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Kinematics analysis of freestyle swimming athletes at the 2019 Indonesia Open Aquatic Championship (IOAC)

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Abstract

This study aims to determine the kinematics of the men's 50 meter and 100 meter freestyle swimming athletes. This research method uses quantitative descriptive with 50 meter swimmers and 100 meter freestyle men at the 2019 IOAC championship. The instrument used was a Sony Rx-10Mark IV camera placed in the highest stands at a distance of 25 m in a 50-meter pool. The video results were analyzed using the Kinovea 0.8.27 software by calculating the SF, SV, SR, and SL. The results showed that the average number of a 50mmeter had an SF of 13.06, SV of 1.89 $m.s^{-1}$, SR of 59.08 $cycles.min^{-1}$, and SL of 1.92 $m.cycle^{-1}$. For the 100 meter number, the average SF value is 11.8 at a distance of 50-meter and 12.08 at 100 meter. In comparison, the SV average is 1.73 $m.s^{-1}$ at a distance of 50 and 1.72 $m.s^{-1}$ at a distance of 100-meter. For SR, the average is 46.35 $cycles.min^{-1}$ distance of 50 meter and 50, 2 100 m distance. For SL, the average is 2.25 $m.cycle^{-1}$ distance of 50-meter and 2.08 distance of 100-meter. In conclusion, there are differences in the kinematics of swimming between the men's 50 meter and 100 meter freestyle in SV and SR, while those in SF and SL tend to be the same. For further research, it is expected to examine other kinematic parameters such as start, underwater, height, arm length, and others to know more about things that can support swimming performance.

Keywords: Swimming, Kinematics, Freestyle.

INTRODUCTION

Swimming is a sport that all ages can do because it has a low risk of injury and has many health benefits. In swimming, all muscles are activated to move to increase muscle and cardiovascular strength and endurance (Yfanti et al., 2014). In addition to being beneficial for health, swimming is also a sport for competitions so that swimmers compete for achievements by swimming as fast as possible (Pyne & Sharp, 2014).

According to the swimming sport, it is necessary to pay attention to excellent and correct techniques to gain achievements in swimming (Arif et

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al., 2019). Kinematic analysis is often used to analyze human motion in a multidimensional manner. Kinematics analysis can analyze in-depth the basic motion, including the velocity and magnitude of the angle (Clark et al., 2016). Kinematics analysis can be done by recording a video of the athlete's motion, then with motion analysis software tracking specific movements so that the speed and frequency of the stroke will be known. (Pansiot, Lo, and Yang 2010). In swimming, the timing is affected by the starting, swimming, turning, and finishing phases (Taladriz et al., 2016). Meanwhile, according to Ribeiro et al. (2017), Time records in swimming are affected by power, speed, stroke frequency, and stroke efficiency.

It is necessary to have a benchmark as a consideration to find out the success of the exercise that has been done. Currently, there are no benchmarks that can be used as a reference for training results in swimming. Thus, it is necessary to study the data of national and international elite athletes as a reference, especially the kinematics data of athletes with national and international achievements. Referring to this data, regional athletes can measure to what level their current abilities are and to know what needs to be improved in training.

Indonesia Open Aquatic Championship (IOAC) 2019 is an aquatic competition event in four sports: swimming, diving, water polo, and artistic swimming. Participants of this event are national athletes throughout Indonesia. This event is also a selection for the Papua 2020 pre-pons and Tokyo 2020 Olympic qualification events. Therefore, this event can be used as a benchmark or reference to the extent of a swimmer's technical ability, especially his kinematic motion.

Research on swimming kinematics has been carried out, such as research by Callaway (2015), who researched an instrument that can measure the kinematic motion of freestyle swimming using accelerometers. Prins & Murata (2008) has also researched the kinematics of swimmers with disabilities. Then Formicola & Rainoldi (2015) have also researched the kinematics of starting motion to know the effective motion when starting a swimmer. They explain that the study of kinematic motion in swimming is

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essential to do as a material for evaluating the performance of swimmers. This study will examine the kinematics of elite national athletes directly in the competition, not during training, so it can be said that the analysis carried out is performance analysis, not motion analysis as was done in previous studies. Furthermore, it will be a differentiator from previous research that evaluates during practice, while this research was conducted during the competition.

