DISABILITY AND REHABILITATION: ASSISTIVE TECHNOLOGY
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CASE REPORT

Pacing strategy of a wheelchair athlete in a 5x and 10x Ironman ultra triathlon: a case study

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ABSTRACT

Objective: For disabled athletes such as wheelchair athletes, there is no knowledge about competing and pacing during a long-distance triathlon such as an Ironman triathlon. This study aimed to investigate the pacing strategy of a paraplegic wheelchair athlete competing and finishing a Quintuple Iron ultra-triathlon (i.e., five times 3.8 km swimming, 180 km handbike cycling and 42.195 km wheelchair racing in five days) and a Deca Iron ultra-triathlon (10 times the same distance in 10 days).

Methods: Data from an ultra-distance triathlon race (Swissultra) covering 5x and 10x Ironman distance were collected. Official performance data were acquired from the race organizer's website and athlete's personal information from the athlete through online interviews. The athlete is a man born in 1962, the races analysed in this study were held in the summer of 2017 (5x) and 2019 (10x). The split times for swimming, cycling and running, the overall race times for each Ironman and the lap times in cycling (handbike) and running (wheelchair) were analysed.

Results: The athlete finished the Quintuple Iron ultra-triathlon in an overall race time of 66:28:31 h:min:s and the Deca Iron ultra-triathlon in 137:03:20 h:min:s. He adopted an even pacing in both races in split disciplines and for overall race time.

Conclusion: The paraplegic wheelchair athlete was able to finish both a Quintuple and a Deca Iron ultra-triathlon by adopting an even pacing in all split disciplines and for overall race time.

➤ IMPLICATIONS FOR REHABILITATION

- Triathlon is a growing sport among athletes with spinal cord injury.
- Ultra-triathlons are ultra-endurance events and pacing is a key aspect to a successful race regardless the athlete's category.
- An athlete with a spinal cord injury finished a 5x and 10x Ironman ultra-triathlon applying an even pacing strategy.

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Swimming; cycling; running; disabled athlete; spinal cord injury

Introduction

Ironman triathlon is of high popularity where both the number of races and athletes in the last years has dramatically increased [1]. Furthermore, the performance of elite [2,3] and recreational Ironman triathletes [4] has improved in the last decades. Pacing is an important aspect in endurance performance in general [5] and also in triathlon [6]. Regarding Ironman triathlon, pacing has been investigated during the cycling and running split [7–9]. For both female and male elite Ironman triathletes, a positive pacing (i.e., slowing down) for both cycling and running has been described [7].

The distribution of speed, work, or pacing throughout an exercise task is very important to optimize performance [5,10]. Triathlon provides a unique model for pacing analysis due to the involvement of sequential swimming, cycling and running [6], and a proper strategy is fundamental in ultra-endurance triathlon [11]. Intrinsically, research shows that pacing is partially controlled on a subconscious level [12] and partially by "pacing strategy" [6]. In a triathlon race, pacing is affected by variety of external factors, such as sea currents, wind speed, topography [13,14] or even individual factors, such as gender or age [11]. Additional challenges that may affect pacing and performance in ultra-endurance triathlons performed in more than one race day included sleep, recovery and nutrition [15].

Disabled athletes such as wheelchair athletes perform sport primarily in basketball [16], rugby [17] and wheelchair racing [18]. To date, no data exists about a wheelchair athlete competing in an Ironman and no study has ever investigated how a wheelchair athlete would pace during an Ironman triathlon. Compared to their able-bodied counterparts, wheelchair Ironman triathletes relied on skeletal muscles of trunk and upper limbs [19]. In addition, upper and lower limbs showed different patterns of total, central (e.g., greater in knee extensors) and peripheral fatigue (e.g., greater in elbow flexors) [20].

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In this case study, we describe the pacing of the first and only wheelchair athlete worldwide to compete and finish a Quintuple Iron ultra-triathlon (i.e., 5 Ironman triathlons in 5 days) and a Deca Iron ultra-triathlon (i.e., 10 Ironman triathlons in 10 days). Based upon existing findings in pacing during a Deca Iron ultra-triathlon in able-bodied athletes [21,22], the hypothesis is a positive pacing (i.e., slowing down over days) also in a disabled athlete during both a Quintuple and a Deca Iron ultra-triathlon.

Materials and 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.

