12 (3) (2023) 237 - 246
Journal of Physical Education, Sport, Health and Recreations
http://journal.unnes.ac.id/sju/index.php/peshr

Profiling Hydrodynamic Aspects of Finswimming Athletes: Biffins Relay Position

Sungkowo[1]✉, Tandiyo Rahayu[2], Bambang Widjanarko[3], Taufiq Arif Setyanto[4], Donny Wira Yudha Kusuma[5], Agus Kristiyanto Kumbara[6], Atchara Purakom[7]

Faculty of Sports Science, Universitas Negeri Semarang, Indonesia[125]
Research center for hydrodynamics Technology-National research and innovation agency[34]
Universitas Negeri Sebelas Maret, Indonesia[6]
Department of Physical Education and Sports, Faculty of Education and Development Science, Kasetsart University, Thailand[7]

Article History

Received October 2023
Accepted October 2023
Published Vol.12 No.(3) 2023

Keywords:
Hydrodynamic Analysis; Bi-Finswimming Technique; Resistance Test.

Abstract

One of the most significant aspects of diving is technical and physical analysis. As a result, this analysis must be conducted so that dive comprehension and learning become more effective and efficient. bi-finswimming movement and Speed testing approach in diving, on the other hand, necessitate specialised equipment. Furthermore, studies on hydrodynamic analysis in diving are still scarce in Indonesia. Thus, the objective of this research was to examine the hydrodynamics of bi-finswimming 4x100 metre bi-finswimming relay athletes. The descriptive quantitative research method was employed, along with a survey. Document analysis approaches, interviews as problem rationalisation and field tests were used to collect data. Four elite swimmers had been participated in this study. A resistance dynamometer and a Qualisys underwater camera were among the research tools. The data analysis technique used. According to the survey results, bi-fin swimmers have varied techniques that fall into three categories: effective, less effective, and ineffective. Understanding and mastering the bi-finswimming style can reduce drag, from the resistance dynamometer results, the data showed that each swimmer has differences in resistance with A position (straight arms), B position (left arm recovery), C position (right arm recovery) with speed of 1 m/h, 1,25 m/h, 1,50 m/h, 1,75 m/h, and 2 m/h respectively. Conclude that every finswimming swimmer has their own technique. By understanding and able to perform the proper technique, we believe that swimmers could minimalize the resistance and able to produce the bigger force.

How to Cite

Sungkowo., Rahayu, T., Widjanarko, B., Setyanto, T. A., Kusuma, D. W. R., Kumbara, A. K., & Purakom, A. (2023). Profiling Hydrodynamic Aspects of Finswimming Athletes: Biffins Relay Position. Journal of Physical Education, Sport, Health and Recreation, 12 (3), 237-246.

✉ Correspondence address :
E-mail: sungkowo@mail.unnes.ac.id

p-ISSN 2460-724X
e-ISSN 2252-6773

INTRODUCTION

Physical performance and proper fundamental technique are the keys to elite sports performance(Bottoni et al., 2011; Michaela et al., 2016). The basic movement of finswimming must be mastered by swimmers as the crucial requirement to achieve the best performance(Kunitson et al., 2015; Michaela et al., 2016). To be at that level, swimmers must train systematically, continuously, and sustainably(Amaro et al., 2017). Although there are many factors that could affect performance, they can be coped with the excellent movement skills of the athlete (Nakashima et al., 2019; Scott A. Riewald, 2015).

Diving is inextricably linked to technical and physical factors (Hakim et al., 2020; Kovacs & Walter, 2015). According to the literature research, sports associated with achievement have many factors that must be addressed to reach high achievement (Gould et al., 1999). Furthermore, the standard for becoming a professional athlete is based on several factors (Bompa O. Tudor, 2019). According to another study, psychological, physiological, physical, and technical factors all influence an athlete's performance (Yudhistira et al., 2021; Yudhistira & Tomoliyus, 2020; Yulianto & Yudhistira, 2021).

Finswimming techniques and physics must be mastered and developed to become perfect (SUGENG & ISWAHYUDI, 2020; Valentino et al., 2022). The finswimming technique is one of the most significant in diving (Ivanitsky & Moskovchenko, 2012). According to research, diving competitors who grasp the finishing technique will be able to minimise drag, reduce fatigue, and provide effective propulsion (Crowley et al., 2017; Papic et al., 2020).

An necessary study for a more thorough analysis is the finswimming technique. This is because athletes will be able to minify resistance and produce efficient propulsion by mastering these techniques. This basic technique needs to be explained, where the trainer must be able to identify the error's position and choose the most appropriate technique.

Technical analyses on diving must be performed, and as time passes, these analyses must combine modern aspects and not just follow the lead of one scientific field. The authors will carry out a hydrodynamics-fundamental analysis. Incompressible liquids are particularly said to be impacted by both internal and exterior forces by the scientific discipline of hydrodynamics, which studies fluid motion (Barbosa et al., 2013; Surinati & Marfatah, 2019).

The previous studies, applying Micro Electro Mechanical Systems (MEMS) in finswimming movement analysis as the sensory instrument to analyze the finswimming movement for 50 m stated that there are significant differences in elite compared to sub-elite, and the elites are better in movement techniques (20%) form the sub-elite. The study analysed the leg acceleration and the difference in speed-angle (Lin, 2015).

