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Pacing strategy and tactical positioning during cyclo-cross races

Authors: Arthur H. Bossi, Ciaran O'Grady, Richard Ebreo, Louis Passfield, James G. Hopker.

School of Sport and Exercise Sciences, University of Kent, Chatham Maritime, Chatham, Kent, England.

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Correspondence:
Arthur Henrique Bossi
School of Sport and Exercise Sciences
University of Kent at Medway
Medway Building
Chatham Maritime
Chatham, Kent
ME4 4AG
England
asnb3@kent.ac.uk
+44 (0)7398 944056

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Abstract

Purpose: To describe pacing strategy and competitive behaviour in elite-level cyclo-cross races. **Methods:** Data from 329 men and women competing in 5 editions (2012–2016) of UCI Cyclo-cross World Championships were compiled. Individual mean racing speeds from each lap were normalised to the mean speeds of the whole race. Lap-by-lap and final rankings were also explored. Pacing strategy was compared between sexes and between top- and bottom-placed cyclists. **Results:** A significant main effect of laps was found in 8 out of 10 races (4 positive, 3 variable, 2 even and 1 negative pacing strategies) and an interaction effect of ranking-based groups was found in 2 (2016, male and female races). Kendall's tau-b correlations revealed an increasingly positive relationship between intermediate and final rankings throughout the races. The number of overtakes during races decreased from start to finish, as suggested by significant Friedman tests. In the first lap, normalised cycling speeds were different in 3 out of 5 editions—men were faster in 1 and slower in 2 editions. In the last lap, however, normalised cycling speeds of men were lower than those of women in 4 editions. **Conclusions:** Elite cyclo-cross competitors adopt slightly distinct pacing strategies in each race, but positive pacing strategies are highly probable in most events, with more changes in rankings during the first laps. Sporadically, top- and bottom-placed groups might adopt different pacing strategies during either male or female races. Men and women seem to distribute their efforts differently, but this effect is of small magnitude.

Keywords: *cyclocross; off-road cycling; pacing profile; tactics; sex differences.*

Introduction

Cyclo-cross is a competitive discipline that demands from the athletes a mix of road and off-road cycling and running abilities. Races consist of many laps (~1 h in total) of a short course (~3 km) comprising pavement, sand, wooded trails, grass, steep hills and built obstacles. Often, the circuit requires competitors to dismount, carry their bikes while running, and remount. These features elicit intermittent high-intensity efforts throughout the race [1]. Despite being absent in the Olympic Games, cyclo-cross is a popular discipline, and its World Championships have been contested since 1950. However, contrary to road cycling [2,3] and mountain biking [4], this modality is virtually unexplored from a scientific point of view. As suggested by Bishop [5], sports science has not always informed sports practice and descriptive work is one of the first stages necessary to advance a new research field.

Among the factors underpinning endurance cycling performance, pacing strategy is one of the most studied [6,7]. Descriptive [8-10] and experimental [11-13] studies have been published across disciplines, and, interestingly, a variable gradient course has been considered an extra challenge to the adoption of optimal pacing strategies [6,8-10,13]. It is difficult to predict, however, whether the conclusions of studies describing pacing strategy in cross-country mountain bike races [8,9] are transferable to cyclo-cross—despite their resemblance in some aspects such as the uneven circuits and the lap-by-lap format. Abbiss et al. [9] collected data in 2009, and, since then, race duration has been reduced by ~30 min to the actual ~1.5 h. It is possible that pacing strategy in the 1-h cyclo-cross could be different from the 'old' 2-h mountain biking, due to the known effect race duration exerts on intensity distribution [6]. More recently, Martin et al. [8] analysed pacing strategy during a cross-country race of ~1.5 h in 6 recreationally trained cyclists (VO_{2max} = 55.1 ± 6.0 $mL \cdot kg^{-1} \cdot min^{-1}$). Whether their results—an even between-lap pacing strategy—reflect also the pattern of elite athletes competing in cyclo-cross is unknown.

Of note, it has been shown that adjustments in racing speed are more closely related to terrain gradient in running than in cycling [14]. Since cyclo-cross involves alternations between both exercise modes [1], a unique pacing profile would be unsurprising, especially if the amount of running performed per lap varies as the race progresses. In this regard, establishing how elite athletes pace themselves during cyclo-cross races will provide coaches and scientists with an in-depth understanding of this discipline, generating opportunities for experimental research [5] and training interventions aiming to improved racing preparation and tactics. We hypothesised cyclists generally adopt a positive pacing strategy to gain a good position in the first laps, with top performers adopting a more even distribution than less successful competitors. The first aim of this study was to test this hypothesis.