METHOD

This study uses a quantitative descriptive method with the research subject being the finalist swimmers A 50 meter and 100 meter freestyle men in the 2019 Indonesia Open Aquatic Championship (IOAC) with eight athelete per number. The research was conducted at the Aquatic center GBK Jakarta on December 13-16, 2019. Data collection using a Sony Rx-10Mark IV camera with full HD resolution with a setting of 100 frames per second (fps), the camera is placed in the highest stands at a distance of 25 meters in a 50-meter pool as illustrated in Figure 1. Next, the video results will be analyzed using the Kinovea 0.8.27 software.

The video recording results will be analyzed based on kinematics, including stroke frequency (SF), swimming velocity (SV), stroke length (SL), and stroke rate (SR). Measurement of kinematic values from a distance of 25 meters to eliminate the influence of jump start, reversal, and underwater.

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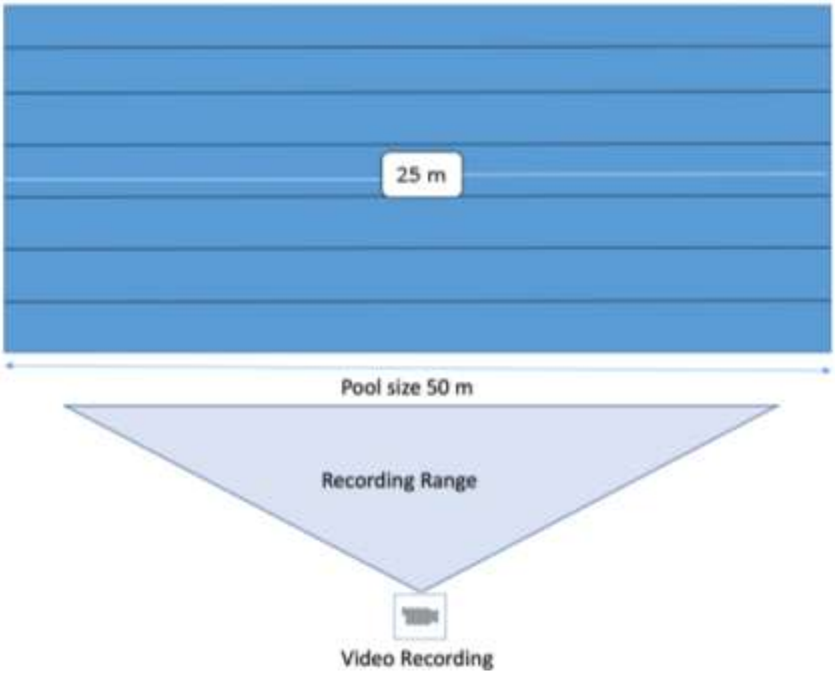

Figure 1. Camera placement in data collection

Stroke Frequency (SF) was obtained from the calculation of the right and left-hand stroke (1 cycle) (Castle, 2011). Swimming Velocity (SV) is obtained from calculating the distance traveled divided by travel time (V1 = D50/t50, V2 = D100/t100, D50 = distance traveled from 25 meters – 50-meter, D100 = distance traveled from 75 meters – 100-meter, t50 = time taken by athletes from a distance of 25-50-meter), and t100 = time traveled by athletes from a distance of 75-100-meter) (ms^{-1}), Stroke rate (SR) is the result of dividing SF per time traveled from distance 25-50 and 75-100 in minutes ($cycle.min^{-1}$). Stroke Length (SL) is obtained from the results of SV divided by SR ($m.cycle^{-1}$) (Lätt et al., 2010).

The data collected is calculated on the average and standard deviation, compared to the kinematic value of the men's 50 meter freestyle number with the 100 meter freestyle. Data analysis used a free sample t-test with the help of SPSS 2.0 software.

