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Analysis of stroke rate (SR) and Stroke Length (SL) the Three Fastest Breaststroke Swimmers at the Tokyo Olympics 2021

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Abstract

Background: Swimming velocity results from a combination of stroke rate (SR) and stroke length (SL). Previously, it was rare to find studies that discussed the pattern of SR and SL length in Olympic swimmers, especially in breaststroke swimmers, as a benchmark reference in a study.

Objectives: This study aimed to determine the practical pattern of the stroke rate (SR) and stroke length (SL) of 100 m and 200 m breaststroke swimmers ranked first to third at the 2021 Tokyo Olympics.

Methods: This study uses quantitative descriptive analysis research with non-test techniques using observation. These non-test techniques involve the systematic observation and recording of the SR and SL length of breaststroke swimmers at the 2021 Tokyo Olympics, as this study aims to determine their patterns.

Results: The results of this study show: in the 100 meters breaststroke men's effective SR pattern (45-75 strokes/min) and SL length (1.33-2.14 m/stroke); 200 meters breaststroke men's effective SR pattern (33-49 strokes/min) and SL length (1.55-2.77 m/stroke); 100 meters breaststroke women's effective SR pattern (30-63 strokes/min) and SL length (1-2.14 m/stroke); and 200 meters breaststroke women's effective SR pattern (32-48 strokes/min) and SL length (1.6-2.5 m/stroke).

Conclusion: This research concludes that the effective pattern of SR and SL of 100 m and 200 m breaststroke swimmers, as identified in the results, can serve as a benchmark for understanding and improving the performance of competitive breaststroke swimmers.

Keywords: stroke rate, stroke length, breaststroke, swimming.

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INTRODUCTION

Today's development of science and technology has brought progress in various fields, including swimming (Melnikov, Shynkaruk, & Seleshchuk, 2024). Swimming is one type of aquatic sport that is in great demand by various levels of society throughout the world because swimming can be done by various groups ranging from children to adults, both men and women. Swimming sports have various purposes, including health, educational, recreational, and competitive sports (Mulyana et al., 2024; Liu, 2020).

In competitive sports, the achievement determined in a swimming competition is based on the velocity of time. Many factors can affect swimming performance, both physical and psychological factors. Physical factors include endurance, strength, flexibility, speed, and explosive power (Price, Cimadoro, & Legg, 2024; Sriundy Mahardika, 2023). The most crucial factor in achievement swimming is that swimmers must be able to reduce or minimize resistance in the water so that swimmers can go faster.

Swimming is a sport that is a staple in every multi-event sports championship, including the National Sports Week (PON), SEA Games, Asian Games, and the Olympics, where 40 gold medals are up for grabs. Professional athletes' pinnacle of success is representing their country at the Olympics. This is a monumental feat, as it is reserved for a select few who have proven their mettle through rigorous selection processes and international championship performances. These processes involve fierce competition with athletes from around the world.

To be able to participate in the Olympic event, a swimming athlete needs to add points to the international championships ahead of the nearest Olympics. In the development of the Indonesian swimming contingent's achievements in winning medals in the international arena, the Indonesian swimming contingent is still unable to compete in the Olympics, world, and Asian classes. The achievements of the Indonesian swimming contingent so far can only compete at the Southeast Asian level. It is also evident in the last 4 SEA Games that the Indonesian swimming team showed a setback in acquiring gold medals. In the 2017 SEA Games, Malaysia won 4 gold medals; in 2019, the Philippines only won 1 gold medal; in 2021, Vietnam won 2 gold medals; and in 2023, Cambodia won 3 gold medals.

Regarding the development of the achievements of the Indonesian National Swimming Team, quoted from Akuatikindo's Instagram post, on September 8, 2023, Indonesian national team swimmer Felix Victor Iberle managed to set a new match record at the World Junior Championship with a record time of 26.98 seconds for the Men's 50-meter Chest Style. The previous World Junior Championship record was owned by Nicolo Martinenghi (Italy), with a time of 27.02 seconds. Felix can also improve his Indonesian national record time of 27.56 seconds set at the 2023 SEA Games in Cambodia on May 11, 2023.

Seeing the excellent potential in the younger generation of Indonesian swimmers in order to achieve achievements to compete in the highest multi-event championship event, the Olympics, Felix Victor Iberle must prepare himself to compete in the numbers contested in the Olympics, namely the 100-meter breaststroke and 200-meter breaststroke. At the 2021 Tokyo Olympics, there were elite worlds record-holding swimmers who became champions, such as Adam Peaty (men's 100-meter breaststroke world record), Izaac Stubblety-Cook (men's 200-meter breaststroke world record), Lily King (women's 100 meter breaststroke world record) and Tatjana Schoenmaker (broke the women's 200 meter breaststroke world record at the 2021 Tokyo Olympics).

The success of a swimming athlete winning a competition is basically due to his ability to increase swimming speed, namely by increasing thrust, reducing resistance in the water, or a combination of both (Mullen, 2018). In swimming, a swimmer is required to be able to use a little energy (efficient) but produce maximum motion (practical). Therefore, the ability to regulate speed by learning the ratio between the stroke rate (SR) and stroke lengths (SL) must be mastered. To maintain SR and SL, optimal endurance is needed, namely by producing low lactic acid (Setiawan, 2015). Aerobic exercise is one of the training methods that can produce low lactic acid. Aerobic exercise can reduce lactic acid production by 50%, while anaerobic exercise is only 20-30% (Lucero, 2011).

