Pacing profile in the main international open-water swimming competitions

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Pacing profile in the main international open-water swimming competitions

ROBERTO BALDASSARRE1, MARCO BONIFAZI2, & MARIA FRANCESCA PIACENTINI1

1Department of Movement, Human and Health Sciences, University of Rome Foro Italico, Rome, Italy & 2Department of Medical, Surgical and Neuro Sciences, University of Siena, Siena, Italy

Abstract

Purpose: Different aspects of pacing in endurance events have been investigated, however, there are very limited information on pacing strategies during open-water swimming. The aim was to describe and compare the pacing profile used by male and female open-water swimmers (OW-swimmers) during the 5-, 10- and 25 km races in the main international competitions.

Methods: A total of 438 performances were analysed for 5 km, 579 for 10 km and 189 for 25 km, from 2012 to 2017. Swimmers were divided into four groups based on finishing time. G1 whose finishing times were within 0.5% of the winner’s time, G2 between 0.51% and 1% slower than winner’s time; G3 between 1.1% and 2% slower than winner’s time; G4 over 2% of winner’s time. Kolmogorov–Smirnov test was used to verify the normal distribution of data and repeated measures ANOVA was performed. Results: G1 adopted a negative pacing and significantly increased the speed in the last split compared with the other groups during the 5-, 10- and 25-km races in both males and females (p<.001). During the 5- and 10-km race, the last split speed of G1 was significantly faster compared to the other groups in both males and females (p<.05).

Conclusions: OW-swimmers that used a conservative approach remaining in G1 until the finish of the race, increase the possibility to win a medal in the main international competitions.

Keywords: Endurance, performance, competition

Highlights

- Fastest open-water swimmers adopted a negative pacing during the 5-, 10-, and 25-km races in the main international competitions.
- The last split in both female and male fastest group was significantly faster compared to the slowest groups.
- A conservative pacing (remaining in the lead pack for the majority of the race and increasing speed only in the last split) allows to optimize the benefits of drafting, to reduce the energy cost of swimming and to increase the possibility to win a medal.
- The coaches should include training sessions on negative pacing to improve the ability of athletes to increase speed in a fatigued condition.

Introduction

Open-water swimming (OWS) is an endurance sport, present at World and Continental Championships with the 5, 10 and 25 km events, with the 10 km the only event present at the Olympic games (OG) since 2008. A multi-lap 2500-m long course is usually used for all distances to allow regular feeding during the race (Baldassarre, Bonifazi, Zamparo, & Piacentini, 2017; FINA, 2017). During the Budapest World Championship (2017), the best male and female swimmers completed the 5-km race in 54:31.4 and 59:07.0, the 10-km race in 1:51:58.5 and 2:00:13.7, the 25-km race in 5:02:46.4 and 5:21:58.4, respectively (h:mm:ss.0; http://www.omegatiming.com). An optimal pacing profile has been shown to be important for success in endurance races (Hanley, 2014a, 2015, 2016; Mytton et al., 2015; Renfree & Gibson, 2013). Pacing strategy is the process whereby humans regulate their rate of energy expenditure in a way that allows them to complete a task (such as an endurance race) in the minimal time while controlling the
magnitudes of homeostatic disturbance (Foster et al., 2012). Pacing strategies can be categorised as positive pacing (the athlete's speed decreases during the competition), negative pacing (increasing speed), even pacing (a stable speed is maintained), variable pacing (speed is varied throughout), parabolic U-shaped pacing (speed is greater at the beginning and in the last portion of the race), parabolic J-shaped pacing (finishing speed is greater than the starting speed) and parabolic reverse J-shaped pacing (starting speed is greater than the finishing speed) (Abbiss & Laursen, 2008).

Several factors have been shown to influence pacing adopted during a race, e.g.: the difficulty of accelerating at the beginning of the race, the magnitude of slowing down resulting from the loss of power output due to fatigue, the power losses to the environment, and the amount of essentially wasted kinetic energy at the end of the race (de Koning et al., 2011).

