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Analyses of the dynamics of changes between individual men's events in front crawl during the XIX Olympic Games in Beijing 2008

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The main purpose of this study was to analyze tactical solutions used by swimmers, the finalists of the 19th Beijing Olympics in 2008, in individual front crawl events at distances of 50, 100 and 200 m. Observations were carried out on 7 swimmers, the Beijing Olympics medalists competing in front crawl individual events. Detailed analyses were run on: 1) Sports results obtained by the finalists at distances of 50, 100 and 200 m front crawl; 2) block time; 3) results of each 50 m lap time (100 and 200) called split times except 50 m front crawl (there is no split time in 50 m); and 4) the mean swimming speed (V) on individual laps of the analyzed races. To determine the correlation between the response time, the time of individual laps, and the final time of the analyzed front crawl races, Pearson's linear correlation coefficient *r* was obtained. As a result of detailed analyses of the test material it is believed that not only tactics for an individual race is important, but equally significant is to elaborate the strategy for the whole event and to prepare the swimmer to compete in the system of heats, semifinals and finals. However, some of the following tactical objectives can be formulated: sprinters (a distance of 50 and 100 m front crawl) should start at maximum speed, according to their abilities, and try to maintain that speed until the end of the race; middle-distance swimmers (200 m front crawl) should adopt the most optimal tactical solutions characterized by increasing speed in the second half of the distance.

Key words: *swimming performance, strategic solutions, male swimmers, front crawl*

1. Introduction

The determinants of achieving good swimming results are the subject of numerous scientific studies. The studies in many cases deal with the physiological aspects of a swimmer, mainly in the context of anaerobic capacity [1]–[3], as well as the aspects of technique [4] and motor skills [5]–[8]. A large group of authors focus on the analysis of kinematic parameters such as stroke length and stroke rate [9]–[11], pointing at those indicators as important factors in swimming efficiency at different distances and disciplines [12], [13]. There are also numerous different field studies available in the literature, such as studies on coordination or technical parameters, for instance, the start or turns, which are also significant in the swimming race, and consequently in the final sports achievement [6], [14], [15]. A tactical analysis in the context of obtaining satisfactory sports results seems to appear somewhat less frequently in the related literature [16], [17]. The literature dealing with competitive swimming distinguishes three basic tactical approaches: ES (even splitting), NS (negative splitting) and PS (positive splitting) [18]. The first one is considered the most effective, and at the same time enjoys the greatest popularity among athletes and coaches. Its main goal is to equally distribute the pace in both halves of the distance.

In the second approach, the swimmer gradually increases speed throughout the race, which leads to the

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fact that the first half of the distance is swum slower than the second half. It is believed that this approach is not as effective as a tactical solution, at least as far as sport physiology is concerned, but it is recommended for extraverts and low endurance swimmers who are able to accelerate upon the final meters of a race. The last of the three models can give an advantage mainly due to the psychological effect on the opponents. It is characterized by a higher speed in the first half of the distance than the other, which increases the chances of a favorable place at the finish, but only in the case of maintaining the optimal physiological preparations [19], [20].

The ability to approach the various stages of the competition (heats, semifinals and finals) is a different issue. It is crucial from the energy system point of view to rationally distribute strength and reach the finals at the least cost and effort. The tactics often applied by the most prominent swimmers, in heats, semifinals and finals alike, is to swim at 95% capacity, or to decelerate in an appropriate, final part of the qualifying stages. The overall approach, however, depends on the event, the distance, as well as individual predisposition, or placing in the race [21], [22].

What inspired the authors to make detailed observations on this subject was meeting the needs and expectations of modern male competitive swimming in terms of tactical analysis in front crawl. The main aim of this study was to analyze tactical solutions used by competitive swimmers, medalists of the XIX Summer Olympic Games in Beijing in individual front crawl races at distances of 50, 100 and 200 meters.

Therefore the following research questions were posed:

1. What kinds of tactics in individual front crawl competition were used by the finalists of the XIX Olympic Games Beijing in 2008?