Analyzing stroke rate (SR) and stroke length (SL) is crucial in swimming as they significantly influence performance, training strategies, and physiological responses. Understanding the interplay between these two parameters allows coaches and athletes to optimize swimming techniques and enhance competitive outcomes. Different combinations of SR and SL can yield optimal swim speeds, as evidenced by variations in performance between junior and senior swimmers during races (Morais et al., 2023).

Swimming velocity is obtained through a combination of SR and SL. SR represents the speed of every one-cycle arm stroke of a swim style, while SL is the length of the arm stroke. Based on this definition, the addition or subtraction of SR and SL determines an increase or decrease in swimming velocity. These variables were used in previous studies to characterize swimming SR and SL (Maglischo, 2003). Riewald & Rodeo (2015) argued that SL can provide propulsion efficiency and help evaluate individual technique progress.

Furthermore, Hollander et al. (2005) asserted that increased swimming speed is produced by increasing SR with a relatively small reduction in SL. The effectiveness of each stroke style is related to the performance of the swimming competition, with short-distance swimming competitions having higher SR and low SL. In comparison, medium- and long-distance swimming competitions have a higher effectiveness rate in higher SL and lower SR (Garland Fritzdorf et al., 2009).

Table 1. Average SR and SL in world-class swimmers in competitive events

Events	SR in (stroke/min)	SL in (m/stroke)
Men		
50 freestyle	56-67	1.88-2.16
100 freestyle	50-56	2.17-2.50
200 freestyle	43-51	2.25-2.41
400 freestyle	38-46	2.20-2.60
800 freestyle	NA	NA
1.500 freestyle	39-43	2.26-2.56
100 backstroke	48-53	2.05-2.20
200 backstroke	42-44	2.27-2.46
100 breaststroke	52-55	1.50-1.88
200 breaststroke	38-42	2.14-2.28
100 butterfly	52-56	1.90-2.15
200 butterfly	48-54	1.91-2.18
Women		
50 freestyle	60-65	1.79-1.96
100 freestyle	53-56	1.80-2.05
200 freestyle	48-54	2.10-2.20
400 freestyle	42-55	1.75-2.20
800 freestyle	44-54	1.75-2.10
1.500 freestyle	NA	NA
100 backstroke	50-56	1.75-2.03
200 backstroke	42-44	1.90-2.08
100 breaststroke	47-53	1.60-1.90
200 breaststroke	34-45	1.97-2.48
100 butterfly	52-56	1.77-1.85
200 butterfly	45-54	1.74-1.90

Source: (Maglischo, 2005)

It is observed that the development of achievements obtained by one of the new Indonesian swimmers shows opportunities in the international junior class focusing on breaststroke, and researchers have yet to find any results of SR and SL analysis studies at the latest Olympic events in the past 20 years. Table 1 shows the result of the SR and SL analysis of the world-class swimmer competition at the 1996 Atlanta Olympics and the 1998 World Swimming Championships in Perth, Australia. Moreover, there is no data on SR and SL for world-class breaststroke swimmers, which is a reference in analyzing or evaluating the effectiveness of the latest breaststroke swimming SR and SL. The results of this study are expected to add to the literature for coaches and researchers as well as to analyze the development of the 100-meter and 200-meter breaststroke swimming numbers at the Olympics and support the theory of swimming biomechanics for the younger generation of the Indonesian swimming contingent in order to compete in the upcoming Olympics.

METHODS

Study Design and Participants

This study uses a descriptive quantitative analysis method with non-test techniques obtained through observation. This study aims to determine the effective patterns in SR and SL swimmers ranked first to third in breaststroke at the 2021 Tokyo Olympics. Researchers can analyze based on data, namely facts about reality obtained through observation (Winarni, 2021). The population in this study is the event of the 2021 Tokyo Olympics swimming competition. The object is the official video recording of the men's and women's breaststroke swimming finals 100 meters and 200 meters at the 2021 Tokyo Olympics. The sample in this study amounted to 12 participants. Participants are six male and six female swimmers, each of who are the fastest swimmers ranked first to third in the video of the final of the breaststroke swimming 100 meters and 200 meters at the 2021 Tokyo Olympics.

Research Instruments

The stages in collecting data for this research are: The first stage is preparing a notebook, laptop, and Excel software to collect data. In the second stage, researchers collected personal data on athletes ranked first to third in the final of the 2021 Tokyo Olympics in the 100-meter and 200-meter breaststroke numbers on the official website (www.worldaquatics.com). In the third stage, researchers observed video recordings of the final of the Olympic men's and women's breaststroke swimming 100 meters and 200 meters from the official YouTube of the Olympics (https://www.youtube.com/@Olympics). In the fourth stage, the researcher counts each participant's stroke count of each participant, and the results of the stroke count will be recorded and counted in the book, then copied into Excel. In the fifth stage, researchers recorded the time results of each participant from the final time and then recorded them in Excel. The last stage is the interpretation of the results of the analysis.