Another study performed by Basbosa stated that changes in hydrodynamic during the season occurred by non-linear mode way, there is an interaction between the development and training periodization which is become the personal choices of each young swimmer. Hence, the swimming technique efficiency consisted of speed fluctuation, stroke index, and entropy estimation or thermodynamic quantity (Barbosa et al., 2015). Although the aforementioned research is used as a reference because it is pertinent, there are differences in the techniques, testing apparatus, samples, and research locations. As a result, the author's research treats these variations as original. Additionally, there hasn't been much research done on this chapter in Indonesia. Therefore, it is expected that the research will be useful for academics and athletes, particularly divers. Through the Hydrodynamics Technology Research Centre, the National Research and Innovation Agency (BRIN) and Semarang State University have collaborated on this study.

Based on the elucidation above, the differences in the techniques become more interesting to study, and to identify which technique is more effective. This study aims to analyse finswimming movement based on the hydrodynamic analysis in bifins-divers (4 x 100 m relay) namely resistance dynamometer, and qualisys (tracking sensor).

METHODS

The quantitative descriptive research method was utilised, together with a survey (Akhiruyanto et al., 2022; Hadi et al., 2022; Simanjuntak et al., 2022). The variables of this study are bi-finswimming motion techniques and resistance tests. This study included four female bi-finswimming relay diving participants from the National Sports Week. A survey was used to obtain information. The tests were carried out at the Agency for the Assessment and Application of Technology's hydrodynamics laboratory or the BRIN hydrodynamics technology centre in Surabaya, Indonesia. The population in this study is swimmers at the central java training camp called who participated in the quadrennial national sports competition XX in Papua, at female bifins relay (N= 4), and the total sampling technique was selected.

There are two variables in this study which consisted of bifins movement technique resistance test. The interest pattern of each variable can be seen on **Figure 1**.

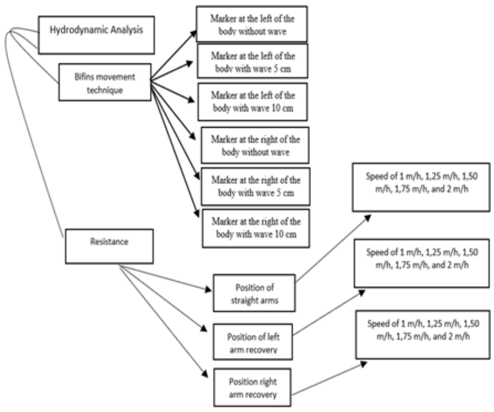

Figure 1. Two variables in this study which consisted of bifins movement technique resistance test

Instrument dan Procedure

All data collection activity was performed at hydrodynamics laboratory of badan pengkajian dan penerapan teknologi (BPPT) or balai teknologi hidrodinamika (BRIN) in Surabaya. Hydrodynamics analysis using a resistance dynamometer and qualisys (under-water camera) was set to measure the performance of the swimmer's technique (Hidrodinamika, 2021; Qualisys, 2015). The calibration of qualisys under-water camera can be seen in the **Table 1**.

Table 1. The calibration results of camera

Camera	X (mm)	Y (mm)	Z (mm)	Points	Avg. residual (mm)	Calibration passed
01	-2859.27	4766.74	-13.89	1370	0.72087	Valid
02	368.40	5032.20	-93.18	1376	0.48534	Valid
03	2439.49	4818.11	-61.11	1456	0.60806	valid

Table 2. The resistance dynamometer

Input mass (kg)	Input (N)	Output (N)	Out after zero (N)	Delta (N)
Push Validation				
0	0	-6,7	0,0	0,0
5	49	-55,5	-48,8	-0,2
7	68,6	-75,1	-68,4	-0,2
17	166,6	-173,0	-166,2	-0,4
12	117,6	-124,0	-117,3	-0,3
5	49	-55,5	-48,8	-0,2
0	0	-6,7	0,0	0,0
Pull Validation				
0	0	22,6	0,0	0,0
5	49	71,6	49,1	0,1
10	98	120,7	98,2	0,2
15	147	169,8	147,2	0,2
20	196	218,8	196,3	0,3
15	147	169,8	147,3	0,3
10	98	120,8	98,2	0,2
5	49	71,8	49,2	0,2
0	0	22,6	0,1	0,1

The instrument involves passive and active drag analysis. Bifins technique is related to anthropometry, swimming kinematics, and movement efficiency. Swimmers received three different trials as follows: 1)without wave, 2) Wave 5 cm, and 3) Wave 10 cm. The testing of bifins movement technique with a qualisys under-water camera **Figure 2**.

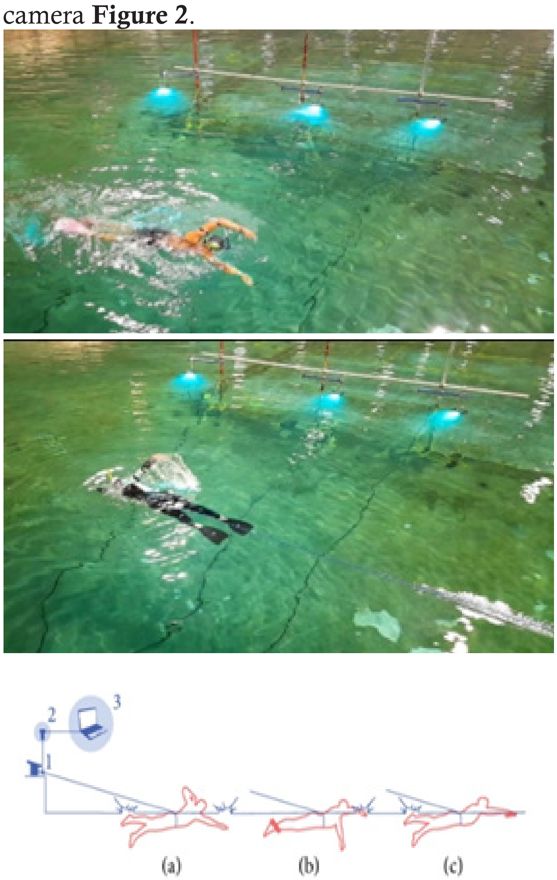

Figure 2. Testing the bi-finswimming motion technique with the Qualisys underwater camera