An important aspect to consider when investigating race results is to separate analysis by sex. There seems to be no doubt that men and women differ in exercise performance [9,15] and inherent physiology [16,17]. Moreover, some studies in running also suggest sex-based differences in pacing strategy [18,19]. Men usually slow down more than women during a race, which authors attribute to distinct psychological traits, such as those related to confidence and risk perception [18,19]. Anecdotally, race dynamics in cyclo-cross are greatly influenced by opponents' behaviour and the need to have a clear view of obstacles, potentially interfering with pacing strategy [20-24]. Therefore, an exacerbated outcome of the aforementioned psychological differences might be hypothesised—i.e. larger inter-sex difference in race intensity distribution. Accordingly, the second purpose of this study was to verify whether sex-based differences in pacing strategy could be found among elite competitors in cyclo-cross races.

Methods

Participants and study design

For this study, specific ethical approval was not sought as there were no interventions and it involved the analysis of publicly available data (http://www.uci.ch). We analysed data from elite men and women competing in 5 editions (2012–2016) of the UCI Cyclo-cross World Championships. Descriptive data on course characteristics and weather/course conditions are presented respectively in tables 1 and 2.

[Table 1]
[Table 2]

Initially, lap-by-lap and final times were collated for pacing strategy analysis of each race. Cycling's world governing body (UCI) requires timekeeping providers to adopt systems with 0.001-s accuracy. Mean racing speed from each lap was then percentage normalised to the mean speed of the whole race for each athlete. This procedure was used in order to eliminate the effect of differences in absolute racing speed among cyclists [7,25]. Cyclists that did not finish the entire races were excluded (n = 138) and composition of the final sample (n = 329) is presented in table 3. As expected, some athletes competed repeatedly in different editions. However, dissimilar courses and weather, together with the yearly time span between races, imply individual's performance and pacing strategy were always unique [6,7,23]. Additionally, to provide a better understanding of tactical arrangements and its influence on pacing strategy [22-24], lap-by-lap and final rankings were explored.

[Table 3]

Because lap number varied between male and female races and among editions, data were analysed separately, totalling 10 individual races. The general pacing strategy of each one was classified according to lap differences in exercise intensity and following the descriptors utilised by Abbiss and Laursen [6]: negative, positive, even, parabolic and variable. Normalised cycling speeds of the first and the last lap of each edition were compared between sexes, as we expected a larger effect (if present) close to the start or finish [6]. In order to analyse the effect of performance levels on pacing strategy, finishers of each race were divided into two equal size groups according to their final rankings—top placed and bottom placed. In the case of an odd number of finishers, the bottom-placed half included one more individual.

Statistical analysis

Data were assessed for normality using Shapiro-Wilk's tests and subsequent analyses were chosen accordingly. To analyse pacing strategies of each individual race, two-way mixed ANOVAs were performed with a focus on the main effect of laps and the interaction effect of ranking-based groups. Given that data were previously percentage normalised, the main effect of ranking-based groups would be null. Following ANOVA, Bonferroni's pairwise comparisons were used to identify where significant differences existed within the data. Effect sizes were calculated as partial eta-squared (η_p^2). The relationship between lap-by-lap and final rankings were determined by Kendall's tau-b correlations [26]. Friedman's test was carried out to investigate whether ranking changes—in absolute values—would be different among laps. Finally, sex differences were assessed by independent-samples *t* tests and standardised effects sizes (Cohen's *d*). Data analyses were performed using SPSS package (23.0, IBM, Armonk, USA) and statistical significance was set at $P \leq 0.05$.