Despite several aspects of pacing in endurance events have been investigated in recent years (Hanley, 2014a, 2015, 2016; Renfree & Gibson, 2013), scientific research examining the pacing strategies of swimmers employed during official competitions is scarce (Abbiss & Laursen, 2008). Specifically, mainly pool events have been investigated. International level athletes have been shown to adopt a parabolic U-shaped pacing during 800-m (female) and 1500-m (male) swimming events (Lipińska, Allen, & Hopkins, 2016a, 2016b; McGibbon, Pyne, Shephard, & Thompson, 2018) with a fast start and a final end spurt. The ability to produce an end spurt in the final lap(s) are key in pool events (McGibbon et al., 2018). Moreover, pacing patterns have been shown to display a low variability from heats to finals, independently on final time. Therefore pacing profile in elite swimmers seems reproducible in training and within different competitions, because the athletes are isolated in their own lane, compared to track races where competitors share the same lane (Skorski, Faude, Caviezel, & Meyer, 2014).

Mytton et al. (2015) compared the pacing of 1500-m running and 400-m swimming. Although the duration and the net energetics of both events are comparable, the authors showed that the 400-m swimmers adopted a U-shaped pacing as previously reported while the 1500-m runners adopted a J-shaped pacing. Another interesting finding was that medallists and non-medallists of both events differed in the ability to increase speed in the last part of the race.

In competitive swimming, most of the pool events are in the range of about 21 s to 15 min, and all of them are supported by some combination of phosphate energy, anaerobic glycolysis, and aerobic combustion of carbohydrate, fat, and protein (Capelli, Pendergast, & Termin, 1998; Pyne & Sharp, 2014). Whereas open-water swimming includes events from 1 to 5 h and the main substrates oxidized during the race are carbohydrate and fat (Zamparo & Bonifazi, 2013). The specific contributions of the energy systems depend on both the length of the race and the intensity (Pyne & Sharp, 2014). The open-water swimming events longer than 5 km may be considered glycogen depleting (Shaw, Koivisto, Gerrard, & Burke, 2014). A depletion of muscle and liver glycogen are associated with a decline in the swimming economy at a given speed (Zamparo et al., 2005). Considering the different energy demands of pool swimming compared to open-water swimming, a different distribution of work and energy through the exercise should be adopted. Three studies (Vogt, Rüst, Rosemann, Lepers, & Knechtle, 2013; Zingg, Rüst, Rosemann, Lepers, & Knechtle, 2014a, 2014b) have analysed the swimming performance of elite open-water swimmers (OW-swimmers) in the main international competitions (World Cups, European championships, World Championship and OG). These studies showed that gender differences during OWS are smaller compared to other endurance or ultra-endurance performances of the same time duration.

It has been demonstrated that performance in longer-duration events is likely to be optimized by a negative pacing strategy with an increase in power output or speed at the end of the event (Foster et al., 1993; Renfree & Gibson, 2013). In fact, half-marathon runners who won a medal during international events, have been shown to maintain an even pacing increasing the speed during the final 1.1 km, while the slower runners showed a parabolic reverse J-shaped pacing (Hanley, 2015). Marathon medallists have been shown to adopt an even pace, while the slower marathon runners show a positive pace both in World Championship (WC) and OG (Hanley, 2016). During longer events such as ultra-endurance races (>4 h) athletes progressively reduce speed, resulting in the adoption of a positive pace (Abbiss & Laursen, 2008).

Differently, from running, a common tactic observed during OWS competitions is to stay in the back of the lead pack or behind the leader of the race benefiting from drafting (Chatard & Wilson, 2003) and increasing speed only during the last lap (Munatones, 2011). Only one study, (Rodriguez & Veiga, 2017) investigated the pacing profile of open-water swimmers in the 10-km race during the WC of Kazan (2015). The fastest swimmers adopted a conservative starting strategy with a negative pacing profile, increasing the chances of race success. The fastest swimmers of both genders were, in fact, able to increase speed by ~3% during
the last quarter of the race (2.5 km) compared to the first. Chata 
and Wilson (2003) showed a reduction in the energy cost of swimming of 11–38% swimming behind another swimmer at a distance of 0–50 cm. Remaining in the pack for the majority of the race is advantageous to save energy for the critical stages. Moreover, swimmers utilizes most of the energy to overcome water resistance (Zamparo, Capi 
elli, & Pendergast, 2011), because the energy cost of locomotion in swimming is higher compared to other types of human locomotion (di Prampero, 1986; Holmer, 1979). The specific characteristics of water locomotion suggest that the pacing adopted by a 
thletes of other land disciplines of the same time duration (e.g. running and cycling) cannot be transferred to OWS competitions. Moreover, the optimal pacing strategy for a particular exercise incorporates knowledge of the endpoint with the memory of prior events of similar distance or duration and knowledge of external (environmental) and internal (metabolic) conditions (Gibson et al., 2006). Considering that OWS is a tactical race, and pacing can be influenced by external factors such as currents, tides, waves and water temperature (Baldassarre et al., 2017), the results obtained in only one international competition (Rodriguez & Veiga, 2017) cannot be generalized. Although only the 10 km is an Olympic event, the 5 and the 25 km are present at world and continental championships however no study analysed pacing profiles of these distances. Therefore, the aim of the present study was to describe and compare the pacing pro 
filed used by male and female swimmers, according to performance level, during the 5-, 10- and 25-km races in the main international competitions (OG; WC and European championships, EC). We hypothesized that all OW-swimmers, independently on performance level, would adopt a negative pacing during the 5-, 10- and 25-km race.