Data Analysis

Then, in the data analysis technique, the stages are as follows: In the first stage, an easy method to calculate stroke rate (SR) with an ordinary stopwatch is to calculate the time of one stroke cycle. The resulting value will be expressed as time-per-cycle (seconds/stroke). The accuracy of determining SR in this way can be improved by measuring the time of two or more cycles and then finding the average by dividing the travel time by the number of stroke counts. For example, if the time for three strokes is 3.30 seconds, divide the time (3.30 seconds) by 3 (strokes) and calculate the result as 1.10 seconds/stroke. So, it can be formulated as follows:

$$SR = \Delta t / sc \quad (1)$$

Description:

SR = Stroke Rate or the number of stroke cycles (arm stroke and leg rotation) per minute (stroke/min).

Δt = Effective swimming duration time (calculated when surfacing the water after underwater kick)

Sc = stroke count or number of arm strokes

It was then converted into units (stroke/min) to make it easier for athletes to understand SR. Changing the unit from (seconds/stroke) to SR/minute is enough to divide the SR result (seconds/stroke) by 60 seconds. Then, the result becomes SR (stroke/min). Then, the second stage calculates Stroke Length (SL); according toMaglischo (2003), the most common method is to calculate the number of SLs the swimmer needs to complete a known distance and then divide that number by the distance. For example, if a swimmer needs 20 stroke counts to cover a distance of 40 m, his average SL for that distance is 2.0 m/stroke (40 ÷ 20 = 2.0). So, it can be formulated as follows:

$$SL = \Delta d / sc \quad (2)$$

Description:

SL = Stroke Length or distance (m) of the swimmer's body rate movement per one stroke cycle (m/stroke).

Δd = Effective swimming distance (calculated when coming to the surface of the water after the underwater kick)

Sc = stroke count or number of arm strokes

RESULTS

The data in this study are the results of an analysis of the men's and women's 100-meter and 200-meter Breaststroke swimming at the 2021 Olympic championships in Tokyo. The research data is a table and graph of the percentage of SR and SL of male and female Chest-style swimmers at 100 meters and 200 meters obtained from the research subject. Table 2 is the Biodata of the 2021 Tokyo Olympics Breaststroke Swimmers.

Table 2. Biodata of Breaststroke Swimmers Tokyo Olympics 2021

Men's 100 m Breaststroke				
Rank	Name	Final Time (sec)	Age (year)	Height (cm)
1	Adam Peaty	57.37	27	191
2	Arno Kamminga	58.00	26	184
3	Nicolo Martinenghi	58.33	22	187
Men's 200 m Breaststroke				
Rank	Name	Final Time (sec)	Age (year)	Height (cm)
1	Izaac Stubblety-Cook	2:06.38	22	181
2	Arno Kamminga	2:07.01	26	184
3	Matti Mattsson	2:07.13	28	197
Women's 100 m Breaststoke				
Rank	Name	Final Time (sec)	Age (year)	Height (cm)
1	Lydia Jacoby	1:04.95	17	178
2	Tatjana Schoenmaker	1:05.22	24	178
3	Lilly King	1:05.54	24	174
Women's 200 m Breaststroke				
Rank	Name	Final Time (sec)	Age (year)	Height (cm)
1	Tatjana Schoenmaker	2:18.95	24	178
2	Lilly King	2:19.92	24	174
3	Annie Lazor	2:20.84	27	173

Table 3. Split Times 100 meter Men's Breaststroke Tokyo Olympics 2021

Distance	Split Times (sec)		
	Adam Peaty	Arno Kamminga	Nicolo Martinenghi
15 m	5.5	5.9	5.6
25 m	11.6	11.7	11.3
35 m	17.4	18.0	17.7
50 m	26.7	27.0	27.1
65 m	34.9	35.4	35.5
75 m	41.0	41.6	41.8
85 m	47.4	48.2	48.3
100 m	57.37	58.00	58.33

Based on Table 3, it can be seen that Adam Peaty's split times show the fastest time dominance in each split time from the start at a distance of 15 m, followed by Nicolo Martinenghi in second position at a distance of 25 m with a difference of 0.3 seconds. At 50m, the second position was secured by Arno Kammingga, who caught up with Nicolo Martinenghi. Then, at a distance of 50 m to 100 m, the position of the fastest swimmer was locked by Adam Peaty, who dominated in the first position, finishing with a final record time of 57.37 seconds. In second place was Arno Kamminga, who had a final time of 58.00 seconds. Moreover, the third position was obtained by Nicolo Martinenghi with a final time of 58.33 seconds.

