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What pacing strategy 800m and 1500m swimmers use?

Qual estratégia de prova que nadadores de 800m e 1500m usam?

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Abstract – Pacing strategy (PS) has a decisive impact on performance, especially on long-term races. The objective of this study is to characterize the PS used in swimming races of 800m and 1500m freestyle by the finalists of the Olympic trials of the United States, Europe and Brazil, and the Olympic finalists of 2016. Time partials of 63 athletes were analyzed using a decision tree and the CHAID method. The results showed that parabolic was adopted by swimmers of 800m, they start in first lap (29.67 ± 0.88 s), followed by an increase in time (+1.77 s) and a subsequent increase in time (32.04 ± 0.89 s), at the end, the swimmers presented an acceleration, reducing the average of the to 31.44 s. And by the free 1500m swimmers, divided into blocks with a faster average start (29.25 ± 1.15 s), half of the slowest race (30.30 ± 0.76 s), and a new acceleration at the end of the event (29.92 ± 1.12 s), both in the selective Olympic Games and the 2016 and 2016 Olympic final. The worst partials times were observed in the Brazilian Selective (Test Event) (31.11 ± 0.78 s). Medalist, despite presetting the same OS, can sustain a better rhythm throughout he 800m (31.52 ± 1.03 s) and 1500-m (29.80 ± 0.78). We conclude that parabolic PS is the optimal strategy adopted by swimmers of 800-m and 1500m freestyle.

Key words: Athletic performance; Sports; Swimming.

Resumo – *A estratégia de prova (EP) tem impacto determinante no desempenho esportivo, principalmente em provas de longa duração. O objetivo foi caracterizar a EP utilizada em provas de natação de 800m e 1500m livre por finalistas das seletivas olímpicas dos Estados Unidos, Europa, Brasil e finalistas olímpicos de 2016. As parciais de tempo de 63 atletas foram analisadas por meio de árvore de decisão, utilizando o método CHAID. Os resultados mostraram que a EP parabólica foi adotada pelas nadadoras de 800m, com início (29.67 ± 0.88 s) seguido de um aumento de tempo (+1.77 s) e posterior novo aumento de tempo (32.04 ± 0.89 s), ao término as atletas apresentaram uma aceleração reduzindo a média para próximo à 31.44 s. E pelos atletas de 1500m livre, divididos em blocos com média inicias mais rápidas (29.25 ± 1.15 s), meio da prova mais lento (30.30 ± 0.76 s) e nova aceleração ao final da prova (29.92 ± 1.12s), tanto nas seletivas olímpicas quanto na final olímpica de 2016. Os piores tempos das parciais foram observados na seletiva olímpica do Brasil (evento teste) (31.11 ± 0.78 s). Atletas medalhistas, apesar de apresentarem a mesma EP, conseguem sustentar um melhor ritmo ao longo da prova de 800m (31.52 ± 1.03 s) e 1500-m (29.80 ± 0.78). Conclui-se que a EP parabólica é a estratégia ótima adotada pelos nadadores de 800m e 1500m.*

Palavras-chave: *Desempenho atlético; Esportes; Natação.*

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INTRODUCTION

There are factors determinant for performance improvement in swimming, such as physiological[1], biomechanical[2], technical[3] and the best race strategy to be adopted[4,5]. The way speed and energy expenditure are distributed during a given distance is called pacing strategy (PS)[6]. PS has a significant impact on performance in long races, and has therefore been frequently studied with international athletes, especially in individual sports such as athletics[7] and rowing[8].

PS was analyzed with different distances and types of swimming. In velocity races, the all-out strategy is considered the most adequate[9]. In 100m and 200m breaststroke, the most observed PS is the positive, where the athlete starts with a high intensity and tries to sustain it along the race[10,11]. However, in a later study, on which different PSs were analyzed, it was concluded that the most appropriate PS for 200m breaststroke would be a constant PS due to a high accumulation of lactate that the positive PS would cause[12].