Methods

Subjects

The official finishing and split times of OWS competitions were obtained from the web site of Ligue Européenne de Natation (LEN, http://www.len.eu), Fédération Internationale de Natation (FINA, www.fina.org) and International Olympic Committee (IOC, www.olympic.org). Only the races where the split times were available in the official results were included in the analysis. A total of 7 events were included: OG of 2016 in Rio (23-males and 25-females for the 10 km); WC of 2013 in Barcelona (52-males and 42-females for the 5 km; 62-males and 49-females for the 10 km; 32-males and 18-females for the 25 km), 2015 in Kazan (47-males and 38-females for the 5 km; 69-males and 51-females for the 10 km; 24-males and 17-females for the 25 km) and 2017 in Budapest (61-males and 57-females for the 5 km; 65-males and 59-females for the 10 km; 25-males and 18-females for the 25 km); EC of 2012 in Piombino (34-males and 19-females for the 5 km; 35-males and 20-females for the 10 km; 9-males and 4-females for the 25 km), 2014 in Berlin (24-males and 22-females for the 5 km; 37-males and 28-females for the 10 km; 14-males and 13-females for the 25 km) and 2016 in Hoorn (24-males and 18-females for the 5 km; 31-males and 23-females for the 10 km; 10-males and 10-females for the 25 km).

Athletes who did not start or finish or who were disqualified were not included in the analysis. A total of 438 (242-male and 196-female) performances were analysed for the 5 km, 579 (322-male and 255-female) for the 10 km, and 180 (114-male and 80-female) for the 25 km from 2012 to 2017. Because data are public and available on the internet, no formal ethics committee approval was necessary.

Data analysis

The study was designed as an observational research to describe the pacing profile of OW-swimmers in the main international competitions. The final race times of each swimmer were converted in speed (m s\(^{-1}\)). Split times were obtained for each 2.5 km (1st=2.5 km, 2nd=5 km, 3rd=7.5 km, 4th=10 km, 5th=12.5 km, 6th=15 km, 7th=17.5 km, 8th=20 km, 9th=22.5 km, 10th=25 km) and the mean speed (m s\(^{-1}\)) for each split was calculated.

A positive pacing was defined when the swimmers decreased significantly speed in the last split compared to the first, and a negative pacing when the swimmers increased significantly speed in the last split compared to the first. An even pacing was defined when the speed did not change throughout the race.

Swimmers in each race were divided into four groups based on finishing time, and each swimmer assigned in one group only. Group 1 (G1; 61-males and 24-females for the 5 km, 112-males and 85-females for the 10 km, and 26-males and 25-females for the 25 km) whose finishing times were within 0.50% of the winner’s time, Group 2 (G2; 40-males and 27-females for the 5 km, 51-males and 24-females for the 10 km, and 11-males and 4-females for the 25 km) between 0.51% and 1% slower than winner’s time; Group 3 (G3; 29-males and 17-females for the 5 km, 46-males and 33-females for the 10 km, and 15-males and 12-females for the 25 km) between 1.1% and 2% slower than winner’s time; Group 4 (G4; 112-males and 128-females for the 5 km, 113-males and 113-females for the 10 km, and 62-males and 39-females for the 25 km) over 2% slower than winner’s time.
of winner’s time. These percentage was selected according to the performance density of OWS competitions observed in previous studies (Baldassarre et al., 2017; Vogt et al., 2013; Zingg et al., 2014a, 2014b). Moreover, the number or races that each athlete performed during each championship was calculated.