2. What was the swimming speed variability of the medalists at each front crawl distance at Beijing 2008 Olympics?

2. Materials and methods

Observations have been carried out on 7 swimmers, Olympic medalists of the XIX Summer Olympic Games Beijing 2008, competing in individual front crawl events. The swimmers represented eight countries: United States (3), Australia (1), France (1), Brazil (1), and South Korea (1). Three of them stood on the podium twice, while all of the others won a single medal.

Characterization of the sample

The average age of the front crawl finalists stood at 23.3 years (the youngest athlete was 19 years old and the oldest 33 years old). The average height was 191.5 cm (varying from 183 cm to 202 cm), and the body mass was 84.9 kg on average (between 74 and 96 kg).

To illustrate the height and weight of the finalists competing in front crawl, Fig. 1 shows average values of selected somatic features for front crawl competition, in which the swimmers specialized.

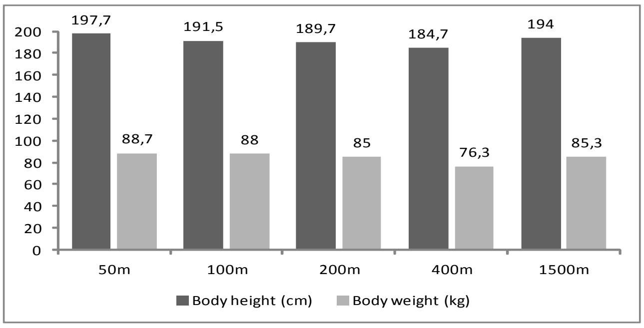

Fig. 1. Mean values of body height (cm) and weight (kg) of front crawl medalists at Summer Olympics Beijing 2008

As the data presents below, the highest average value of body height and body weight belong to swimmers who specialize in the sprint – 50 m front crawl – (197.7 cm and 88.7 kg) followed by long-distance who specialize in 1500 m distance (194.0 cm and 85.3 kg) and the short 100 m front crawl (191.5 cm and 88.00 kg).

The results of the front crawl finals of the 2008 Beijing Olympic Games, in the form of official times and split times were obtained from the website www.swimrankings.net, gathering a database from the European Swimming Federation (LEN). A detailed comparative analysis of the results of swimming race components was performed for the above-mentioned finalists of the front crawl events in order to accomplish the purpose of testing. These results are summarized for each athlete individually, taking into account all of their participation in each event (from the qualifiers to the finals) and the results obtained by their rivals. Therefore, the following was analyzed in detail:

- The results achieved by the finalists of the 50, 100 and 200 meter front crawl events;
- Block time; since this is the combination of block time (the interval between the starting signal and the first movement on the block) and movement time (vertical and horizontal force off the block), in total being the time difference from the starting signal to when the swimmer's feet leave the block [23].

- Results of each 50 m section of the analyzed distances (100, 200 m) called split times (50 m); and average swimming speed (*V*) of the individual sections of the distance. At the distance of 50 m front crawl there is no split time in 50 m.

Basic statistical methods were used in this paper, presenting the data in absolute numbers and percentages. The Mann–Whitney U test was used in order to determine the distribution of data differing from normal. To determine the correlation between response start time, the individual sections of the distances and the final results, Pearson's linear correlation was used by calculating the correlation coefficient *r*. The authors used Statiscica 6.0 software from StatSoft Poland in order to do statistical calculations.

3. Results

50 m front crawl event

In the final 50 m front crawl event the top three places were as follows:

1st place – Cesar Cielo (BRA),

2nd place – Eamon Leveaux (FRA),

3rd place – Alain Bernard (FRA).

Table 1 shows detailed results of the 50 m front crawl races: the heats, semifinals and finals.

As the data in Table 1 and Fig. 2 show, the fastest response time was achieved by the Brazilian swimmer, Cesar Cielo, reaching a value of 0.67–0.68 s in all three races, both qualifying and finals. The bronze medalist, Frenchman Alain Bernard had the second-fastest block time (0.73–0.75 s), and his fellow-countryman, the silver medalist, Eamon Leveaux was the third (0.75–0.79 s).

