RACE DISTANCE SEGMENTS OF THE WOMEN'S 100 METERS INDIVIDUAL MEDLEY AT THE SHORT COURSE WORLD SWIMMING CHAMPIONSHIP 2024

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ABSTRACT
Introduction. An analysis of a swimmer's performance in the different segments of the race distance, compared to that of swimmers with similar or better results, can reveal his/her strengths and weaknesses. The number of studies analyzing short-course races is limited, so our study could enrich the information in this field. Aim and Objectives. The purpose of this study was to analyze the segments of the race distance in the women's 100 m individual medley at the World Swimming Championships Budapest 2024 and to reveal the strengths and weaknesses of the Bulgarian swimmer DP. The analysis would help to show the reserves for improving her performance. Methods. The official results of the competition were used, as well as a video analysis of video footage shot during the competition. An analysis was made of the different segments in the 100 m IM event from the heats, semi-final, and final of the Bulgarian athlete (7th in the event) and the semi-final swim of the world record holder and champion in the event. Results. The champion swam faster in the butterfly, backstroke, and freestyle laps. She also made longer underwater swimming. The Bulgarian swimmer swam a little faster in the breaststroke lap. Discussion. The Bulgarian swimmer swam at speeds that meet the standards for European elite swimmers, as reported in a recent study. She swam at a significantly higher speed in butterfly and breaststroke, slightly faster in backstroke, and approximately at the same speed as the normative data in freestyle. The champion took great advantage of her good underwater swimming and longer, more powerful strokes. Conclusion. In summary, the champion in the event swam at a higher speed in 3 of the 4 strokes. The Bulgarian swimmer, who was slightly faster only in the breaststroke, should focus her training on improving her butterfly speed, underwater swimming length and speed, and stroke length at all strokes. She should also work on improving her tactical skills and special endurance.

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INTRODUCTION

The sports result in swimming depends on numerous factors. The swimmer's abilities with the greatest influence on the performance are related, on the one hand, to his genetically determined talents, and on the other hand, are a result of his training in various directions. A thorough analysis of the performance of a given athlete in the different segments of the race distance, compared to that of swimmers with similar or better results, can reveal the reserves for improving his result when he has reached the limit of his capabilities (Mason, 2017). The main components that swimming experts distinguish in the race distance are start, turn, finish, and clean swimming between these segments (Platonov, 2011). The effectiveness of the swimmer's actions in the execution of individual elements and overcoming different sections is determined by integral skills and qualities. Each of the components has a certain influence on the final result according to the event and depends on the relatively different abilities of the swimmer (Cossor & Mason, 2001; Marinho et al., 2020; Olstad et al., 2020).

The lengths of the sections of the race distance and the variables that are the subject of analysis in the known publications have some differences. They are determined by the researchers according to the available equipment, the competition rules, the facts established so far, and the trends in the analyzed event (Gonjo & Olstad, 2020). Some authors recommend, in addition to the adopted fixed sections, to use sections with individual distances (Veiga et al., 2012).

The efficiency of the start is usually assessed by the time to overcome the first 15 meters: from the starting signal to the swimmer's head crossing the 15-meter marker. This is related to the higher speed after the start compared to the swimming speed and the rules allowing swimming underwater up to 15 meters after the start in the freestyle, backstroke, and butterfly events. In the past, 10-meter and 7.5-meter sections have also been used (Absalyamov et al., 1985; Arellano et al., 1994). Some studies have mea-

sured the time from the starting signal to the appearance of the swimmer's head above the water surface or to the completion of the first cycle of movements after surfacing (Gonjo & Olstad, 2020). Swimming underwater after the start and turns should be considered when developing a racing strategy (Gonjo et al., 2022; Veiga, Roig, 2015). Additionally, the starting reaction can also be considered.