Races characteristics

The Swissultra (www.swissultra.ch) is an ultra-distance triathlon held since 2016 where races covering 5x, 10x or 20xIronman (i.e., 3.8 km swimming, 180 km cycling and 42.195 km running) are held. Swimming is held in a 50 m outdoor pool with a temperature of 20–23 °C. Cycling is held on a completely flat and traffic-free course where 20 laps of 9 km must be performed. Running is held on a completely free course where 35 laps of 1.2 km must be completed. Each lap is measured electronically with a chip system.

The race is held in the last two weeks of August where temperatures vary during the day from 25–35 °C. Often, rain falls in the late afternoon and evening. The cycling course is held in a large and broad valley (Rheintal) where the first half turns from north to south to a turning point to complete the second half from south to north. Early in the morning the wind is blowing from south to north and changes before noon from north to south.

Both Quintuple and Deca ultra-triathlon have an overall time limit of 20 h per day and a specific time limit for swimming (2 h; started every day at 7:00 a.m.), cycling (up to 11:00 p.m.) and running (3:00 a.m. of the following day).

Athlete characteristics

The athlete (57 years, 170 cm, 56 kg) is born in 1962 and competed in 2017 at the age of 55 years in the Quintuple Iron ultra-triathlon held in August in Buchs, Switzerland, and in 2019 at the age of 57 years in the Deca Iron ultra-triathlon. He suffers from a complete paraplegia L1 since 1998. He trains for 15–20 h per week. During summer, he trains primarily handbike cycling, but seldom wheelchair racing. During winter, he trains cross-country skiing. Since several years he is a member of the Swiss national team in handbike cycling and competes in handbike cycling races where he won the European cup in marathon cycling and in 2010, he was the overall winner of the European cup. He also competed in a team in the Gigathlon (www.gigathlon.com), a multi-day race consisting of swimming, cycling, running, inline skating and mountain biking) held in Switzerland where he took the part of cycling in a team. Apart from the Gigathlon, he competed in a team in the Tortour (www.tortour.com), a cycling race around Switzerland.

Regarding handbike training, he completed between 2004 and 2010 about 12,000–14,000 km per year, since 2011 he favours handbike cycling in the mountains with 8,000–9,000 km per year. The athlete stated different routines depending for the winter, with only indoor 10–12 h of weekly training performed on a spinning bike. Outdoor training begins in April with the handbike, with long-distance range up to 100 km per day and 500 km per week (20–25 h/week). In May, the focus on endurance is uphill, with approximately 300 km or 20–25 h/week. June is characterized by interval trainings, volume ranging 20–25 h per week, and two or three races to test optimal pacing strategies. July has a decreased intensity and volume, 15–20 h/week, and is used as tapering the physical fitness and test race equipment. The athlete's training regimen were not designed by an exercise specialist or coach, the athlete made up with his own experience and decided the specifics of each training session before it starts depending on the weather and self-perception of fatigue/fitness.

The handbike he used during the Swissultra was designed and built especially for him. It is a knee/seat bike on three wheels. The seat takes 80% of the body weight, and the remaining 20% is knee support area. The seat and crank height are adjusted to the athlete's height. The bicycle components are analogous to the racing bikes [23]; the racing class of the athlete is H5 at UCI-Cycling [24]. The wheelchair for the marathon split was a Top End racing wheelchair (https://topendwheelchair.invacare.com/racing-chairs/category/racingchairs-topend).

Race strategy of the athlete

The athlete adopted for both races the same strategy. He lives in Schaan, Principality of Liechtenstein, which is 5 min by car away from Buchs, Switzerland. He lives alone in an apartment without a family.

During the races, a crew of 17 persons worked in shifts: crew member A – swimming 6:30 a.m. to 9:30 a.m.; crew member B and C – handbike route 9:00 a.m. to 3:00 p.m.; crew member D – marathon 3:00 p.m. to the end; different crew the next day. The crew members were responsible for his food, drinks, clothes, utensils and mechanics. The shifts were divided by the disciplines and changed during the transitions from one discipline to the other. For each discipline (swimming, handbike and wheelchair) they had to provide his specific equipment and clothes. When there was a period of rain, he made a short break and the crew helped in changing clothes.

