Florianapolis	April	21°C	1 lap of 1.9 km in the ocean	1 lap of 90 km	3 laps of 21.1 km

Figure 1. **The 10 fastest race courses regarding all women and men.**

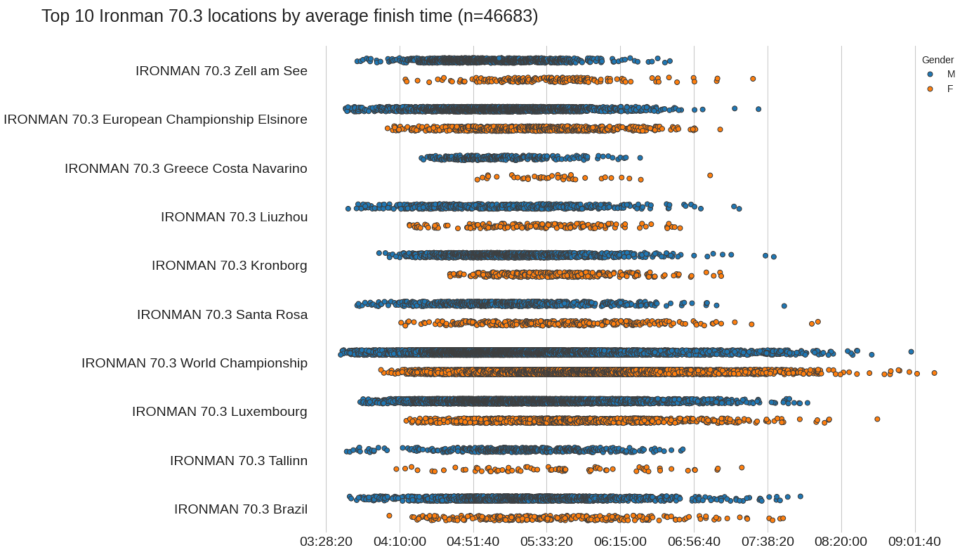


Figure 2. **The 10 fastest swimming courses regarding all women and men.**

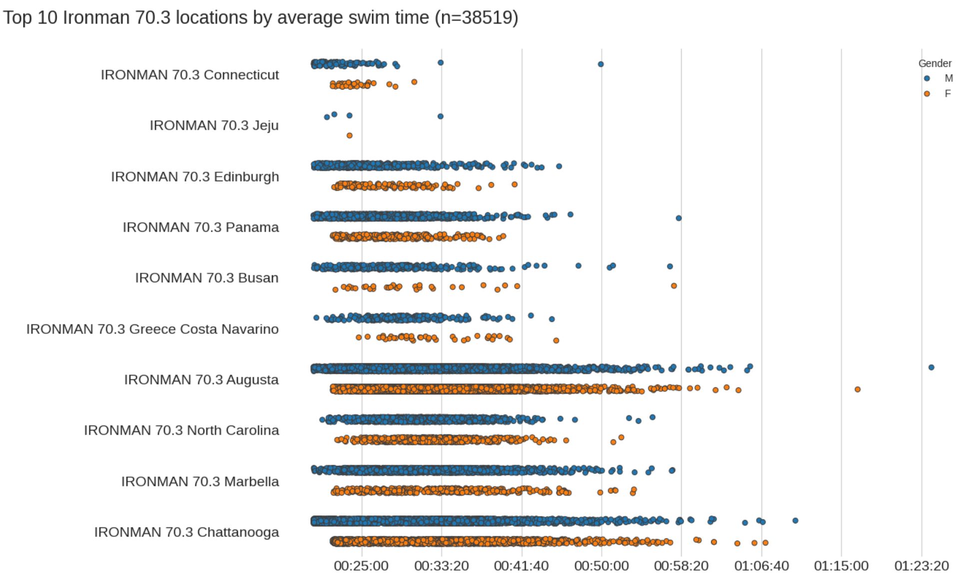


Figure 3. **The 10 fastest cycling courses regarding all women and men.**

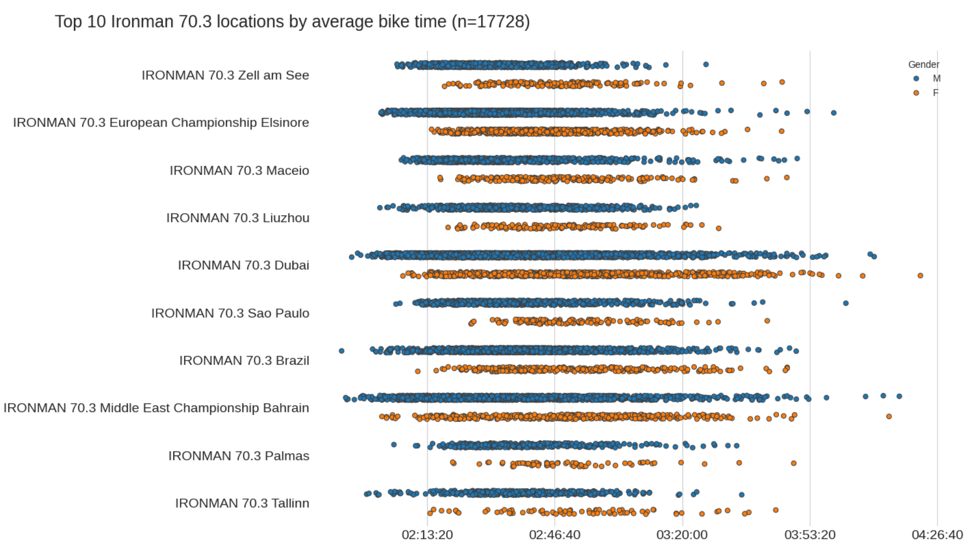
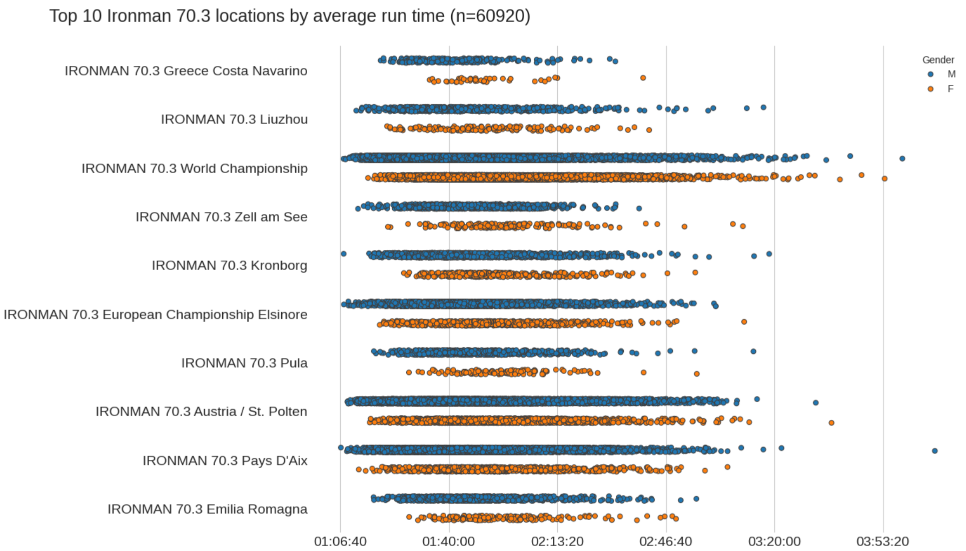


Figure 4. **The 10 fastest running courses regarding all women and men.**



For the elite subsample, consisting of the top 100 males and top 100 females in each Ironman 70.3 location, the fastest overall race times were recorded at the Ironman® 70.3 European Championship Elsinore (Denmark) (**Figure 5**), with significant differences comparatively to the other courses. In swimming, cycling and running, the fastest courses were founded by Ironman® 70.3 Connecticut (US), Ironman® 70.3 Middle East Championship (Bahrain), and Ironman® 70.3 World Championship, respectively (Figure 6, Figure 7, and Figure 8). The characteristics of the European Championship Elsinore include swimming in a bay, and an altitude difference of 600m in cycling and 28.6m in running from the start to the finish, respectively. Significant differences were shown between race courses.