The efficiency of the turn is usually determined by the time of 15-meter segments, including 5 meters before the wall and 10 meters after the wall. Some apply a variant of 7.5 + 7.5 meters, but it should be borne in mind that the turn affects the speed after the push off from the wall more than the speed of swimming to it. Other variants of the turn segments can also be found in the literature: 20 meters (5 + 15); from the last entry of the hand or hands into the water (or the head in breaststroke) before the turn to the appearance of the swimmer's head on the surface of the water or to the completion of the first cycle of movements after surfacing; from touching the wall until the swimmer's head breakout. In addition, the time to swim to the wall, the time for the rotational movements next to the wall, and the time after touching the wall with the feet could be taken into account (Absalyamov et al., 1985; Gonjo, Olstad, 2020).

The time and speed of the last 5, 7.5, or 10 meters of the distance (from the crossing of the relevant line by the swimmer's head to touching the wall) are used to assess the finish. They are determined by the special endurance of the swimmers and their ability not to slow down their speed due to the adjustment of movements. The segments of the race distance that remain after subtracting the sections affected by the start, turns, and finish are usually called clean swimming. The swimming speed in the individual segments is measured, as well as the average swimming speed. Other parameters that are subject to analysis are the stroke length (the distance covered in one cycle of the swimmer's movements) and the stroke rate (the number of cycles per minute) during the clean swimming (Absalyamov et al., 1985; Gonjo, Olstad, 2020; Platonov, 2011; Popov et al., 2018).

A key factor in a swimmer's performance is the ability to distribute his or her efforts over the course of the race according to his or her speed and endurance capabilities. In all events, except the 50 meters, competitors do not exert maximum effort in the initial meters to avoid early development of acidosis, which would lead to a significant decrease in speed and deterioration of the result. Each swimmer must be able to control his or her speed in the different segments of the race by controlling the stroke rate and effort according to the event and his or her current capabilities (Maglischo, 2003).

Aim and Objectives

The purpose of this study was to analyze the segments of the race distance in the women's 100 m individual medley at the World Swimming Championships Budapest 2024 and to reveal the strengths and weaknesses of the competitors. Bulgarian swimmer DP was of particular interest to us. The analysis would help to show the reserves for improving her performance. The number of studies analyzing short-course races is limited (Gonjo & Olstad, 2020), so our study could enrich the information in this field.

METHODOLOGY

An analysis was made of the different segments in the 100 m IM event from the heats, semi-final, and final of the Bulgarian athlete DP (7th in the event) and the semi-final swim of the world record holder and champion in the event, GW, from the World Swimming Championships in Budapest 2024.

For the purposes of the study, the official results of the competition were used, as well as video analysis of video material shot during the competition. A Sony FDR-AX53 video camera with 4K resolution and a shooting speed of 25 frames per second was used for the shooting, which determines the accuracy of the segments measured through video analysis of 0.04 s. The software, Kinovea version 0.9.1, was used for video analysis.

From the official results of the competition were taken: the final result (t100), the breakdowns for 50, 75 meters (t-50, t-75), the times for swimming the four 25 m sections (tI-25, tII-25, tIII-25, tIV-25) and the starting reaction (RT), which corresponds to the time from the moment of the starting signal to the moment of separation of the feet from the starting block. The second 50 m (tII-50) were calculated.

The following data were obtained from the video analysis: time for the first 15 meters (t15); time for the three turns (tT-I, tT-II, tT-III); time to finish - (tF); number of strokes in the individual 25-meter sections (SI-25, SII-25, SIII-25, SIV-25); stroke rate (SR15 m, SR40 m SR65 m и SR90 m); cycle time (ST15m, ST40m, ST65m, ST90m); length of the underwater swimming (U-I25, U-II25, U-III25, U-IV25) and speed of the distance swim in different segments of the distance (V15, V15-25, V25-40, V40-50, V50-65, V65-75, V75-90 и V90-100).

