

# Differences in pacing during cycling and running in ultra-triathlons – The example of ‘Swissultra’

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**Abstract. – OBJECTIVE:** The knowledge of the most predictive split discipline and the pacing during a triathlon race is of utmost importance for planning an ultra-triathlon race. This study aimed at investigating the pacing during cycling and running splits in three different multi-stage ultra-triathlon race formats (i.e., Quintuple, Deca, and Double Deca Iron ultra-triathlon with 5x, 10x and 20x the daily distance of a full Ironman-distance triathlon).

**SUBJECTS AND METHODS:** A total of 48 male ultra-triathletes competing in Quintuple (n=14), Deca (n=25), and Double Deca (n=9) Iron ultra-triathlon “swissultra” between 2016 and 2019 in Switzerland were analyzed. For each race day, we calculated the total performance (sum of all laps time), average individual performance (average of all laps time within a race day) and pacing variation (coefficient of variation of race laps time) for cycling and running. Discipline (cycling and running) and race distance (Quintuple, Deca, and Double Deca Iron ultra-triathlon) were used as independent parameters. The primary outcome variables were the time performance (daily and total) and the pacing variation. We applied two general linear models (GLM): the first model was a one-way ANOVA comparing total and daily performance by race distance, and the second model was a two-way ANOVA (race distance × discipline) using pacing variation (average pace oscillation) as a dependent variable.

**RESULTS:** The first GLM identified a significant race distance effect for total performance in both cycling ( $F = 375.6$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.943$ ) and running ( $F = 267.8$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.922$ ) with Double Deca Iron ultra-triathlon being the fastest and Quintuple Iron ultra-triathlon the slowest. The GLM for daily average performance showed no significant effect of race distance on cycling performance ( $F = 0.171$ ;  $p = 0.843$ ;  $\eta_p^2 = 0.008$ ), but on running performance ( $F = 6.408$ ;  $p$

$= 0.004$ ;  $\eta_p^2 = 0.222$ ). The two-way GLM comparing pacing variation showed a significant effect for race distance ( $F = 11.81$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.344$ ) with Deca presenting larger pace variation than Quintuple and Double Deca Iron ultra-triathlon in both cycling and running, but not for discipline ( $F = 0.067$ ;  $p = 0.797$ ;  $\eta_p^2 = 0.001$ ), nor for interaction ( $F = 1.469$ ;  $p = 0.241$ ;  $\eta_p^2 = 0.061$ ).

**CONCLUSIONS:** Athletes achieved a stable cycling performance independent of the length of the race, and the cycling split had an influence on the subsequent running split depending upon the length of the race.

*Key Words:*

Swimming, Cycling, Running, Ultra-endurance.

## Introduction

Multi-stage ultra-marathons require athletes to cover a distance longer than a marathon in each day<sup>1,2</sup>. These running events have a long tradition, with a recent increase in popularity<sup>1,3</sup>. In particular, running a marathon daily for 7 consecutive days<sup>4,5</sup>, 10 marathons in 10 days<sup>6,7</sup>, and up to 100 marathons in 100 days<sup>8</sup> are one of the most popular events.

In triathlon, after the invention of the full Ironman-distance covering 3.8 km swimming, 180 km cycling, and 42.2 km running with the ‘Ironman® Hawaii’<sup>9</sup> the multi-stage ultra-triathlon races have been created, with the first being the Deca Iron ultra-triathlon (10 full Ironman-distance triathlons in 10 days) held for the first time in 2006 in Monterrey, Mexico<sup>10,11</sup>.

While single athletes were able to cover 33 full Ironman-distance triathlons in 33 days<sup>12</sup> up to 40 full Ironman-distance triathlons in 40 days<sup>13</sup>, the race format of daily competing a full Ironman-distance triathlon were basically the Quintuple Iron ultra-triathlon (5 full Ironman-distance triathlons in 5 days)<sup>14,15</sup> and the Deca Iron ultra-triathlon (10 full Ironman-distance triathlons in 10 days)<sup>14-17</sup> with the extension to the Double Deca Iron ultra-triathlon covering 20 full Ironman-distance triathlons in 20 days<sup>18</sup> and the Triple Deca Iron ultra-triathlon with 30 full Ironman-distance triathlons in 30 days<sup>16</sup>.