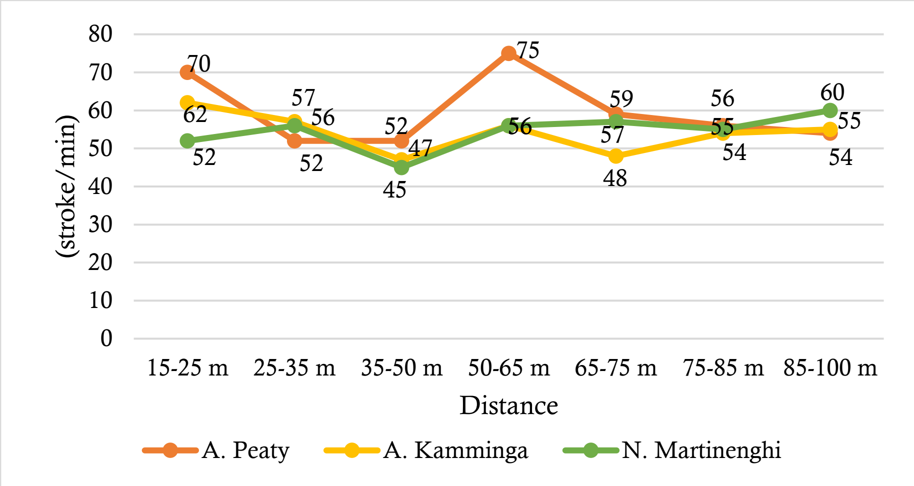

Figure 1. Chart of Stroke Rate 100 meter Men's Breaststroke Tokyo Olympics 2021

Based on Figure 1 above, the highest SR was achieved by Adam Peaty (75 strokes/min) at 50-65 meters, and the lowest SR was achieved by Martinenghi (45 strokes/min) at 35-50 meters. The average SR of the three fastest swimmers in the men's 100-meter breaststroke final were: 1). Adam Peaty (52-75 strokes/min); 2). A. Kammingga (47-62 strokes/min); and 3). N. Martinenghi (45-60 strokes/min).

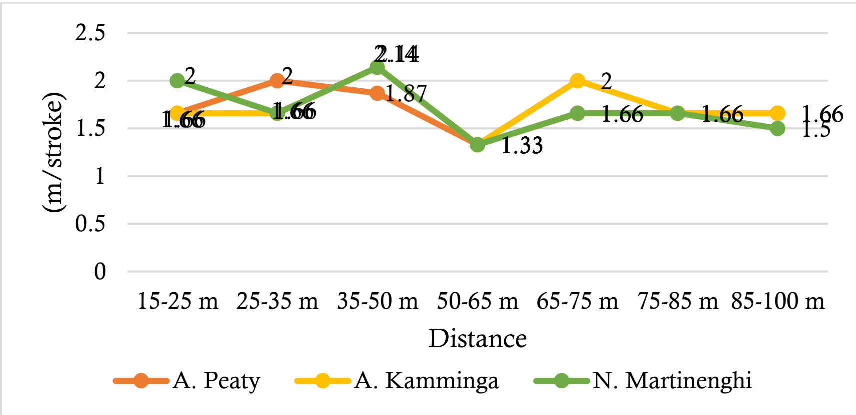

Figure 2. Chart of Stroke Length 100 meter Men's Breaststroke Tokyo Olympics 2021

Based on Figure 2 above, it is known that the highest SL was obtained by Nicolo Martinenghi & Kamminga (2.14 m/stroke) at 35-50 meters, and the lowest SL was obtained by the three swimmers (1.33 m/stroke) at 50-65 meters. The average SL of the three fastest swimmers in the men's 100-meter breaststroke final, namely: 1). Adam Peaty (1.33-2 m/stroke); 2). A. Kammingga (1.33-2.14 m/stroke); and 3). N. Martinenghi (1.33-2.14 m/stroke).

Table 4. Split Times Men's 200 meter Breaststroke Tokyo Olympics 2021

Distance	Split Times (sec)		
	I. Stubblety-Cook	Arno Kamminga	M.Mattsson
25 m	12.6	12.1	12.5
50 m	29.1	28.1	28.9
75 m	44.7	43.2	43.9
100 m	1:01.7	1:00.0	1:00.8
125 m	1:17.3	1:15.6	1:16.1
150 m	1:34.1	1:32.9	1:33.3
175 m	1:49.6	1:49.1	1:49.0
200 m	2:06.36	2:07.01	2:07.13

Based on Table 4, A. Kamminga's split times dominated at 25-175 meters, and M. Mattsson still secured the second position at 25-175 meters. Stubblety-Cook began to overtake the two leading rivals at 175-200 meters (the final 25 meters) and, at the same time, sharpened the new Olympic record with a time of 2:06.36 seconds.

