

# ANALYSIS OF PACING STRATEGIES IN 10 KM OPEN WATER SWIMMING IN INTERNATIONAL EVENTS

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## Abstract:

The purpose of this study was to ascertain the pacing strategies employed in 10 km open water swimming events, and to define which split time was most determinant for the final performance as a function of sex and classification in International Championships of the highest level. Six international competitions over the last five years were analysed retrospectively: Olympic Games, World Championships, and European Championships. The data corresponded to a total of 437 swimmers' competition histories (257 men, 180 women). A two-way analysis of variance (sex [2 levels: men, women], classification [3 levels: 1<sup>st</sup> to 3<sup>rd</sup>, 4<sup>th</sup> to 8<sup>th</sup>, 9<sup>th</sup> and below]) was performed for each split (0-2.5 km, 2.6-5.0 km, 5.1-7.5 km, and 7.6 to 10 km) and half (0-5 km, 5.1-10 km). The Bonferroni *post-hoc* test was used to compare means, and Pearson's simple correlation coefficient to determine correlations between the split times and the final performance (total time). In general, the medal winners and the seconde tier classified swimmers, both men and women, employed a negative pacing strategy (the first half of the race was swum slower than the second). Women, however, in proportional terms swam a faster first partial (0 to 2.5 km) than men. These results could help coaches convince their swimmers that the first split of the event should be swum as slowly as possible, while still ensuring that they are in the leading group.

**Key words:** long-distance swimming, coaching, physical performance, sport, training

## Introduction

Swimming has been part of the modern Olympic Games from their beginning in Athens 1896. Although in the very beginning, swimming competitions were held in open water, whether in the sea, lakes, or rivers, most competitions from 1900 onwards were held in some sort of a swimming pool. In 1908 the Fédération Internationale de Natation (FINA) was created and established, after which most swimming competitions took place in standardized swimming pools with lane ropes and still water, while open water swimming was left for recreational swimmers. In the late 20<sup>th</sup> and in the beginning of the 21<sup>st</sup> century, ultra open water swimming events, such as "English channel swimming", became popular once again (Eichenberger, et al., 2012).

Following this increasing popularity, in 1986 FINA created the World Cup for long distance swimming events, and they were also included in the World Master Championship (FINA restricted these

competition swimmers to being at least 25 years of age). Finally, in 2008 the 10 km open water swimming event was included in the Olympic Games. This led to swimmers training professionally under the supervision of qualified coaches (Vogt, Rust, Rosemann, Lepers, & Knechtle, 2013) and to a rise in the number of scientific studies in the context of these events. Nonetheless, much of the research on open water swimming events has centred on "extreme" competitions (Eichenberger, et al., 2012, 2013; Munatones, 2011; Ulsamer, Rüst, Lepers, & Knechtle, 2014). In regard to performance analysis, although it is difficult to compare one race with another due to different conditions in each competition, such as wind, waves, and currents, the results have remained stable over the last few years, as also has the sex difference in performance at around 7% (Vogt, et al., 2013). In this sense, between 2000 and 2012, the swimming speed of the annual top ten women decreased in the 5 km and 25 km but increased in the 10 km (Zingg, Rüst, Rosemann,

Lepers, & Knechtle, 2014b), whereas in men it only decreased in the 5 km but remained stable in the 10 km and 25 km (Zingg, et al., 2014b). However, if just the annual fastest times are analysed, the speed remained stable for both sexes and all three distances (5, 10, and 25 km) (Zingg, Rüst, Rosemann, Lepers, & Knechtle, 2014a). Other studies on open water swimming have analysed the effect of age or wetsuits on race performance. They found that, for the 75-79 and 85-89 age groups, men and women's performances were similar (Knechtle, Nikolaidis, Rosemann, & Rust, 2016), and that wetsuits had a positive influence on swimming speed in both sexes (Ulsamer, et al., 2014). Although the differences between men and women's performances have been stable for a long time, performance density differs between the two sexes. In particular, the performance density (from 1<sup>st</sup> to 10<sup>th</sup> place) at the Olympic Games in Rio (2016) was found to be 0.07% for men, but even 0.81% for women (Baldassarre, Bonifazi, Zamparo, & Piacentini, 2017).