Focusing specifically on long-distance races[6], observed that finalists of 800m and 1500m freestyle of world championships use parabolic PS[13,14], as has already been observed for 400m freestyle events[11]. The parabolic PS is characterized by a faster start, followed by a reduction in speed in the middle of the race and then an increase in the last 50m, called sprint. This decrease in speed in the middle of the race, besides interfering with the number and length of strokes, is intended to provide the athlete with energy savings until the end of the race, which in turn becomes decisive in long races[15-18].

The importance of using PS in individual long-distance modalities and its influence on the athlete's performance is well known[15]. However, it is relevant to analyze the type of PS adopted by swimmers who participated in some of the main Olympic trials, as well as the Olympic finalists of 2016. Such analysis makes it possible to identify whether parabolic PS was the strategy used by athletes classified and not classified during the Olympic selections and the Olympic finals. These information will help coaches adapt the practices in order to improve the performance of their swimmers during the meet, targeting the development of the proper strategies during the whole season.

Therefore, the objective of this study is to characterize the PS used by 800m and 1500m freestyle finalists of the trials of the United States, Europe, Brazil and Olympic finalists of 2016.

METHOD

Participants

The race results of 63 athletes were analysed, of which 32 were men (21.83 ± 2.74 years) and 31 were women (21.96 ± 2.81 years), finalists of the 800m and 1500m freestyle races of the 2016 Olympic Trials (US Trials, European and Maria Lenk – Test Event), as well as 2016 Olympic finalists. We considered as an inclusion criterion the analysis of performances resulting from the end of each race, not considering qualifiers, since it is expected that, in the finals, the athletes execute the best pacing strategy. In addition, authors who evaluated qualifiers and finals found that athletes use a more conservative tactic in the qualifiers in order to proceed to the finals, directly interfering with PS analysis[19]. Data were obtained from the official websites, free of access, of the respective organizing confederations and the *Federation Internationale de Natation* (FINA).

Instruments and Procedures

The PS was calculated from the total time and from the 50m partials of each race (16 partials in the 800m, and 30 partials in the 1500m race), and the criterion adopted for the study was a "time"- dependent continuous variable.

Statistical analysis

Data analysis was performed using decision trees and chi square automatic interaction detection (CHAID). The decision tree is a multivariate statistical technique that, based on iterative processes and established criteria, allows dividing an initial data set (single node) into subgroups statistically different from each other in relation to a variable[20]. The dependent variable in this case was the time obtained in each partial, and the independent variable was partial number. The minimum number of cases stipulated for the subgroups was 30 times. The CHAID method uses chi-square statistic (X^2) to identify homogeneity between variables, and the result is expressed by a graphical representation. Data were expressed as mean and standard deviation. The effect size was evaluated by Cohen *d*. All analyses were conducted using the statistical software IBM SPSS, version 24 (IBM Corp., Armonk, NY), adopting a significance level of 5%.

RESULTS

The mean time of partials, expressed in seconds, in 800m and 1500m freestyle races are shown in Tabel 1.

Table 1. CHAID analysis for pacing strategy in 800m and 1500m freestyle race.

800 m (Mean: 31,99 ± 1,21) (n=512) Adjust p Values=0.000 F=71.201 df1=3. d2=508		1500 m (Mean: 30,17 ± 0,90) (n=930) Adjust p Values=0.000 F=39.764 df1=4. d2=925	
Lap	Time (Mean ± SD)	Lap	Time (Mean ± SD)
≤ 1,00 (n=32)	29,67 ± 0,88	≤ 3,00 (n=93)	29,25 ± 1,15
1,00 – 2,00 (n=32)	31,44 ± 1,19	3,00 – 12,00 (n=279)	30,16 ± 0,70
2,00 – 5,00 (n=96)	32,04 ± 0,89	12,00 – 18,00 (n=186)	30,30 ± 0,76
5,00 – 15,00 (n=320)	32,32 ± 1,03	18,00 – 27,00 (n=279)	30,47 ± 0,78
> 15,00 (n=32)	31,44 ± 1,19	> 27,00 (n=93)	29,92 ± 1,12