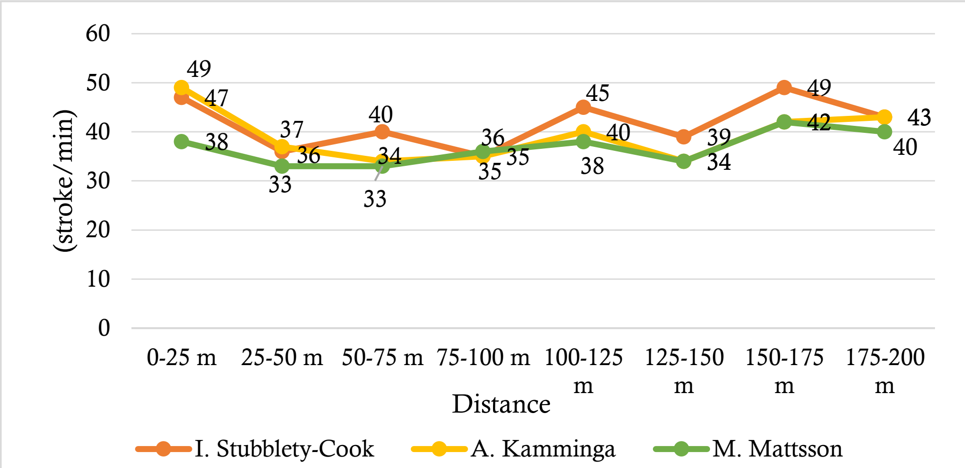

Figure 3. Chart of Stroke Rate 200 meter Men's Breaststroke Tokyo Olympics 2021

Based on Figure 3 above, it can be seen that the highest SR is owned by A. Kamminga (49 strokes/min) and Stubblety-Cook (49 strokes/min), and the lowest is owned by Mattsson (33 strokes/min). The average SR of the three fastest swimmers in the men's 200-meter breaststroke final, namely: 1). I. Stubblety-Cook (36-49 strokes/min); 2). A. Kammingga (34-49 strokes/min); and 3). M. Mattsson (33-42 strokes/min).

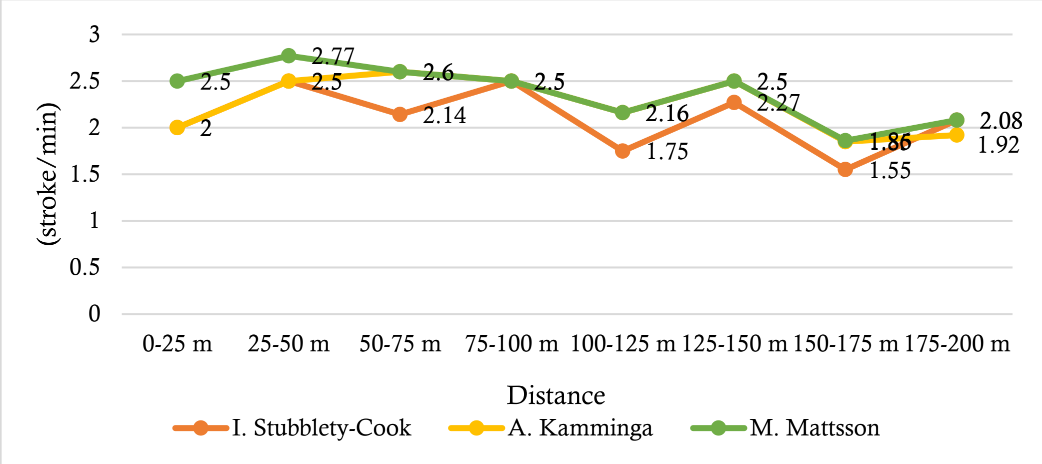

Figure 4. Chart of Stroke Length Men's 200 meter Breaststroke Tokyo Olympics 2021

Based on Figure 4 above, the highest SL was obtained by M. Mattsson (2.77 m/stroke) at a distance of 25-50 meters, and the lowest SR was obtained by Stubblety-Cook (1.55 m/stroke) at a distance of 150-175 meters. The average SLs of the three fastest swimmers in the men's 200-meter breaststroke final were: 1). Stubblety-Cook (1.55-2.5 m/stroke), 2). A. Kamminga (1.85-2.6 m/stroke), and 3). M. Mattsson (1.85-2.77 m/stroke). Stubblety-Cook started to catch up at 175-200 meters and matched Mattsson's SL of 2.08 m/stroke in the final 25 meters.

Table 5. Split Times Women's 100 meter Breaststroke Tokyo Olympics 2021

Distance	Split Times (sec)		
	L. Jacoby	T. Schoenmaker	Lilly King
15 m	6.9	6.7	6.6
25 m	13.4	13.3	13.2
35 m	20.2	20.1	19.9
50 m	30.7	30.4	30.7
65 m	40.4	39.8	40.0
75 m	47.2	46.7	47.3
85 m	54.1	54.1	54.3
100 m	1:04.95	1:05.22	1:05.54

Based on Table 5 above, Lily King's split times dominated in the first 35 meters, and then Schoenmaker took the first position in 50-85 meters. Jacoby chased Schoenmaker and Lily King in the last 15 meters and finished the fastest in the women's 100-meter breaststroke final with a time of 01.04.95 seconds.

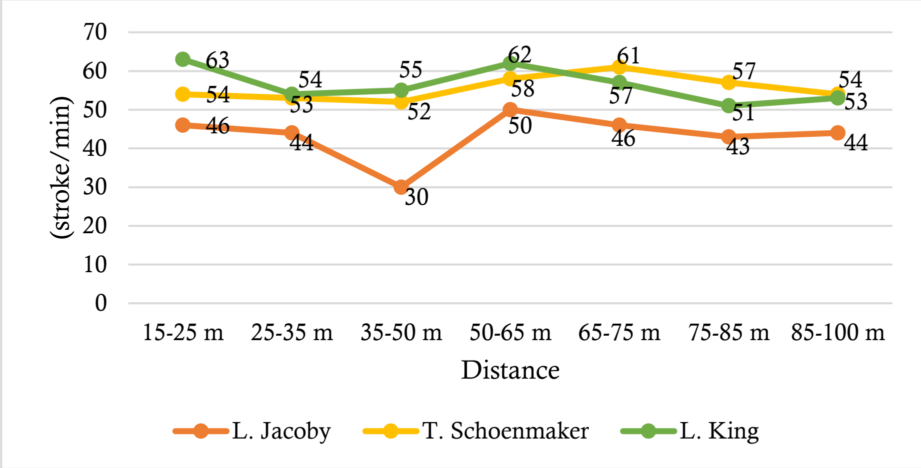

Figure 5. Chart of Stroke Rate Women's 100 meter Breaststroke Tokyo Olympics 2021