Block time proved to be important in 50 meters front crawl, as confirmed by Pearson's linear correlation, which showed a strong dependence of block time with the final result and the factor adopted the value of $r = 0.7$ ($p < 0.001$).

Cielo and Bernard gradually increased their swimming speed from one race to another, achieving the best results in the final event (Cielo – 21.30 s and Bernard – 21.49 s). A significant difference is also noticeable in the results between the first and the later races of the swimmers. Leveaux achieved a better result in the heats (21.46 sec) and a slightly worse result in the semifinal (qualifying to the finals only in

Table 1. Detailed results (s) of front crawl sprinters in the 50 m race

P	Swimmer	Heats			Semi-finals			Finals			+ (s)
		RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	
1	Cielo	0.67	2.33	**21.47**	0.67	2.34	**21.34**	0.68	2.35	**21.30**	–
2	Leveaux	0.75	2.33	**21.46**	0.79	2.30	21.76	0.75	2.33	21.45	0.15
3	Bernard	0.74	2.30	21.78	0.75	2.32	21.54	0.73	2.33	21.49	0.19

Legend: P – place, RT – block time (s), SS – swimming speed (m/s) "+" – loss to the winner (s).
New Olympic Records are marked in bold.

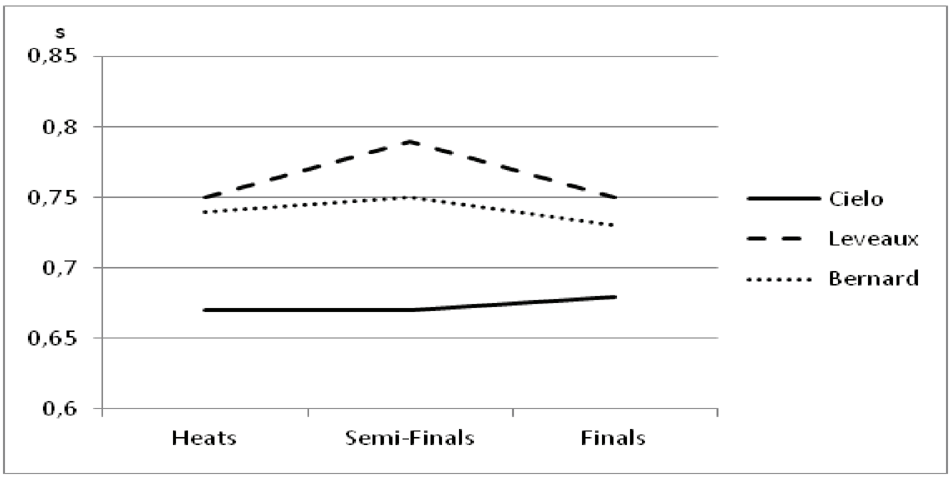

Fig. 2. Block times (s) of the medalists in the subsequent stages of the competition in the 50 m front crawl event

the 7th place) to win a silver medal in the finals (21.45 seconds).

100 m front crawl event

In the final race at a distance of 100 m front crawl the order was as follows:

1st place – Alain Bernard (FRA),

2nd place – Eamon Sullivan (AUS),

3rd place – ex aequo: Jason Lezak (USA) and Cesar Cielo (BRA).

Table 2 shows detailed results of the final competition of men's 100 m front crawl event.

The results of the individual 100 m front crawl events (Table 2) show a visible difference (of 0.35 s) between the 1st and the 2nd place, and the results of the swimmers who finished in third position, achieving the same result in the final (47.67 s), in which only the Brazilian (Cielo) clearly improved his previous results. Bernard and Sullivan, except for the heats, swam at high speeds, beating the two world records in the semifinals. Bernard was also able to maintain the high performance in the finals (47.21 sec), beating the Australian (47.32 sec) by 0.11 s. All three athletes (Bernard, Lezak and Cielo), except for the Australian Sullivan, got their best results in the finals (Fig. 3). The Australian Eamon Sullivan had the best block time (average of 0.66 s) before swimmers Cielo (0.7 s), Lezak (0.72 s) and Bernard (0.75 s).