He slept at home and ate the first muesli after getting up. The swim started every morning at 7 a.m. After swimming, he made a short break and ate a second muesli at around 9 a.m. A little later, he took a sandwich as a snack. After 90 km on the handbike, he took a lunch break of 20 min at around 1 p.m. and ate the first half of lunch offered by the organizer. After eating, he went to the toilet. He then did another lap of handbike, ate then the second half of the lunch and took coffee and cake. At around 4 p.m., he took another full meal offered by the organizer with the intention that the food should be digested by around 5:30 p.m. before the start of the split with the racing wheelchair. During the marathon split with the racing wheelchair, he was mostly fed with small snacks such as bananas, figs, pretzel sticks, biscuits by his support crew. He also drank a carbohydrate electrolyte drink. Due to the fact that he wore special gloves for the wheelchair, all food and drinks were provided bite-sized by his support crew. At 9:30 p.m. he ate potatoes and cheese. After each stage, he drove alone back home by car. When he got home every evening after an Ironman, he had to cook, take a shower, wash clothes, eat dinner, and relax. He was able to sleep in his own bed and was well recovered in the morning for the next start.

The athlete had an initial pacing goal to finish within the time limit of the race maintaining an optimal pacing strategy expecting small and linear performance decreases every race day.

Data analysis

Data were obtained from the official race website of Swissultra at www.swissultra.ch/de/resultate. We collected the split times for swimming, cycling and running, the overall race times for each Ironman and the lap times in cycling (handbike) and running (wheelchair).

Each discipline (swimming, cycling (handbike) and running (wheelchair)) was performed in small loops, with time being recorded for every lap. Average speed and average pace were calculated for each lap, as well as average performance for each discipline in each race day. Data from each day of the Quintuple and Deca Iron ultra-triathlon were displayed in overall and split analyses. Data are expressed as mean, standard deviation (SD) and the coefficient of variation (%). The coefficient of variation (CV) is the a relative (%) measure of dispersion of the data, calculated as $CV = \sigma/\mu \times 100$ (standard deviation/average $\times$ 100). A higher CV means a higher variation of the pace. Repeated measures ANOVA with within- between-interactions was applied to detect interactions in average performance throughout the days (within; time) for handbike and wheelchair (between; group). ANOVA analysis had a power (1-beta) of 67% and 53% to detect a large effect size ($d \geq 0.7$) in the Quintuple and Deca races, respectively. Non-linear regressions (second and third order) were used in selected variables to identify possible patterns throughout race days. Pearson's correlation coefficient was applied to test the association between the variables. The significance level was set as $p < 0.05$. Statistical Software for the Social Sciences was used in all statistical procedures (SPSS v25, Chicago, Ill, USA).

Results

Table 1 shows the split and overall race time in each day for the Deca Iron ultra-triathlon of the athlete. The total race time was 137 h 3 min and 20 s. Table 2 shows the split and overall race time in each day for the Quintuple Iron ultra-triathlon. The total race time was 66 h 28 min and 31 s.

Figure 1 displays the average speed to complete each lap in handbike and wheelchair in each day in the Deca Iron ultra-triathlon. The data show a repeatable down in the handbike split between 81 and 108 (i.e., middle of the split) in almost every race day. For the wheelchair split (i.e., the marathon), no pattern for a pacing variation can be visualized throughout the days.

Figure 2 displays the average speed to complete each lap in both the handbike and the wheelchair split in each day in the Quintuple Iron ultra-triathlon. Similar to the Deca Iron ultra-triathlon, the data show a repeatable down in the handbike split between 81 and 108 (i.e., middle of the split) in almost every race day. For the wheelchair split, no pattern for pacing variation can be visualized throughout the days.

The average speed in each day was always higher in the handbike compared to the wheelchair split ($p < 0.05$) and no time-effect was found to neither handbike or wheelchair in the Deca Iron ultra-triathlon (Figure 3(A)). Similarly, in the Quintuple Iron ultra-triathlon, the average speed in each day was always higher in the handbike compared to the wheelchair split ($p < 0.05$) and no time-effect was found in neither handbike or wheelchair (Figure 3(B)). An even pacing was found in both the Deca and the Quintuple Iron ultra-triathlon in the swim split ($R^2 = 0.75$; $R^2 = 0.59$, respectively), in the handbike split ($R^2 = 0.41$; $R^2 = 0.91$, respectively), in the wheelchair split ($R^2 = 0.29$; $R^2 = 0.62$, respectively) and for overall race time ($R^2 = 0.23$; $R^2 = 0.76$, respectively).

Table 1. Race time in the Deca Iron ultra-triathlon.