Based on Figure 5 above, it can be seen that the highest SR graph belongs to Lily King (63 strokes/min), and the lowest SR belongs to L. Jacoby (30 strokes/min). The average SR of the three fastest swimmers in the women's 100-meter breaststroke final, namely:1). L. Jacoby (30-50 strokes/min), 2). T. Schoenmaker (51-62 strokes/min), and 3). Lily King (51-63 strokes/min).

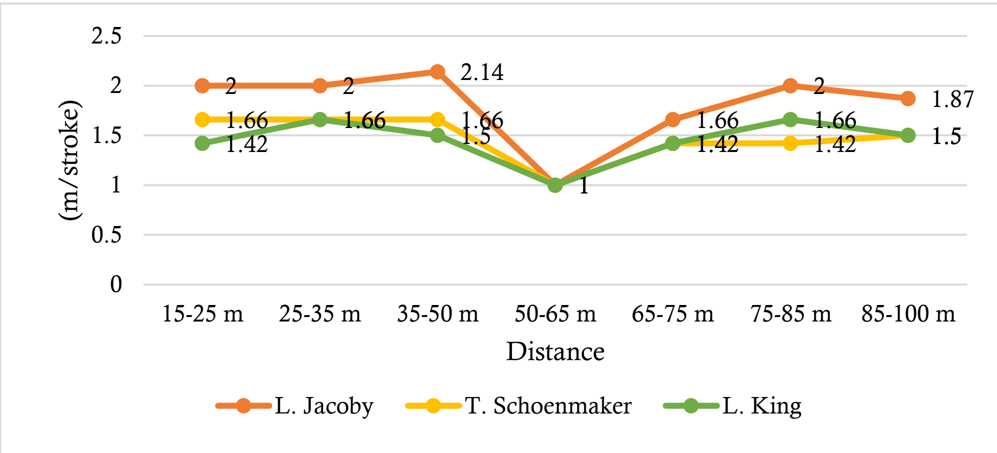

Figure 6. Chart of Stroke Length Women's 100 meter Breaststroke Tokyo Olympics 2021

Based on Figure 6 above, the highest SL was obtained by L. Jacoby (2.14 m/stroke) at a distance of 35-50 meters, and the lowest SL was obtained by the three swimmers (1 m/stroke) at a distance of 50-65 meters. The average SL of the three fastest swimmers in the women's 100-meter breaststroke final, namely: 1). L. Jacoby (1-2.14 m/stroke), 2). T. Schoenmaker (1-1.66 m/stroke), and 3). Lily King (1-1.66 m/stroke).

Table 6. Split Times Women's 200 meter Breaststroke Tokyo Olympics 2021

Distance	Split Times (sec)		
	I. Stubblety-Cook	Arno Kamminga	M.Mattsson
25 m	12.6	12.1	12.5
50 m	29.1	28.1	28.9
75 m	44.7	43.2	43.9
100 m	1:01.7	1:00.0	1:00.8
125 m	1:17.3	1:15.6	1:16.1
150 m	1:34.1	1:32.9	1:33.3
175 m	1:49.6	1:49.1	1:49.0
200 m	2:06.36	2:07.01	2:07.13

Based on Table 6 above, Schoenmaker and Lily King had the fastest split times in the initial 50 meters (31.2). In the 100 meters, Lily King (1:06.4) dominated, being the fastest, followed by Scbhoenmaker (1:07.0) and A. Lazor (1:08.6). In the 150 meters, Schoenmaker (01:42.4) was first followed by Lily King (1:42.5). And Schoenmaker (2:18.95) finished in first place while breaking the world record at the 2021 Tokyo Olympics.

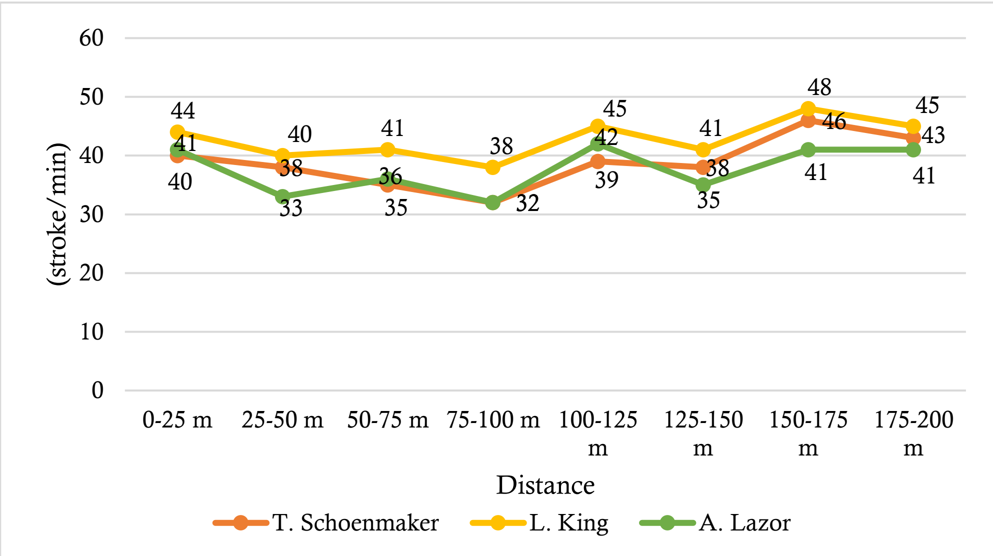

Figure 7. Chart of Stroke Rate Women's 200 meter Breaststroke Tokyo Olympics 2021