Figure 5. **The 10 fastest race courses regarding the top 100 women and men.**

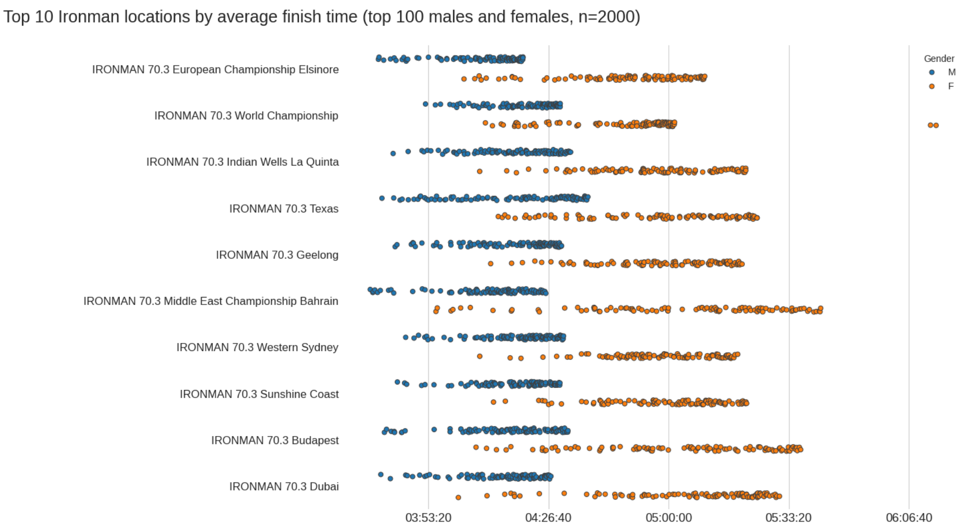


Figure 6. **The 10 fastest swimming courses regarding the top 100 women and men.**

Figure 7. **The 10 fastest cycling courses regarding the top 100 women and men.**

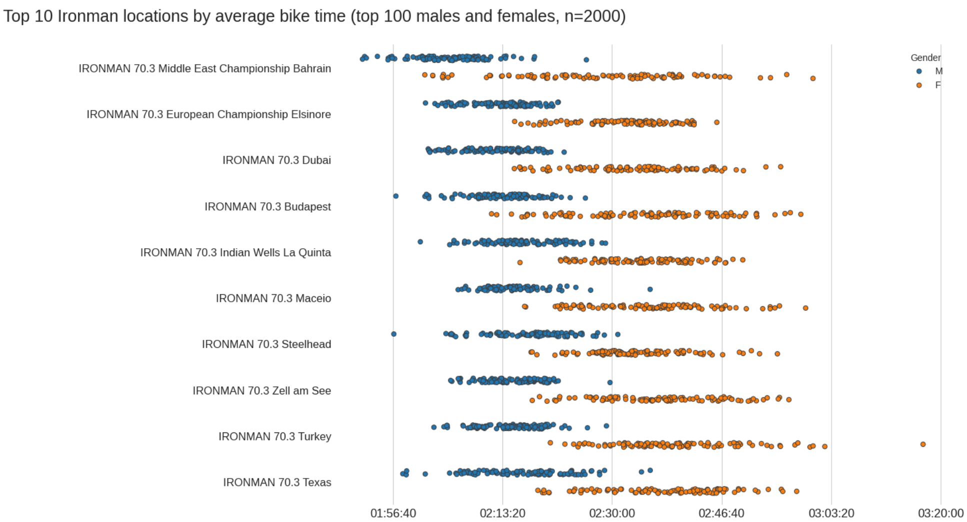
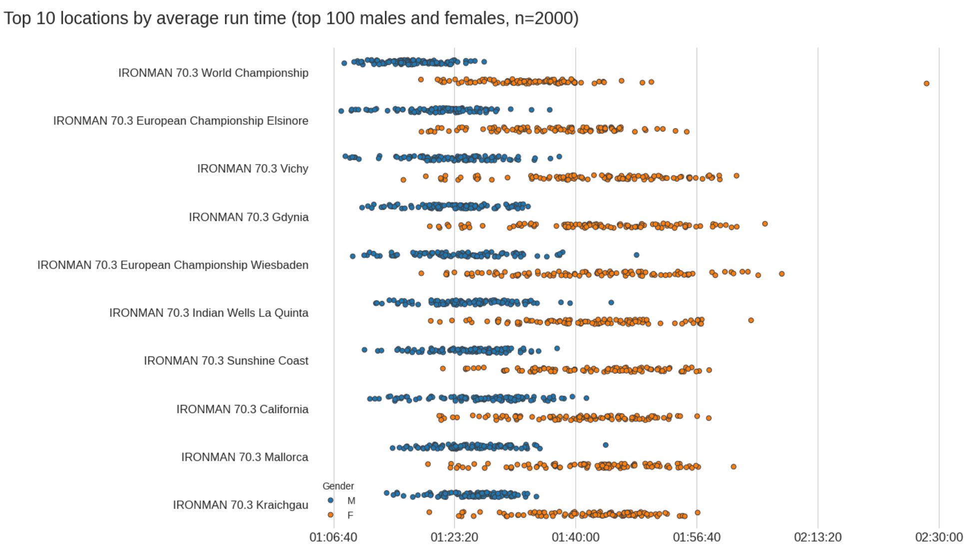