	Race time (hours:minutes: seconds)			
	Overall	Swimming	Handbike	Wheelchair
Day 1	13:36:19	01:41:30	08:48:59	02:51:18
Day 2	13:48:32	01:48:15	08:42:37	03:00:06
Day 3	13:56:11	01:56:46	08:38:40	03:11:16
Day 4	13:45:38	01:53:15	08:49:43	02:52:55
Day 5	13:31:40	01:52:20	08:30:28	02:58:48
Day 6	13:29:12	01:54:40	08:22:11	03:02:10
Day 7	14:01:13	01:54:21	08:28:57	03:29:02
Day 8	14:08:44	01:54:03	08:55:30	03:10:06
Day 9	13:40:01	01:52:06	08:38:58	02:54:05
Day 10	13:05:50	01:48:04	08:11:23	02:54:51
Average (SD)	13:42:20 (18:07)	01:51:32 (04:27)	08:36:45 (13:37)	03:02:28 (11:34)
Total	137:03:20	18:35:20	86:07:26	30:24:37

SD: standard deviation (minutes: seconds). Each day consists of 3.8 km swimming, 180 km of handbike (cycling split) and 42 km of wheelchair cycling (running split).

Table 2. Race time in the Quintuple Iron ultra-triathlon.

	Race time (hours:minutes:seconds)			
	Overall	Swimming	Handbike	Wheelchair
Day 1	13:21:59	01:41:38	08:23:17	03:07:44
Day 2	12:57:37	01:42:55	08:22:28	02:42:14
Day 3	13:10:55	01:42:23	08:33:48	02:43:31
Day 4	13:24:11	01:45:51	08:32:48	02:55:54
Day 5	13:33:49	01:44:05	08:38:57	02:57:10
Average (SD)	13:17:42 (12:24)	01:43:22 (01:28)	08:30:16 (06:23)	02:53:19 (09:28)
Total	66:28:31	8:36:52	42:31:18	14:26:33

SD: standard deviation (minutes: seconds). Each day consists of 3.8 km swimming, 180 km of handbike (cycling split) and 42 km of wheelchair cycling (running split).

The coefficient of variation (CV) in Deca Iron was similar throughout the first six days for the wheelchair, with the highest CV in day 7 (18.9%) and the lowest in day 8 (6.0%). The handbike started (Day 1) with the highest CV, and had the lowest on the last day (8.3%). In the Quintuple Iron ultra-triathlon, the CV was very stable (~14%) for the handbike throughout the five race days. For the wheelchair split, the CV started very high (17.6%), became stable in the middle days and increased again in the last day (14.2%).A third-order polynomial equation was able to fit CV pattern along the race for Quintuple Iron ultra-triathlon (handbike $R^2 = 0.98$; wheelchair $R^2 = 0.99$), but for the Deca Iron ultra-triathlon only handbike fitted (handbike $R^2 = 0.98$; wheelchair $R^2 = 0.01$) (Figure 4).

In the Deca Iron ultra-triathlon, the correlation analysis showed a negative correlation between performance and CV for the handbike, but not for the wheelchair split. Conversely, a positive correlation was identified between performance and CV for the handbike in the Quintuple Iron ultra-triathlon, with a negative correlation between performance and CV for the wheelchair (Figure 5).

Discussion

This case study investigated the pacing during the cycling (i.e., handbike) and running (i.e., wheelchair) split in a disabled athlete competing in both a Quintuple and a Deca Iron ultra-triathlon.