Based on Figure 7 above, the highest SR was obtained by Lily King (48 strokes/min) at a distance of 150-175 meters, and the lowest SR was obtained by Schoenmaker (32 strokes/min) A. Lazor (32 strokes/min) at 75-100 meters. The average SRs of the three fastest swimmers in the women's 200-meter breaststroke final were: 1). T. Schoenmaker (32-46 strokes/min), 2). Lily King (38-48 strokes/min) and 3). A. Lazor (32-42 strokes/min).

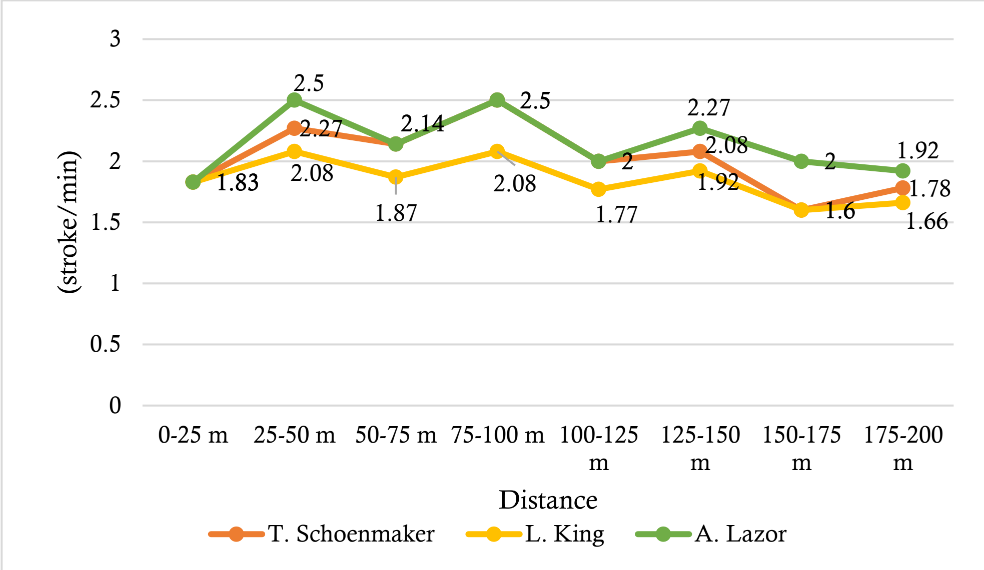

Figure 8. Chart of Stroke Length Women's 200 meter Breaststroke Tokyo Olympics 2021

Based on Figure 8 above, the highest SL was obtained by A. Lazor (2.5 m/stroke) at 25-50 meters and Schoenmaker (2.5 m/stroke) at 75-100 meters, then the lowest SL was obtained by Schoenmaker (1.6 m/stroke) and Lily King (1.6 m/stroke) at 150-175 meters. The average SL of the three fastest swimmers in the women's 200-meter breaststroke final, namely: 1). T. Schoenmaker (1.6-2.5 m/stroke), 2). Lily King (1.6-2.08 m/stroke) and 3). A. Lazor (1.83-2.5 m/stroke).

DISCUSSION

Based on the data described in the analysis of breaststroke swimmers at the 2021 Tokyo Olympics, the sprint number (100-meter breaststroke) shows differences in characteristics between the fastest male and female swimmers. In Figure 1 and Figure 2, the orange graph shows the fastest male swimmer, Adam Peaty, dominating from the initial 50 meters to the finish 100 meters by showing high SR and medium SL. This is in line with Gonjo and Olstad (2021), who state that the higher the stroke rate, the shorter the stroke length. Adam Peaty showed a high SR pattern (70 strokes/min) after starting at a distance of 15-25 meters. The SR pattern decreased at a distance of 25-50 meters (57-52 strokes/min). After reversing at a distance of 50 meters, Adam Peaty's SR pattern was high again (75 strokes/min) at a distance of 50-65 meters, then SR decreased slowly from (59-54 strokes/min) with a stable SL (1.66 m/stroke). This can be seen as a reference in giving distance to the opponent; Adam Peaty uses a very high SR pattern every time he makes a repulsion from the start of the first 50 meters to the reversal in the second 50 meters, utilizing the thrust from the wall so that it can give distance to Adam Peaty's rivals.