It is well known that pacing strategy is highly relevant to performance in most elite sports, especially those that involve competing over long distances and/or prolonged times such as cross country running (Deaner & Lowen, 2016), marathon running (Hanley, 2016), cycling (Davies, et al., 2016), and long distance swimming (Baldassarre, et al., 2017). The swimming marathon is the event at the Olympics that most closely resembles 10 km open water swimming. It takes about two hours for the top competitors, and pacing is important to achieve a good end result. It has been demonstrated that faster marathon runners tend to run at a more even pace than slower runners (Abbis & Laursen, 2008; Hanley, 2016). Others have found that many runners use a slightly U-shaped pacing strategy in which the first and the last parts are run slightly faster than the middle part (March, Vanderburgh, Titlebaum, & Hoops, 2011). No studies have reported sex differences in marathon runners' pacing strategies (Abbis & Laursen, 2008; March, et al., 2011).

A pacing strategy can be defined as the temporal distribution of energy expenditure during the event (Mauger, Neuloh, & Castle, 2012). Optimal pacing in swimming is especially important due to the increasing drag as speed increases (Maglischo, 2003). In swimming, two pacing strategies were described initially (Maglischo, 2003): positive pacing, also called fast-slow (Skorski, Faude, Caviezel, & Meyer, 2014b), and negative pacing, also called slow-fast (Skorski, et al., 2014b). In the former, the first half of the race is swum faster than the second, of course taking into account that the first lap swum is normally the fastest given the effect of the start on the partial time. In the latter (negative pacing), the two halves of the race tend to be swum in equal times. Later, another four strategies were defined: all-out, even pacing, parabolic

or U-shaped, and variable (Abbis & Laursen, 2008). The all-out strategy consists of beginning the race fast and trying to maintain that rhythm. The even pacing strategy consists of maintaining a constant speed during the race with hardly any variation. The parabolic strategy implies that the beginning and finish are done faster than the middle part. Finally, the variable strategy is when there is no clear pacing strategy and the partials vary from one to another without any apparent logic.

In events of a long-duration cyclic nature, such as the marathon, the pacing strategy would seem to be clear. One study, for example (Hanley, 2016), which examined different marathon events, found that the medalists (men and women) used the even pacing strategy from 10 km onwards, whereas slower "finishers" dropped off the lead pack at approximately half-distance. The same was found in a study of just the New York marathon from 2006 to 2011 (Santos-Lozano, Collado, Foster, Lucia, & Garatachea, 2014). In a sport such as the triathlon, which combines quite distinct specialties, the pacing strategy is not so clear, precisely because of how different the disciplines it consists of are. Nonetheless, it appears that reduced intensity in the swimming or the cycling could result in faster subsequent cycling or running, respectively (Wu, Peiffer, Brisswalter, Nasaka, & Abbiss, 2014).

In swimming, the pacing strategies used have been studied in several events: freestyle (Damasceno, et al., 2013; Lipinska, Allen, & Hopkins, 2015, 2016; Mauger, et al., 2012; Nikolaidis & Knechtle, 2014; Shimadzu, Shibata, & Ohgi, 2008), breaststroke (Thompson, MacLaren, Lees, & Atkinson, 2003, 2004), individual medley (Saavedra, Escalante, García-Hermoso, Arellano, & Navarro, 2012), and a mix of events (Robertson, Pyne, Hopkins, & Anson, 2009; Skorski, et al., 2014b). In 400 m freestyle, for instance, the situation is unclear since no statistically significant differences were found between world-level swimmers' use of either a positive or a parabolic pacing strategy (Mauger, et al., 2012). In the longer distance swimming-pool events (800 m and 1500 m), swimmers use a parabolic pacing strategy (Damasceno, et al., 2013). The greatest increase in elite swimmers' split times in freestyle events occurs in the second lap, and there is a decrease in the last lap except in the last 100 m event (Nikolaidis & Knechtle, 2014). In the Olympic pool swimming, a study found that it was the middle part of the 200 m and 400 m which determined the winners (Robertson, et al., 2009). Some studies have gone further than just describing the pattern used; they have shown that the pacing profile for elite swimmers seems to be the same in heats and finals in 400 m freestyle (Skorski, Faude, Abbiss, Caviezel, Wengert, & Meyer, 2014a). Similarly, manipulating the speed in the first partial could affect the performance of junior swimmers in "simulated race" 400 m freestyle (Skorski, et al.,

2014b). With respect to open water swimming, a recent study (Rodríguez & Veiga, 2017) found that the swimmers classified both from 1<sup>st</sup> to 3<sup>rd</sup> place and from 4<sup>th</sup> to 10<sup>th</sup> in a 10-kilometer event used an even pacing strategy, while those classified after 51<sup>st</sup> place in men and 39<sup>th</sup> in women used the positive pacing strategy. Nevertheless, it has to be noted that the study considered data from just a single championship.