Given the plethora of factors associated with performance, the nature of triathlon, and the relationship between the three race components<sup>19</sup>, triathletes try to calculate their planned splits and overall race times before it starts<sup>20</sup>. The intensity and influence of each discipline on the subsequent discipline pace (i.e., cycling performance influencing running performance) are essential, and the different distances and disciplines highly influence pacing strategies during a triathlon<sup>21-24</sup>.

For a sprint distance triathlon, swimming<sup>22</sup> or cycling<sup>24,25</sup> were the best discipline predictors.

For an Olympic distance triathlon, different studies have obtained contradictory results, indicating the importance of swimming<sup>22</sup>, cycling<sup>24</sup> or running<sup>26,27</sup> as the most predictive split discipline. For the half-distance Ironman triathlon (Ironman<sup>®</sup> 70.3), cycling was the most predictive<sup>22</sup>, whereas, for the full Ironman-distance triathlon, several studies have found running to be the most predictive split discipline. In one study, running and cycling were predictive<sup>26</sup>. In other analyses, however, only the cycling split was the most predictive for the full Ironman-distance triathlon<sup>28</sup>, whereas, in other analyses, running was the most critical split discipline for the full Ironman-distance<sup>22</sup>.

However, pacing oscillation within the split disciplines cycling and running seems to be of importance as well<sup>29,30</sup>. This is most likely due to changes in elevation in the course profile<sup>30</sup>. Another study also identified Ironman<sup>®</sup> triathletes with a positive pacing and a continuous decrease in speed during both the cycling and the running split<sup>31</sup>.

Previous literature<sup>12-18</sup> also described pacing during multi-stage ultra-triathlons. A female triathlete setting a world record in Quintuple and Deca Iron ultra-triathlon adopted an even pacing strategy for cycling and running, without a variation within- or between race days<sup>14</sup>. For a Deca Iron ultra-triathlon, the pacing was positive (i.e., daily performance decreased over days)<sup>16</sup>.

In a Double Deca<sup>18</sup> and a Triple Deca Iron ultra-triathlon<sup>16</sup>, the daily performance remained unchanged across days (i.e., even pacing). An athlete who completed 33 full Ironman-distance triathlons in 33 days achieved an even pacing in cycling and running, resulting in an even pacing in overall race time<sup>12</sup>. In a self-paced world record attempt in 40 full Ironman-distance triathlons in 40 days, cycling times became slower across days, whereas running times undulated over days<sup>13</sup>.

Little is known regarding the influence of the single split disciplines on overall race performance in a multi-stage ultra-triathlon. In a case report<sup>13</sup> from 40 full Ironman-distance triathlons in 40 days, overall race time was influenced by cycling and running performance but not by swimming performance. Little is also known regarding (i) which split discipline is the most predictive in a multi-stage triathlon; and (ii) how ultra-triathletes pace within the cycling and running split during a multi-stage. Therefore, the present study aimed at investigating the pacing of cycling and running splits in three different multi-stage ultra-triathlon race formats (i.e., Quintuple, Deca, and Double Deca Iron ultra-triathlon). Based upon existing knowledge, we hypothesized that (i) pacing would be even in a Double Deca Iron ultra-triathlon compared to shorter distances and (ii) cycling and running performance would decrease during a single split.

## Subjects and Methods

### *Ethical Approval*

This study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland (Ethikkommission St. Gallen), 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). All procedures adhered to the ethical standards set by the Declaration of Helsinki.

### *The Race*

The 'swissultra' ([www.swissultra.ch](http://www.swissultra.ch)) has been held since 2016, annually, in August. It offers different race formats in the continuous version (no break) and the 'one per day' format (i.e., every morning start of a full Ironman-distance triathlon). In 2020 and 2021, the race was not held due to the COVID-19 pandemic.

The formats are five times the full Ironman-distance triathlon (i.e., Quintuple Iron ultra-

triathlon with 19 km swimming, 900 km cycling, and 210 km running in total), ten times the full Ironman-distance triathlon (i.e., Deca Iron ultra-triathlon with 38 km swimming, 1,800 km cycling, and 420 km running in total) and 20 times the full Ironman-distance triathlon (i.e., Double Deca Iron ultra-triathlon with 76 km swimming, 3,600 km cycling and 840 km running in total). While the first two distances were offered in both formats, the Double Deca Iron ultra-triathlon was held only in the daily format (i.e., 20 full Ironman-distance triathlons in 20 days).