The time for the first 15 meters (t15) was measured from the moment the competitor's foot left the starting block to the moment head passed 15 m after the start. The finishing time (tF) was recorded from the moment the head passed 15 m before the wall to the moment when the hand touched the wall at the end. The measurement of the turn time was made from the time the head passed 5 m be-

fore the turn wall to the time the head passed 15 m after the turn wall. To calculate the length of the underwater path, the corridor floats were counted to the line of the head's exit from the water after the turn. The time for one cycle (ST) is calculated by dividing by 3 the time for three cycles after the 15th, 40th, 65th, and 90th meter. The stroke rate (SR) of the 15th, 40th, 65th, and 90 m was calculated by dividing 60 (1 min) by the time for one cycle. The speed of different segments of the competition were calculated for the first 15 m (until the head passes the 15th meter) and the second 10 m (until the hand/hands touch the wall) of each 25 m in the different strokes. The speed of the first 15 meters includes the starting reaction, underwater swimming, and the initial swimming movements (if any) until the head passes the 15th meter. Each subsequent 15 m starts from the touch of the wall of the previous stroke and ends when the head passes the 15th meter. Each 10 m of each stroke begins when the head passes the 15th meter and ends when the competitor touches the wall.

RESULTS

The first 25 (butterfly) of the world record holder was faster by between 1.00 and 1.23 seconds compared to the different swims of the Bulgarian competitor (Table 1). For the second 25 (backstroke), this difference was between 0.80 and 1.17 seconds. In the third 25 (breaststroke), the Bulgarian was faster by between 0.04 and 0.25 seconds. In the fourth 25-meter (front crawl) event, the world champion was faster by between 0.90 and 1.09 seconds. Thus, the champion gains more lead in the first 50 m (between 1.87 and 2.26) compared to the second 50 m (between 0.70 and 1.05).

Table 1. *Components of the race distance in the analyzed swims of the women's 100 m individual medley in Bucharest 2024.*

Name	GW	DP		DP		DP	
Segments	**semi-final**	***d***	**heats**	***d***	**semi-final**	***d***	**final**
RT (s)	0.75	-0.06	0.69	-0.06	0.69	-0.05	0.7
t-25 (s)	11.16	1.23	12.39	1.00	12.16	1.08	12.24
t-50 (s)	24.76	2.03	26.79	1.87	26.63	2.26	27.02
t-75 (s)	41.76	1.99	43.75	1.62	43.38	2.12	43.88
t-100 (s)	55.71	3.08	58.79	2.57	58.28	3.02	58.73
*t*I-50 (s)	24.76	2.03	26.79	1.87	26.63	2.26	27.02
*t*II-50 (s)	30.95	1.05	32.00	0.70	31.65	0.76	31.71
*t*I-25 (s)	11.16	1.23	12.39	1.00	12.16	1.08	12.24
*t*II-25 (s)	13.60	0.80	14.40	0.87	14.47	1.18	14.78
*t*III-25 (s)	17.00	-0.04	16.96	-0.25	16.75	-0.14	16.86
*t*IV-25 (s)	13.95	1.09	15.04	0.95	14.9	0.90	14.85
V15 (m/s)	2.56	0.31	2.24	0.26	2.30	0.29	2.27
V15-25 (m/s)	1.89	0.14	1.75	0.11	1.78	0.11	1.78
V25-40 (m/s)	1.94	0.16	1.79	0.18	1.76	0.22	1.72
V40-50 (m/s)	1.70	0.03	1.67	0.02	1.68	0.05	1.65
V50-65 (m/s)	1.52	0.02	1.50	-0.02	1.54	0.00	1.52
V65-75 (m/s)	1.40	-0.03	1.44	-0.03	1.43	-0.03	1.43
V75-90 (m/s)	1.78	0.13	1.65	0.13	1.65	0.10	1.68
V90-100 (m/s)	1.81	0.14	1.68	0.10	1.72	0.13	1.69
*t*15 (s)	5.12	0.88	6.00	0.72	5.84	0.80	5.92
*t*T-I (s)	10.56	0.68	11.24	0.80	11.36	1.00	11.56
*t*T-II (s)	12.68	0.36	13.04	0.12	12.80	0.25	12.93
*t*T-III (s)	11.96	0.60	12.56	0.56	12.52	0.40	12.36
tF (s)	8.36	0.66	9.02	0.55	8.91	0.59	8.95
U-I25 (m)	14.0	-2.0	12.0	-2.0	12.0	-1.5	12.5
U-II25 (m)	14.0	-2.0	12.0	-2.0	12.0	-2.0	12.0
U-III25 (m)	10.0	-1.5	8.5	-1.5	8.5	-1.5	8.5
U-IV25 (m)	14.0	-7.0	7.0	-7.0	7.0	-8.5	5.5
SI-25 (count)	5	2	7	2	7	2	7
SII-25 (count)	9	3	12	3	12	3	12
SIII-25 (count)	8	3	11	3	11	3	11
SIV-25 (count)	10	8	18	9	19	10	20
SR15m (cpm)	57.7	0.7	58.4	4.8	62.5	4.8	62.5
SR40m (cpm)	42.9	6.6	49.5	7.1	50.0	4.0	46.9
SR65m (cpm)	44.1	15.1	59.2	13.6	57.7	11.4	55.6
SR90m (cpm)	44.1	8.8	52.9	9.5	53.6	9.5	53.6
ST15m (s)	1.04	-0.01	1.03	-0.08	0.96	-0.08	0.96
ST40m (s)	1.40	-0.19	1.21	-0.20	1.20	-0.12	1.28
ST65m (s)	1.36	-0.35	1.01	-0.32	1.04	-0.28	1.08
ST90m (s)	1.36	-0.23	1.13	-0.24	1.12	-0.24	1.12