Statistical analysis

Data are presented as mean ± standard deviation (SD). All statistical analysis was performed using the statistical software PASW statistics 22 (SPSS Inc, Chicago, Illinois United States). All data were tested for normal distribution using a Kolmogorov–Smirnov test.

The sample was split by gender and for all race distances and a separated mixed ANOVA for repeated measures was performed to assess differences in the between splits for each group, considering the splits (i.e. 5km, 1st split vs 2nd split) as within factor and group (G1 vs G2 vs G3 vs G4) as between factors. When significant interaction was observed, the sample was divided by group and an ANOVA for repeated measures was performed to assess the differences between the splits mean speed. When a significant F-value was achieved, a post hoc procedure with Bonferroni correction was performed to locate the differences. In addition, one-way ANOVA with Bonferroni post hoc test was performed to compare the mean speeds of last split between the groups. The level of significance was set at \( p \leq .05 \).

Results

Number of races performed by each athlete during each event

During the WC and EC analysed between 2012 and 2017, 471 athletes competed in only 1 race per championship (178 athletes only in the 5 km, 195 only in the 10 km and 98 only in the 25 km). A total of 332 athletes competed in 2 races, (220 athletes competed in both the 5- and 10 km, 23 competed in both the 5- and 25 km and 89 in both the 10- and 25 km). Only 19 athletes competed in all three distances in a single championship.

Table I. Percentage change (Δ) in mean speed compared to the previous race splits of female and male swimmers during 5-, 10- and 25-km race (mean ± SD).

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<td>G1</td>
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<td>5.3 ± 2.6</td>
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<td>G1</td>
<td>7.4 ± 2.0</td>
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<td>G1</td>
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<td>G1</td>
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<td>G1</td>
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<td>4.7 ± 3.2</td>
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<td>3.4 ± 2.4</td>
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<td>G4</td>
<td>3.1 ± 3.0</td>
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</table>
Pacing

The percentage change in mean speed compared to the previous race splits of female and male swimmers during 5-, 10- and 25-km race is reported in Table I.

5 km

The mean speed for each group of female swimmers is shown in Figure 1(A). A significant main effect was observed within splits ($F_{1, 192}=560.73$, $p < .001$). A significant interaction effect between splits and groups was noted ($F_{3, 192}=73.42$, $p < .001$), indicating that the pacing differed within the groups.

All groups adopted a negative pacing. A significant increase in speed was observed between the 1st and 2nd split in G1 ($F_{1, 38}=559.09$, $p < .001$), G2 ($F_{1, 25}=632.44$, $p < .001$), G3 ($F_{1, 12}=39.55$, $p < .001$), and G4 ($F_{1, 117}=76.88$, $p < .001$). In the last split there was significant difference in the mean speed between groups ($F_{3, 192}=62.70$, $p < .001$): G4 was significantly slower compared to G1 ($p < .001$), G2 ($p < .001$) and G3 ($p < .001$).

The mean speed for each group of male swimmers is shown in Figure 1(B). A significant main effect was observed within splits ($F_{1, 238}=675.82$, $p < .001$). A significant interaction effect between splits and groups was noted ($F_{3, 238}=61.35$, $p < .001$), indicating that the pacing differed within the groups. Follow-up analysis showed a significant increase of speed in the 2nd and 4th split compared to the 1st and 3rd split, respectively, in G1 ($F_{3, 252}=143.65$, $p < .001$) and G2 ($F_{3, 69}=68.48$, $p < .001$). G3 showed a significant increase of speed in the 2nd and 4th split.