Despite all the aforementioned studies, there has been no study that analyses the pacing strategy in open water swimming, therefore more studies are needed in general for different swimming events (Lipinska, et al., 2015). So, given this context, the purpose of the present study was to ascertain the pacing strategies employed in the 10 km open water swimming events and to define which split time was the most determinant for the final performance as a function of sex (men and women) and classification (1<sup>st</sup> to 3<sup>rd</sup>, 4<sup>th</sup> to 8<sup>th</sup>, 9<sup>th</sup> and below) in international championships.

## Methods

### Cases

Six international championships were analysed: one Olympic Games (2016), two World Championships (2013, 2015), and three European Championships (2012, 2014, 2016). A total of 437 records were analyzed (257 men and 180 women). We did not use the data from previous championships as the four partial times for each event were unavailable.

### Procedures

All the results were retrieved from the websites of the corresponding championships, which were in the public domain. The official timekeeping page of the championship was used (<http://www.omegatiming.com/>). The data were retrieved by one of the authors (A.G-H), and entered manually into an Excel spreadsheet file. They were then subjected to a random check by another author (JMS) in order to detect possible errors. The use of data that is publicly available on official websites is usual in the field of performance analysis of swimming in general, and of open water swimming events in particular (Knechtle, et al., 2016; Ulsamer, et al., 2014; Vogt, et al., 2013; Zingg, et al., 2014 a,b). The study followed the principles of the Declaration of Helsinki.

### Statistical analysis

Basic descriptive statistics (mean and standard deviation) were used to characterize the sample with respect to both the final time and to each split time plus their percentages. The normality of the data distribution was confirmed by the Kolmogorov-Smirnov test. A one-way ANOVA with the corresponding *post-hoc* analyses was used to estab-

lish differences among splits (0 to 2.5 km, 2.6 to 5 km, 5.1 to 7.5 km, and 7.6 to 10 km) and halves (0 to 5 km and 5.1 to 10 km) in raw times. These analyses were sex stratified and calculated separately for each classification group (top classified: 1<sup>st</sup> to 3<sup>rd</sup>; middle classified: 4<sup>th</sup> to 8<sup>th</sup>; and lowest classified: 9<sup>th</sup> and below). Two-way ANOVAs (sex [2 levels: men, women] × classification [3 levels: 1<sup>st</sup> to 3<sup>rd</sup>, 4<sup>th</sup> to 8<sup>th</sup>, 9<sup>th</sup> and below]) were performed for each split (0 to 2.5 km, 2.6 to 5 km, 5.1 to 7.5 km, and 7.6 to 10 km). The Bonferroni *post-hoc* test was used to compare means. For these analyses we used the percentages in each split, since the use of raw times would have resulted in differences between all the independent variables (sex and classification) – there will always be differences between men and women in times. The division of swimmers into top classified (1<sup>st</sup> to 3<sup>rd</sup>), middle classified, (4<sup>th</sup> to 8<sup>th</sup>), and lowest classified (9<sup>th</sup> and below) has been used in previous studies (Saavedra, et al., 2012). Finally, Pearson's simple correlation coefficient was used to determine correlations between the splits (partial times) and the final performance (total time). Apart from statistical significance, the values of this statistics were assigned linguistic labels following recommendations in literature (Cohen, 1993): >0.1 small; >0.3 moderate; >0.5 large; >0.7 very large; and >0.9 nearly perfect. A p-value of <.05 was considered to correspond to statistical significance.