The arm movement technique for bifins is the same with crawl style swimming, arm movement is divided into some parts, they are: entry and straightening, stroke (bottom sweeping and catch, inner sweeping, upper sweeping), and recovery (Cohen et al., 2018; Dalamitros et al., 2014). According to sub-arm movements, bottom sweeping and inner sweeping are considered as movements with big force to drove forward (de Medeiros Vidal et al., 2020; Maglischo EW, 2003). Bottom sweeping with elbow degree 90° – 120° (both arms). Inner sweeping with 400 – 600 (both arms). The leg movement in bifins also the same with crawl style, but only using fins (CMAS, 2019). to move both legs upbeats and downbeats alternately, knee flexion then rises to 300 – 400 (Maglischo EW, 2003; Selim Alili, 2013). The criteria of bifins movement technique can be seen in the table 3 (Cohen et al., 2018; Maglischo EW, 2003; Selim Alili, 2013).

Table 3. The criteria of bifins movement technique

Number	Leg-angle	Criteria
1	Under 190	No effective
2	200 - 290	Less effective
3	300 - 400	Effective
4	410 - 500	Less effective
5	510 - up	No effective
Number	**Low-prod-angle**	**Criteria**
1	Under 690	No effective
2	700 - 890	Less effective
3	900 - 1200	Effective
4	1210 - 1400	Less effective
5	1410 - up	No effective
Number	**inner-prod-angle**	**Criteria**
1	Under 190	No effective
2	200 - 390	Less effective
3	400 - 600	Effective
4	610 - 800	Less effective
5	810 - up	No effective

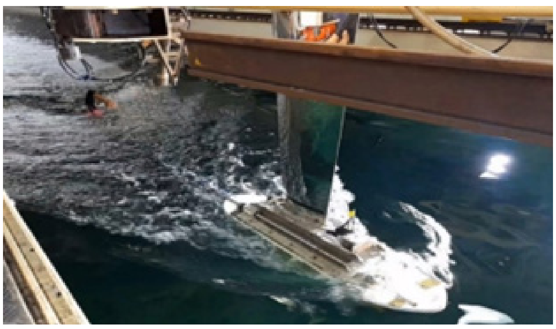

Figure 3. The testing of resistance dynamometer instrument.

Resistance dynamometer in finswimming must be able to minimize water resistance toward the swimmer's body (Barbosa et al., 2015; Papic et al., 2020). The water stream and the swimmers' body type affect the resistance, and there are three different testing positions: 1) Sliding position of both hands in front, 2) Recovery position of the right arm, and 3) Recovery position of the left arm.

RESULTS AND DISCUSSION

These results are aiming to explore the correlation between hydrodynamics analysis of bifins with the water without wave, with wave and resistance test. The snippets of some movements to catch the bottom sweeping, inner sweeping, and leg degree can be seen in table 4. Data from one swimmer in three different water conditions (without wave, wave 5 cm, and wave 10 cm).

Table 4. Results of analysis of bi-finswimming motion techniques on athletes number 1-4

Number	Wave Conditions	The bottom sweeping degree (°) Left	The bottom sweeping degree (°) Right	Inner sweeping degree (°) Left	Inner sweeping degree (°) Right	Leg degree (°) Left	Leg degree (°) Right
	First bifins swimmer						
1	Without wave	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	Wave 5 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	Wave 10 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Second bifins swimmer						
1	Without wave	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	Wave 5 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	Wave 10 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Third bifins swimmer						
1	Without wave	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	Wave 5 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	Wave 10 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Fourth bifins swimmer						
1	Without wave	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	Wave 5 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	Wave 10 cm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Interpretation of results Athlete number 1

Based on the table 4 above, the results of bifins analysis test with a marker at the left of the body are as follows: Without wave: a) the bottom sweeping degree is 129º which is considered less effective, b) the inner sweeping degree is 127º which is included in the ineffective category, and c) the leg degree is 40º (effective). Wave 5 cm are: a) the bottom sweeping degree is 134º which is considered ineffective, b) the inner sweeping degree is 140º which is included in the ineffective category, and c) the leg degree is 39º (effective). Wave 10 cm are: a) the bottom sweeping degree is 145º which is considered ineffective, b) the inner sweeping degree is 154º which is included in the ineffective category, and c) the leg degree is 18º (ineffective).

The results of bifins analysis test with a marker at the right of the body are as follows: Without wave: a) the bottom sweeping degree is 159º which is considered ineffective, b) the inner sweeping degree is 158º which is included in the ineffective category, and c) the leg degree is 53º (ineffective). Wave 5 cm are: a) the bottom sweeping degree is 147º which is considered ineffective, b) the inner sweeping degree is 154º which is included in the ineffective category, and c) the leg degree is 46º (less effective). Wave 10 cm: a) the bottom sweeping degree is 146º which is considered ineffective, b) the inner sweeping degree is 152º which is included in the ineffective category, and c) the leg degree is 44º (less effective).