10 km

The mean speed for each group of female swimmers is shown in Figure 2(A). A significant main effect was observed within splits ($F_{3, 753}=85.72$, $p < .001$). A significant interaction effect between splits and groups was noted ($F_{9, 753}=61.35$, $p < .001$), indicating that the pacing differed within the groups. Follow-up analysis showed a significant increase of speed in the 2nd and 4th split compared to the 1st and 3rd split, respectively, in G1 ($F_{3, 252}=143.65$, $p < .001$) and G2 ($F_{3, 69}=68.48$, $p < .001$). G3 showed a significant increase of speed in the 2nd and 4th split.
compared to the 1st and 3rd split, respectively, and a significant decrease of speed in the 3rd split compared to the 2nd split ($F_{3, 96} = 38.81, p < .001$). A significant increase in speed was observed between the 1st and 4th split in G1 ($p < .001$), G2 ($p < .001$) and G3 ($p < .001$). G4 showed a significant decrease of speed in the 3rd split compared to the 2nd split and between the 1st and 4th split ($F_{3, 336} = 35.76, p < .001$). In the last split, there was a significant difference in the mean speed between groups ($F_{3, 251} = 263.55, p < .001$): G1 and G2 were significantly faster compared to G3 (G1, $p = 0.05$; G2, $p = 0.015$) and G4 ($p < 0.001$).

The mean speed for each group of male swimmers is shown in Figure 2(B). A significant main effect was observed within splits ($F_{3, 954} = 147.93, p < .001$). A significant interaction effect between splits and groups was noted ($F_{9, 954} = 11.01, p < .001$), indicating that the pacing differed within the groups. Follow-up analysis showed a significant increase in speed in the 2nd and 4th splits compared to the 1st and 3rd splits, respectively, in G1 ($F_{3, 333} = 389.51, p < .001$), G2 ($F_{3, 150} = 210.51, p < .001$) and G3 ($F_{3, 135} = 43.45, p < .001$). A significant increase in speed was observed between the 1st and 4th split in G1 ($p < .001$), G2 ($p < .001$) and G3 ($p < .001$). G4 showed a significant decrease of speed after the 2nd split in time course and between the 1st and 4th split ($F_{3, 336} = 44.3192, p < .001$). In the last split, there was significant difference in the mean speed.
between groups \( (F_{3, 318} = 263.55, p < .001) \): G1 and G2 were significantly faster compared to G3 (G1, \( p < .001 \); G2, \( p = .031 \)) and G4 (\( p < .001 \)).

\[ 25 \text{ km} \]

The mean speed for each group of female swimmers is shown in Figure 3(A). A significant main effect was observed within splits \( (F_{9, 684} = 15.36, p < .001) \). A significant interaction effect between splits and groups was noted \( (F_{27, 884} = 9.51, p < .001) \), indicating that the pacing differed within the groups.

Follow-up analysis showed a significant decrease of speed in the 9th split compared to the 8th split and a significant increase in speed in the 10th split compared to the 9th split in G1 \( (F_{9, 216} = 18.90, p < .001) \) and G2 \( (F_{9, 27} = 29.50, p < .001) \). A significant increase in speed was observed between the 1st and the 10th split \( (p < .001) \) in G1 \( (p < .001) \) and G2 \( (p < .001) \). G3 showed a significant difference in speed in the 9th split compared to the 8th split \( (F_{9, 90} = 6.61, p = .047) \). G4 showed a significant decrease of speed between the 7th and 9th splits \( (F_{9, 342} = 14.82, p < .001) \), and a significantly increasing speed in the 10th split compared to the 9th split \( (p = .002) \). G3 \( (p = 1.00) \) and G4 \( (p = 1.00) \) did not show a significant difference in speed between the 1st and the 10th split. In the last split, there was significant difference in the mean speed between groups \( (F_{3, 76} = 24.00, p < .001) \): G1 and G2 were significantly faster compared to G3 \( (G1, p = .005; G2, p = .05) \) and G4 \( (G1, p < .001; G2, p = .005) \).

The mean speed for each group of male swimmers is shown in Figure 3(B). A significant main effect was observed within splits \( (F_{9, 990} = 24.39, p < .001) \). A significant interaction effect between splits and groups were noted \( (F_{27, 990} = 17.95, p < .001) \), indicating that the pacing differed within the groups. Follow-up analysis showed a significant increase of speed in the 2nd \( (p < .001) \), 3rd \( (p = .014) \) and 10th \( (p < .001) \) split compared to the 1st, 2nd and 9th split, respectively, in G1 \( (F_{9, 225} = 35.740) \). A significant increase in speed was observed between the 1st and the 10th split \( (p < .001) \).