RESULTS

This study calculates the stroke parameters of men's freestyle swimmers at 50 meters and 100 meters in *the Indonesia Open Aquatic*

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Championship (IOAC) 2019. Research result *Indonesia Open Aquatic Championship (IOAC)* 2019 presented in Table 1. below:

Table 1: Men's 50m meter freestyle swimming kinematics IOAC 2019

Parameter	trajectory								Amount	Average	SD
	1	2	3	4	5	6	7	8			
SF	13	13.5	11.5	13.5	11.5	14	14	13.5	104.5	13.06	1.02
SV (ms^{-1})	1.86	1.86	1.93	1.91	1.93	1.87	1.82	1.82	15.09	1.89	0.04
SR (cycle.min^{-1})	58.04	60,16	53.24	61.93	53.24	64.02	62.87	59.12	472.64	59.06	4.10
SL(m. $cycle^{-1}$)	1.92	1.85	2.17	1.85	2.17	1.79	1.79	1.85	15,40	1.92	0.16
T total (seconds)	00.24.63	00.24.44	00.24.16	00.23.51	00.24.14	00.24.35	00.24.55	00.24.64			
Champion	7	5	3	1	2	4	6	8			

Description: SF (Stoke Frequency), t25-50 (travel time from a distance 25 to 50), SV (Swimming Velocity), SR (Stroke Rate), SL (Stroke length)

Table 1 above shows that, in the 50-meter freestyle competition, the average swimming velocity (SV) was 1.89 ms^{-1} with the highest value of 1.93 ms^{-1} on track three. Then the average value of stroke frequency (SF) obtained a value of 13.06, with the highest value of 14 on tracks six and seven. In the stroke rate (SR), the average value was 59.08 cycles.min^{-1} with the highest value of 64.02 cycles.min^{-1} on track six. While for stroke length (SL), the average value is 1.92 m.$cycle^{-1}$ with the highest value of 2.17 on tracks thee and five.

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Table 2: Kinematics of 100-meter freestyle swimming

Parameter		trajectory								Amount	Average	SD
		1	2	3	4	5	6	7	8			
SF	50	12.5	11.5	12	9.5	11	11.5	10.5	11	89.5	11.19	0.92
	100	14	13	12	11	12	11.5	11.5	11.5	96.5	12.06	0.98
SV (ms^{-1})	50	1.75	1.72	1.75	1.75	1.74	1.70	1.69	1.71	13.81	1.73	0.03
	100	1.68	1.67	1.71	1.77	1.76	1.81	1.74	1.70	13.84	1.72	0.05
SR ($cycle.min^{-1}$)	50	52.48	47.42	50.38	39.94	45.99	46.81	42.51	45.24	370.79	46.35	4.01
	100	56.45	52.03	49.28	46.81	50.81	50.00	47.92	46.88	400.18	50.02	3.19
SL($m. cycle^{-1}$)	50	2.00	2.17	2.08	2.63	2.27	2.17	2.38	2.27	17.99	2.25	0.19
	100	1.79	1.92	2.08	2.27	2.08	2.17	2.17	2.17	16.67	2.08	0.16
T total (seconds)		0.54.22	0.53.87	0.53.34	0.52.79	0.53.21	0.53.37	0.53.88	0.54.34			
Champion		7	5	3	1	2	4	6	8			

Description: SF (Stroke Frequency), t25-50 (travel time from a distance 25 to 50), SV (Swimming Velocity), SR (Stroke Rate), SL (Stroke length)

Table 2 above shows that, in the 100 meter freestyle competition, the average swimming velocity (SV) was 1.73 ms^{-1} at a distance of 50 meter with the highest score of 1.75 ms^{-1} on the 1.3,4 track, and 1.72 ms^{-1} at a distance of 100 meter with the highest value of 1.81 ms^{-1} on track six. Then the stroke frequency (SF) value obtained an average value of 11.19 at a distance of 50 meter with the highest value of 12.5 on track one and 12.06 at a distance of 100 meter with the highest value of 14 on track one.

In the stroke rate (SR) parameter, the average value was 46.35 $cycles.min^{-1}$ with the highest value was 52.48 $cycles.min^{-1}$ on track one, measured at a distance of 50 meter at a distance of 100 meter, the stroke rate (SR) value is 50.02 $cycle.min^{-1}$ with the highest value 56.45 on track one. For the stroke length parameter, at a distance of 50, the average value of stroke length (SL) is two 25 $m.cycle^{-1}$ with the highest value of 2.63 $m.cycle^{-1}$ on track four. Then at a distance of 100-meter, the average stroke length (SL) is 2.08 $m.cycle^{-1}$ with the highest value of 2,27 $m.cycle^{-1}$ on track four. To compare the parameter values of stroke frequency, swimming

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velocity, stroke rate, and stroke length at numbers 50-meter and 100 is presented in table 3.