Interpretation of results athlete number 2

The results of bifins analysis test with a marker at the left of the body are as follows: Without wave: a) the bottom sweeping degree is 147º which is considered ineffective, b) the inner sweeping degree is 144º which is included in the ineffective category, and c) the leg degree is 29º (less effective). Wave 5 cm are: a) the bottom sweeping degree is 148º which is considered ineffective, b) the inner sweeping degree is 146º which is included in the ineffective category, and c) the leg degree is 29º (less effective). Wave 10 cm are: a) the bottom sweeping degree is 144º which is considered ineffective, b) the inner sweeping degree is 142º which is included in the ineffective category, and c) the leg degree is 34º (effective).

The results of bifins analysis test with a marker at the right of the body are as follows: Without wave: a) the bottom sweeping degree is 119º which is considered effective, b) the inner sweeping degree is 132º which is included in the ineffective category, and c) the leg degree is 40º (effective). Wave 5 cm are: a) the bottom sweeping degree is 120º which is considered effective, b) the inner sweeping degree is 133º which is included in the ineffective category, and c) the leg degree is 43º (less effective). Wave 10 cm: a) the bottom sweeping degree is 144º which is considered effective, b) the inner sweeping degree is 128º which is included in the ineffective category, and c) the leg degree is 26º (less effective).

Interpretation of results athlete number 3

The results of bifins analysis test with a marker at the left of the body are as follows: without wave: a) the bottom sweeping degree is 154º which is considered ineffective, b) the inner sweeping degree is 151º which is included in the ineffective category, and c) the leg degree is 31º (effective). Wave 5 cm are: a) the bottom sweeping degree is 150º which is considered ineffective, b) the inner sweeping degree is 146º which is included in the ineffective category, and c) the leg degree is 28º (less effective). Wave 10 cm are: a) the bottom sweeping degree is 150º which is considered ineffective, b) the inner sweeping degree is 147º which is included in the ineffective category, and c) the leg degree is 33º (effective).

The results of bifins analysis test with a marker at the right of the body are as follows: without wave: a) the bottom sweeping degree is 159º which is considered ineffective, b) the inner sweeping degree is 159º which is included in the ineffective category, and c) the leg degree is 35º (effective). Wave 5 cm are: a) the bottom sweeping degree is 155º which is considered ineffective, b) the inner sweeping degree is 158º which is included in the ineffective category, and c) the leg degree is 17º (ineffective). Wave 10 cm: a) the bottom sweeping degree is 152º which is considered ineffective, b) the inner sweeping degree is 155º which is included in the ineffective category, and c) the leg degree is 31º (effective).

Interpretation of results athlete number 4

The results of bifins analysis test with a marker at the left of the body are as follows. Without wave: a) the bottom sweeping degree is 105º which is considered effective, b) the inner sweeping degree is 105º which is included in the ineffective category, and c) the leg degree is 8,1º (ineffective). Wave 5 cm are: a) the bottom sweeping degree is 100º which is considered effective, b) the inner sweeping degree is 95º which is included in the ineffective category, and c) the leg degree is 9,3º (ineffective). Wave 10 cm are: a) the bottom sweeping degree is 103º which is considered effective, b) the inner sweeping degree is 94º which is included in the ineffective category, and c) the leg degree is 7,3º (ineffective).

The results of bifins analysis test with a marker at the right of the body are as follows: Without wave: a) the bottom sweeping degree is 107º which is considered effective, b) the inner sweeping degree is 112º which is included in the ineffective category, and c) the leg degree is 26º (less effective). Wave 5 cm are: a) the bottom sweeping degree is 112º which is considered effective, b) the inner sweeping degree is 117º which is included in the ineffective category, and c) the leg degree is 24º (less effective). Wave 10 cm: a) the bottom sweeping degree is 109º which is considered effective, b) the inner sweeping degree is 119º which is included in the ineffective category, and c) the leg degree is 18º (less effective).

Table 5. Results of resistance testing on bi-finswimming relay athletes

	No	Speed	Position "A" both hands straight (Final Force)	Position "B" Left-hand recovery (Final Force)	Position "C" Right-hand recovery (Final Force)
Number 1 athlete	1	1,00	2,916	5,009	5,068
	2	1,25	4,752	6,159	5,928
	3	1,50	6,863	7,934	8,228
	4	1,75	9,350	11,367	10,067
	5	2,00	13,203	16,298	15,265
Number 2 athlete	1	1,00	3,101	3,679	3,691
	2	1,25	4,441	4,854	5,260
	3	1,50	5,213	5,619	6,888
	4	1,75	6,166	7,188	9,083
	5	2,00	9,463	10,747	11,753
Number 3 athlete	1	1,00	2,637	3,960	3,649
	2	1,25	3,501	5,287	4,717
	3	1,50	4,927	6,498	6,262
	4	1,75	7,193	8,531	8,427
	5	2,00	9,135	11,452	11,274
Number 4 athlete	1	1,00	2,615	3,795	3,498
	2	1,25	3,470	4,925	4,495
	3	1,50	4,370	5,476	5,353
	4	1,75	5,671	7,114	7,376
		2,00	8,139	10,291	10,846

Interpretation of results Athlete number 1

According to the table above The results of resistance dynamometer with A position (straight arms) with differences in speed are: 1) 1 m/h produces resistance force 2,916 kg, 2) 1,25 m/h produces resistance force 4,752 kg, 3) 1,50 m/h produces resistance force 6,863 kg, 4) 1,75 m/h produces resistance force 9,350 kg, and 5) 2 m/h produces resistance force 13,203 kg. The results of resistance dynamometer with B position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 5,009 kg, 2) 1,25 m/h produces resistance force 6,159 kg, 3) 1,50 m/h produces resistance force 7,934 kg, 4) 1,75 m/h produces resistance force 11,367 kg, and 5) 2 m/h produces resistance force 16,298 kg. The results of resistance dynamometer with C position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 5,068 kg, 2) 1,25 m/h produces resistance force 5,928 kg, 3) 1,50 m/h produces resistance force 8,228 kg, 4) 1,75 m/h produces resistance force 10,067 kg, and 5) 2 m/h produces resistance force 15,265 kg.