G2 showed a significant increase in speed in the 2nd split compared to the 1st split \( (F_{9, 90} = 8.895, p = .041) \). No significant differences were observed in speed between the 3rd and the 10th split \( (p = 1.00) \). A significant increase in speed was observed between the 1st and 10th split \( (p = .009) \). G3 showed a significant increase in speed in the 2nd split compared to the 1st split \( (F_{9, 125} = 15.859, p < .001) \), while no significant differences were observed in speed between the 1st and the 10th split \( (p = .35) \). G4 showed a significant decrease of speed between the 6th and 9th split \( (F_{9, 549} = 52.560, p < .001) \) and between the 1st and 10th split \( (p = .003) \).

In the last split, there was significant difference in the mean speed \( (F_{3, 110} = 63.24, p < .001) \): G1 was significantly faster in the last split compared to G2 \( (p = .002) \), G3 and G4 \( (p < .001) \). G2 was significantly faster in the last split compared to G4 \( (p < .001) \).

**Discussion**

The aim of the present study was to describe and compare the pacing profile of male and female swimmers during the 5-, 10- and 25-km OWS races in the main international competitions.

The main finding of the present study supports our hypothesis, that both male and female fastest swimmers adopted a negative pacing compared with the slower swimmers. In the last split, the speed significantly increased by \( \sim 7\% \), \( \sim 6\% \), \( \sim 4\% \) in both females and males of G1 during the 5-, 10- and 25-km races, respectively. Moreover, the last split in both female and male fastest groups (G1 and G2) was significantly faster compared to all other groups in all three distances.

We can compare our data with only 1 previous study that analysed pacing during the 10-km race of the 2015 World Championship in Kazan and reported that male medallists adopted a negative pacing and were located very far from the first positions (40th, 43rd and 57th places) in the first lap, then slowly progressed towards the lead pack in the following laps, and finally increased their speed during the final lap (Rodriguez & Veiga, 2017). We took into consideration the overall 579 performances on the 10-km distance between 2012 and 2017 and for males found similar results. For females instead, Rodriguez and Veiga (2017) reported that the best female athletes adopted an even pacing strategy and the athletes from the other groups decreased speed and dropped off; while we showed that the best females, similarly to the males race, adopted a negative pacing significantly increasing speed in the last lap of the race. Interesting in fact is that both males and females adopt a similar strategy in the 10-km race (a race that lasts approximately 1 h 50 min for males and 2 h for females), a result that seems in contradiction with the gender differences observed in pacing during international marathon competitions. Male medallists maintain an even pace throughout the race, whereas the female medallists adopt a more conservative initial pace increasing the speed in the final 2.2 km (Hanley, 2016).

The pacing profile observed during the 25-km race showed that both females and males of G1 adopted a negative pacing, while the slowest swimmers adopted a positive or an even pacing. An interesting finding is the decrease in speed during the 5th or 9th split of female swimmers during the 25-km race. This drop
of speed, may be mainly explained by tactical reasons due also by the organization of the race (FINA, 2017). During the race, females start 10–15 min after the males, with the probability that female swimmers will be overtaken by a lap. This delay has an important influence on the female races, because during the middle or the end of the race (approximately between the 6th and 8th split) male swimmers start increasing the speed while simultaneously the female swimmers decrease the speed waiting to be overtaken (personal communication of an OWS coach). The unification of the female group with the male group allows the fastest female swimmers to benefit from drafting behind male swimmers and allows them to increase speed and leave behind the other swimmers. This means that the potential winners need to be correctly positioned in the front part of the pack at this stage of the race.

Although a negative pacing profile is thought to improve performance by reducing the rate of carbohydrate depletion (Abbiss & Laursen, 2005), lowering excessive oxygen consumption (Sandals, Wood, Draper, & James, 2006) and lowering blood lactate concentration (Sandals et al., 2006), during ultra-endurance events (>4 h), athletes tend to adopt a positive pacing strategy (Abbiss & Laursen, 2008). Angehrn, Rüst, Nikolaidis, Rosemann, and Knechtle (2016) reported that elite Ironman athletes adopted a positive pacing, decreasing their speed in cycling and running, in most races of 2014.

However, Ironman races are no draft during cycling. Therefore, the reasons for a positive pacing strategy in these distances may be related to the decline in neuromuscular activity and continuous reduction in skeletal muscle glycogen content during competition (Rauch, 2005; Vleck, Bentley, Millet, & Burgi, 2008; Wu, Abbiss, Peiffer, Brisswalter, & Nosaka, 2014).