Results

Results are presented as mean ± SD, unless otherwise stated. Figure 1 displays pacing strategy adopted by top- and bottom- p laced groups in each race. A significant main effect of laps was found in 8 out of 10 races (2016 M: $F = 20.36$, $P < 0.001$, $\eta_p^2 = 0.34$; 2016 F: $F = 0.90$, $P = 0.411$, $\eta_p^2 = 0.02$; 2015 M: $F = 17.74$, $P < 0.001$, $\eta_p^2 = 0.35$; 2015 F: $F = 5.83$, $P = 0.008$, $\eta_p^2 = 0.12$; 2014 M: $F = 21.54$, $P < 0.001$, $\eta_p^2 = 0.35$; 2014 F: $F = 11.31$, $P < 0.001$, $\eta_p^2 = 0.22$; 2013 M: $F = 34.08$, $P < 0.001$, $\eta_p^2 = 0.53$; 2013 F: $F = 3.55$, $P = 0.028$, $\eta_p^2 = 0.13$; 2012 M: $F =$

8.22, $P < 0.001$, $\eta_p^2 = 0.27$; 2012 F: $F = 2.19$, $P = 0.074$, $\eta_p^2 = 0.07$). In addition, an interaction effect of ranking-based groups was found in 2 races (2016 M: $F = 2.44$, $P = 0.049$, $\eta_p^2 = 0.05$; 2016 F: $F = 11.55$, $P < 0.001$, $\eta_p^2 = 0.24$; 2015 M: $F = 1.45$, $P = 0.219$, $\eta_p^2 = 0.04$; 2015 F: $F = 1.15$, $P = 0.310$, $\eta_p^2 = 0.02$; 2014 M: $F = 0.79$, $P = 0.555$, $\eta_p^2 = 0.01$; 2014 F: $F = 0.38$, $P = 0.713$, $\eta_p^2 = 0.01$; 2013 M: $F = 1.80$, $P = 0.131$, $\eta_p^2 = 0.05$; 2013 F: $F = 1.48$, $P = 0.233$, $\eta_p^2 = 0.06$; 2012 M: $F = 2.12$, $P = 0.094$, $\eta_p^2 = 0.08$; 2012 F: $F = 0.77$, $P = 0.542$, $\eta_p^2 = 0.02$). Table 4 presents the mean racing time, time spent by the first and last cyclist, and general pacing strategy adopted by the whole group. Moreover, the main effect of laps is displayed and significant differences are indicated.

[Figure 1]
[Table 4]

Kendall's tau-b correlations revealed an increasing positive relationship (all $P < 0.001$) between intermediate and final rankings throughout the races (figure 2). Table 5 displays median ranking changes, 25th and 75th percentiles of the data. As a general trend, the number of overtakes during races decreased from start to finish, as suggested by significant Friedman tests (2016 M: $\chi^2 = 29.77$, $P < 0.001$; 2016 F: $\chi^2 = 16.89$, $P < 0.001$; 2015 M: $\chi^2 = 31.54$, $P < 0.001$; 2015 F: $\chi^2 = 16.63$, $P = 0.001$; 2014 M: $\chi^2 = 62.39$, $P < 0.001$; 2014 F: $\chi^2 = 17.40$, $P < 0.001$; 2013 M: $\chi^2 = 34.41$, $P < 0.001$; 2013 F: $\chi^2 = 11.40$, $P = 0.022$; 2012 M: $\chi^2 = 27.13$, $P = 0.001$; 2012 F: $\chi^2 = 10.25$, $P = 0.017$).

In the first lap, normalised cycling speeds were different between men and women in 3 out of 5 editions, but the fastest sex varied. Men were faster in 2013, and slower in 2014 and 2012 (2016: -0.4, $t = -0.88$, $P = 0.378$, $d = -0.02$; 2015: 1.1, $t = 1.34$, $P = 0.185$, $d = 0.08$; 2014: -1.0, $t = -2.31$, $P = 0.023$, $d = -0.08$; 2013: 1.6, $t = 2.28$, $P = 0.027$, $d = 0.13$; 2012: -1.9, $t = -2.90$, $P = 0.006$, $d = -0.15$). In the last lap, however, normalised cycling speeds of men were lower than those of women in 4 editions (2016: -1.8, $t = -5.34$, $P < 0.001$, $d = -0.18$; 2015: -1.11, $t = -2.38$, $P = 0.020$, $d = -0.09$; 2014: -0.8, $t = -1.96$, $P = 0.053$, $d = -0.06$; 2013: -2.1, $t = -3.95$, $P < 0.001$, $d = -0.15$; 2012: -1.4, $t = -2.18$, $P = 0.035$, $d = -0.10$).