Interpretation of results athlete number 2

The results of resistance dynamometer with A position (straight arms) with differences in speed are: 1) 1 m/h produces resistance force 3,101 kg, 2) 1,25 m/h produces resistance force 4,441 kg, 3) 1,50 m/h produces resistance force 5,213 kg, 4) 1,75 m/h produces resistance force 6,166 kg, and 5) 2 m/h produces resistance force 9,463 kg. The results of resistance dynamometer with B position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,679 kg, 2) 1,25 m/h produces resistance force 4,854 kg, 3) 1,50 m/h produces resistance force 5,619 kg, 4) 1,75 m/h produces resistance force 7,188 kg, and 5) 2 m/h produces resistance force 10,747 kg. The results of resistance dynamometer with C position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,691 kg, 2) 1,25 m/h produces resistance force 5,260 kg, 3) 1,50 m/h produces resistance force 6,888 kg, 4) 1,75 m/h produces resistance force 9,083 kg, and 5) 2 m/h produces resistance force 11,753 kg.

Interpretation of results athlete number 3

Based on the table above, the results of resistance dynamometer with A position (straight arms) with differences in speed are: 1) 1 m/h produces resistance force 2,637 kg, 2) 1,25 m/h produces resistance force 3,501 kg, 3) 1,50 m/h produces resistance force 4,927 kg, 4) 1,75 m/h produces resistance force 7,193 kg, and 5) 2 m/h produces resistance force 9,135 kg. The results of resistance dynamometer with B position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,960 kg, 2) 1,25 m/h produces resistance force 5,287 kg, 3) 1,50 m/h produces resistance force 6,498 kg, 4) 1,75 m/h produces resistance force 8,531 kg, and 5) 2 m/h produces resistance force 11,542 kg. The results of resistance dynamometer with C position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,649 kg, 2) 1,25 m/h produces resistance force 4,717 kg, 3) 1,50 m/h produces resistance force 6,262 kg, 4) 1,75 m/h produces resistance force 8,427 kg, and 5) 2 m/h produces resistance force 11,274 kg.

Interpretation of results athlete number 4

Based on the table above, The results of resistance dynamometer with A position (straight arms) with differences in speed are: 1) 1 m/h produces resistance force 2,615 kg, 2) 1,25 m/h produces resistance force 3,470 kg, 3) 1,50 m/h produces resistance force 4,370 kg, 4) 1,75 m/h produces resistance force 5,671 kg, and 5) 2 m/h produces resistance force 8,139 kg. The results of resistance dynamometer with B position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,795 kg, 2) 1,25 m/h produces resistance force 4,925 kg, 3) 1,50 m/h produces resistance force 5,476 kg, 4) 1,75 m/h produces resistance force 7,114 kg, and 5) 2 m/h produces resistance force 10,291 kg. The results of resistance dynamometer with C position (left arm recovery) with differences in speed are: 1) 1 m/h produces resistance force 3,498 kg, 2) 1,25 m/h produces resistance force 4,495 kg, 3) 1,50 m/h produces resistance force 5,353 kg, 4) 1,75 m/h produces resistance force 7,376 kg, and 5) 2 m/h produces resistance force 10,846 kg.

.

Based on the previous study of adolescent finswimmers, from two different intensity treatments both could affect early myocardial adaptations (P < .05), this phenomenon marked by the increase myo-cardiac mass of left ventricle (101,34 ± 23,65), concentric and eccentric hypertrophy. This might be caused by different training protocol and training mode (Stavrou et al., 2018). Another previous study, applying Micro Electro Mechanical Systems (MEMS) in finswimming movement analysis as the sensory instrument to analyze the finswimming movement for 50 m stated that there are significant differences in elite compared to sub-elite, and the elites are better in movement techniques (20%) form the sub-elite. The study analysed the leg acceleration and the difference in speed-angle (Lin, 2015). Furthermore, a study performed by Basbosa stated that changes in hydrodynamic during the season occurred by non-linear mode way, there is an interaction between the development and training periodization which is become the personal choices of each young swimmer. Hence, the swimming technique efficiency consisted of speed fluctuation, stroke index, and entropy estimation or thermodynamic quantity (T. M. Barbosa et al., 2015). There are many factors that could affect the capability of swimmers such as the swimming technique and the equipment (Steinberg et al., 2011).

From the results of the hydrodynamic analysis test on Bifins Relay Swimmer number 1 at the bottom sweeping angle only had 2 less effective criteria and 4 ineffective criteria. The results showed that the left arm technique at the bottom sweeping angle with conditions without waves, with waves with less criteria effective which results in a less than optimal thrust and has an impact on the diver's forward pace which is less effective. In the 10cm wave, the angle is too high which results in ineffective propulsion due to the influence of the 10cm wave resulting in an unstable diver's technique. Furthermore, in the right arm technique at the downward sweep angle with no waves, the 5 cm wave and 10 cm wave are ineffective criteria which result in the diver's speed boost being ineffective. In the deep sweep angle in the position of the left arm, and right arm, conditions without waves and waves are ineffective criteria that affect the forward speed very ineffective. Where the sweep angle is too high it has an impact on the movement speed which is not effective. Then the left leg angle has an effective criterion of 2 in conditions without waves and 5 cm waves. From these results, the left leg technique already has a good kick and has an impact on an effective forward thrust. But in the 10 cm wave with ineffective criteria, from these results, the left leg technique has an ineffective prod and has an impact on ineffective forward thrust because in 10 cm wave conditions the leg technique cannot maintain its technique. At the right leg angle, criteria 1 is ineffective in conditions without waves, and 2 criteria are less effective in waves of 5 cm, and in waves of 10 cm. from these results the right leg with a position without having a prod and forward speed is not effective. In conditions with waves, the legs have less effective propulsion and propulsion which results in a less-than-optimal diver's speed.