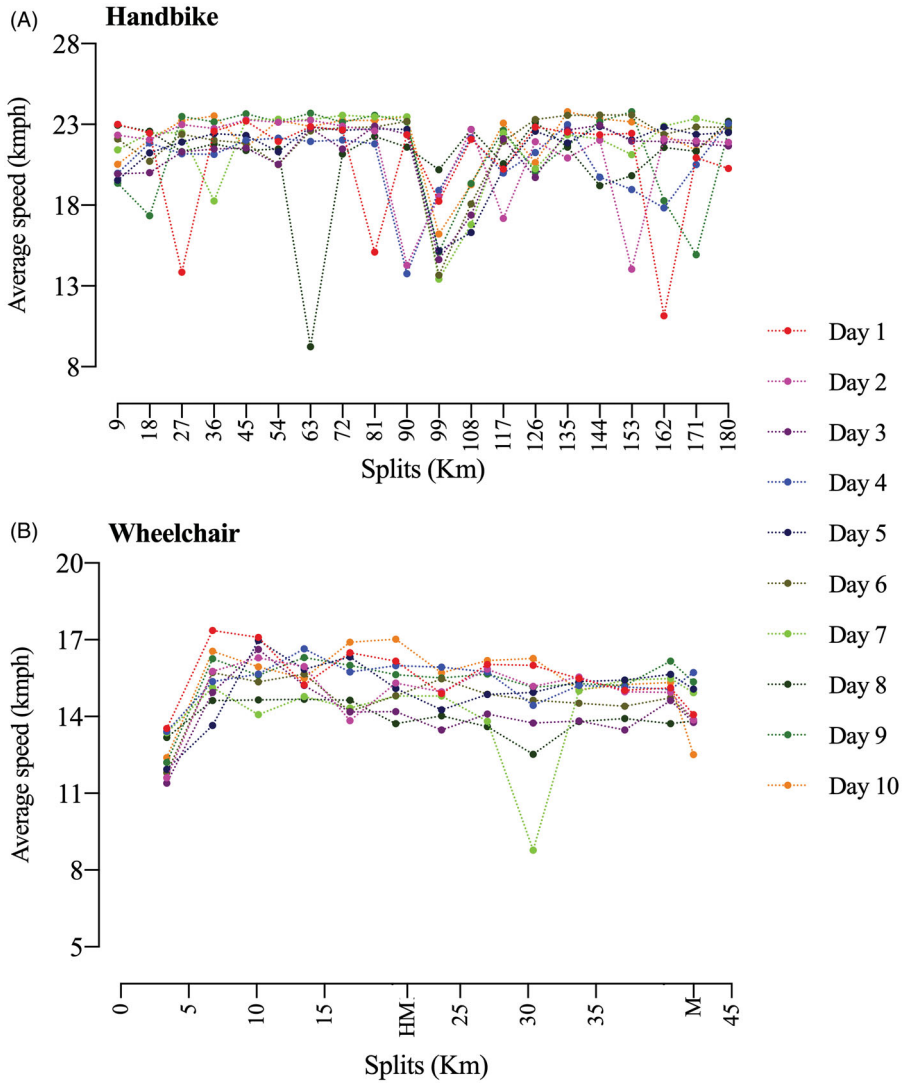

Figure 1. Pacing in each of the 10 days in a Deca Iron ultra-triathlon in the handbike and wheelchair of a Paralympic triathlete; HM: half-marathon; M: marathon.

Based upon previous reports about pacing in a multi-stage triathlon, it was assumed that the disabled athlete would become slower across days as well as across split disciplines.

The results show, however, an even pacing [5] for swimming, the handbike split (i.e., cycling part), the wheelchair split (i.e., running part) and for overall race time during both the Quintuple and the Deca Iron ultra-triathlon. These findings are in contrast to elite Ironman triathletes where performance decreased (i.e., positive pacing) during both the cycling and running split [7] and to Deca Iron ultra-triathletes with a decrease in performance across days in both split disciplines and overall race time [21,22].

A potential explanation for the even pacing in both handbike and wheelchair cycling could be the previous experience of the athlete. On the one hand, he has many years of training experience with many kilometres on the hand bike and, on the other hand, he has already competed in many long competitions with the hand bike. A study investigating predictor variables for a successful finish in a Deca Iron ultra-triathlon found that both the number of finished Triple Iron ultra-triathlons (i.e., 11.4 km swimming, 540 km cycling and 126.6 km running) and the personal best time in a Triple Iron ultra-triathlon were related to overall race time in a Deca Iron ultra-triathlon [22].

A further interesting finding was a negative correlation between performance and CV in the Deca Iron ultra-triathlon and a positive correlation was between performance and CV in the Quintuple Iron ultra-triathlon for the handbike. These correlations are most probably due to his breaks for eating leading to the decrease in speed in the middle of the handbike split.

Regarding the race strategy of the athlete he always organized his meals according to the same scheme during an Ironman with a first break for eating at around 1 p.m. after 90 km of handbike cycling followed by a second break shortly after and a third break at around 4 p.m. before changing to the wheelchair split. This strategy was most likely the result of his experience in earlier races

After 90 km on the handbike, he took a lunch break of 20 min at around 1 p.m. and ate the first half of lunch offered by the organizer. After eating, he went to the toilet. He then did another lap of handbike, ate then the second half of the lunch and took coffee and cake. At around 4 p.m., he took another full meal offered by the organizer with the intention that the food should be digested by around 5:30 p.m. before the start of the split with the racing wheelchair.