## Results

Figure 1 shows the differences among the four splits and between the halves for each classification group and both sexes. The ANOVA established differences among splits for all three classification groups in men (Figure 1A) and women (Figure 1B) ( $F_{3,45}=15.87$ ,  $p<.001$  and  $F_{3,78}=24.63$ ,  $p<.001$ , respectively). The *post-hoc* analyses revealed that in the top (i.e., 1<sup>st</sup> to 3<sup>rd</sup>) and middle classified swimmers (4<sup>th</sup> to 8<sup>th</sup>), only the 2<sup>nd</sup> and 3<sup>rd</sup> splits did not differ significantly in raw times. Furthermore, in the lowest classified men (9<sup>th</sup> and below), significant *post-hoc* differences were established for all four splits. For the top and middle classified women, only the 4<sup>th</sup> split differed significantly from the other three splits. For those women with the lowest classification, the 1<sup>st</sup>, 2<sup>nd</sup>, and 4<sup>th</sup> splits were significantly faster than the 3<sup>rd</sup> split. In the top and middle classified men, the 1<sup>st</sup> half was significantly slower than the 2<sup>nd</sup> half ( $F_{1,17}=58.40$ ,  $p<.001$  and  $F_{1,29}=112.98$ ,  $p<.001$ ; respectively), with there being no significant differences between the halves in the lowest classified men ( $F_{1,208}=0.06$ ,  $p=.79$ ) (Figure 1C). Similarly, the top and middle classified women swam slower in the 1<sup>st</sup> than in the 2<sup>nd</sup> half ( $F_{1,15}=11.35$ ,  $p<.005$  and  $F_{1,26}=21.92$ ,  $p<.001$ , respectively), but the ANOVA showed no significant difference in raw times between the halves in the lowest classified women ( $F_{1,136}=2.11$ ,  $p=.15$ ) (Figure 1D).

Table 1. Mean, standard deviation (SD) (time and percentage), two-way ANOVA (sex, classification, and interactions) with the Bonferroni post-hoc test and effect sizes of the differences (Cohen's d) in 10 km open water events

Classification		Percentage (%)		Differences (%) by sex in each classification						
		Men (n=257)	Women (n=180)	F	p	Effect size				
		Mean (SD)	Mean (SD)							
1 <sup>st</sup> – 3 <sup>rd</sup> (n=34) (a)	1 <sup>st</sup> split	25.89 (0.61)	25.44 (0.64)	4.317	<b>0.046</b>	0.71				
	2 <sup>nd</sup> split	25.29 (0.30)	25.24 (0.54)	0.094	0.761	0.11				
	3 <sup>rd</sup> split	25.14 (0.69)	25.26 (0.56)	0.295	0.591	-0.19				