The results of the hydrodynamic analysis test on bifins relay swimmer number 2 at the downward sweep angle only had 2 effective criteria and 4 ineffective criteria. resulting in a push that is not optimal and has an impact on the diver's forward pace which is not effective. Furthermore, in the right arm technique, the downward sweep angle with no waves and 5 cm waves is an effective criterion that results in maximum thrust and has an impact on the effective diver's speed. However, for waves with a height of 10 cm, the criteria are not effective, which results in the detection rate not being maximized. Why is the angle 144° because the effect of a 10 cm high wave greatly affects the swimmer's body and the diver's movement technique? On the inside sweep angle of both the left and right arms, conditions without waves and waves are ineffective criteria that affect the forward speed very ineffective. Where the inside sweep angle is a continuation of the bottom sweep, which has an impact on the movement speed which is not effective. Then the left leg angle has criterion 2 which is less effective in conditions without waves and 5 cm waves, in 10 cm waves with effective criteria. From these results, the left leg technique already has a good whip and has an impact on good forward thrust, because in 10cm wave conditions the leg technique can get the criteria for being effective. At the right leg angle, criteria 1 is effective in conditions without waves, and 2 criteria are less effective in waves of 5 cm, and in waves of 10 cm. from these results the right leg has a whip and the forward thrust is less effective

The results of the hydrodynamic analysis test on Bifins Relay Swimmer number 3 at the downward sweep angle have criteria in all conditions without waves and with waves having the criteria of ineffective. These results show that the left arm technique at the downward sweep angle has an angle that is too high which results in not optimal thrust and has an impact on the diver's forward speed which is not effective. Furthermore, the right arm technique at the downward sweep angle also has an ineffective criterion which results in not maximal thrust and has an impact on the diver's ineffective speed. The swimmer in the downward sweep technique has a technical resistance that is not effective when influenced by wave conditions. At the deep sweep angle in the position of the left arm, and right arm, conditions without waves and waves are ineffective criteria that affect the forward speed to be ineffective. Where the inside sweep angle is a continuation of the bottom sweep, which has an impact on the less effective movement speed. Then the left leg angle has an effective criterion in conditions without waves, a 5 cm wave has the criterion of less effective and a 10 cm wave has an effective criterion. From these results, the left leg technique already has a good whip and has an impact on effective forward thrust because in all wavy and non-wave conditions the angle of the leg technique is good. The right leg angle has the criteria for being effective in conditions without waves and 10 cm waves which have an impact on effective forward thrust because in all wave and non-wave conditions the angle leg technique is good. but in waves of 5 cm, the criteria are not effective. from these results, the right leg technique has effective propulsion and forward acceleration, but in the 5cm wave condition the angle is too small

The results of the hydrodynamic analysis test on Bifins Relay swimmer number 4 at the bottom sweeping angle have criteria in all wave conditions with an effective criterion of 6. The results show that the left arm technique at the bottom sweeping angle with conditions without waves, with waves with effective criteria which results in maximum boost and impact on the diver's forward rate, is very effective. Furthermore, the right arm technique at a downward sweep angle with no waves, 5 cm waves, and 10 cm waves are effective criteria that result in maximum thrust and have an impact on the diver's speed very effectively. The swimmer named Ashifa in the downward sweep technique has good resistance even though it is influenced by waves. At the angle of sweep in Bifins Relay swimmer number 4 in the position of the left arm, and right arm, conditions without waves and waves are ineffective criteria which affect the forward pace to be less effective. Where the inside sweep angle is a continuation of the bottom sweep, which has an impact on the less effective movement speed. Then the left leg angle has ineffective criteria in conditions without waves, waves of 5 cm, and waves of 10 cm. From these results, the left leg technique does not have good propulsion and the impact on forward thrust is not effective because in all wavy and non-wave conditions the angle of the leg technique is too small. The right leg angle has less effective criteria in conditions without waves and 5 cm waves which have an impact on the forward thrust which is less effective because in all wave and non-wave conditions the leg angle technique is small. Likewise, for waves of 10 cm, the criteria are not effective. from these results, the right leg has a protrusion and the forward thrust is ineffective because the angle is too small.