[Figure 2]
[Table 5]

Discussion

This is the first study to investigate pacing strategy in cyclo-cross. As delineated by Bishop [5], this discipline is at the stage of description of the factors that might influence performance outcomes. Our findings suggest cyclo-cross competitors adopt slightly distinct pacing strategies in each race, thus making it difficult to attribute a single pattern to this discipline by analysing lap times only. Nevertheless, a positive pacing strategy was often found, especially if the first lap was not considered, partially supporting our hypothesis. Moreover, top- and bottom-placed groups did not differ in their pacing strategy, except for the races in 2016. Finally, according to our second hypothesis, men and women distributed their efforts differently, an effect particularly evidenced in the last lap of races, where men rode proportionally slower.

More than 20 years ago, Hansen et al. [1] had assessed race demands of three elite cyclo-cross athletes competing in three different races. They found cyclists typically varied their efforts from zero to 800-900 W, most pedalling sequences lasted 5-20 s and total running times amounted to 3, 22 and 11 min in races of 58, 55 and 61 min, respectively. According to Abbiss and Laursen's descriptors [6], pacing strategies in cyclo-cross are variable. This is expected, due to the nature of the course that does not allow for steady-state riding to occur. However, we ponder that lap analyses are useful to understand exercise intensity trends and the competitive behaviour on a macro scale, allowing bigger sample sizes and multiple races to be investigated. Given that the World Championships are the most important races of the season, both in terms of points awarded and prestige, we assume most athletes performed at their best. We believe the findings presented here are therefore generalizable to most competitions at the elite level.

In this study, we found unequivocal positive pacing strategies in 4 out of 10 races. Moreover, in 3 races that we classified pacing strategy as variable, a positive profile would have been found had the first lap been ignored. Lower speeds in the first lap do not necessarily imply lower exercise intensity. Possibly, it reflects congestion in the circuit, where cyclists often accelerate to gain or hold a position but do not always choose the fastest line [23]—a classic scenario of every cyclo-cross race. This suggests the first few laps are critical to race outcomes. The fact we found an increasingly positive relationship between intermediate and final rankings, plus the number of overtakes generally decreasing from start to finish, strengthen this conclusion. Interestingly, our results resemble those of cross-country mountain bike races of the past (~2 h, pre-2014 UCI rule change) [9,27]. Abbiss et al. [9] showed elite men and women were faster in the second than the first lap and performance declined progressively among men and maintained or declined among women. Conversely, Stapelfeldt et al. [27] showed national-level mountain bikers produced the highest power outputs during the first lap of their races (also ~2 h). Taken our results and those of others [9,27] together, we wonder whether power output files from cyclo-cross races would show positive pacing strategies more often than not.

Two of the cyclo-cross races in the current study were categorised as having an even pacing strategy and one as a negative pacing strategy. Martin et al. [8] also found an even pacing strategy in a cross-country mountain bike race of ~1.5 h, although their conclusion has been criticised [28]. Therefore, it is difficult to explain why these pacing strategies were evident based upon the descriptive data we had access to (i.e. weather and course conditions, and the number of cyclists that finished each race). One possibility is that the behaviour of favourite cyclists may have influenced the pacing strategy of the whole group of competitors [22-24]. This is yet to be demonstrated in official cyclo-cross competitions, but environment-controlled studies suggest this could be a factor. Not only the presence [20], but also the behaviour of an opponent [21] affects pacing strategy, especially during the initial phases of a performance trial. A second possibility might be related to how often, and for how long, cyclists had to run during each race [1]. As fatigue ensues, cyclists tend to carry their bikes during sections otherwise rideable. Given that terrain gradient exerts a bigger impact on speed during running than cycling [14], it is expected that more frequent and longer running sections of a course lead towards positive pacing strategies, whereas sparser and shorter running sections lead towards even profiles. Future studies should address these hypotheses to reveal what determines the general behaviour of cyclo-cross competitors.

Pacing strategy is generally recognised as a determinant of cycling performance, mainly when the terrain is not entirely flat [6,8-10,13], which is the case of cyclo-cross. Intriguingly, our results revealed that top- and bottom-placed cyclists only differed in their pacing strategy during the 2016 UCI Cyclo- cross World Championships. The lack of difference in most races might be due to the start-order procedure that is determined as per the most recent UCI athletes' classification. This system has been shown to preclude major changes in rankings from the grid line-up to the finish line [29], a conclusion also reflected by our Kendall's tau-b correlations. It is therefore conceivable that top-placed cyclists led the pacing strategy of the bottom placed [22-24], with small gaps between athletes after each lap and at the finish (see table 4). In 2016, however, the best men decreased their exercise intensity in the middle of the race in comparison to less successful competitors, probably due to a higher-intensity first lap—although not reaching statistical significance. Conversely, best women started proportionally slower and finished faster than less successful competitors. Conflicting results were also found in a cross-country mountain bike World Championships [9]. Top-placed men maintained a significantly more even pacing strategy over the race compared to the bottom placed, whereas women did not display different behaviours across performance groups [9]. Unfortunately, our 2016 results are difficult to reconcile due to the retrospective nature of our analyses.