In the one per day format, each athlete has to perform a full Ironman-distance triathlon daily (i.e., 3.8 km swimming, 180 km cycling, and 42.2 km running) without a rest day. These races occur in closed circuits where the athlete performs several laps until achieving the goal distance. Swimming is held in a 50 m outdoor pool with a temperature of ~20-23°C depending upon the weather. Cycling is held on a completely flat and traffic-free course where 20 laps of 9 km must be performed. The cycling course is held in a large and broad valley (Rheintal at the Swiss border to Austria and Fürstentum Liechtenstein) 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 blows from south to north and changes before noon from north to south. Running is held on a different traffic-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 three weeks of August, where temperatures vary during the day from 25°C to 35°C. In August, rain falls very often in the late afternoon and evening. Each athlete had their support for proper hydration, nutrition, and eventual mechanical issues during the race.

### Data

All data were obtained from the race website of 'swissultra' (www.swissultra.ch). Cycling and running portions of each event were realized in a closed standard circuit, in which the race time for each lap was recorded for each athlete. For each race day, we calculated the total performance (sum of all laps), individual average performance (average of all laps within a race day) and pacing variation (coefficient of variation of race laps). Discipline (cycling and running) and race distance (Quintuple, Deca, and Double Deca Iron ultra-triathlon) were used as independent parameters.

### Statistical Analysis

The primary outcome variables were time performance (daily and total) and the pacing variation. All linear variables were tested with the Kolmogorov-Smirnov test and showed normal distribution. Different general linear models (GLM) were applied as follows: the first model was a one-way ANOVA comparing total and daily performance by race distance. The second model was a two-way ANOVA (race distance' discipline) using pacing variation (average pace oscillation) as a dependent variable. The least significant difference (LSD) technique was used as a post-hoc test for pairwise comparisons. We applied Pearson's correlation coefficient to identify any potential correlation between pacing variation and performance in different conditions (clustered by race distance and discipline). Partial eta square ( $\eta_p^2$ ) was applied for effect size measures. All statistical analyses were carried out using the Statistical Software for the Social Sciences v. 25 (IBM Corp., Armonk, NY, USA), considering a confidence interval at 95%.

### Results

The analyses included a total of 48 male ultra-triathletes competing in Quintuple Iron ultra-triathlon ( $n=14$ ), Deca Iron ultra-triathlon ( $n=25$ ), and Double Deca Iron ultra-triathlon ( $n=9$ ), in events that occurred between 2016 and 2019. The first GLM identified a significant race distance effect for total performance in both cycling ( $F = 375.6$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.943$ ) and running ( $F = 267.8$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.922$ ). Post-hoc comparisons showed Double Deca Iron ultra-triathlon with the best and Quintuple Iron ultra-triathlon with the lowest time performances (Figures 1A and 1B).

The GLM for daily average performance showed no significant effect of race distance on cycling performance ( $F = 0.171$ ;  $p = 0.843$ ;  $\eta_p^2 = 0.008$ ), but on running performance ( $F = 6.408$ ;  $p = 0.004$ ;  $\eta_p^2 = 0.222$ ). Post-hoc analyses showed that athletes competing in the Deca Iron ultra-triathlon had higher time performances than in the Quintuple Iron ultra-triathlon and in the Double Iron ultra-triathlon (Figures 1D and 1E).

The two-way GLM comparing pacing variation showed a significant effect for race distance ( $F = 11.81$ ;  $p < 0.001$ ;  $\eta_p^2 = 0.344$ ), but not for discipline ( $F = 0.067$ ;  $p = 0.797$ ;  $\eta_p^2 = 0.001$ ), nor for interaction ( $F = 1.469$ ;  $p = 0.241$ ;  $\eta_p^2 = 0.061$ ). Pairwise comparisons showed for athletes

**Table I.** Matrix correlation for Quintuple Iron ultra-triathlon. Data expressed as the correlation coefficient ( $r$ ).

	Running pace oscillation	Cycle performance (Daily average)	Run performance (Daily average)	Cycle performance (total)	Run performance (total)
Cycling pace oscillation	0.165	0.737*	0.715*	0.737*	0.715*
Running pace oscillation	-	-0.051	-0.132	-0.051	-0.132
Cycling performance (Daily average)	-	-	0.867**	1.000**	0.867**
Running performance (Daily average)	-	-	-	0.867**	1.000**
Cycling performance (total)	-	-	-	-	0.867**

\*:  $p < 0.05$ ; \*\*:  $p < 0.001$ .

competing in the Deca Iron ultra-triathlon a larger pace variation than in the Quintuple Iron ultra-triathlon and in the Double Deca Iron ultra-triathlon in both cycling and running (Figure 1C).

Cycling pace variation was significantly and positively correlated with daily cycling performances in the Quintuple Iron ultra-triathlon and Double Deca Iron ultra-triathlon, daily running performances in the Quintuple Iron ultra-triathlon, and overall cycling performance in the Double Deca Iron ultra-triathlon and the Quintuple Iron ultra-triathlon, and with overall running performance in the Quintuple Iron ultra-triathlon (Figure 2). Tables I-III display a matrix correlation with the  $p$ -values and coefficients for Quintuple, Deca, and Double Deca Iron ultra-triathlon, respectively.

Running pace variation was significantly and negatively correlated with daily cycling and overall performance in the Deca Iron ultra-triathlon and cycling pace variation in the Deca Iron ultra-triathlon (Figure 3).

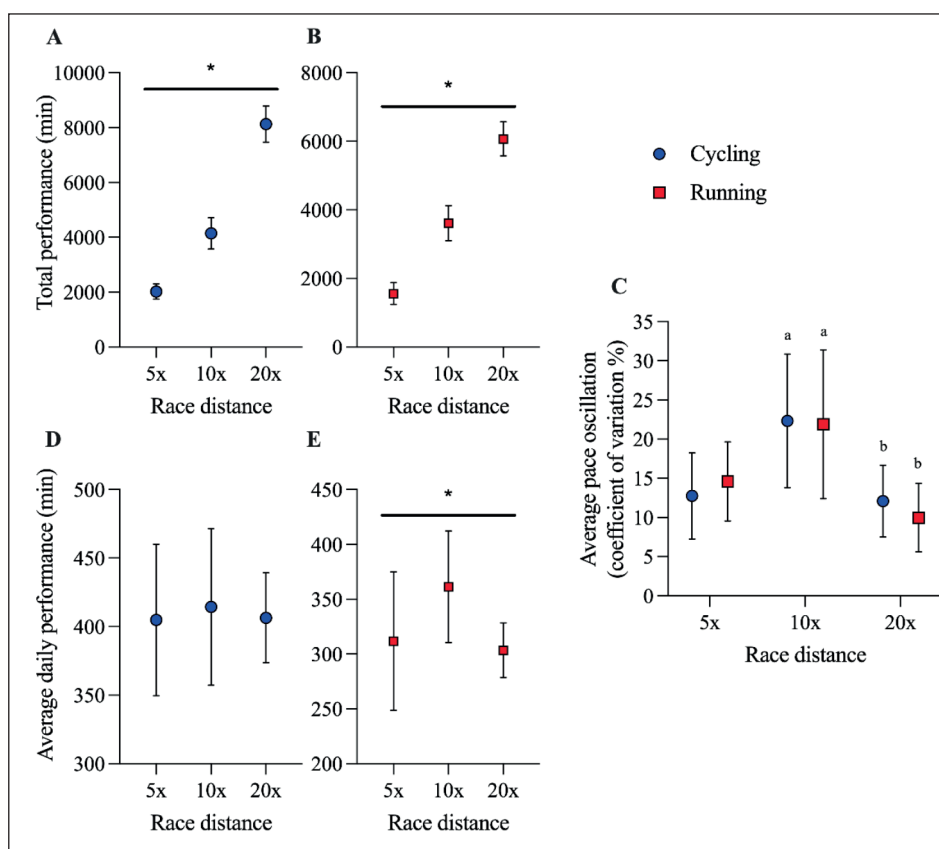
## Discussion

This study intended to investigate the cycling and running split pacing during three different multi-stage ultra-triathlons (i.e., Quintuple, Deca, and Double Deca Iron ultra-triathlon). We hypothesized that pacing would be even in a Double Deca compared to shorter distances and that cycling and running performance would decrease during a single split. The main findings were as follows: (i) there was no difference in average daily cycling performance, meaning that athletes were not cycling faster because they had more or fewer race days; (ii) athletes competing in the Deca Iron ultra-triathlon were slower than athletes in the Quintuple and the Double Deca Iron ultra-triathlon; (iii) athletes in the Deca Iron ultra-triathlon showed a higher pacing variation in both cycling and running compared to athletes in the Quintuple and in the Double Deca Iron ultra-triathlon; (iv) athletes in both the Quintuple and the Double Deca Iron

**Table II.** Matrix correlation for Deca Iron ultra-triathlon. Data expressed as the correlation coefficient ( $r$ ) and  $p$ -value.