Most probably he developed this nutrition strategy during his earlier races. Very little is known regarding nutrition in wheelchair athletes [25]. In able-bodied ultra-endurance cyclists, it is known, however, that appropriate nutrition during a race is an important predictor for a successful race outcome [26]. We must also be

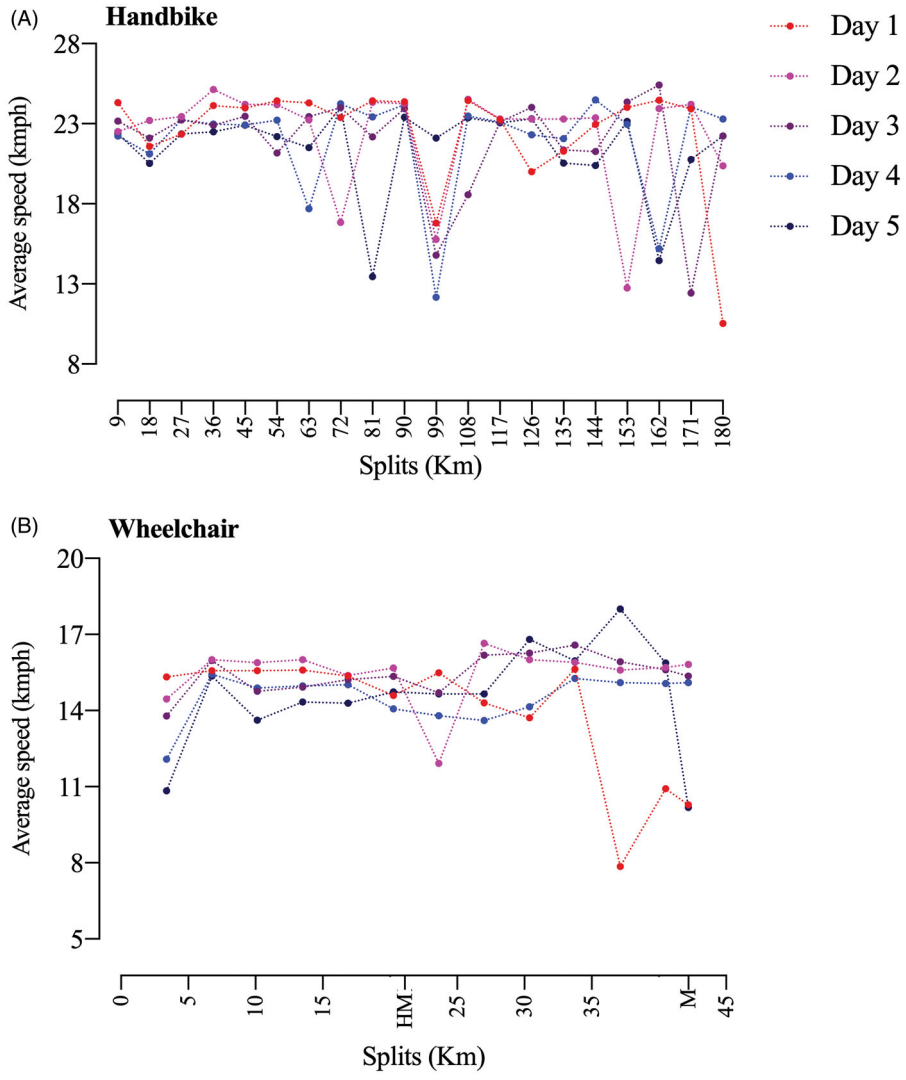

Figure 2. Pacing variation and average speed in each of the 10 days in a Deca Iron ultra-triathlon in the handbike and wheelchair of a Paralympic triathlete.