The data showed that athletes use parabolic PS in the 800m and 1500m freestyle races (Tabel 1). In the 800m, the first 50m are the fastest part of the race (29.67 ± 0.88 s), followed by a marked deceleration up to 100m (increase of 1.77s, 6% decrease in speed). From the 100m, the deceleration is less accentuated, characterizing two moments in the race: 100-250m and 250-750m, when the sprint occurs. The last 50m are similar to the 100m partials. In the 1500m race, the first and the last 150m were identified as the initial and final sprints, respectively, presenting the shortest times. In the middle of the race, three blocks are identified (150-600m, 600-900m and 900-1350m).

In relation to the comparison between competitions (Figure 1) by CHAID analysis ($F_{2,509}$ = 208.457; p < 0.0001), the lowest partial time average of the 800m freestyle race was observed for the 2016 Olympic finalists (31.17 ± 0.83 s), followed by the European and the US Trials (31.73± 0.82 s). The worst partial time was observed for Maria Lenk (33.35 ± 1.12 s). The comparison between the average of Olympic finalists' partials with Maria Lenk partials reveals an effect size of high magnitude (*d* = 2.24 – very large). Considering the times of the first and last partials (50 *vs*. 800m) for Olympic finalists, there was a decrease in performance by 3.4% (29.03 ± 0.47 s *vs*. 30.00 ± 1.07 s; *d* = 1.26 – very large), 3.5% in the European (29.93 ± 0.29s *vs*. 30.96 ± 0.81s; *d* = 1.87 – very large), 6.6% in the Maria Lenk (30.66 ± 0.94 s *vs*. 32.96 ± 1.38s; *d* = 1.98 – very large), and 7.3% in the US Trials (29.10 ± 0.50 *vs*. 31.21 ± 0.85 s; *d* = 3.13 – very large).

In the 1500m freestyle race, by CHAID analysis ($F_{3.926}$ = 231,986, p < 0.0001), the lowest partial time in the race was observed for the Olympic finalists (29.57 ± 0.59s), followed by the European (29.83 ± 0.66 s), the US Trials (30.19 ± 0.71 s). The worst time was observed for Maria Lenk (31.11 ± 0.78 s) (Figure 3). The comparison between the average of Olympic finalists' partials with Maria Lenk partials reveals an effect size of high magnitude (*d* = 2.25). Considering the times of the first and last partials (50 *vs*. 1,500m) for Olympic finalists, there was a decrease in performance by 4.6% (27.45 ± 0.33 s *vs*. 28.71 ± 0.50 s; *d* = 3.04 – very large), 3.6% in the European (27.60 ± 0.26 s *vs*. 28.59 ± 0.58 s; *d* = 2.36 – very large), 5.1% in the Maria Lenk (28.54 ± 0.39 s *vs*. 30.00 ± 1.07 s; *d* = 2.00 – very large), and 2.9% in the US Trials (28.00 ± 0.44 *vs* 28.81 ± 0.75 s; *d* = 1.36 – very large).

Regarding performance, by the CHAID analysis ($F_{1.510}$ = 51,678, p<0,0001), the medalists presented a lower average time of partials in the 800-m race compared to non-medalists (31.52 ± 1.03 s *vs*. 32.28 ± 1.24 s, respectively; *d* = 0.67) (Figure 3). In the 1,500-m race, by CHAID analysis ($F_{1.928}$ = 107,737, p<0.0001), the medalists presented a lower average time of partials compared to non-medalists (29.80 ± 0.78 s *vs*. 30.40 ± 0.91 s, respectively; *d* = 0.71) (Figure 3). The effect size observed in the comparison between medalists and non-medalists had a moderate magnitude in both races.