Pearson's correlation coefficient between the reaction time and the result in the final race was $r = 0.23$, which indicates a low correlation between these variables and is not statistically significant. The Australian Eamon Sullivan had the best reaction time (average of 0.66 s) before swimmers Cielo (0.7s), Lezak (0.72 s) and Bernard (0.75 s).

As shown in Table 3, the best result in the first half of the distance, at 50 m, was achieved by Sullivan (22.48 s) in the heats, and by Sullivan in the semifinals and the finals (22.48 s and 22.84 s). The fastest in the second half of the distance was Bernard, both in the heats and the final race (24.53 s and 24.68 s) and Sullivan in the semifinals (24.84 seconds). The greatest speed over a 100 m distance of all athletes was achieved in the semifinals by the Australian swimmer Sullivan (2.13 m/s). It should also be noted that the average speed of the finalists in the 100 m front crawl event ranged within 2.10–2.12 m/s. Presented are the results achieved in the individual components of the distance in the competitive 100 meters front crawl in successive stages of the races. It may be noted that the French Olympic champion Bernard covered the whole

Table 2. Detailed results of men's 100 m front crawl event (s)

P	Swimmer	Heats			Semi-finals			Finals			+ (s)
		RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	
1	Bernard	0.74	2.09	47.87	0.76	2.12	**47.20**	0.74	2.12	47.21	–
2	Sullivan	0.66	2.10	47.80	0.65	2.13	**47.05**	0.67	2.12	47.32	0.11
3	Lezak	0.73	2.07	48.33	0.73	2.09	47.98	0.70	2.10	47.67	0.46
3	Cielo	0.71	2.08	48.16	0.72	2.09	48.07	0.68	2.10	47.67	0.46

Legend: P – place, RT – block time (s), SS – swimming speed (m/s), „+" – loss to the winner (s).
New Olympic Records are marked in bold.

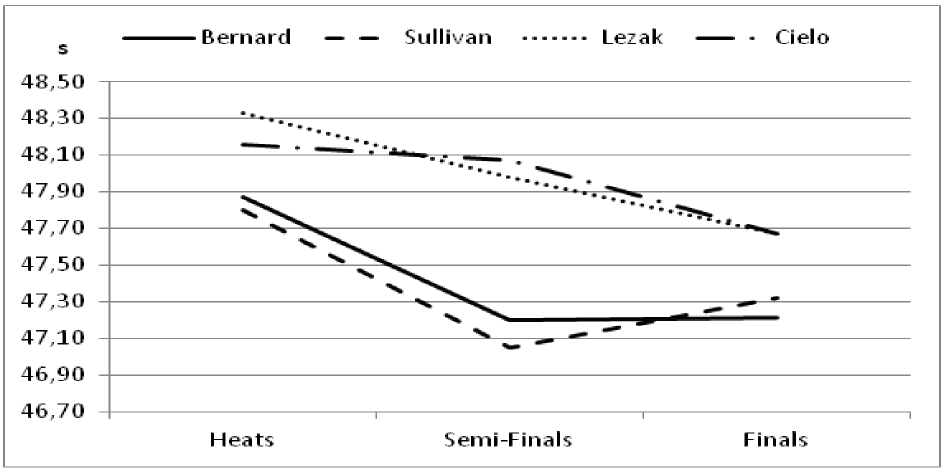

Fig. 3. Swimmers' results in successive stages of the 100 m men's front crawl event

distance in the heats fairly slowly to successively increase the speed by 0.67 s in the semis and 0.66 s in the finals. Sullivan reached his limits in the semifinals, and swam 0.21 s slower in the second half of the final than the Frenchman. Lezak noted steadily progressive split times of the first and third race, but in any case, his first 50 m was the slowest of all the medal winners (22.81 s to 23.08 s). The Brazilian Cielo, got almost identical results in the heats and the semifinals obtaining similar results in the first and the second half of the distance. In the finals his second half of the distance was relatively weaker (24.93 s).