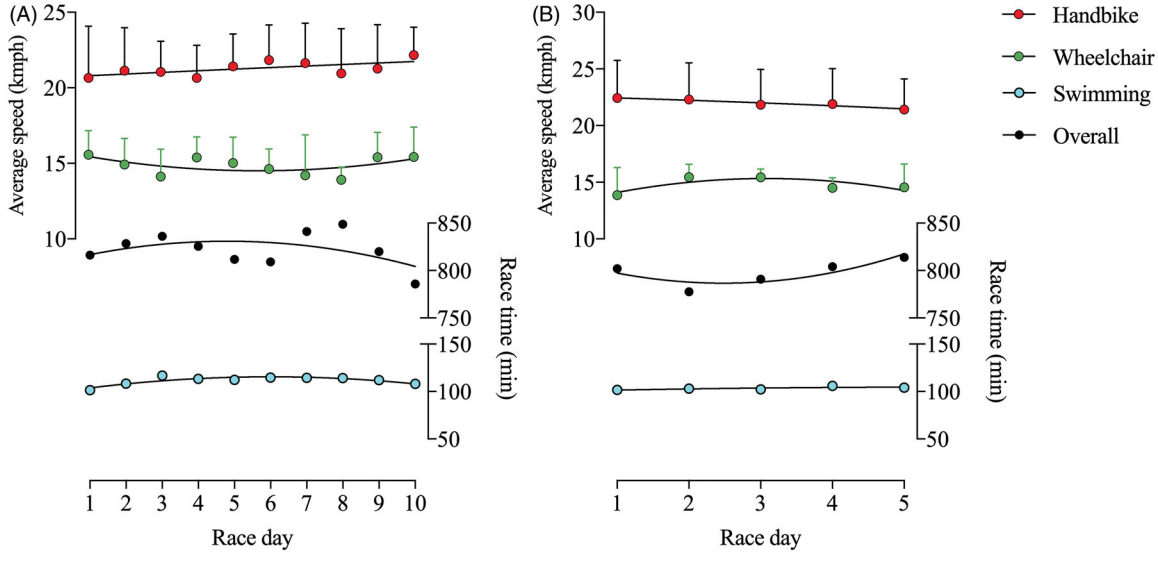

Figure 3. Pacing in each of the 5 days in a Quintuple Iron ultra-triathlon in the handbike and wheelchair of a Paralympic triathlete; HM: half-marathon; M: marathon.

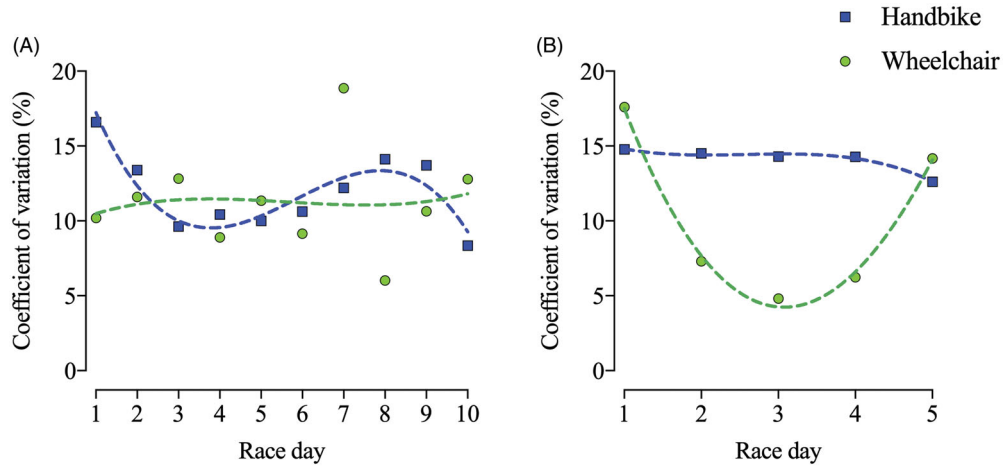

Figure 4. Pacing variation and average speed in each of the 5 days in a Quintuple Iron ultra-triathlon in the handbike and wheelchair of a Paralympic triathlete.