	Running pace oscillation	Cycling performance (Daily average)	Running performance (total)	Cycling performance performance	Running (Daily average) (total)
Cycling pace oscillation	0.836**	-0.254	0.309	-0.254	0.309
Running pace oscillation	-	-0.535*	-0.058	-0.535*	-0.058
Cycling performance (Daily average)	-	-	0.568*	1.000**	0.568*
Running performance (Daily average)	-	-	-	0.568*	1.000**
Cycling performance (total)	-	-	-	-	0.568*

\* $\chi^2$  test; \*\*Student's  $t$ -test; \*\*\*Fisher's exact test.



**Figure 1.** Total performance (A-B), average pace oscillation (C), and average daily performance in 5x (Quintuple Iron ultra-triathlon), 10x (Deca Iron ultra-triathlon), and 20x (Double Deca Iron ultra-triathlon). (D-E)\*: All race distances are different ( $p < 0.05$ ) from each other; a: Different from 5x within the same discipline; b: Different from 10x within the same discipline.

**Table III.** Matrix correlation for Double Deca Iron ultra-triathlon. Data expressed as the correlation coefficient ( $r$ ) and  $p$ -value.

	Running pace oscillation	Cycling performance (Daily average)	Running performance (Daily average)	Cycling performance (total)	Running performance (total)
Cycling pace oscillation	0.540	0.710*	0.152	0.710*	0.152
Running pace oscillation	-	0.537	0.539	0.537	0.539
Cycling performance (Daily average)	-	-	0.755*	1.000**	0.755*
Running performance (Daily average)	-	-	-	0.755*	1.000**
Cycling performance (total)	-	-	-	-	0.755*

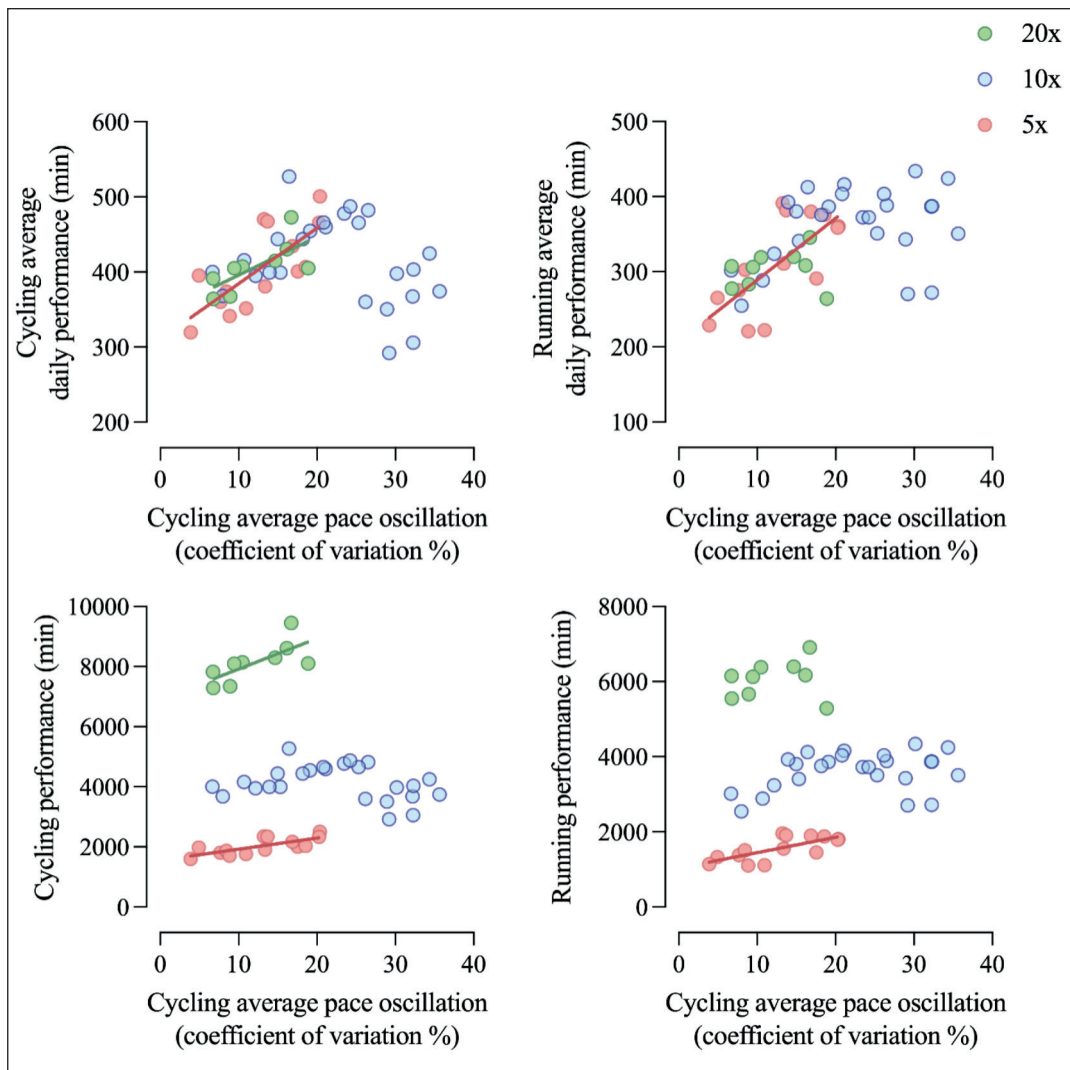
\*:  $p < 0.05$ ; \*\*:  $p < 0.001$ .