Recent studies by Deaner et al. [18,19] have suggested male and female athletes do not execute the same pacing strategy during a race. In this regard, Deaner et al. analysed 14 running marathons, adjusting women's performances by 12% to address men's greater maximal oxygen uptake [18]. They found women often slow down less than men in the second half of races, a difference they attributed to physiological aspects, decision-aking characteristics, or both [18]. More recently, Deaner et al. tested this hypothesis by investigating the pacing strategy of high-school children in 5-k cross-country running races [19] , where glycogen-depletion differences between sexes [17] are less of a concern. Interestingly, they found similar results and therefore concluded sex differences in pacing strategy are probably associated to distinct psychological traits, such as those related to confidence, goal orientation, risk perception, or a willingness to tolerate discomfort [19]. Given the distinct environmental conditions and race circuits used by male and female cyclists in the current study, it is not possible to attribute differences between sexes to physiological or psychological factors. However, our results do support the suggestion that there is a difference in pacing strategy between sexes among elite cyclo-cross competitors. This trend was often clearer on the last lap of each race, where male cyclists rode proportionally slower in 4 out 5 editions we analysed. These results must be interpreted carefully, though. Firstly, because the magnitude of differences in normalised cycling speeds between sexes was generally small. Secondly, because female races are much shorter, and optimal pacing strategies have been shown to vary according to race duration [6]. Thirdly, because our statistical analyses—comparing normalised cycling speeds of the first and last laps of each edition—assume similar proportions of race duration are represented, which is not actually true. Thus, a prospective study design where similar race durations are chosen to directly compare male and female cyclo-cross athletes is preferable to confirm our results.

One further interesting finding from our study is that most cyclists did not vary their exercise intensity between laps by more than 5% around the mean race speed, regardless of the race considered. This was even more remarkable as each lap represented between 10 and 25% of the total distance, depending on the race edition. This lack of pacing variability is in stark contrast to laboratory-based studies where pacing strategy has been experimentally manipulated to investigate its impact on performance. For example, Mattern et al. [12] manipulated power output by 15% below and above the mean of the first 4 min of a ~32.6-min self-paced time-trial (which case 4 min represented ~12.2% of the completion time). They showed well-trained cyclists failed to select an optimal start strategy during a 20-km time-trial, with 10 out of 13 participants recording their fastest times during the lower-intensity starting condition. Moreover, using an observational study design, Thomas et al. [11] demonstrated cyclists adopted a fast-start strategy during a 20-km time-trial (~32.5 min), with the first 30% completed 4-10% above the mean power output; the next 60%, 1-7% below the mean power output; and the last 10%, 6% above the mean power output. Therefore, it is fair to say that elite cyclo-cross competitors have been performing their pacing strategies well [22,23]. Despite the stochastic nature of this discipline [1], meaning each lap needs to be negotiated according with the demands of the rolling circuit [13] and in response to other competitors [22-24], they are still able to maintain a lap-by-lap scheme in perspective, with low variability in their lap times. It could be argued, then, that cyclists adopted an even pacing strategy. Indeed, the practical significance of minor between-lap differences needs to be further explored. Nonetheless, our statistical classification suggests that, although of small magnitude, the (mostly positive) patterns we found did not happen by chance.

This study is not without limitations. As mentioned previously, power output files could provide insights beyond those offered here by analysing lap-by-lap performances, particularly the influence of cycling-running transitions on pacing strategy and performance. In addition, descriptive research is only a starting point in the process of implementing performance solutions, and studies with a more controlled environment are also needed [5,23]. Finally, establishing the veracity of a large dataset is always a concern [30]. However, we are confident that if errors exist, they are minor, as we acquired information directly from UCI.

Practical Applications

Our findings are likely to be used by athletes and coaches when developing optimal pacing strategies for cyclo-cross races. Cyclists aiming to reach the highest levels of this discipline must be aware that a powerful start and good positioning abilities are required to be among the best competitors, given that lap times are generally faster in the first laps. Moreover, we propose that strong efforts (i.e. to overtake opponents and to overcome steep ascents and running sections) must be well paced and performed throughout a race, as large (> 5%) deviations in mean speed of each lap are probably detrimental to overall performance. In addition, the decision- aking process involved in choosing the right actions during a race is probably important to warrant a pacing strategy close to optimal [23,24]. Therefore, training programmes cannot ignore this component.

Conclusion

In summary, this study shows elite cyclo-cross competitors adopt slightly distinct pacing strategies in each race, but positive pacing strategies are highly probable in most events. Our results also suggest that, sporadically, top- and bottom- placed cyclists might adopt different pacing strategies during either male or female races. Finally, male and female cyclo- cross athletes seem to distribute their efforts differently, but this effect is of small magnitude, likely reflecting the shorter races of the female category.

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Table & Figure Captions

Table 1 – Course distance, number of laps for each race, altitude of the host city, elevation difference between the highest and lowest point of the circuit, elevation gain per lap and maximum gradient along the course.

Table 2 – Start time, weather and course conditions during each race.

Table 3 – Study's sam ple (Finishers; n = 329) and excluded individuals (LAP/DNF/DNS/DSQ; n = 138).

Table 4 – Total racing time, general pacing strategy and laps where normalised cycling speeds were statistically different.

Table 5 – Absolute ranking changes among all competitors per lap of each race.

Figure 1 – Pacing strategy adopted by top- (filled circles) and bottom-placed (open circles) groups in each race. M: males; F: females; *: significant main effect of laps; §: significant difference between groups at the point (simple effects).

Figure 2 – Kendall's tau-b correlations between interm ediate and final rankings of each individual race (all $P < 0.001$).

Table 1 – Course distance, number of laps for each race, altitude of the host city, elevation difference between the highest and lowest point of the circuit, elevation gain per lap and maximum gradient along the course.

Year	Host City	Course Distance (km)	Laps	Altitude (m)	Elevation Difference (m)	Elevation Gain (m)	Maximum Gradient (%)
2016	Heusden-Zolder (Belgium)	3.27	M: 8 / F: 4	43	19	59	24.7
2015	Tábor (Czech Republic)	3.13	M: 8 / F: 5	437	23	48	28.3
2014	Hoogerheide (Netherlands)	3.36	M: 8 / F: 4	11	17	50	12
2013	Louisville (USA)	2.79	M: 9 / F: 6	142	8	25	45.9
2012	Koksijde (Belgium)	2.94	M: 10 / F: 5	1.5	14	25	30.8

M: males; F: females.

Table 2 – Start time, weather and course conditions during each race.

Race	Start Time	Precipitation	Atmospherics	Course Conditions	Temperature (°C)	Humidity (%)	Wind (km/h)
2016 M	3:00 pm	Rain	Overcast	Slick/Claggy Mud	6	93	15
2016 F	3:00 pm	Rain	Overcast	Wet/Slippy Mud	7	86	20
2015 M	2:00 pm	Snow	Overcast	Slippy Mud/Ice	1	84	10
2015 F	2:00 pm	None	Overcast	Slippy Mud/Ice	0	83	6
2014 M	3:00 pm	None	Sunny	Claggy Mud	8	78	16
2014 F	3:00 pm	None	Overcast	Claggy Mud	8	85	18
2013 M	2:30 pm	Snow	Overcast	Slippy Mud/Ice	0	88	21
2013 F	11:00 am	Snow	Overcast	Slippy Mud/Ice	-3	95	18
2012 M	3:00 pm	None	Overcast	Sand/Slippy Mud	3	72	14
2012 F	11:00 am	None	Overcast	Sand/Slippy Mud	2	83	11

M: males; F: females.

Table 3 – Study's sample (Finishers; n = 329) and excluded individuals (LAP/DNF/DNS/DSQ; n = 138).

Race	Finishers	LAP/DNF/ DNS/DSQ
2016 M	41	20
2016 F	38	1
2015 M	35	25
2015 F	44	2
2014 M	42	19
2014 F	41	3
2013 M	32	13
2013 F	25	7
2012 M	24	40
2012 F	31	8

M: males; F: females; LAP: lapped; DNF: did not finish; DNS: did not start; DSQ: disqualified.