Therefore, the negative pacing profile adopted by OW-swimmers also in the 25 km may be explained by the beneficial effect of drafting through the race. Swimming behind another swimmer at a distance of 0 to 50 cm reduces by 11–38% the metabolic response of the draftee (Chatard & Wilson, 2003). A sheltered position in fact allows the swimmer to control the race and to save energy for the critical moments (start/end) and thus decreases significantly the metabolic cost (Chatard & Wilson, 2003). The energy cost of swimming (CS) represents the energy expended to cover one unit of distance at a given speed and with a given stroke rate (SR) (Zamparo et al., 2011). Zamparo et al. (2005) reported an increase in CS and stroke rate (SR) due to development of fatigue in OWS and a consequent decrease in stroke length (SL). Since the distance per stroke is an index of propelling efficiency, the deterioration of stroke mechanics in fatigued subjects could be expected to lead to a progressive increase in CS (Zamparo et al., 2005). Therefore, the data of the present study showed that the fastest OW-swimmers in all three distances adopted a conservative pacing by remaining in the lead pack for the majority of the race, increasing speed only in the last split. This pacing strategy allows to optimize the benefits of drafting, to reduce the energy cost of swimming and to increase the possibility to win a medal especially for the fastest swimmers (Rodriguez & Veiga, 2017).

Considering that energy cost of locomotion in swimming is higher compared to other types of human locomotion (di Prampero, 1986; Holmer, 1979), minimizing the energy expenditure (e.g. drafting) is important during OWS competitions more than during running. Swimming alone most of the race is equivalent to an increase in the energy expenditure without any advantage. In fact, during the male 10-km the Olympic Games that took place in Rio in 2016, the athlete Jarrod Poort swam alone in the first position for 7.5 km but he was caught by the lead pack during the last split and finished the race in 21st position (www.olympic.org).

This type of strategy is similar to what reported by sprinters road cyclists, that remain in the group for the majority of the race and within the last 10 min prior to the sprint are required to find the best positions within the pack before the final kilometres, when the speed dramatically increases for the final end spurt (Menaspa, Quod, Martin, Peiffer, & Abbiss, 2015). Therefore, both OW-swimmers and road cyclists need to remain in a sheltered position in the pack during in the first phases of the race and thereafter position themselves accordingly to be able to increase speed without remaining blocked by other athletes.

Because swimmers remain packed for the major part of the race and sprint for the final 400–500 metres the ability of OW-swimmers is to correctly decide on the timing of increasing speed in the last part of the race for the end spurt. The end spurt is typically observed also in 800- and 1500-m swimming events (Lipinska et al., 2016a, 2016b; McGibbon et al., 2018), marathon running (Hanley, 2016) and 3000-m cycling time trials (Foster et al., 2004). The athletes appear to distribute their energetic resources over the duration of the event in a manner that preserves the ability to contribute to muscular power output from anaerobic sources even during the closing stages of the event (Foster et al., 2004).

It must be pointed out that many of these athletes compete in 2 or 3 races at major championships. Approximately 47% of the athletes performed more than 1 race during major championships and only 53% competed only in 1 race. Considering that the
EC and WC last one week, the pacing strategy may be affected by the fatigue residual of a previous race, considering that only two days of rest are usually granted between races.

A limitation of the present study was that we took into consideration only the official splits while information on the last 500 metres would have been much more significant. Most of the races are decided in the last metres of the competition, however the FINA provides split data every 2.5 km. A second limitation of the study was the impossibility to estimate the impact of environmental conditions on the pacing strategy during each race.

Conclusions

The main finding of the present study indicated that both male and female OW-swimmers adopted a negative pacing strategy during the 5-, 10- and 25-km competitions, increasing significantly the speed during the last split of the races. On the contrary, the slowest swimmers adopted a positive or an even pacing. OW-swimmers that use a conservative approach increase the possibility to win a medal during the main international competitions.

The data of the present study can help coaches and athletes during training to develop an optimal pacing. The training schedule should include several exercises on negative pacing to in order to significantly increase speed in a fatigued condition.

Disclosure statement

No potential conflict of interest was reported by the authors.

References