ultra-triathlon with a higher pacing variation in cycling showed a slower cycling and running performance compared to the Deca Iron ultra-triathlon; and (v) athletes in the Deca Iron ultra-triathlon with a slower cycling performance had a higher running pacing variation.

**No Difference in Average Daily Cycling Performance**

A first important finding was that cycling performance remained stable independently from the race duration. This was an unexpected finding since the pacing was positive for both cycling





**Figure 2.** Correlation between cycling pacing oscillation and performance for cycling and running in 5x (Quintuple Iron ultra-triathlon), 10x (Deca Iron ultra-triathlon), and 20x (Double Deca Iron ultra-triathlon). Linear regression line: significant ( $p < 0.05$ ) correlations.

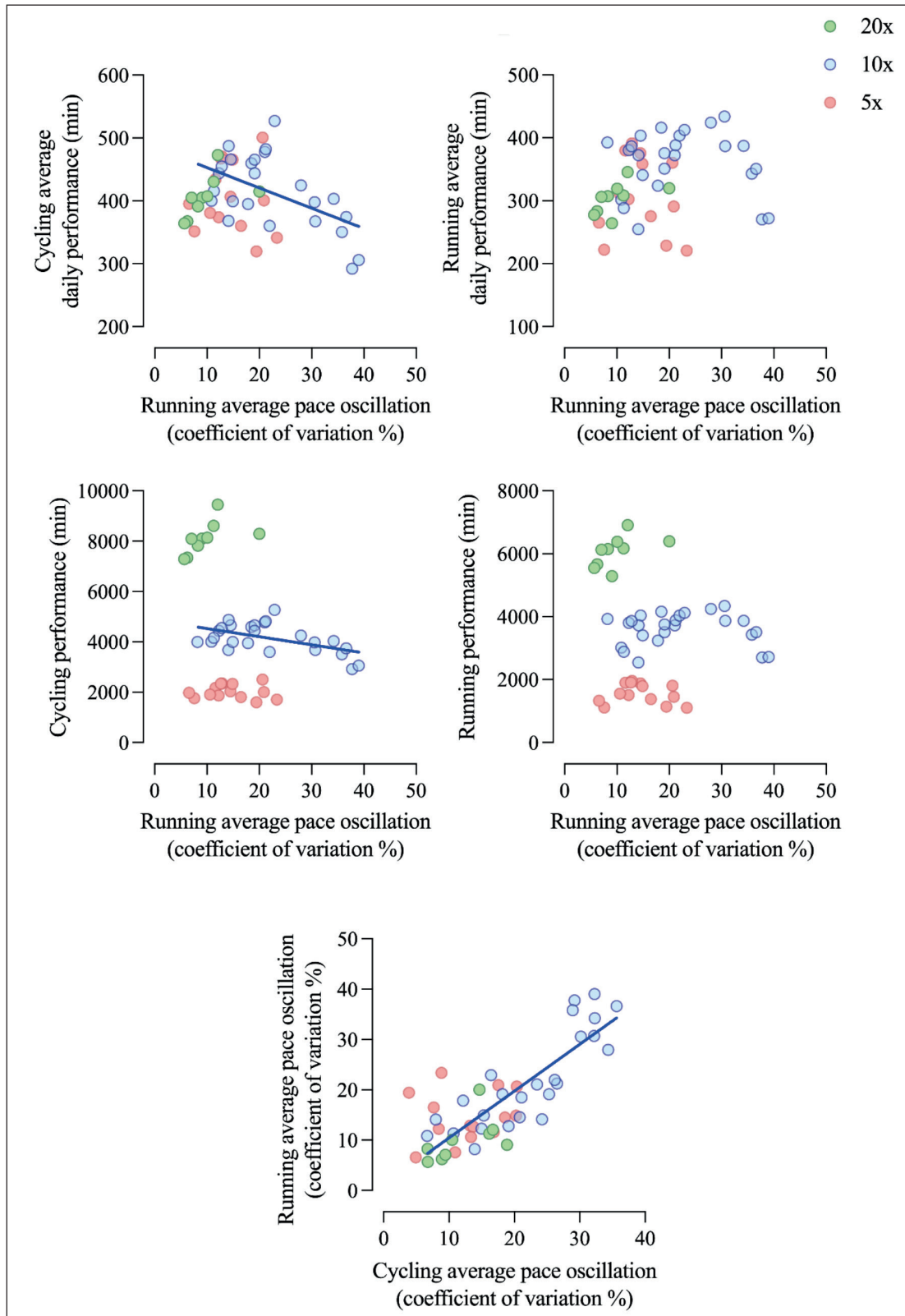
and running in a single full-distance Ironman® triathlon<sup>31</sup>. In 7,687 cycling and 11,894 running split times of 1,392 triathletes (1,263 men, 129 women), a study found a continuous decrease in speed for both women and men<sup>31</sup>.

However, ultra-triathletes competing in multi-stage triathlons seemed to adopt an even pacing in order to finish such a race successfully. In a Double Deca<sup>18</sup> and a Triple Deca Iron ultra-triathlon<sup>16</sup>, the daily performance remained unchanged across days (i.e., even pacing). Also, in record attempts, ultra-triathletes maintained their speed over days or even weeks. An athlete who competed for the first time in history the total distance of 33 full Ironman-distance triathlons within 33 consecutive