The results of the resistance test of 4 swimmers in position "A" with both arms straight, Position "B" with left arm recovery, Position "C" with right arm recovery using 5 different speeds, for more details see the table for position "A" with both arms straight as follows:

position "A"

Name	Height	Weight	Speed	Resistance Strength
The first swimmer	162 cm	67 kg	1 – 2 m/h	4,752 – 13,203 kg
The second swimmer	156 cm	55 kg	1 – 2 m/h	3,101 – 9,463 kg
The third swimmer	168 cm	57 kg	1 – 2 m/h	2,637 – 9,135 kg
The fourth swimmer	157 cm	46 kg	1 – 2 m/h	2,615 – 8,139 kg

position "B"

Name	Height	Weight	Speed	Resistance Strength
The first swimmer	162 cm	67 kg	1 – 2 m/h	5,009 – 16,298 kg
The second swimmer	156 cm	55 kg	1 – 2 m/h	3,679 – 10,747 kg
The third swimmer	168 cm	57 kg	1 – 2 m/h	3,960 – 11,452 kg
The fourth swimmer	157 cm	46 kg	1 – 2 m/h	3,795 – 10,291 kg

position "C"

Name	Height	Weight	Speed	Resistance Strength
The first swimmer	162 cm	67 kg	1 – 2 m/h	5,068 – 15,265 kg
The second swimmer	156 cm	55 kg	1 – 2 m/h	3,691 – 11,753 kg
The third swimmer	168 cm	57 kg	1 – 2 m/h	3,649 – 11,274 kg
The fourth swimmer	157 cm	46 kg	1 – 2 m/h	3,498 – 10,846 kg

The results of the resistance test regarding the endurance strength of swimmers with an assessment of the resistance strength value are smaller than the swimmer has effective water resistance, conversely, if the swimmer has a greater water resistance values then he has ineffective water resistance. The smaller the value of the resistance strength, the swimmer can make the forward movement of the bifins number finswimming effectively. The table shows that the number 4 bifins relay swimmer has the least resistance compared to the other swimmer.

CONCLUSION

From this discussion it was concluded that each finswimming swimmer has a different style of technique, some have an effective style and some have an ineffective style (Barbosa et al., 2013; Kunitson & Port, 2017; Stavrou et al., 2018). The basic technique of finswimming is important to understand because by understanding and mastering this technique, swimmer can minimize obstacles and can generate great power (Cohen et al., 2018; Nicolas & Bideau, 2009).

REFERENCES

Akhiruyanto, A., Hidayah, T., Amali, Z., Yudhistira, D., & Siwi, A. B. (2022). Evaluation on the Physical Condition of Football Extracurricular Participants before and during the COVID-19 Pandemic. 10(2), 303–308. https://doi.org/10.13189/saj.2022.100221

Amaro, N. M., Morouço, P. G., Marques, M. C., Fernandes, R. J., & Marinho, D. A. (2017). Biomechanical and bioenergetical evaluation of swimmers using fully-tethered swimming: A qualitative review. Journal of Human Sport and Exercise, 12(4), 1346–1360. https://doi.org/10.14198/jhse.2017.124.20

Barbosa, T. M., Costa, M. J., Morais, J. E., Morouço, P., Moreira, M., Garrido, N. D., Marinho, D. A., & Silva, A. J. (2013). Characterization of speed fluctuation and drag force in young swimmers: A gender comparison. Human Movement Science, 32(6), 1214–1225. https://doi.org/10.1016/j.humov.2012.07.009

Barbosa, T. M., Morais, J. E., Marques, M. C., Silva, A. J., Marinho, D. A., & Kee, Y. H. (2015). Hydrodynamic profile of young swimmers: Changes over a competitive season. Scandinavian Journal of Medicine and Science in Sports, 25(2), e184–e196. https://doi.org/10.1111/sms.12281

Bompa O. Tudor, B. A. C. (2019). Periodization theory and methodology of training. Human Kinetics, Inc.

Bottoni, A., Lanotte, N., Boatto, P., Bifaretti, S., & Bonifazi, M. (2011). Technical skill differences in stroke propulsion between high level athletes in triathlon and top level swimmers. Journal of Human Sport and Exercise, 6(2), 351–362. https://doi.org/10.4100/jhse.2011.62.15

CMAS. (2019). CMAS RULES CMAS Finswimming Rules Version 2019 / 01 Index. 01, 3.

Cohen, R. C. Z., Cleary, P. W., Mason, B. R., & Pease, D. L. (2018). Forces during front crawl swimming at different stroke rates. Sports Engineering, 21(1), 63–73. https://doi.org/10.1007/s12283-017-0246-x

Crowley, E., Harrison, A. J., & Lyons, M. (2017). The Impact of Resistance Training on Swimming Performance: A Systematic Review. Sports Medicine, 47(11), 2285–2307. https://doi.org/10.1007/s40279-017-0730-2

Dalamitros, A. A., Manou, V., & Pelarigo, J. G. (2014). Laboratory-based tests for swimmers: Methodology, reliability, considerations and relationship with front-crawl performance. Journal of Human Sport and Exercise, 9(1), 172–187. https://doi.org/10.4100/jhse.2014.91.17

de Medeiros Vidal, J., Tucher, G., Nogueira, L., Novaes, R. C., de Souza Vale, R. G., de Castro, M. O. R., da Silva Medeiros, N. G., & de Cassio Costa Telles, S. (2020). Crawl technique observation sheet for beginning swimmers: An evaluation proposal for swimming teachers. Motriz. Revista de Educacao Fisica, 27, 1–6. https://doi.org/10.1590/S1980-65742021016920

Gould, D., Guinan, D., Greenleaf, C., Medbery, R., & Peterson, K. (1999). Factors affecting olympic performance: Perceptions of athletes and coaches from more and less successful teams. Sport Psychologist, 13(4), 371–394. https://doi.org/10.1123/tsp.13.4.371

Hadi, Yudhistira, D., Romadhoni, S., & Kurnianto, H. (2022). Analysis of Agility, Strength and Power Differences in Basketball Players in Relation to Age. International Journal of Human Movement and Sports Sciences, 10(4), 748–753. https://doi.org/10.13189/saj.2022.100415

Hakim, A. L., Subandowo, M., & Rohman, U. (2020). Jurnal Kejaora : Jurnal Kesehatan Jasmani dan Olah Raga. Jurnal Kejaora: Jurnal Kesehatan

Jasmani Dan Olah Raga, Volume 5 Nomor 2, Edisi November 2020 LATIHAN, 5(November), 62–65.