Table 3. Kinematics comparison of the men's 50-meter and 100-meter freestyle swimming IOAC 2019

Parameter	Group (Mean±SD)		P (sig)
	FR 50-meter (n=8)	FR 100-meter (n=8)	
SF	13.06 ± 1.02	12.06±0.98	0.065
SV (ms-1)	1.89±0.04	1.72±0.05	0.000*
SR (cycle.min-1)	59.08 ± 4.10	50.02 ± 3.19	0.000*
SL (m.cycle-1)	1.92±0.16	2.08±0.16	0.64

Notes: * significantly different; SF (Frequency Stock); SV (Swimming Velocity); SR (Stroke Rate); SL (Stroke length), FR (Free Style)

From table 3 above, it is known that the kinematics value of men's 50-meter freestyle swimming is obtained from stroke frequency (SF), swimming velocity (SV), stroke length (SL), and stroke rate (SR) at a distance of 25-meter 50-meter (avoid starting and underwater) (see table 1). At the same time, the kinematics value of men's 100 meter freestyle swimming is obtained from stroke frequency (SF), swimming velocity (SV), stroke length (SL), and stroke rate (SR) at a distance of 75-meter 100-meter (avoiding reversals and underwater) (see table 2). From the results of the free sample t-test, there were significant differences between the kinematics values of the men's 50 meter freestyle and 100 meter swimming velocity (SV) and stroke length (SL) parameters with p<0.05.

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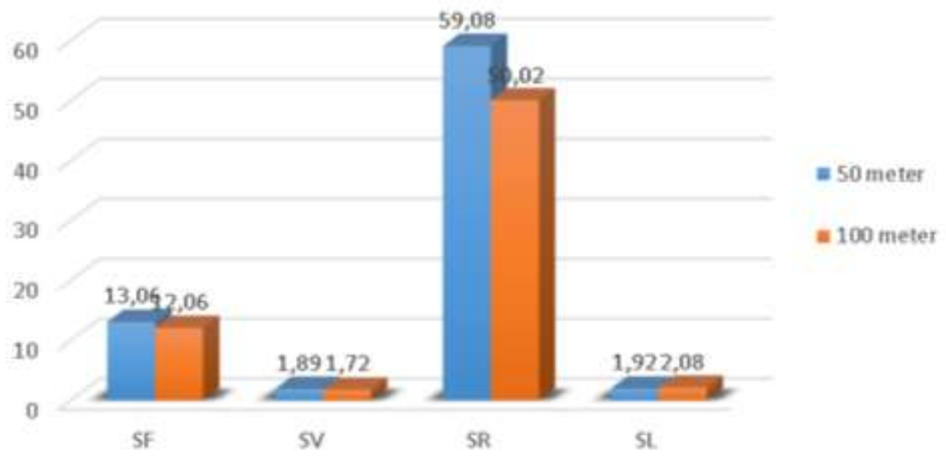

Figure 2. Bar chart of freestyle swimming kinematics differences men's 50-meter and 100-meter

DISCUSSION

This study aims to obtain a reference for the kinematic value of national swimmers to be used as a benchmark for swimming performance. As a national reference, the research subjects must use national swimming athletes. The 2019 Indonesia Open Aquatic Championship (IOAC) is an aquatic championship that competes in four aquatic sports: swimming, water polo, diving, and artistic swimming. (Antara., 2020). This championship was attended by 1,500 swimmers from Indonesia, a selection event for the PON Papua and the 2021 Tokyo Olympics (Public Relations 2019). By knowing the kinematics of the best swimmers from the 2019 IOAC championship, other swimmer athletes will measure their swimming ability by comparing their kinematic abilities with the best athletes at the 2019 IOAC championship of national athletes.