Meanwhile, female swimmer Lydia Jacoby showed dominance in effective SL in the first 50 meters, following right behind her two rivals, Schoenmaker and Lily King, until in the last 25 meters, Lydia Jacoby caught up with Schoenmaker and Lily King. Schoenmaker and Lily King are too high on SR if seen in more detail, but the resulting SL is lower. This agrees with Colwin (2002) that in maintaining SR and SL, there is a need for optimal endurance. If the SR is higher, the swimmer enters the anaerobic motion zone, where lactic acid production is higher than in the aerobic zone (McGibbon et al., 2018). If the swimmer cannot withstand a high SR, it will result in a lower SL (Dekerle, 2020).

The intermediate number (200-meter breaststroke) can be seen from the different strategies shown by the fastest male and female swimmers. The fastest male 200-meter breaststroke swimmer, Izaac Stubblety-Cook, showed his strategy pattern by increasing SR every 50 meters. Due to anthropometric factors, Kamminga (184 cm) and Mattsson (197 cm) are taller than Stubblety-Cook (181 cm). It can be seen in Figure 9 and Figure 12 that in the first 150 meters, Kamminga and Mattsson swam by dominating high SL; at a distance of 150 meters, Kamminga and Mattsson were overtaken by Stubblety-Cook who was able to increase SR, and in the last lap, Stubblety-Cook's SR pattern was seen high at 0-25 meters, 50-75 meters, 100-125 meters, 150-175 meters, and SR decreased between distances that were not mentioned, by compensating for Mattsson's SL, so that Stubblety-Cook finished the fastest and broke the Olympic Record for the men's 200-meter breaststroke at the 2021 Tokyo Olympics. As explained in Kleshnev's (2006) article entitled "Method of analysis of speed, stroke rate, and stroke distance in aquatic loco-motions," more minor athletes cannot achieve such a long stroke distance (SL), so they must use a higher stroke speed (SR) to compete with others. Thompson et al. (2004) asserted that SR has nothing to do with height but that SL does. Taller swimmers have a more extended SL (Barbosa et al., 2023).

In Figure 5 and Figure 6, it can be seen that in the 200-meter breaststroke for women, Schoenmaker showed almost the same thing as Stubblety-Cook. Schoenmaker swam with an intermediate SR and SL pattern; SR began to increase in the last 50 meters when she caught up with Lily King, who dominated in the first 150 m with a higher SR. So when Lily King's conditions experienced an increase in SR and a decrease in SL, Schoenmaker could still increase SR and SL higher and more stable than Lily King. As Mullen (2018) explained in the book "Swimming Science: Optimum Performance in the Water," when SL decreases, SR will increase and vice versa. They were followed by the swimmer's endurance when maintaining optimal SR and SL (Setiawan, 2015).

Swimmers' performance in stroke rate (SR) and stroke length (SL) is influenced by a complex interplay of physiological, biomechanical, and psychological factors (Liu, Chen, Zhu, 2021; Pendergast, & Zamparo, 2011). While muscle strength, power, and aerobic/anaerobic capacities are essential for effective swimming techniques, the coach-athlete relationship and motivation also play significant roles in enhancing performance. The following sections detail these factors and suggest exercises to improve SR and SL. Greater muscle strength and power are crucial for explosive starts and turns, directly impacting SR and SL (Price, Cimadoro, & Legg, 2024). Proper technique, including body position and kicking efficiency, significantly affects SR and SL. Optimizing these elements can lead to improved performance (Ruiz-Navarro et al., 2022). Tethered Swimming, a swim-specific resistance training method, enhances strength and power, directly correlating with improved SR and SL (Muniz-Pardos et al., 2019).

SR and SL determine the swimming speed for each swimming style at various distances. Determining an effective combination of SR and SL is necessary so that athletes can achieve the best time balanced with endurance (Mujika & Crowley, 2019). If efforts can be made to improve SR and SL simultaneously, the swimmer's final time record results will be better.

CONCLUSION

Based on the results of the research and discussion that has been presented in the previous chapter, it can be concluded from this study that the number of SRs for both men and women shows the same pattern: the shorter the swimming distance, the higher the SR and the farther the swimming distance, the lower the SR, the opposite applies to the SL length. In the men's 100-meter breaststroke swimming in the 2021 Tokyo Olympics championship, an effective SR pattern (45-75 strokes/min) and SL length (1.33-2.14 m/stroke) are needed to reach the first to the third rank. In the men's 200-meter breaststroke to reach first to third place, an effective SR pattern (33-49 strokes/min) and SL length (1.55-2.77 m/stroke) are needed. Meanwhile, in women's 100-meter breaststrokes, swimming to reach first to third place requires an effective SR pattern (30-63 strokes/min) and SL length (1-2.14 m/stroke). Moreover, swimming 200 meters breaststroke for women to reach the first to third rank requires an effective SR pattern (32-48 strokes/min) and SL length (1.6-2.5 m/stroke). While the analysis of SR and SL is vital for performance enhancement, it is also essential to consider that individual swimmer characteristics and preferences can lead to variations in optimal stroke combinations, highlighting the need for personalized training approaches.

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CONFLICT OF INTEREST

The author hereby declares that this research is free from conflicts of interest with any party.

AUTHOR'S CONTRIBUTION

Alim contributed in preparing concepts, formulating methods, in collecting and analyzing the data, and presenting the results. Supriatna contributed in processing the results, interpreting and drawing conclusions. Hanief contributed in supervising the sport education intervention, as well as interpreting and drawing conclusions.

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