*Note: *d - difference*

In the turns, the difference was the largest in the butterfly to backstroke (between 0.68 and 1.00 sec), followed by the breaststroke to freestyle (between 0.40 and 0.60) and the backstroke to breaststroke (between 0.12 and 0.36) in favor of GW. The champion's time in the last 15 m (8.36) was also faster than that of DP, whose fastest finish was 8.91 s, or 0.55 s slower. The world record holder achieved significantly longer underwater swimming times in the butterfly, backstroke, and breaststroke, with a difference of about 1.5-2 meters, and in the freestyle, between 7 and 8.5 meters. The speed of both competitors in the first 15 m is higher than that of the subsequent 10 m of clean swimming for the first three laps. The exception is the freestyle lap, where the clean swimming is at a higher speed. It should be noted that the backstroke, breaststroke, and freestyle laps were measured from touching the wall at the completion of the previous stroke.

The number of strokes of GW was smaller, with the difference in butterfly being 2 cycles, in backstroke – 3 strokes (one and a half cycles), in breaststroke – 3 cycles, and in crawl – 8 to 10 strokes (4-5 cycles). DP swam with a higher stroke rate, being the highest in the breaststroke, with a difference between 11.4 and 15.1 cpm.

DISCUSSION

The graph in Figure 1 shows the variation in speed of the first 15 m (until the head passes the 15th meter) and the second 10 meters (until the hand/hands touch the wall) of each 25 m in the different strokes. The significantly higher speed of the world record holder in the event compared to the Bulgarian competitor can be seen in 3 of the 4 strokes of the 100 m individual medley. Only in the breaststroke, both the first 15 m and the second 10 m of the 25 m section were similar for both competitors, with a slight advantage for DP in the surface swimming. Also, in the second part of the 25 m section (from 40th to 50th meter) in the backstroke style, the Bulgarian swam at a speed close to that of the winner.

Considering the comparison made, we can conclude that the strongest strokes of DP in this swim were breaststroke and backstroke. This is consistent with a recent study that analyzed data on the contribution of each of the four swimming strokes to the 200 m and 400 m individual medley performance of 501 elite female swimmers (González-Ravé1 et al., 2023). However, the analyzed swim of DP was in the 100 m individual medley. Additionally, she performs better in the 50m freestyle than in the 50m backstroke, according to the World Aquatics Point Scoring. On the other hand, GW excels in butterfly and freestyle. Her weakest stroke is breaststroke. This suggests that she may have swum the first 25m of the butterfly stroke with ease and saved her energy for the breaststroke.

Another recent study highlighted the significant importance of the breaststroke in the 100m individual medley for women (Born et al., 2022), which is DP's strongest stroke. The Bulgarian swimmer swam at speeds that meet the standards for European elite swimmers, as reported in the same study. She swam at a significantly higher speed in the butterfly and breaststroke, was slightly faster in the backstroke, and swam approximately at the same speed as the normative data in freestyle. Considering that the butterfly is her weakest stroke according to the World Aquatics Point Scoring system, she should focus her training on improving it and consider swimming the first 25 meters more efficiently.

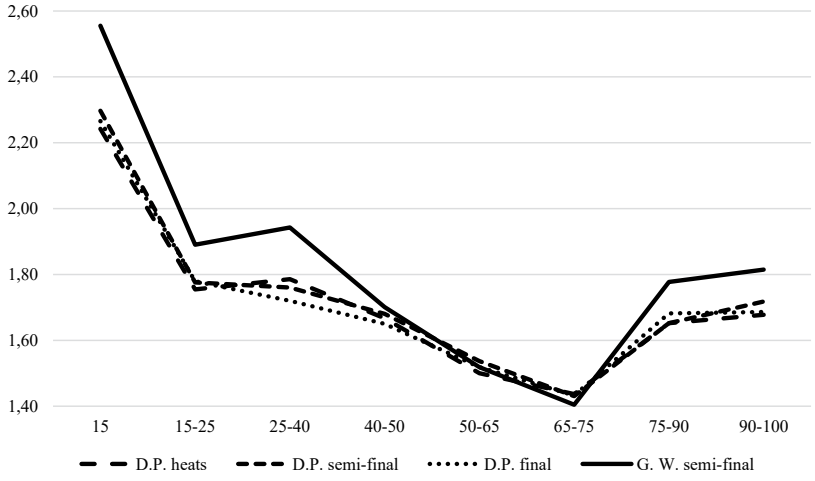

Figure 1. *Speed over the distance of the three swims of DP and the semi-final swim of GW (world record) in the 100 m IM.*

The speed of the first 15 m in the butterfly, backstroke, and front crawl laps of the world record holder was significantly higher, probably due to the greater length and speed of her underwater swimming. In most cases, the champion had the greatest advantage in the butterfly stroke, and this was mainly due to the faster first 15 m (between 0.26 and 0.31 m/s). The speed of the first 15 meters in the butterfly lap depends not only on underwater swimming and surface swimming (1-3 m), but also on the quality of the start. The start includes RT (where DP was slightly faster), a jump phase, a flight phase, a glide, and underwater swimming (Popov et al., 2018). The speed of the first 15 m in the backstroke, breaststroke, and front crawl laps depends not only on the underwater swimming surface (1-9.5 m), but also on the turn phase, push-off phase, and the glide. However, it is obvious that the champion took great advantage of her good, undulating movements underwater in the butterfly, backstroke, and freestyle laps.

DP swam with a higher stroke rate at all strokes compared to GW. The difference was greatest in the breaststroke, where the Bulgarian swam a little faster. However, GW swam faster in the other three strokes with longer strokes. This may be due to greater strength abilities, better technique, and possibly greater height and other anatomical characteristics. During the last 10 meters of the event (freestyle), the champion maintained a significantly higher speed, indicating conservation of strength from swimming the previous three styles, better special endurance, and likely a more refined front crawl technique.

CONCLUSION

In summary, the champion and world record holder in the event swam at a higher speed in three of the four strokes of the 100 m individual medley compared to the Bulgarian competitor, who was slightly faster only in the breaststroke. The champion was better mainly in the first 40 and the last 25 meters. She demonstrated faster underwater swimming in the sections where the undulation technique was employed, as well as improved special endurance for the last 10 meters. The Bulgarian swimmer should focus her training on improving her butterfly speed, underwater swimming length and speed, and stroke length at all strokes. She should also work on improving her tactical skills and special endurance. Swimming more easily in the first 25 meters can save her energy for the finish and thus achieve a better result.

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