DISCUSSION

The objective of this study was to determine the PS used by 800m and 1500m freestyle race finalists of the Olympic trials of the United States, Europe and Brazil, and the Olympic finalists of 2016. The selection of the

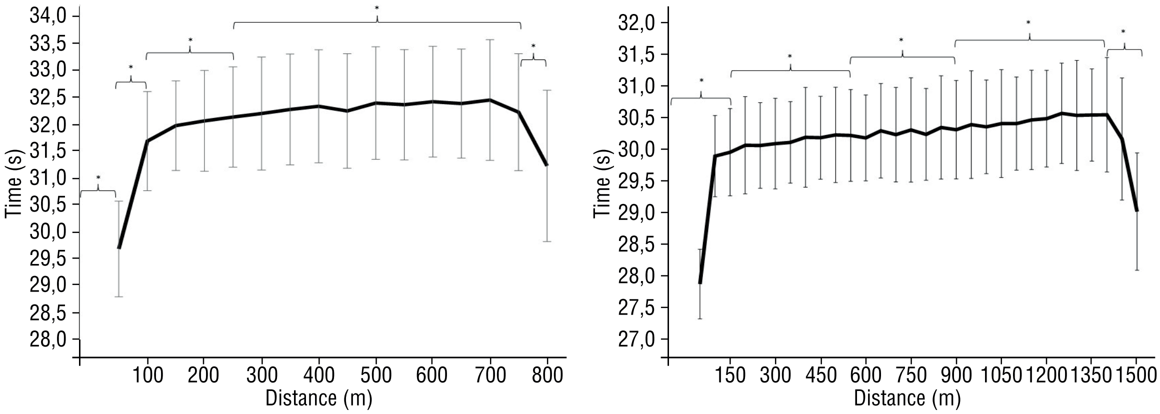

Figure 1. Distribution of time partials in the 800m and 1500m freestyle race. (* statistically significant difference between race moments).

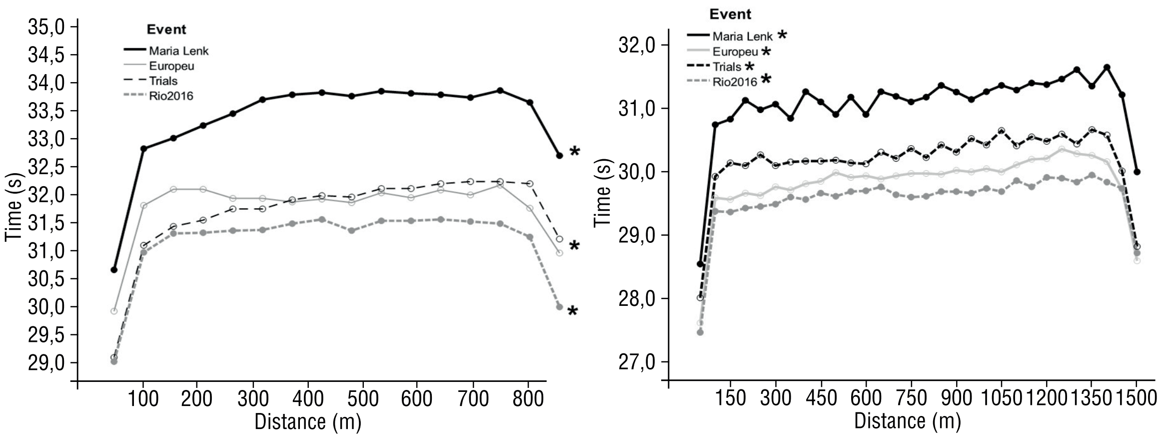

Figure 2. Distribution of time partials in the 800m and 1500m freestyle between different competitions. (* statistically significant difference between competitions).
Source: The authors.

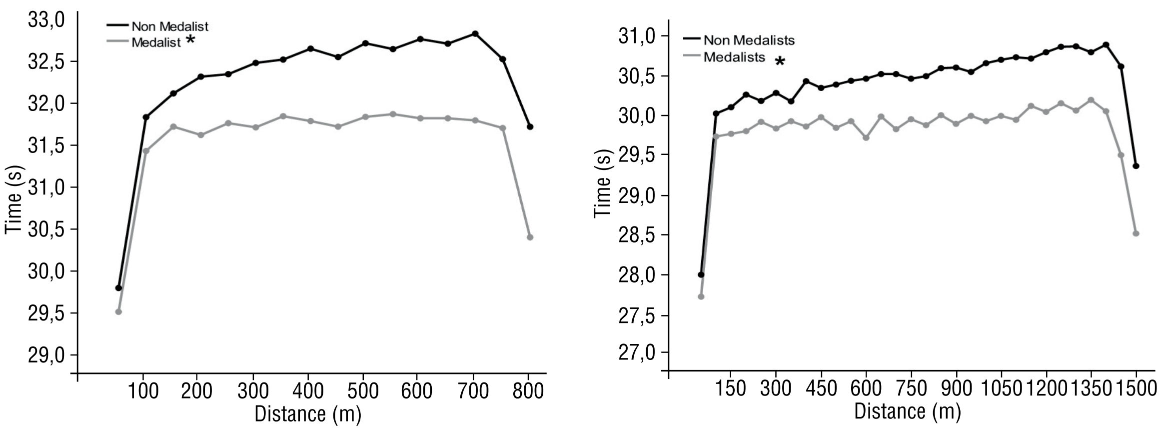

Figure 3. Distribution of time partials in the 800m and 1500m freestyle race between medalists and non-medalists (*statistically significant difference between groups).
Source: The authors.

trials was based on the host countries' main long-distance swimmers in 2016 and on the Test Event. This it represents the only chance that the main athletes in the world have to know the competition venue of the Olympic Games. We observed that the PS used by both the finalists of the Olympic trials and the finalists of the 2016 Olympic Games was the parabolic (more intense start and finish). Additionaly, the best athletes medalists of competitions presented the mean time shorter than the other athletes of each competition (non-medalists). We found that the Test Event, Maria Lenk, had the slowest performance among all competitions, presenting an even greater variability during the middle of the race. It is important to note that the host country classified two athletes for the 1,500-m and no athletes for the 800-m freestyle swimming for the 2016 Olympic Games.

Verifying the PS used in the sport is of fundamental importance to know, in a practical environment (competition), which is the best strategy aiming a maximum sporting performance. Some studies have already analyzed the PS used by athletes at different competitive levels, such as rowers[8], skaters[21] and runners[22] and identified specificities related to PS in each of them. Most studies pointed out the use of parabolic PS.

Based on the analysis of all the races of 800m and 1500m freestyle races (Tabel 1 and Figures 1, 2 and 3), we can see that the PS used in both races was the parabolic, since the initial and the final laps were better when compared to the rest of the race. By specifically analyzing the 800m freestyle (Figure 1), it is possible to observe a significant reduction in time at the beginning of the race, the first 50 meters, which was probably a consequence of the impulse and the slip after jumping from the start block[13,14,23]. It can also be observed that the second partial (50-100m) was different, slower than the starting meters and faster than the rest of the race. This is probably due to the onset of a race characterized by a sprint, which is later adapted and returned to the normal rhythm of an athlete. After the initial meters, the athletes keep a rhythm until the 250m. After this turn, the pace of race remains unchanged until the 750m. In the last part, the athletes considerably increase speed *(final sprint*), resulting in a lower time, similar to the second turn, characterizing the parabolic PS. These results corroborate the findings of other sports[8,21] and also swimmers in different strokes and distances[24].

In the 1500m freestyle race, it can be observed that the race is divided into 5 moments, also characterizing a parabolic PS (Tabel 1 and Figure 1). The first 150m are considered the initial sprint of the athletes. After this period, they adapt to the race pace. After the initial period, the athletes divide the race into practically 3 blocks, 150-600m (block 01 - 450m), 600-900m (block 02 - 300m) and 900-1350m (block 03 - 450m). The last 150m are characterized by the final sprint. Similar to the results of the 800m races, it creates a parabolic PS. The results observed in the 1500m race are similar to that of the study conducted by Lipińska *et al.*[13], who reported that the two initial and two final laps had the highest rhythm. In block 03, a probable explanation for athletes to assume a slower rhythm at this moment of the race is the model of tele-anticipation[25], whose purpose is to save energy so that afterwards a final sprint is performed, even if the performance of the athlete is impaired. De Souza Castro *et al.*[4] identified that, for the 200m butterfly, the finalists were more stable in all partials and that the third partial is crucial for the overall race performance.