200 m front crawl event

In the final 200 m front crawl event, the following swimmers took the three top places:

1st place – Michael Phelps (USA),
2nd place – Tae-Hwan Park (KOR),
3rd place – Peter Vanderkaay (USA).

Detailed results of the final competition of men's 200 m front crawl event are shown in Table 4.

The final race in men's 200 m front crawl (Table 4) was dominated by Michael Phelps of the USA (1:42.96), ahead of Tae-Hwan Park of South Korea (+1.89 s) and Peter Vanderkaaya (+2.18 s), also from the USA.

When taking into consideration the start block time (Table 4) at this distance, it was Tae-Hwan Park who got the best result for this parameter over all three races (0.67–0.68–0.67 s), before Phelps (0.73–0.74–0.73 s) and Vanderkaay (0.73–0.75–0.75 s).

The linear correlation coefficient between the response time and the final result for this distance stood at –0.09, which means that there was no significant correlation between these variables.

Figure 4 shows a comparison of the performance of the medalists in 200 m front crawl in successive stages of the competition.

Table 3. Split times (s) recorded in the final of the Beijing Olympics on the sub-sections of 100 m men's freestyle event

Swimmer	Men's 100 m freestyle	
	50 m	100 m
Bernard	22.53s	24.68s
Sullivan		22.48s
Lezak	22.86s	24.81s

Table 4. Detailed results of men's 200 m front crawl event (s)

P	Swimmer	Heats			Semi-finals			Finals			+ (s)
		RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	RT (s)	SS m/s	Time (s)	
1	Phelps	0.73	1.88	1:46.18	0.74	1.88	1:46.28	0.73	1.94	**1:42.96**	–
2	Park	0.67	1.88	1:46.73	0.68	1.89	1:45.99	0.67	1.91	**1:44.85**	1.89
3	Vanderkaay	0.73	1.86	1:47.39	0.75	1.89	1:45.76	0.75	1.90	**1:45.14**	2.18

Legend: P – place, RT – block time (s), SS – swimming speed (m/s), „+" – loss to the winner (s).
New Olympic Records are marked in bold.

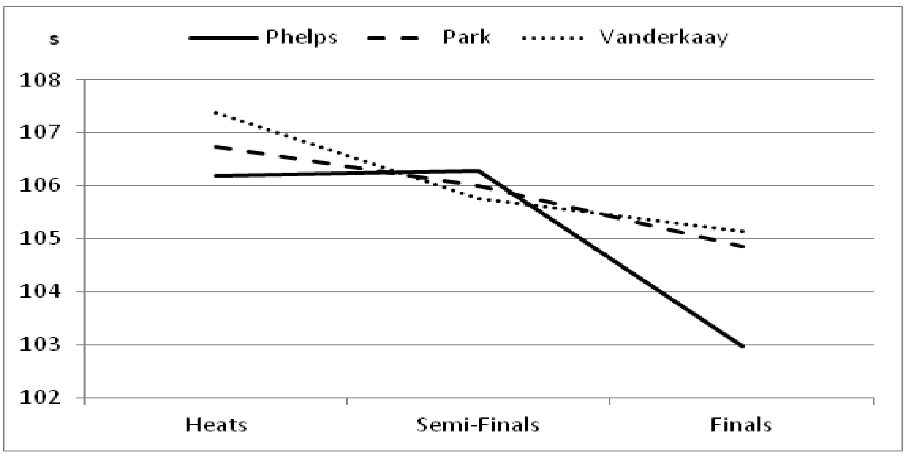

Fig. 4. Swimmers' results in successive stages of the 200 m men's front crawl event

Michael Phelps presented the greatest progress of results in various stages of the event, obtaining the final result of 1:42.96 min, significantly improving the results of previous runs (1:46.18 min and 1:46.28 min). Park and Vanderkaay also demonstrated an improvement (–1.88 s and –2.25 s) in the finals compared to the heats. The latter two swimmers showed a speed increase from race to race (from 0.1 to 0.2 m/s), whereas Phelps achieved the same results in the first two races and he achieved the highest speed in the final race (1.94 m/s).

The mean values of swimming speed for all competitors in the qualifying rounds were 1.87 m/s, 1.89 m/s the semifinals and 1.92 m/s in the finals.

The summary of laps (each 50 m distance) for men's 200 m freestyle is presented in Table 5.

cal solutions, led by their morpho-functional abilities. It seems that there is no such thing as one optimized, standard tactical model, which combined with the maximum possible swimming speed would always guarantee final success. However, the most desired ways of racing can be specified and applied to men's front crawl 50, 100 and 200 meters competitions [24], [25].

Tactics for 50 m front crawl distance seem to have little importance for the optimal result, because of the short length of the race, lack of turns and strength-speed nature of the event. This situation forces the swimmer to develop and maintain a maximum swimming speed during the whole race, which equaled 2.337 m/s ± 0.01 for the medalists. It is desirable at all distances of the Olympics to qualify to the next stages

Table 5. Split times (s) recorded in the final of the Beijing Olympics on the sub-sections of 200 m men's freestyle event

Swimmer	Men's 200 m freestyle			
	50 m	100 m	150 m	200 m
Phelps	24.31s	25.98s	26.55s	26.12s
Park	24.91s	26.63s	27.14s	26.17s
Vanderkaay	24.97s	26.70s	26.94s	26.53s

The largest differences in the individual components of the 200 m front crawl race (Table 5) were shown by Michael Phelps in the final runs and they were respectively: 1.5 s (first 50 m), 0.99 s (50–100 m), 0.51 s (100–150 m) and 0.75 s (150–200 m). The difference was relatively lower for the other two swimmers – respectively 0.14–0.68 s (Park) and 0.43–0.67 s (Vanderkaay). In the final, Phelps achieved the best lap times, and in each of the races his third 50 m was swam the fastest of all stages of the competition. The best results on the first 50 m of the distance was reached by Vanderkaay, both in qualifying (25.58 s) and the semifinals (25.14 s). All the competitors swam the first half of the distance faster than the other (Phelps –0.92 s; –1.58 s; –2.38 s; Park –0.93 s; –1.73 s; –1.77 s; Vanderkaay –1.49 s, –1.5 s, –1.8 s), and the gold medalist Michael Phelps got the best results on all the race components: 50, 100, 150 and 200 m (50.29 s in the first half of the distance, and 52.67 s in the second half of the distance) in the final.

4. Discussion

The results of this research may suggest that individual tactics play a very important role in swimming. Each athlete makes their own choice of specific tacti-

of the competition with the results deviating from the best performance, which allows a competitor to minimize the fatigue effect and to mobilize the body for further starts.

As follows from the data, the winners of the analyzed races (50, 100 and 200 m front crawl) achieved the best results in the finals, except for the 100 m distance, where the winner's difference to the results in the semifinals was –0.01). During the final races the medalists have shown various characteristic ways of dealing with the distances. Characteristic for all medalists in the 100 m race was swimming the first 50 m section at a much faster pace (the average was higher by 2.16 s than the finals) than the second half of the distance. But it seems to be logical, because it is influenced by the start [23], [26], [27].

The same tactics were used for a distance of 200 m, but the difference between the results of both 100 m sections increased in each next phase of the competition, as did the performance on individual laps. It seems that in front crawl sprint races up to 200 m the most effective tactic is to achieve and maintain the longest possible maximum swimming speed until the end of the race.

According to a study by Robertson et al. [17], there is considerable overlap between the results of the race, and the results for the split times on a lap of the race. At a distance of 100 m the greatest impact on the final achievement is the result achieved in the last 50 m of the race. It was shown that the time on the third 50 m lap for a distance of 200 m and the second and third 100 m lap of the 200 m front crawl show the strongest relationship with the final result.

In addition, it was found that the improvement of laps with the lowest determination rate for the final result would give a measurable effect towards getting higher places in the final classification [28], [29]. The analysis of the results of this research prove that the lap times in the final races of the Beijing Summer Olympics 2008 differ somewhat from the above data. The dependence has been confirmed for a 50 m front crawl events.