	4 <sup>th</sup> split	23.61 (0.49)	23.79 (0.86)	0.585	0.450	-0.25				
	1 <sup>st</sup> half	51.09 (0.60)	50.69 (0.91)	2.369	0.134	0.52				
	2 <sup>nd</sup> half	48.75 (0.68)	48.05 (1.08)	0.959	0.335	0.78				
4 <sup>th</sup> – 8 <sup>th</sup> (n=57) (b)	1 <sup>st</sup> split	25.81 (0.60)	25.43 (0.59)	5.974	<b>0.018</b>	0.64				
	2 <sup>nd</sup> split	25.19 (0.34)	25.23 (0.54)	0.125	0.726	-0.05				
	3 <sup>rd</sup> split	25.07 (0.72)	25.27 (0.54)	1.328	0.254	-0.31				
	4 <sup>th</sup> split	23.69 (0.52)	23.60 (1.46)	0.081	0.776	0.08				
	1 <sup>st</sup> half	51.00 (0.53)	50.66 (0.84)	3.524	<b>0.066</b>	0.48				
	2 <sup>nd</sup> half	48.76 (0.64)	48.87 (1.58)	0.134	0.716	-0.09				
9 <sup>th</sup> and below (n=346) (c)	1 <sup>st</sup> split	25.19 (1.01)	24.87 (0.88)	9.163	<b>0.003</b>	0.33				
	2 <sup>nd</sup> split	24.81 (0.59)	24.94 (0.54)	4.552	<b>0.034</b>	-0.22				
	3 <sup>rd</sup> split	25.14 (0.67)	25.22 (0.57)	1.476	0.225	-0.12				
	4 <sup>th</sup> split	24.74 (1.07)	24.81 (0.96)	0.482	0.488	-0.06				
	1 <sup>st</sup> half	50.00 (1.21)	49.81 (1.07)	2.144	0.144	0.17				
	2 <sup>nd</sup> half	49.66 (1.26)	50.04 (1.13)	1.475	0.225	-0.31				
Differences (%) by classification for each sex			Men			Women				
			F	p	Diff.	F	p	Diff.		
	1 <sup>st</sup> split		9.170	<b>&lt;0.001</b>	a,b>c	7.526	<b>&lt;0.001</b>	a,b>c		
	2 <sup>nd</sup> split		9.436	<b>&lt;0.001</b>	a,b>c	4.757	<b>&lt;0.001</b>	b>c		
	3 <sup>rd</sup> split		0.129	0.880	n.s.	0.088	0.915	n.s.		
	4 <sup>th</sup> split		22.972	<b>&lt;0.001</b>	a,b<c	19.951	<b>&lt;0.001</b>	a,b<c		
	1 <sup>st</sup> half		16.491	<b>&lt;0.001</b>	a,b>c	11.236	<b>&lt;0.001</b>	a,b>c		
2 <sup>nd</sup> half		17.425	<b>&lt;0.001</b>	a,b<c	13.913	<b>&lt;0.001</b>	a,b<c			
Interactions	Sex		Classification			Sex * Classification				
			F (1,436)	Diff.	p	F (2,436)	Diff.	p	F (2,436)	p
	1 <sup>st</sup> split		8.216	m>w	<b>0.004</b>	16.064	a,b>c	<b>&lt;0.001</b>	0.103	0.902
	2 <sup>nd</sup> split		0.815	n.s.	0.367	13.554	a,b>c	<b>&lt;0.001</b>	0.241	0.786
	3 <sup>rd</sup> split		1.987	n.s.	0.159	0.020	n.s.	0.980	0.193	0.825
	4 <sup>th</sup> split		0.155	n.s.	0.694	42.776	a,b<c	<b>&lt;0.001</b>	0.211	0.810
	1 <sup>st</sup> half		3.709	n.s.	0.055	26.828	a,b>c	<b>&lt;0.001</b>	0.254	0.776
	2 <sup>nd</sup> half		1.169	n.s.	0.280	30.999	a,b<c	<b>&lt;0.001</b>	0.067	0.935