days achieved an even pacing in both split times and overall race times<sup>12</sup>. In a self-paced world record attempt in 40 full Ironman-distance triathlons in 40 days, swimming and cycling times became slower across days, whereas running times got faster until the 20<sup>th</sup> day and, after that, became slower until the 40<sup>th</sup> day<sup>13</sup>. Our findings suggest that athletes plan their pacing strategy, probably in a physiological comfortable speed/pace so that they can maintain the pace across all race days.

#### ***Decrease in Speed with an Increasing Race Distance***

Another important finding was that athletes competing in the Deca were slower than athletes



**Figure 3.** Correlation between running pacing oscillation and performance for cycling and running in 5x (Quintuple Iron ultra-triathlon), 10x (Deca Iron ultra-triathlon), and 20x (Double Deca Iron ultra-triathlon). Linear regression line: significant ( $p < 0.05$ ) correlations.

in the Quintuple and the Double Deca Iron ultra-triathlon. The Deca Iron ultra-triathlon seems to be the most popular race distance since several studies have investigated this distance in contrast to the Quintuple and the Double Deca Iron ultra-triathlon<sup>10,17</sup>. The Deca Iron ultra-triathlon was also the first multi-stage ultra-triathlon, with the first edition held in 2006 in Monterrey, Mexico<sup>10</sup>.