It is still important to highlight, when comparing competitions, that the Test Event presented the worst performance of the athletes. This was not expected, since it was the last Olympic trial for the host country, besides the test event for foreign athletes. In the 800m race, for example, the decline in performance from the 1st to the last quarter in the Test Event was doubled when compared to the finalists of the 2016 Olympic Games. However, even with a difference between the rhythm of the athletes classified and those not classified for the Olympic Games, we perceived that the PS used by all the athletes is the parabolic (Figure 2). These results corroborate with the studies conducted with runners[26] and skaters[21], who found similar PSs regardless of the athletes' competitive expertise. For the 1500m freestyle race, we observed that the European competition presented a performance similar to the Olympic Games when comparing the first 3 ranked athletes. This result can be justified by the fact that, among the eight Olympic finalists, 4 were European.

No differences were observed in PS between medalists and non-medalists (Figure 3), but we identified that medalists presented a better initial and final sprint and a better average time along the partials of the 800 and 1500m freestyle races. This means that pacing strategy itself does not discriminate swimmers, but other factors are crucial for the best athletes to be able to impose a stronger rhythm. This shows that medalist athletes differ from the other athletes because they are able to keep a stronger rhythm throughout the races. Saavedra *et al.*[5] noticed that the backstroke is the most important part of the race for males, medal winners, of the 200m and 400m medley. The same is true for the women, but just for the 200m, while on the 400m the freestyle becomes the most important part of the race for the women. Practices can be modify individually using this information.

As a practical implication for coaches and athletes, this study presented an alternative so that the athletes may take on a more efficient PS, since. In practice athletes of 800m races divide the race into two moments and athletes of 1500m races mostly use a pacing strategy of dividing the race into 5x 300m or 3x 500m, and that the athlete must use a parabolic PS. The practical challenge for those involved in the training process is to develop a work that teaches that parabolic PS is the best strategy even for newer categories, and that a work is developed optimizing the middle of races (rhythm). Another point to emphasize is the model of tele-anticipation, which in practice is highly used by athletes. However, it should be noted that the athlete must learn to save the correct amount of energy without damaging the previous block, since the final sprint will often define the athletes' results, since the competitive level is similar among experienced swimmers.

The limitations of this study are the impossibility of collecting other variables that could explain the PS adopted by athletes and the difference between medalists and non-medalists, such as technical and biomechanical indicators, since data are from the real competition environment. In addition, the results apply only to finalist swimmers of the races and competitions analyzed. It was not possible to analyze other swimmers, especially Olympic swimmers, who could not reach the finals.

CONCLUSION

It can be concluded that: 1- The PS used by the best swimmers of 800m and 1500m freestyle races was the parabolic; 2- The parabolic PS was observed both in Olympic trials and in the Olympic 2016 finals used by both medalist and non-medalist athletes; 3- In both 800m and 1500m freestyle races, the races are divided into blocks (5), i.e., the moments in which athletes change the pacing, which may help athletes and coaches to work with other types of PS. Therefore, coaches should focus their efforts so that the parabolic PS is improved and that the pacing, in the middle of the race, is increasingly intense and stable.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval
This research is in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement
The authors have no conflict of interests to declare.

Author Contributions
Conceived and designed the experiments: GTO, FZW e RMF. Performed the experiments: GTO, RMF, EMP e EFC. Analyzed the data: FZW. Contributed reagents/materials/analysis tools: RMF, MAMS e EMP. Wrote the paper: GTO, RMF, FZW, EFC, EMP, MAMS.

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