Note. 1<sup>st</sup> split=0 to 2.5 km; 2<sup>nd</sup> split=2.1 to 5 km; 3<sup>rd</sup> split=5.1 to 7.5 km; 4<sup>th</sup> split=7.6 to 10 km. 1<sup>st</sup> half=0 to 5 km; 2<sup>nd</sup> half=5.1 to 10 km. Diff, differences; n.s., not significant.

Table 1 presents the results corresponding to the 10 km open water event. The fastest split (the smallest percentage of the total time of the race) was the fourth (7.6 to 10 km) for both the men and women. Also, the second half (5.1 to 10 km) was faster than the first (0 to 5 km) in both men and

women. The men spent a greater percentage of time in the first split (0 to 2.5 km) ( $F_{1,436}=8.216, p<.004$ ). With regard to the classification, the best swimmers of both sexes (1<sup>st</sup> to 3<sup>rd</sup> and 4<sup>th</sup> to 8<sup>th</sup>) spent a greater percentage of time in the first (0 to 2.5 km) ( $F_{2,436}=16.064, p<.001$ ) and second (2.6 to 5 km)

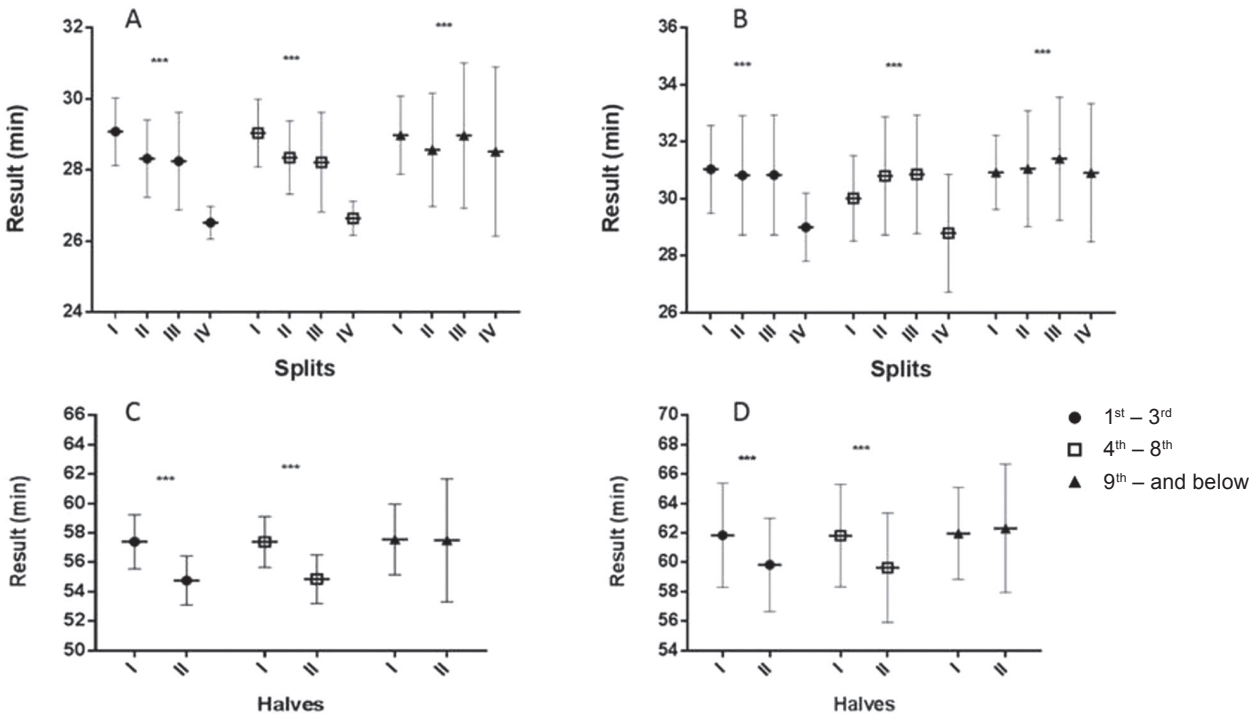


Figure 1. Partial times (minutes) of the four splits (I=0-2.5 km; II=2.6 to 5 km; III=5.1 to 7.5; IV=7.6 to 10.0 km) for men (A) and women (B) swimmers who finished from 1<sup>st</sup> to 3<sup>rd</sup> (●), 4<sup>th</sup> to 8<sup>th</sup> (◻), and 9<sup>th</sup> and below (▲). Partial times (minutes) of the two halves (I=0-5 km; II=5.1 to 10.0 km) for men (C) and women (D) swimmers who finished from 1<sup>st</sup> to 3<sup>rd</sup> (●), 4<sup>th</sup> to 8<sup>th</sup> (◻), and 9<sup>th</sup> and below (▲). \*\*p<.01; \*\*\*p<.001.

( $F_{2,436}=13.554, p<.001$ ) splits and less in the fourth split (7.6 to 10 km) ( $F_{2,436}=42.776, p<.001$ ) than the lowest classified swimmers (9<sup>th</sup> and below). The same was the case for the halves where the best swimmers (1<sup>st</sup> to 3<sup>rd</sup> and 4<sup>th</sup> to 8<sup>th</sup>) spent a greater percentage of time in the first half (0 to 5 km) ( $F_{2,436}=26.828, p<.001$ ) and less in the second half (5.1 to 10 km) ( $F_{2,436}=30.999, p<.001$ ) than the lowest classified swimmers (9<sup>th</sup> and below). There was no interaction between sex and classification in split times (1<sup>st</sup> to 4<sup>th</sup>) or halves (1<sup>st</sup> and 2<sup>nd</sup>).

Table 2 presents the correlations of the times corresponding to each of the splits (partial times) with the final performance (total time) in the race. All the variables in the four splits and in all the classifications correlated with performance ( $p<.001$ ). For medalists and swimmers classified 4<sup>th</sup> to 8<sup>th</sup>, the second split (2.6 to 5 km) was most strongly correlated with the final performance in both sexes, while for those from 9<sup>th</sup> and below it was the third split (5.1 to 7.5 km). Almost all the correlations may be considered as “large” ( $r>0.5$ ) or “very large” ( $r>0.7$ ), and even “nearly perfect” ( $r>0.9$ ) (Cohen, 1992).