Figure 7. **The 10 fastest cycling courses regarding the top 100 women and men.**



DISCUSSION

The main purpose of this study was to analyse where the fastest split and overall race times were achieved for athletes competing in Ironman® 70.3. Our main findings were that overall fastest Ironman® 70.3 results were achieved on courses situated in the northern hemisphere (Ironman Zell am See and European Championship Elsinore) with lower temperatures and more dynamic terrain than in the southern hemisphere; a better swimming performance was uniformly achieved in geographically protected and calm waters where the course was straight with a minimum of turns; and while overall better cycling results were achieved on a rolling terrain, the top performers favoured a flat course.

Our results reflected the natural, climatic, and economic conditions for different countries hosting Ironman® 70.3 events. For the present study, race courses with lower temperatures and dynamic terrain showed a lower time of conclusion. These results agree with previous studies that showed a negative effect of heat on endurance athletes' performance (Helou et al., 2012; K Weiss et al., 2022), and linked that exposure to higher temperatures is related to increases in core temperature (Laursen et al., 2006). Furthermore, a combination of high humidity and ambient temperature would accentuate greater physiological strains and decrease endurance performance (Lei & Wang, 2021). Besides the influence of weather characteristics on Ironman athletes, most of the studies investigating climatic aspects and endurance performance were performed in the context of running (Hermand et al., 2019; Knechtle et al., 2021; Katja Weiss et al., 2022). These characteristics make comparisons difficult and also suggest that investigating the effect of wheatear characteristics in Ironman® athletes' performance is an emergent topic, especially considering divergent results findings in the present study, in which top participants and younger age groups performed better on courses with higher temperatures.

Considering split disciplines, the main findings showed that a better swimming performance was achieved in geographically protected and calm waters where the course was straight with a minimum of turns. These results can be related to the environmental challenges of the rivers, lakes, oceans, and water channels for athletes, as well as the technical requirements for swimming (Baldassarre et al., 2017). As a discipline performed in outdoor/aquatic space, water characteristics (i.e., temperature, protection) can also impair athletes' performance. A minimal number of turns might favour performance due to stability in the metabolic demands of swimming since it was assumed that an increased number of turns would cause an additional metabolic cost. Furthermore, swimming in hot water would induce significant physiological strain (Chalmers et al., 2021) such as increased oxygen uptake, blood lactate concentrations, rate of perceived exertion, maximal heart rate, and energy cost (Gay et al., 2021), and consequently, deteriorate performance.

In another way, cyclists were befitted with rolling terrain and a flat course (top performers). The association between terrain and cycling performance was not explored previously. However, a flat course seems to be positively associated with performance, given that athletes decrease their metabolic costs (Hoogkamer et al., 2014; Margaria et al., 1963). Otherwise, the characteristics of Ironman® 70.3 race courses, i.e. if they are flat courses in which athletes are constantly in the presence of other cyclists, can be associated with performance, and trend to favour athletes cycling in pelotons to spend less energy and to sustain higher speed (Crouch et al., 2017; Kyle, 1979). Similar results are related to running, in which race courses with flat tracks favour athletes' performance. Previous studies highlighted the higher rate of metabolic energy supply to running uphill (Hoogkamer et al., 2014). In addition, running in a curved path generates a centripetal force on the ground, meaning an increment in runners' metabolic cost, compared to a straight course (Snyder et al., 2021). Besides, in a different context than Ironman athletes, the effect of the race course on athletes' performance can also be visualised in the break of the 2-hour barrier in Marathon - Vienna, 2019 (Snyder et al., 2021).

This study was not free of limitations. The first important limitation was that we did not control for course alterations over time and did not match information about participants' country of residence and the fastest race course. This was important information, given that previous studies indicated a positive effect on competing at home (Thuany et al., 2021). Another point was the lack of information regarding the economic and stakeholders' support for hosting sports events. Ironman® and Ironman® 70.3 events were characterised by a higher cost, considering participants' security and also the built and natural environment, meaning that some places were better prepared to receive these events than others. These characteristics were related to countries' inequalities regarding the possibility of hosting events.

Despite these limitations, the study provides valuable insights that can benefit both coaches and athletes. Practically, coaches can use the results to guide their athletes' preparation, more specifically, considering the characteristics of the race locations identified as the fastest. For instance, if an athlete is gearing up for an Ironman® 70.3 in Zell am See, Austria, coaches can tailor training regimens to simulate the specific conditions of that course, optimising preparation. From a theoretical perspective, the study contributes to a deeper understanding of the factors influencing performance in Ironman® 70.3 competitions. It can fuel discussions on the importance of geography and specific local conditions, such as climate and terrain, in athletes' performances. This may lead to a reevaluation of training and competition strategies, considering not only physical preparation but also adaptation to different environments. Moreover, the results can be leveraged to motivate athletes by demonstrating that performance at certain locations is related to factors beyond individual capabilities, such as the wise choice of the competition venue. Ultimately, both coaches and athletes can use the insights gained to refine their practical approaches and theoretical strategies, aiming for significant improvements in performance in Ironman® 70.3 competitions.

CONCLUSIONS

The fastest Ironman® 70.3 courses were situated in Zell am See in Austria, suggesting that athletes aiming for record-breaking performances may benefit from choosing this course. For the top 100 athletes, the Ironman® 70.3 European Championship Elsinore (Denmark) stands out as particularly fast courses for males and females, respectively. The specific insights into swim, cycle, and run times further provide valuable information for athletes looking to tailor their training regimens. For instance, choosing Ironman® 70.3 Connecticut for the fastest swim times or Ironman® 70.3 Middle East Championship Bahrain for cycling and running may be strategic decisions. Future studies should explore the effects of climate change on sports performance. Disciplines such as Ironman® triathlon, which have a strong interaction with nature, are likely to be influenced by these changes. Exploring this intersection of climate change and sports performance could uncover significant insights into how athletes and sporting events adapt to evolving environmental conditions. These considerations become particularly relevant in understanding the broader implications of climate change on various facets of human activity, extending beyond environmental impact to encompass physical performance and sportsmanship.

DECLARATIONS

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Author Contributions
MT and BK drafted the manuscript, DV performed the statistical analysis and prepared methods and results, EV obtained the data, MA, KW, PTN, RLV, and TR helped in drafting the final version. All authors read and approved the final manuscript.

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Availability of Data and Materials
For this study, we have included official results and split times from the official Ironman® website (www.ironman.com) The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations 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 (EKSG 01/06/2010). The study was conducted in accordance with recognised ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

Consent for Publication
Not applicable.

Competing Interests
Mabliny Thuany, David Valero, Elias Villiger, Marilia Andrade, Katja Weiss, Pantelis Nikolaidis, Rodrigo Vancini, Thomas Rosemann, and Beat Knechtle declare no competing interests.

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