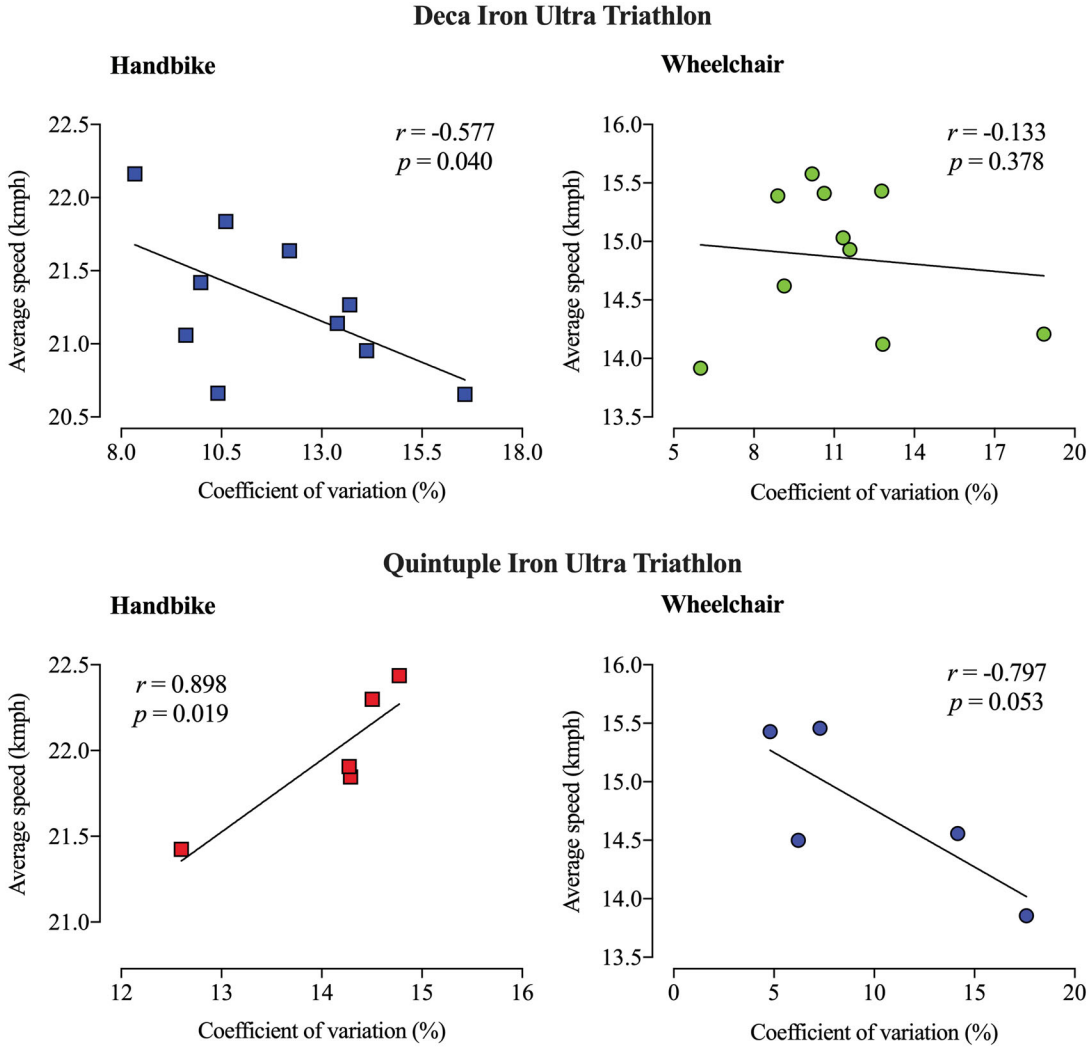

Figure 5. Correlation analysis between pacing variation and average performance in a Deca and a Quintuple Iron ultra-triathlon in the handbike and wheelchair of a Paralympic triathlete.

aware that a wheelchair athlete must use both his hands during handbike and wheelchair cycling and has no possibility to eat and drink while cycling.

Anthropometric and physiological data across race days, such as body mass, body water, heart rate and fasting glucose would be important variables to monitor and analyse, but unfortunately the athlete and staff crew were unable to record this data during the race. This could be pointed as a limitation and a goal for future studies.

A limitation of the present study was the specific characteristics (e.g., length of race and disciplines) of 5x and 10xIronman considered in the present study; thus, caution would be needed

to generalize these findings in other triathlon races. On the other hand, strength was the novelty of the study as it was the first one to analyse the performance characteristics of an Ironman triathlete. In addition, these findings would have practical applications for both scientists (e.g., model muscle fatigue in upper body ultra-endurance exercise compared to full-body exercise) and professionals working with wheelchair athletes (e.g., develop pacing strategies). Although the success of this athlete in these races was achieved without a close follow-up of an exercise specialist or coach, we do not recommend amateur athletes to prepare for such events without professional input. The ability the organize a training regimen to optimize performance and decrease the chances of burnout and injuries requires knowledge and experience.

Conclusion

An experienced paraplegic wheelchair athlete was able to finish both a Quintuple and a Deca Iron ultra-triathlon. The athlete applied an even pacing in all split disciplines and for overall race time and finished both Quintuple and Deca Iron ultra-triathlon within the time limits of the races.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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