**Discussion and conclusions**

The pacing strategy of international swimmers in 10 km open water swimming has been evaluated in this study by quantifying which split is the most determinant for their final performance in races and by establishing its relationship with sex

Table 2. Pearson’s linear simple correlation (r) for the variables (partial time) significantly correlated with performance (time) ( $p < .01$ )

	Men	Women	
1 <sup>st</sup> – 3 <sup>rd</sup>	1 <sup>st</sup> split	0.688	0.868
	2 <sup>nd</sup> split	0.978	0.971
	3 <sup>rd</sup> split	0.853	0.961
	4 <sup>th</sup> split	0.676	0.724
4 <sup>th</sup> – 8 <sup>th</sup>	1 <sup>st</sup> split	0.694	0.881
	2 <sup>nd</sup> split	0.942	0.974
	3 <sup>rd</sup> split	0.858	0.965
	4 <sup>th</sup> split	0.586	0.579
9 <sup>th</sup> – 16 <sup>th</sup>	1 <sup>st</sup> split	0.617	0.759
	2 <sup>nd</sup> split	0.905	0.941
	3 <sup>rd</sup> split	0.940	0.948
	4 <sup>th</sup> split	0.880	0.876

Note. 1<sup>st</sup> split=0 to 2.5 km; 2<sup>nd</sup> split=2.1 to 5 km; 3<sup>rd</sup> split=5.1 to 7.5 km; 4<sup>th</sup> split=7.6 to 10 km.

and final classification. To the best of our knowledge, the present study is the first one of this type considering Olympic events. In general, both the men and women who classified among the first eight employed the negative plan (the first half of the race slower than the second). However, the first partial was relatively slower in men than in women. Finally, the most determinant partial for the final

performance was the second part with no difference with regard to sex or classification.

Men, in comparison with women, swam the first partial (0-2.5 km) slower in proportion, whether analysed as a whole or with dependence on the classification: 1<sup>st</sup> to 3<sup>rd</sup>, 4<sup>th</sup> to 8<sup>th</sup>, and 9<sup>th</sup> and below (Table 1). This could be indicative of a more conservative strategy on the part of the men in comparison with the women. However, both sexes employed the negative pacing strategy, with the first part of the race being slower than the second for both the medalists and those classified from 4<sup>th</sup> to 8<sup>th</sup> place (Table 1). These results are similar to those of a recent study performed for the FINA 2015 World Swimming Championship (Rodríguez & Veiga, 2017). However, this strategy was not employed by those classified in 9<sup>th</sup> to 16<sup>th</sup> places. Thus it seems that the pacing strategy may be different depending on the level of the swimmer (Lima-Silva, et al., 2010). The strategy employed in shorter Olympic events (800 m and 1500 m) is a parabolic pacing (Damasceno, et al., 2013, Lipinska, et al., 2016), contrary to the negative pacing strategy of the present study. A study of international 400 m swimmers agrees with this, with the most employed strategies being the fast-start-even (similar to all-out) and the parabolic (Mauger, et al., 2012). Our results indicating negative pacing are relatively novel in long distance swimming. However, when compared to marathon running (i.e., another competition of approximately the same duration), it seems that the pacing strategy the swimmers use is different, with the marathon runners employing the even pace strategy (Santos-Lorenzo, et al., 2014). This difference in the pacing strategy for the effort over such a length of time could be due to the characteristics of moving in water where drag increases with speed.

Regarding the partials, the first and second are slower than the fourth for both men and women and for both the medalists and those classified from 4<sup>th</sup> to 8<sup>th</sup> place (Table 1). This agrees with previous studies that analyzed the speed tendency in 800 m freestyle showing a slight increase in speed in the last partial (Lipinska, et al., 2015). However the first partial in swimming-pool events is influenced by the underwater movements (Lipinska, et al., 2016), which play no part in open water swimming events. On the other hand, the results show that the fourth partial was the fastest, which agrees with previous studies on elite swimmers in 200, 400, and 800 m freestyle events (Nikolaidis & Knechtel, 2016). This could indicate an increase in effort in the final part of the event, as is the case in most resistance events (Abbiss & Laursen, 2008). Also, as was to be expected, the correlation between the partial times and the final time was either medium or high (Table 2), and, in medalists and those classified from 4<sup>th</sup> to 8<sup>th</sup> place, the second partial was that which presented the strongest correlation with the final time for both men and women (Table 2).