The overall results of the Beijing Summer Olympics 2008 seem very interesting compared to the results achieved during the Olympic Games in Athens 2004. Authors Karpinski and Oprychał [30] analyzed the progression of the results, taking into account the achievement of the selected competition medalists of the Olympic finals. First of all, it has been noted that with the increase in the length of the race finalists presented successively lower body height, and in each event (50, 100, and 200 m front crawl) a significant improvement in performance over the 2004 results was observed, reaching an average of 1.42% (from 50 to 200 m). In the 50 m front crawl the average improvement was 0.55 seconds, in 100 m it was 0.92 seconds, in 200 m – 0.78 seconds.

It also suggested that polyurethane swimwear, banned since 2010, including Jaked01 Full® and Powerskin X-Glide Full®, contributed to such record-breaking athletic performance of the swimmers by reducing friction and water resistance and improving the swimmer's body position in the water, while maintaining optimal performance [31].

Swimming as a sports discipline is not a typical tactical discipline. Athletes compete somewhat with time, and not directly with the opponents, and therefore there is no major interaction during races. Nonetheless, one of many factors determining the success is adequate preparation in the area of both technical and tactical skills. Kjendlie et al. [32], [33] said that individually the factors of body length, body mass, passive torque and active drag all show a statistically significant linear relationship with the absolute values of the cost of swimming. For the cost of swimming a negative and statistically significant correlation was found between the angle of attack and the energy cost of swimming at 1.0 m/s^{-1} only; however, these results were obtained only in one group of adults and children.

The results achieved nowadays at the highest levels are characterized by minimal differences, often falling in the range below 1/10 second. It is therefore clear that qualifying or winning a medal can be determined by a better tactical approach to the race, and not only the psychophysical and functional preparation. The most efficient and economical should be to maintain an equal pace throughout the distance regardless of its length. What is characteristic of the beginning of the race is obtaining a significant speed advantage in the starting jump. The same applies to the last part of the race, the final lap, where the time required for the hand to touch the wall is much shorter than the amount of time needed for the flip turn.

5. Conclusions

As a result of detailed analysis of research material for trying to assess the tactical approaches used by the medalists in front crawl individual events during the Summer Olympic Games in Beijing 2008, the following generalizations have been formulated:

1. Response times to auditory stimuli (start signal) can influence the final result. The medalists at 50 m front crawl showed a dependence on this factor ($p < 0.01$), which means that it is desirable for swimmers competing at these distances to have high efficiency of the nervous system. In other front crawl disciplines the impact of starting block time was marginal, as the relationship between these variables was not statistically significant.

2. The various stages of the competition – heats, semifinals and finals – are a different issue and from the energy system point of view it is desirable to rationally distribute strength and reach the finals at the least cost and effort. The tactics often applied by the most prominent swimmers, in heats, semifinals and finals alike, is to swim at 95% capacity, or to decelerate in an appropriate, final part of the qualifying stages. The overall approach, however, depends on the event, the distance, as well as individual predisposition, or placing in the race, which has been confirmed by investigations performed.

3. It is believed that not only tactics for an individual race is important, but equally significant is to elaborate the strategy for the whole event and to prepare the swimmer to compete in the system of heats, semifinals and finals.

4. However, some of the following tactical objectives can be formulated:

- sprinters (a distance of 50 and 100 m front crawl) should start at maximum speed, according to their abilities, and try to maintain that speed until the end of the race;

- middle-distance swimmers (200 m front crawl) should adopt the most optimal tactical solutions characterized by increasing speed in the second half of the distance.

Practical implications

- It appears that the tactical aspect cannot be overlooked in the training process. It is particularly important that the swimmer can control their swimming speed and adapt it in increasing fatigue, to rationally use their psychophysical and functional potential.
- Improving the technical and tactical elements of the race can largely depend on the detailed analysis of individual races of a competitor, including a simply statistical analysis.

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