Table 4 – Total racing time, general pacing strategy and laps where normalised cycling speeds were statistically different.

Race	Total Time mean (range)	General Pacing Strategy*	Lap Differences $P \leq 0.05$
2016 M	1:09:24 (1:05:52 – 1:13:31)	Variable	1 ≠ 2, 8; 2 ≠ 4, 5, 6, 7, 8; 3 ≠ 4, 5, 6, 7, 8; 4 ≠ 7, 8; 5 ≠ 8; 6 ≠ 7, 8; 7 ≠ 8
2016 F	0:44:43 (0:41:03 – 0:51:48)	Even	N/A
2015 M	1:12:55 (1:09:12 – 1:17:05)	Positive	1 ≠ 8; 2 ≠ 5, 6, 7, 8; 3 ≠ 6, 7, 8; 4 ≠ 6, 7, 8; 5 ≠ 7, 8; 6 ≠ 7, 8
2015 F	0:53:03 (0:49:10 – 0:58:15)	Positive	2 ≠ 4, 5; 3 ≠ 4, 5
2014 M	1:09:07 (1:05:29 – 1:12:31)	Variable	1 ≠ 2, 7, 8; 2 ≠ 3, 4, 5, 6, 7, 8; 3 ≠ 5, 6, 7, 8; 4 ≠ 6, 7, 8
2014 F	0:43:57 (0:39:25 – 0:49:34)	Positive	1 ≠ 3, 4; 2 ≠ 3
2013 M	1:08:31 (1:05:35 – 1:11:35)	Variable	1 ≠ 2, 6, 7, 8, 9; 2 ≠ 4, 5, 6, 7, 8, 9; 3 ≠ 5, 6, 7, 8, 9; 4 ≠ 5, 6, 7, 8, 9; 5 ≠ 8, 9; 7 ≠ 8, 9
2013 F	0:46:40 (0:43:00 – 0:49:36)	Positive	2 ≠ 5, 6; 3 ≠ 6
2012 M	1:08:51 (1:06:07 – 1:11:17)	Negative	1 ≠ 3, 4, 5, 6, 7, 8
2012 F	0:44:26 (0:41:04 – 0:47:59)	Even	N/A

M: males; F: females; *: general behaviour according to Abbiss and Laursen's descriptors [6]; $P \leq 0.05$: significant differences found following Bonferroni pairwise comparisons; N/A: not applicable.

Table 5 – Absolute ranking changes among all competitors per lap of each race.

Race	Ranking Changes median [$Q_1 – Q_3$]								
	Laps 1 – 2	Laps 2 – 3	Laps 3 – 4	Laps 4 – 5	Laps 5 – 6	Laps 6 – 7	Laps 7 – 8	Laps 8 – 9	Laps 9 – 10
2016 M	2 [1 – 4]	1 [0 – 2]	1 [1 – 2]	1 [0 – 2]	1 [0 – 2]	1 [0 – 1.5]	0 [0 – 1]		
2016 F	1 [0 – 2.25]	1 [0 – 1]	0 [0 – 1]						
2015 M	2 [1 – 4]	1 [0 – 3]	1 [0 – 3]	1 [1 – 2]	1 [1 – 2]	0 [0 – 1]	1 [0 – 2]		
2015 F	2 [1 – 3]	2 [1 – 3]	1 [0 – 2]	1 [0 – 2]					
2014 M	3 [1.75 – 6]	1.5 [1 – 3]	1 [1 – 2]	1 [0 – 2]	1 [0.75 – 2]	1 [0 – 1.25]	0.5 [0 – 1.25]		
2014 F	2 [1 – 5]	1 [1 – 3]	0 [0 – 1]						
2013 M	2 [1.25 – 3]	1 [1 – 3]	1 [0 – 2]	1 [0 – 2]	1 [1 – 1.75]	1 [0 – 2]	1 [0 – 2]	0.5 [0 – 1]	
2013 F	1 [0 – 2]	1 [0 – 2]	1 [0 – 1]	1 [0 – 2]	0 [0 – 1]				
2012 M	2 [1 – 5.75]	1 [0 – 2]	1 [0 – 2]	1 [0 – 2.75]	0.5 [0 – 2]	1 [0 – 1.75]	1 [0 – 1]	1 [0 – 2]	0.5 [0 – 1]
2012 F	1 [1 – 3]	1 [0 – 2]	1 [0 – 2]	1 [0 – 1]					

M: males; F: females; Q_1: 25th percentile; Q_3: 75th percentile.