However, in those classified 9<sup>th</sup> and below, the partial that presented the strongest correlation was the third. These data do not agree with a study on international swimmers of 200 m of all specialties and 400 m freestyle, where the partial most strongly correlated with the final time is the third, except for 200 m men's freestyle and breaststroke where the second partial presents the strongest correlation (Robertson, et al., 2009). The overall characteristics of long distance swimming and its difference from other swimming events (i.e., those performed in swimming pools or amid track lanes) probably constitute the most important reason for such an obvious trend towards a negative pacing strategy. In particular, unlike "standard" swimming events, long distance swimmers do not swim in track lanes. Consequently, at the beginning of a long distance event, the best swimmers avoid peloton-leading positions since the leaders of the peloton have to overcome a relatively greater drag, resulting in greater energy demands for the same swimming speed (Munatones, 2011). Also, one of the main requisites in the first part of open water swimming is to find a proper position in the race, something which depends on the water current, quality of the opponents, buoyancy, etc. Consequently, the negative pacing strategy can allow the swimmer to attain these tactical goals while conserving energy for the later phases and a maximal effort at the finish (e.g., the difference between the 1<sup>st</sup> and 10<sup>th</sup> placed marathon swimmers at the London Olympics was about one minute, which was less than 1% of the total race time).

This study has some limitations. First, the external conditions in open water events, such as wind or currents, could influence the total time and the partial times in the championships. However, FINA tries to have these conditions as controlled as possible. Second, in this study we analyzed the results of the Olympic Games, World Championships, and European Championships. Some studies have noted that there are differences in the mean speed of the ten fastest swimmers at the Olympic Games and the European Championships (Vogt, et al., 2013). The greatest speed difference, however, was found to be between the World Cup Races and the other three championships. This is mainly due to the changing external conditions, which was the reason we decided not to include the World Cup Championship in the present study. Third, there were some differences in the three championships we analyzed, e.g., only the best 25 swimmer participated in the Olympic Games, while about 60 swimmers participated in the World and European Championships. This could have influenced the results of the analysis. Fourth, while an analysis of drafting was not an objective of this study, this technique has an influence on the final performance. Whichever the case, there have been no open water studies into

whether the best swimmers use “drafting” strategies or prefer to lead during the race. Lap speeds and lap rankings at the end of the race have, however, been found to be nearly perfectly related to the finishing positions for both sexes (Rodríguez & Veiga 2017).

In conclusion, the present study has shown that the medalists and the swimmers classified from 4<sup>th</sup> to 8<sup>th</sup> places employ the negative pacing strategy, both men and women, indicating that they take a conservative strategy so as to reach the final part of the event in the best condition possible. However, women use a smaller proportion than men of their total time in the first split (0 to 2.5 km). These results could help coaches find the optimal strategy for each swimmer depending on the swimmer’s level by providing him/her with the information on other factors that can influence their planning of training. For example, the coach might advise their swimmers that the first split of the event should be swum as slowly as possible while guaranteeing that they are in the leading group. They would thus be using mainly aerobic energy, “saving” energy

for the last, decisive split, especially when one considers that many open water races are decided by a sprint over the last 300-500 meters. We have also found evidence for the characteristic pacing strategies used by elite men and women swimmers. Specifically, the top (placed 1<sup>st</sup> to 3<sup>rd</sup>) and middle (placed 4<sup>th</sup> to 9<sup>th</sup>) classified men swimmers continuously increase their swimming speed from the 1<sup>st</sup> to the 4<sup>th</sup> split of the race, whereas this is a characteristic of only the top classified women swimmers. These characteristic pacing strategies could be applied to the training of endurance swimmers, depending on their level. In particular, we would therefore suggest that women swimmers classified currently below the top medalist category might systematically practice negative pacing over the 10 km of a simulated race in their training, which would let them apply this model later in competition. For men swimmers at the middle level of classification, their swimming tempo over the last 2.5 km of a race would seem to be the most important determinant of success.

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