In the men's 50 meter freestyle swimming, the results showed that the swimmer on track four with the fastest time (00.23.51 seconds) had a stroke frequency (SF) of 13.5, a swimming velocity (SV) of 1.91 ms^{-1}, a stroke rate (SR)) 61.93, $cycle.min^{-1}$, Stroke Length (SL) 1.85 $m.cycle^{-1}$. If the kinematics of track four swimmers are compared to other swimmers (see table 1), then the Stroke frequency (SF) is ranked second highest, swimming velocity (SV) is ranked second fastest, Stroke rate (SR) and Stroke Length (SL) are at level three. When viewed from the SF, SV, SR,

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and SV, these values are not very good, so it is necessary to study other parameters such as start and underwater. Like Santos et al. (2020) perform underwater measurements as kinematic parameters in swimming.

In the men's 100-meter freestyle swimming, the results showed that the swimmer on track four with the fastest time (00.52.79 seconds) had a stroke frequency (SF) of 9.5 at 50-meter and 11 at a distance of 100-meter. Then the swimming velocity (SV) is 1.75 ms^{-1} at a distance of 50-meter and 1.77 ms^{-1} at a distance of 100-meter. The stroke rate (SR) is 39.94 $cycle.min^{-1}$ at a distance of 50 meter and 46.81 $cycle.min^{-1}$ at 100 meter. Then the value of stroke length (SL) is 2.63 $m.cycle^{-1}$ at a distance of 50-meter and 2.27 $m.cycle^{-1}$ at a distance of 100-meter. From the kinematics values (SF, SL, SR, SV), the SV value for track four swimmers is the farthest compared to other swimmers (see table 2). This is in accordance with the statement Amjad et al., (2014) that the increase or decrease in swimming speed (SV) is determined by SF and SL.

In swimming, Stroke frequency (SF) and Stroke Length (SL) are the main parameters in determining swimmer performance (Zamparo et al., 2017). The SF and SL values of a swimmer will affect the swimming velocity (SV) to affect travel time (Conceição et al., 2013). Freestyle swimming events have the highest SF than other style swimming events, especially in sprint events (Craig & Pendeegast, 1979). In addition, freestyle swimming is swimming with the highest speed compared to swimming with other styles (Cetin, 2017).

Stroke frequency (SF) is the result of calculating the right and left-hand strokes (1 cycle) (Lomax & Castle, 2011). At the same time, the stroke length (SL) is the distance traveled during one stroke (Amjad et al., 2014). Karsten et al. (2017) reveal that at the same rate, as SF increases, and then SV decreases. Then Zamparo et al. (2017) also revealed that elite swimming athletes have low SF but have long SL. It is also under Amjad et al. (2014) research, who stated in his research that the difference between elite and non-elite athletes is their SL, while their SF is no different.

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Therefore, elite swimmers focus on increasing their SL training to increase their speed (SV) (McCabe and Sanders 2012).

SR results from dividing SF per time traveled from a distance of 25-50 and 75-100 in minutes (cycle.min^{-1}) (do Couto et al., 2014). An increase in SF can be achieved by increasing SR and a decrease in SV (Castro & Guimarães, 2006). This negative relationship between SR and SV can be used as the basis for increasing SF in training and swimming competitions (Craig & Pendeegast, 1979). Confident swimmers swim faster in the short term by increasing their SR, and similar swimmers increase their swimming speed in the long run by increasing their SV (Castro & Guimarães, 2006).

Compared to the 50 meter and 100 meter freestyle swimming kinematics, the results were significantly different in the SV and SR. If seen in Figure 1, it is known that the SV at 100 meter is slower than 50 meter. It is because the farther the distance traveled, the speed (SV) will decrease. However, the SV of the two was not significantly different because swimming in short events (50 meter and 100 meter) carried out by elite swimmers, the SV value tended to be stable (Seifert, Chollet, and Chatard 2007).

CONCLUSION

There are differences in swimming kinematic motion between men's 50-meter freestyle and 100-meter men's freestyle on the swimming velocity (SV) and stroke rate (SR) parameters, while the stroke frequency (SF) and stroke length (SL) parameters tend to be the same. It is expected that swimming athletes will increase their stroke length (SL) to increase their speed (SV) so that their kinematic motion is more efficient. It is hoped that further research can measure other parameters such as start, underwater, height, arm length, and others to know more about things that can support their swimming performance.

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