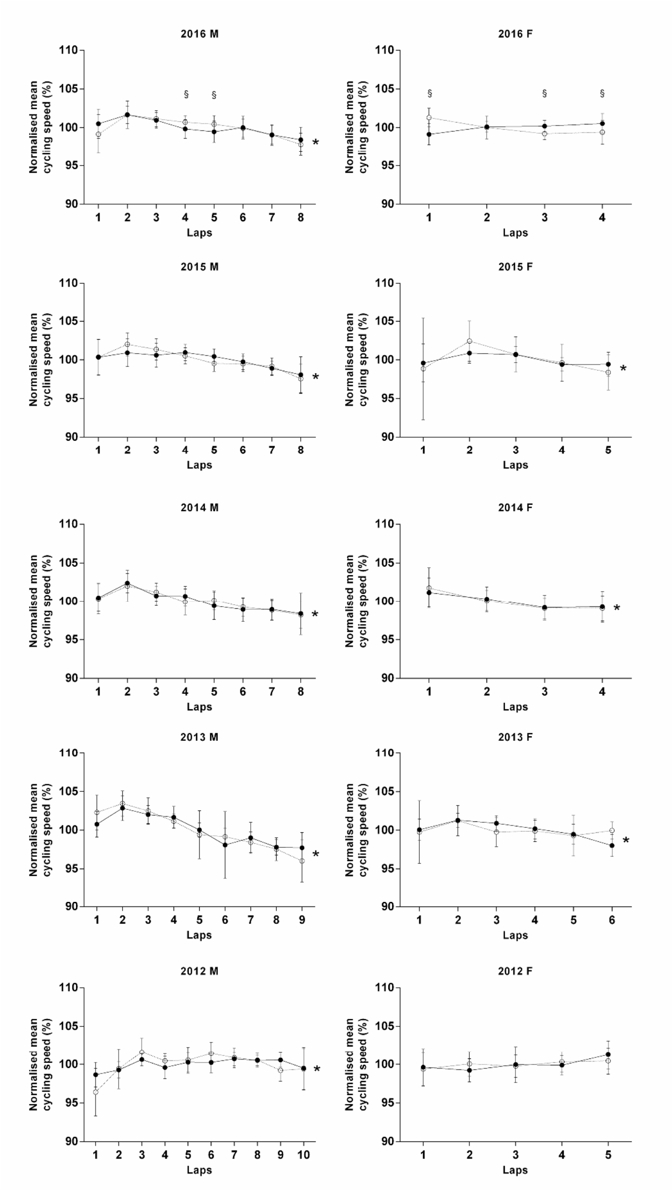

Figure 1 – Pacing strategy adopted by best- (filled circles) and worst-ranked (open circles) groups in each race. M: males; F: females; *: significant main effect of laps; §: significant difference between groups at the point (simple effects).

276x488mm (300 x 300 DPI)

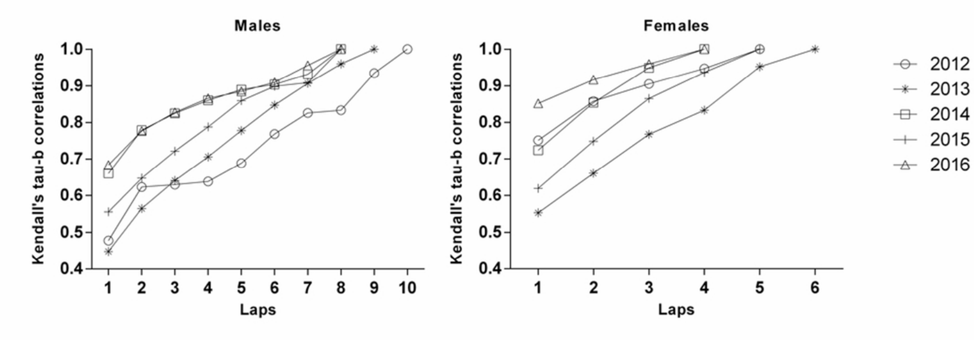

Figure 2 – Kendall's tau-b correlations between intermediate and final rankings of each individual race (all P < 0.001).

88x32mm (300 x 300 DPI)