Previous studies<sup>16,17</sup> showed that pacing in a Deca Iron ultra-triathlon was positive, which is mainly due to the decrease in substantial body mass such as fat mass<sup>10,17</sup>. An essential aspect in a Deca Iron ultra-triathlon is the daily energy deficit<sup>32,33</sup>, leading to a slowing down and resulting in a positive pacing (i.e., increase in daily race times throughout the race)<sup>16,17</sup>. Since there is no knowledge about the change in body mass and energy deficit of longer distances than the Deca Iron ultra-triathlon, future studies need to investigate this aspect in a Double or Triple Deca Iron ultra-triathlon. Another potential part for slower pacing times in Deca Iron ultra-triathlon could be the participation of less experienced athletes, due to the higher popularity of this distance<sup>34</sup>. Thus, less experience in such events could result in over cautious or reckless pacing strategies, resulting in slower overall race times.

### ***Pacing Variation in Cycling and Running Differs Between the Race Distances***

The third finding was that Deca Iron ultra-triathletes showed a higher pacing variation in both cycling and running than Quintuple and Double Deca Iron ultra-triathletes. The length of the multi-stage triathlon seemed to be of importance regarding the influence of the split disciplines. A study compared the pacing between Deca and Double Deca Iron ultra-triathletes. In the Deca Iron ultra-triathlon, swimming and cycling splits were faster than in the Double Deca Iron ultra-triathlon, whereas, in the Double Deca Iron ultra-triathlon, the running splits were faster than in the Deca Iron ultra-triathlon<sup>18</sup>. In addition, considering that previous experience (e.g., athlete training level, a race previously knowledge) is vital to triathlon performance<sup>17,35</sup>, which can influence in the pacing strategy, the highest pacing variation is expected in the lowest experienced athletes, most of the participants in Deca Iron ultra-triathlon events. Less experienced athletes may not always stick to their pacing strategy, increasing pacing variation. In addition, quick stops, to solve mechanical problems during cycling or for nutritional intake, may be more common in less experienced athletes.

### ***Differences in Pacing Variation for Cycling and Running in Deca Iron Ultra-Triathlon***

The last important finding was that Deca Iron ultra-triathletes with a slow cycling performance had a higher pacing variation in running. Several studies have investigated the most predictive split discipline for the single full Ironman® distance<sup>26</sup>. The performance in cycling and running seemed to be the most important, and the performance in cycling influenced the subsequent running split<sup>26</sup>. An analysis of 343,345 athletes competing between 2002 and 2015 in 253 different Ironman® triathlon races showed that the fastest Ironman® triathletes were the relatively fastest in running and transition times<sup>36</sup>. Increased pacing variation could lead to increased physiological distress than a similar average pace within a racecourse. Thus, increased physiological distress during cycling is likely to increase the difficulty for the subsequent running discipline, forcing a change of strategy, increasing pacing variation, and decreasing performance. In this sense, a previous study using a machine learning approach in Olympic distance triathlon showed that for men, the running time was a significant predictor for the final position, with the magnitude of the differences in differential run time being the largest of any race component<sup>19</sup>.

### ***Limitations***

This study has some limitations where we were not able to record food and fluid intake, measure changes in body composition<sup>1,17</sup> and determine the energy deficit occurring during the race<sup>1,32,33,37</sup>. Knowing these aspects for the different race distances might help in the interpretation of the results and aid the understanding of the athletes' experience level and effort perception that can impair the pacing. A decrease in body mass such as fat mass<sup>10,17</sup> leads to a decrease of the energy reserve and will impair performance. We were also not able to record pre-race experience<sup>17,38</sup> and training in the pre-race preparation<sup>2,38</sup>, which are both also of importance for the race outcome.

### ***Conclusions***

In summary, the analysis of pacing during cycling and running a multi-stage ultra-triathlon showed that these athletes achieved a stable cycling performance independent of the length of the race. The cycling split influenced the subsequent run split depending upon the length



of the race. We recommend that future studies monitor the athletes for bathroom stops, nutrition, hydration, and their body composition during and after each race day, as the components transition within a day.

### Conflicts of Interest

The authors declare no conflicts of interest.

### Ethics Approval

The Institutional Review Board of St. Gallen, Switzerland, approved this study (EKSG 01/06/2010).

### Informed Consent

Informed consent was obtained from all individual participants included in the study.

### Availability of Data and Material

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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### Authors' Contributions

K.W. drafted the manuscript, M.T. performed the data processing and statistical analyses, C.V.S. collected the data, P.T.N., I.C. and B.K. helped in drafting the manuscript. All authors approved the final version.

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