Hidrodinamika, B. T. (2021). BPPT Hidrodinamika Surabaya.pdf.

Ivanitsky, V. V, & Moskovchenko, O. N. (2012). Sports Selection-Based Optimisation of Physical Exercise Load for Finswimmers. Журнал Сибирского Федерального Университета. Гуманитарные Науки, 5(8), 1092–1102.

Kovacs, C. R., & Walter, D. (2015). Scuba Diving and Kinesiology: Development of an Academic Program. Journal of Physical Education, Recreation & Dance, 86(3), 12–17. https://doi.org/10.1080/07303084.2014.998394

Kunitson, V., & Port, K. (2017). Analysis of swimming technique among elite finswimmers. Journal of Human Sport and Exercise, 12(Proc3), 831–836. https://doi.org/10.14198/JHSE.2017.12.PROC3.07

Kunitson, V., Port, K., & Pedak, K. (2015). Relationship between isokinetic muscle strength and 100 meters finswimming time. Journal of Human Sport and Exercise, 10(Proc1), 4–6. https://doi.org/10.14198/jhse.2015.10.proc1.42

Lin, C. (2015). MEMS Sensors Applied in Finswimming Movement Analysis. 2(1).

Maglischo EW. (2003). Swimming Fastest: The essential reference in technique, training, and program designs (p. 780). Human Kinetics. https://books.google.co.id/books/content?id=cSSW4RhZOiwC&pg=PA1&img=1&zoom=3&hl=en&ots=qnpB7yS-81&sig=ACfU3U3qkgkNUpOlL-HlHx1lZx8YUpR4IQ&w=1280

Michaela, B., Štastny, J., Jaroslav, M., & Miroslav, J. (2016). Development of an analysis of swimming techniques using instrumentation and the development of a new measurement method at Brno University of Technology. Journal of Human Sport and Exercise, 11(Special issue 1), S146–S158. https://doi.org/10.14198/jhse.2016.11.Proc1.05

Nakashima, M., Yoneda, T., & Tanigawa, T. (2019). Simulation analysis of fin swimming with bifins. Mechanical Engineering Journal, 6(4), 19-00011-19–00011. https://doi.org/10.1299/mej.19-00011

Nicolas, G., & Bideau, B. (2009). A kinematic and dynamic comparison of surface and underwater displacement in high level monofin swimming. Human Movement Science, 28(4), 480–493. https://doi.org/10.1016/j.humov.2009.02.004

Papic, C., McCabe, C., Gonjo, T., & Sanders, R. (2020). Effect of torso morphology on maximum hydrodynamic resistance in front crawl swimming. Sports Biomechanics, 00(00), 1–15. https://doi.org/10.1080/14763141.2020.1773915

Qualisys. (2015). Oqus Underwater - Motion capture camera for advanced underwater measurements. 5–8. internal-pdf://121.149.11.16/PI_Oqus_Underwater_20151124.pdf LB - Qualisys%0Ahttp://www.qualisys.com/cameras/oqus-underwater/

Scott A. Riewald, S. A. R. (2015). Science of Swimming Faster. In Science of Swimming Faster. Human Kinetics. https://doi.org/10.5040/9781492595854

Selim Alili. (2013). Technique And Methodology Of Training In Swimming Crawl. Crnogorska Sportska Akademija, „Sport Mont", 380–388.

Simanjuntak, V., Rahayu, T., & Yudhistira, D. (2022). Analysis of Body Mass Index and Physical Condition of Martial Athletes in West Kalimantan Province : Study towards PON 2021. 10(4), 768–774. https://doi.org/10.13189/saj.2022.100417

Stavrou, V., Tsarouhas, K., Karetsi, E., Michos, P., Daniil, Z., & Gourgoulianis, K. I. (2018). Adolescent finswimmers: Early myocardial adaptations in different swimming styles. Sports, 6(3), 1–9. https://doi.org/10.3390/sports6030078

Steinberg, F., Dräger, T., Steegmanns, A., Dalecki, M., Röschmann, M., & Hoffmann, U. (2011). Title: Fit2dive-A field test for assessing the specific capability of underwater fin swimming with SCUBA. International Journal of Performance Analysis in Sport, 11(1), 197–208. https://doi.org/10.1080/24748668.2011.11868540

Sugeng, I., & Iswahyudi, N. (2020). Profil Daya Tahan Kardiorespirasi Vascular Atlet Putri Finswimming Ku C Dan D Dragon Wira Yudha Kota Kediri Tahun 2019. Buana Pendidikan: Jurnal Fakultas Keguruan Dan Ilmu Pendidikan, 16(29), 31–38. https://doi.org/10.36456/bp.vol16.no29.a2267

Surinati, D., & Marfatah, M. R. (2019). Pengaruh Faktor Hidrodinamika Terhadap Sebaran Limbah Air Panas Di Laut. Oseana, 44(1), 26–37. https://doi.org/10.14203/oseana.2019.vol.44no.1.29

Valentino, H., Kainde, F., Joshua, S. R., & Akay, Y. V. (2022). Design and Development of Scuba Diving Learning Application Mobile-Based. 11(3), 161–166.

Yudhistira, D., Siswantoyo, Tomoliyus, Sumaryanti, Tirtawirya, D., Paryadi, