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Performance and Sex Differences in 'Isklar Norseman Xtreme Triathlon'

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Abstract

The performance and sex differences of long-distance triathletes competing in 'Ironman Hawaii' are well investigated. However, less information is available with regards to triathlon races of the Ironman distance held under extreme environmental conditions (*e.g.* extreme cold) such as the 'Isklar Norseman Xtreme Triathlon' which started in 2003. In 'Isklar Norseman Xtreme Triathlon', athletes swim at a water temperature of ~13-15°C, cycle at temperatures of ~5-20°C and run at temperatures of ~12-28°C in the valley and of ~2-12°C at Mt. Gaustatoppen. This study analysed the performance trends and sex differences in 'Isklar Norseman Xtreme Triathlon' held from 2003 to 2015 using mixed-effects regression analyses. During this period, a total of 175 women (10.6%) and 1,852 men (89.4%) successfully finished the race. The number of female (r^2 = 0.53, *P* = 0.0049) and male (r^2 = 0.37, *P* = 0.0271) finishers increased and the men-to-women ratio decreased (r2 = 0.86, *P* < 0.0001). Men were faster than women in cycling (25.41 ± 2.84 km/h versus 24.25 ± 2.17 km/h) (*P* < 0.001), but not in swimming (3.06 ± 0.62 km/h *vs.* 2.94 ± 0.57 km/h), running (7.43 ± 1.13 km/h *vs.* 7.31 ± 0.93 km/h) and overall race time (874.57 ± 100.62 min *vs.* 899.95 ± 90.90 min) (*P* > 0.05). Across years, women improved in swimming and both women and men improved in cycling and in overall race time (*P* < 0.001). In running, however, neither women nor men improved (*P* > 0.05). In summary, in 'Isklar Norseman Xtreme Triathlon' from 2003 to 2015, the number of successful women increased across years, women achieved a similar performance to men in swimming, cycling and overall race time, and women improved across years in swimming, cycling and overall race time.

Key Words: athlete, cycling, man, running, swimming, woman

Introduction

The Ironman triathlon started in 1977 in Hawaii, USA, with the combination of the three toughest endurance races in Hawaii - the 2.4-mile 'Waikiki Roughwater Swim', the 112-miles of the 'Around-O'ahu Bike Race' and the 26.2-mile 'Honolulu Marathon' - into one event, the 'Ironman Hawaii'.[1] The first official Ironman triathlon was held in 1978 in Honolulu, Hawaii.[1] In 1981, the course moved to Kail-ua-Kona, Hawaii, where 'Ironman Hawaii' is still held as the Ironman World Championship.[1]

The 'Ironman Hawaii' is often considered as one of the most challenging endurance events in the world (18, 19). Each year, around 50,000 triathletes compete in 24 Ironman and five half-Ironman triathlons throughout the world with the aim to qualify for the Ironman World Championship 'Ironman Hawaii' (28). Hawaii's tropical climate in October with temperatures of ~30°C, the humidity of ~70% and crosswinds up to ~70 km/h makes the 'Ironman Hawaii' even more challenging (18).

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[1]Ironman Hawaii', www.ironman.com/triathlon/events/americas/ironman/world-championship
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A further challenge in competing in an Ironman distance triathlon was raised by creating the 'Isklar Norseman Xtreme Triathlon' in 2003 in Norway.[2] The rough and cold climate as well as the hilly course with the finish on 1,850 m above sea level makes the 'Isklar Norseman Xtreme Triathlon' to an intriguing and unique test of ultra-endurance. Located on the same latitude as Alaska the course leads through the fjords and mountains of Norway.[2] The 3.8 km swim starts from the loading bay of a car ferry and continues through the water of the 'Hardangerfjord', one of the longest and deepest fjords of the Norwegian coast, with water temperatures on race morning between 13°C and 15°C.[2]

The 180 km cycling course leads through the mountains, the first 40 km is uphill reaching 1,200 m above sea level. After the second transition at 190 m above sea level, the triathletes have to run 42.2 km of which the first 25 km are flat and following this they end up climbing the local mountain at 1,880 m above sea level. 'Isklar Norseman Xtreme Triathlon' has to be considered as a world class race in long-distance triathlon since the two times winner of 'Ironman Hawaii' Tim DeBoom won the race in 2011.[3]

Several studies analysed performance trends in 'Ironman Hawaii' and its qualifier events (6, 18, 20, 29, 30). The performance improvements in 'Ironman Hawaii' showed an initial phase of rapid improvements during the 1980s and persistent smaller improvements, especially in cycling and running, over the last three decades (6, 18). Further studies showed that primarily master triathletes (*i.e.* triathletes older 40 years of age) improved Ironman triathlon performance over the last two decades (20, 30).

Sex differences in performance have received considerable attention in recent decades (13, 19, 21). Over the past four decades, female participation in endurance events has increased dramatically, and during the same period they improved performance considerably (21). Sex differences in physiological characteristics are likely to be the main factor for the ~10-15% sex difference in endurance performance. Men have a larger skeletal muscle mass compared to women (9), correlating with a greater muscular strength (1), a larger aerobic capacity (11) and lower relative body fatness (12).

The sex difference in total Ironman triathlon performance was ~13% in the Ironman triathlon World Championship in 'Ironman Hawaii' (18) while it was ~15% in 'Ironman Switzerland' as a qualifier for 'Ironman Hawaii' (29). The slightly greater sex difference in the qualifier event was most probably due to a lower proportion of top athletes (28).

In swimming, the sex difference in 'Ironman Hawaii' was ~10%, while it was ~14% in 'Ironman Switzerland'. The smaller sex difference in 'Ironman Hawaii' was reasoned by the prohibition of wearing wetsuits because of the warm water temperatures and by the denser salt water in the ocean. Women have more body fat (12). Wetsuits increase the swimming performance by increasing buoyancy where lean subjects, especially, benefit more from wearing wetsuits than do fatter subjects (2). On the other hand, women with more body fat may profit more from the denser salt water (18, 31).

The mean sex difference in the 180 km cycling trial was ~13% in 'Ironman Hawaii' and in 'Ironman Switzerland' where both courses are relatively flat. In 'Ironman Hawaii' the athletes have to climb ~1,400 m and in 'Ironman Switzerland' ~1,260 m (18, 29). The sex difference in running was ~13% in 'Ironman Hawaii' and ~18% in 'Ironman Switzerland'. It was assumed that only the top female athletes could overcome the disadvantage of a greater body fat in running. In cycling, the muscular advantage of men is proportional to muscle mass and it is even greater in running (22), running being the only weight bearing activity where greater body fat is a limitation.

The sex difference for the course records is about 1 h longer in 'Isklar Norseman Xtreme Triathlon' compared to 'Ironman Hawaii'. In 'Ironman Hawaii', the sex difference in the course records (*i.e.* Craig Alexander in 2011 with 8:03:56 h:min:sec and Mirinda Carfrae in 2013 with 8:52:14 h:min:sec) is ~50 min,[1] whereas the sex difference in the course records in 'Isklar Norseman Xtreme Triathlon' (*i.e.* Henrik Oftedal in 2012 with 10:23:43 h:min:sec and Annett Finger in 2012 with 12:17:04 h:min:sec) is ~1:54 h:min.[2]

However, the performance trends and sex differences in 'Isklar Norseman Xtreme Triathlon' are not known. Neither do we know the sex difference in swimming performance in an Ironman distance triathlon in such cold, salt water, nor the sex difference in performance in the cycling and running part of an Ironman on a hilly course such as the 'Isklar Norseman Xtreme Triathlon'. Such knowledge might be of practical importance for coaches and fitness trainers working with triathletes in order to develop sex-tailored training programs, especially during preparation period before an Ironman-distance event under extreme cold environmental conditions.

In this context, the aims of the present study were therefore (i) to investigate the performance trends and (ii) to analyse the sex differences in performance in 'Isklar Norseman Xtreme Triathlon' from 2003 to 2015,

[2]'Isklar Norseman Xtreme Triathlon', http://nxtri.com/
[3]Tim DeBoom wins 'Norseman Xtreme Triathlon' in 2011, www.nxtri.com/news/archive_2011/tim_deboom_wins_norseman_2011

a definitely unique long-distance triathlon covering the Ironman distance. We hypothesized, firstly, that both women and men improved their performance over the last years similarly to findings in 'Ironman Hawaii' and its qualifier events. Secondly, we expected a smaller sex difference in swimming in the cold salt water in 'Norseman Xtreme Triathlon' compared to classical Ironman races such as 'Isklar Norseman Xtreme Triathlon', and, thirdly, a greater sex difference in cycling and running compared to the other Ironman events because of the great difference in altitude in 'Isklar Norseman Xtreme Triathlon'.

Materials and Methods

Ethics Approval

All procedures used in the study were approved by the Institutional Review Board of Kanton St. Gallen, Switzerland with a waiver of the requirement for informed consent of the participants given the fact that the study involved the analysis of publicly available data.

The Race

The 'Isklar Norseman Xtreme Triathlon' is a long-distance triathlon held annually since 2003 in August in Eidfjord, Norway. The distances of 3.8 km swimming, 180 km cycling and 42.195 km running are equal to the classical Ironman triathlon distances.[2] The number of participants is limited to 310 where ~40% of the starters are from outside Norway and ~15% of the starters are women.[4] The 'Isklar Norseman Xtreme Triathlon' is a point-to-point race with the start in Eidfjord and the finish at Mt. Gaustatoppen.[2] The swim starts from the loading bay of a car ferry at 05:00 a.m. The athletes jump into the fjord and swim through Hardangerfjord to Eidfjord. Generally, in august, the water temperature is very low at ~13-15°C in Hardangerfjord.[5] When the athletes arrive at Eidfjord, they change in the transition area on the bike and cycle the 180 km bike split through the mountains. The first 40 km of the cycling split are uphill reaching ~1,200 m above sea level. The temperatures during the cycling split may vary between 5°C and 20°C. After the finish at Austbygda (~190 m above sea level), the competitors have to run the marathon. After the first flat part of ~25 km of the marathon to Rjukan, the athletes have to climb Mt. Gaustatoppen (~1,880 m above sea level).[5] The weather during the run can be extreme and may change quickly to snow, cold and rain. The temperature during the run split may vary between 12°C and 28°C in the valley and between 2°C and 12°C at Mt. Gaustatoppen.[5]

All competitors need to be supported in 'Isklar Norseman Xtreme Triathlon' by a personal crew. The support crew has to follow the athlete with a car to provide food and drink. In the final mountain climb, the support crew has to follow the athlete since athletes might suffer severe fatigue and problems in the final climb of the run. Severe weather conditions, deadlines and health checks decide whether the race can be held until the official finish at Mt. Gaustatoppen.[5] Official finishers of the full distance in 'Isklar Norseman Xtreme Triathlon' get the black T-shirt and are official finishers called 'Norsemen'. Athletes who finish the race out of the cut-off time on a different route will get the white T-shirt. The cut-off time for the black finisher T-shirt is 14:30 h:min at 32.5 km, and 15:30 h:min at 37.5 km. Only 160 athletes will be permitted to continue from 32.5 km on the black track to Mt. Gaustatoppen under ordinary weather and race conditions. All athletes arriving later will finish on the white track. This means that the 161st athlete to reach 32.5 km will be on the white shirt track even he/she reaches the checkpoint before the cut-off time.[5]

Data Sampling and Data Analysis

The data set for this study was obtained from the official race website of 'Isklar Norseman Xtreme Triathlon'.[2] Only finishers with a black T-shirt were considered. Between 2003 and 2015, the swim distance was shortened in some years due to environmental conditions. Similarly, the bike distance varied between 180 km and 200 km. Finishers with the black T-shirt had to complete the full marathon distance. In order to have comparable data, we calculated for swimming, cycling and running the speed (km/h) for each athlete in each edition. Race times were converted from h:min:sec to min to be comparable between women and men. The men-to-women ratio was calculated by dividing the overall number of men through the overall number of women. In order to avoid a selection bias by limiting the analysis to top athletes such as top ten athletes (18, 23), we included all official female and male finishers in our data analysis.

Statistical Analysis

To investigate changes in performance and sex difference in performance between women and men, mixed-effects regression analyses with finisher as random variable to consider finishers who completed several races was used. We included sex and calendar year

[4] 'Isklar Norseman Xtreme Triathlon', race rules http://nxtri.com/race-info/rules/
[5] 'Isklar Norseman Xtreme Triathlon', race manual https://nxtri.app.box.com/racemanual-2016

Table 1. Number of female and male finishers and the men-to-women ratio

Year	Women	Men	Men-to-Women-Ratio
2003		19	
2004	5	81	16.2
2005	8	128	16.0
2006	8	111	13.8
2007	13	159	12.2
2008	11	150	13.6
2009	13	166	12.7
2010	13	156	12.0
2011	18	157	8.7
2012	36	285	7.9
2013	16	151	9.4
2014	15	148	9.8
2015	19	141	7.4
Total	175	1852	10.6

as fixed variables. The change in the men-to-women ratio across calendar years was investigated using single linear regression analysis. Differences in speed in split disciplines and overall race time were compared using *t*-test. Statistical analyses were performed using IBM SPSS Statistics (Version 22, IBM SPSS, Chicago, IL, USA) and GraphPad Prism (Version 6.01, GraphPad Software, La Jolla, CA, USA). Significance was accepted at $P < 0.05$ (two-sided for *t*-tests). Data in the figures are given as mean ± 95% confidence interval (CI) for the comparison between women and men and as mean ± standard deviation (SD) for changes across years.

Results

Between 2003 and 2015, a total of 175 women (10.6%) and 1,852 men (89.4%) successfully finished the 'Isklar Norseman Xtreme Triathlon' and became official black-T-shirt finishers. The number of female ($r^2 = 0.53$, $P = 0.0049$) and male ($r^2 = 0.37$, $P = 0.0271$) finishers increased during this time period. During the same period, the men-to-women ratio decreased ($r^2 = 0.86$, $P < 0.0001$) (Table 1). Men were faster than women (25.41 ± 2.84 km/h *vs.* 24.25 ± 2.17 km/h) in cycling ($P < 0.001$), but not in swimming (3.06 ± 0.62 km/h *vs.* 2.94 ± 0.57 km/h) and running (7.43 ± 1.13 km/h *vs.* 7.31 ± 0.93 km/h) ($P > 0.05$) (Fig. 1). For overall race time, no differences between women and men (874.57 ± 100.62 min *vs.* 899.95 ± 90.90 min) were found ($P > 0.05$) (Fig. 2). Across years, women improved in swimming and both women and men improved in cycling (*i.e.* race times became faster). In running, however, neither women nor men

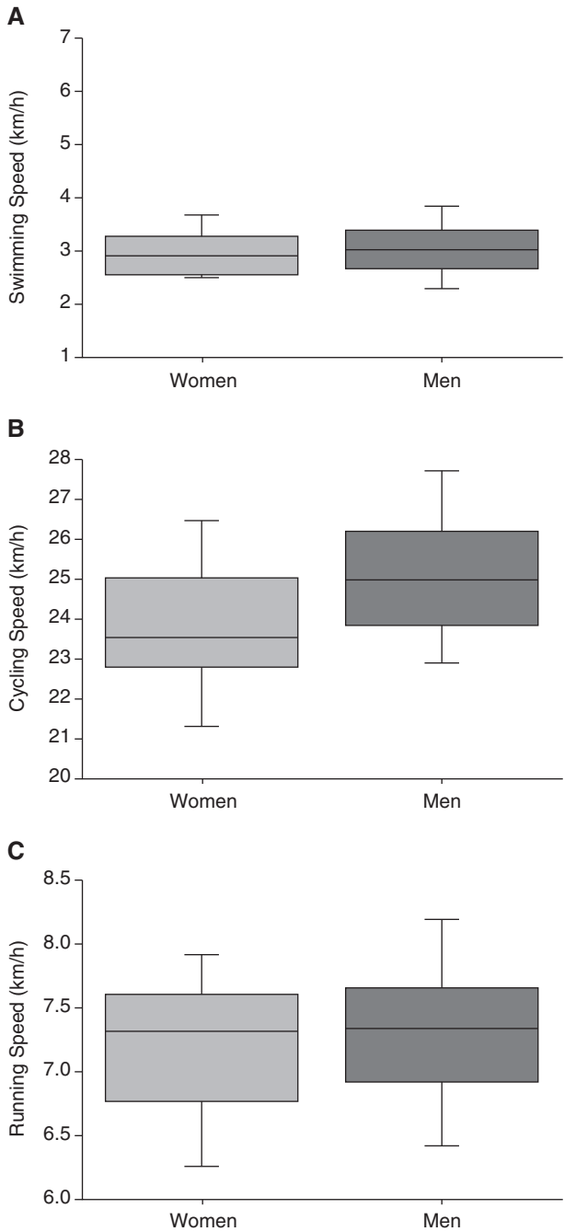

Fig. 1. Speed (km/h) in swimming, cycling and running for women and men (mean ± 95% CI)

improved ($P > 0.05$) (Fig. 3 and Table 2). Overall race time decreased across years in both women and men (Fig. 4 and Table 2).

Discussion

The aims of the present study were to investigate the performance trends and to analyse the sex differences in performance in 'Isklar Norseman Xtreme

Table 2. Results of the mixed-effects regression analyses for swimming speed, cycling speed, running speed and overall race time

Parameter	Estimate	SE	df	t	P
Swimming speed					
Constant term	9.38	8.61	2008.00	1.08	0.276
Calendar year	-0.0031	0.004	2008.13	-0.73	0.463
[sex = female]	-0.11	0.051	1665.77	-2.23	0.026
Cycling speed					
Constant term	-457.97	35.63	1999.76	-12.85	<0.0001
Calendar year	0.24	0.017	1999.69	13.56	<0.0001
[sex = female]	-1.23	0.22	1663.93	-5.45	<0.0001
Running speed					
Constant term	-23.41	16.55	2023.00	-1.41	0.158
Calendar year	0.015	0.008	2022.97	1.85	0.063
[sex = female]	-0.12	0.102	1638.79	-1.19	0.232
Overall race time					
Constant term	21355.45	1224.48	1956.29	17.44	<0.0001
Calendar year	-10.18	0.609	1956.20	-16.72	<0.0001
[sex = female]	30.24	7.92	1646.12	3.81	<0.0001

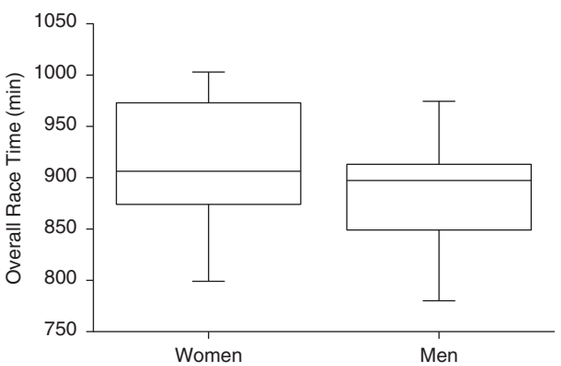

Fig. 2. Overall race times (min) for women and men (mean ± 95% CI)

Triathlon' during a period of 13 years since the first edition in 2003. The most important findings were (i) the number of female and male finishers increased and the men-to-women ratio decreased across years, (ii) men were faster than women in cycling, but not in swimming, running and overall race time and (iii) women improved in swimming and both women and men improved in cycling.

Performance Differences between the Sexes

A first important finding was that men were faster in cycling, but not in swimming, running and overall race time. The faster cycling speed might be explained by anthropometric and physiological differences between women and men (11, 12, 14). Sex differences in anthropometric (9, 12) and physiological characteristics (11) are the most likely main reasons for this difference in cycling speed. Low body fat is an important predictor variable for overall race time in Ironman triathlon (14). Low body fat was associated with faster race times in male Ironman triathletes (12, 14). Female triathletes aged 30-35 years old have ~8% more percent body fat than men (22.8% *vs.* 14.4%, respectively) (12) which is likely to be an advantage for men (14). The relative skeletal muscle mass is ~8% higher in male Ironman triathletes with ~41.0 kg muscle mass in male versus ~28.0 kg in female Ironman triathletes (12). Furthermore, the aerobic capacity is ~14% higher in men with a VO_2peak 61.3 ml/kg/min versus 52.8 ml/kg/min in men and women, respectively (11). However, not only body mass *per se* is a decisive factor to explain sex differences in cycling and running performance. A recent study showed that body composition changes affected energy cost of running during 12 months of specific diet and training in amateur athletes (7).

Generally, female Ironman triathletes are slower than male Ironman triathletes in split disciplines and for overall race time (18, 23). The sex differences vary between 10-15% regarding the different disciplines. The findings that men were not faster compared to women in swimming, running and overall race time in Isklar Norseman Xtreme Triathlon' might be explained by different reasons. A first reason might be the kind of analysis. While Lepers (18) and Rüst *et al*. (23) limited their analysis to the annual ten fastest and did not con-

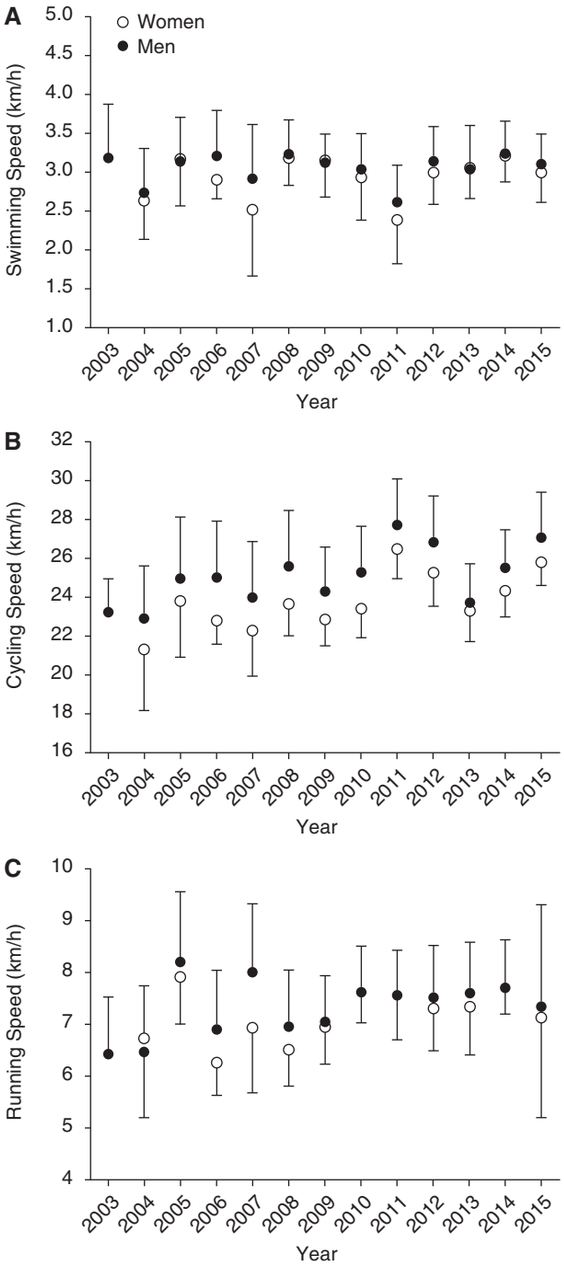

Fig. 3. Speed (km/h) across years in swimming, cycling and running for women and men (mean ± 95% CI)

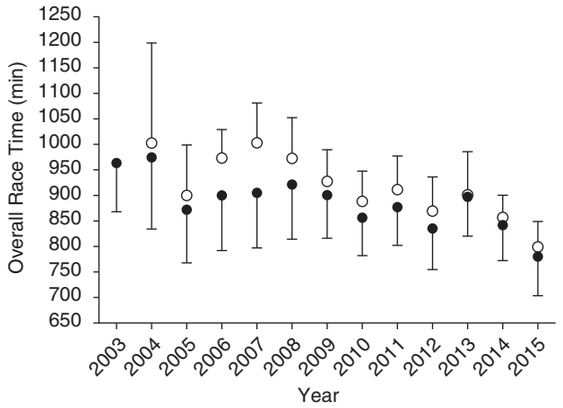

Fig. 4. Overall race times (min) across years for women and men (mean ± 95% CI)

sider analysing the whole sample of athletes for sex differences, we included all annual finishers for the trend across years and compared female and male performance for split and overall performance. A second reason might be the small sample of athletes cometing in 'Isklar Norseman Xtreme Triathlon' compared to 'Ironman Hawaii'. Between 2003 and 2015, a total of 2,027 athletes finished 'Isklar Norseman Xtreme Triathlon'; these are on average 156 annual finishers. In comparison, a total of 39,706 athletes finished between 1985 and 2012 in 'Ironman Hawaii', equal to 1,418 annual finishers (3). In other terms, the overall number of finishers in 'Isklar Norseman Xtreme Triathlon' between 2003 and 2015 corresponds to nearly the annual finisher rate in 'Ironman Hawaii'. A further explanation could be the nationality of the athletes. While in 'Ironman Hawaii' the fastest finishers originate from the United States of America (3), in 'Isklar Norseman Xtreme Triathlon', however, the fastest finishers originate from Norway (27).

Changes in Performance across Years

A second important finding was that women improved in 'Isklar Norseman Xtreme Triathlon' in swimming and both women and men improved in cycling and in overall race time. In running, however, no improvements were recorded. These findings are different to the results reported for 'Ironman Hawaii' (18, 23). Between 1988 and 2007, the annual ten fastest women and men improved in swimming, cycling and running (18). When the annual ten fastest finishers between 1983 and 2012 were considered, men improved in swimming, but not women. For cycling and running, both women and men improved (23). Although Rüst *et al*. (23) compared the split times of the ten fastest swimmer, cyclist and runners competing in 'Ironman Hawaii' between 1983 and 2012 to the split times of the ten fastest finishers overall, no study compared to date the fastest split times for women and men separately.

The different performances in swimming in 'Isklar Norseman Xtreme Triathlon' between women and men might be explained by the cold water in the swimming

split in 'Norseman Xtreme Triathlon'. It has been reported that the best women were swimming faster in cold water than the best men in an open-water ultra-distance swim. In the 46-km 'Manhattan Island Marathon Swim' with water temperatures < 20°C, the best women were ~12-14% faster than the best men (13). Also in the 32-km 'Catalina Channel Swim' held at temperatures of 15-21°C, the fastest women were faster than the fastest men between 1927 and 2014 (16). However, there seems to be a lower limit for women while swimming in cold water. In water colder than 5°C, men were faster than women in 'Ice Mile' (1.609 km) and '1 km Ice event' (1 km) (17).

The main difference in the swimming split between 'Ironman Hawaii' and 'Isklar Norseman Xtreme Triathlon' is the inhibition of wearing wetsuits in 'Ironman Hawaii' because of the warm ocean water temperatures. It is well known that female Ironman triathletes have more body fat compared to male athletes (12). Wetsuits increase the swim performance by increasing buoyancy. Lean subjects benefit more from wearing wetsuits than fatter subjects (2). On the other hand, females with more body fat may profit more from the denser salt water (18, 31). It seems that the advantage for men by wearing wetsuits outweighs the advantage of the cold, salt water for women.

The improvements in cycling in 'Isklar Norseman Xtreme Triathlon' are in line with reports for 'Ironman Hawaii' where both women and men improved their bike split times across years (18, 23). The most likely explanations for the improvements in cycling are technological advances in cycling equipment (8, 10). However, the running speed showed no changes in 'Isklar Norseman Xtreme Triathlon' since the beginning where in contrast, athletes in 'Ironman Hawaii' improved their marathon race times across years (18, 23). A potential explanations could be the short time frame in 'Isklar Norseman Xtreme Triathlon' compared to 'Ironman Hawaii', the low number of finishers, and the kind of data analysis with inclusion of all female and male finishers. However, the most likely explanation could be the fact that triathletes in 'Isklar Norseman Xtreme Triathlon' have to complete a mountain marathon with about 1,700 m increase in altitude compared to a rather flat marathon in 'Ironman Hawaii'. Furthermore, the environmental conditions with influence on marathon race time (4, 5, 32) are different in 'Isklar Norseman Xtreme Triathlon' compared to 'Ironman Hawaii'. Little is known for change in performance across years in mountain marathon running (15, 33). For mountain marathoners, there seemed to be a decrease in performance in recent years. In runners competing in the 'Jungfrau Marathon' held in Switzerland, performance decreased between 2000 and 2014 (15). However, more research is wanted for performance trends in mountain marathon running.

Limitations and Implications for Future Research

Since endurance performance is influenced by environmental conditions such as temperature and humidity, and by race specific characteristics such as changes in altitude, the findings should be generalized only to races with similar characteristics. A limitation is that specific anthropometric (*i.e.* percent body fat) (12, 25, 26) and physiological (*i.e.* maximum oxygen uptake) (11) characteristics were not determined in finishers in 'Isklar Norseman Xtreme Triathlon' but are also missing in scientific literature. Future studies need to determine these specific variables in order to compare with long-distance triathletes (*i.e.* Ironman triathletes) competing under moderate environmental conditions. Additionally, the aspect of previous experience has not been included (24).

Practical Applications

The findings of the present study might be interested for both researchers and coaches working with triathletes. Since there have been very little previous information about Ironman-distance races under extreme cold environmental conditions, these findings can be used in future relevant studies as a reference. Moreover, knowledge about performance characteristics in such races might help coaches to prepare optimally their triathletes before a race in extreme cold, especially considering sex differences. The variation of sex differences by mode of exercise (*i.e.*, among swimming, cycling and running) might be used as a guide for setting specific training goals. For instance, athletes who aim to improve their performance in running should consider reducing body mass, whereas those who intend to increase performance in swimming and cycling should focus on increasing muscle mass. Furthermore, also changes in body composition (*i.e.* reduction in fat mass and/or increase in fat free mass) may improve athletic performance. The findings for sex difference in performance differ from findings for Ironman triathlons such as 'Ironman Hawaii'. The most likely explanations are the different environmental conditions, the differences in the race courses, the lower number of finishers in 'Isklar Norseman Xtreme Triathlon', and the differences in the analyses.

In summary, the number of successful women in 'Isklar Norseman Xtreme Triathlon' increased across years, women achieved a similar performance to men in swimming, cycling and overall race time, and women improved across years in swimming, cycling and overall race time. These findings might be due to the increase in female finishers across years. And both a cold environment and a high altitude to climb in both the running and cycling part of an Ironman triathlon seem to be no disadvantage for women.

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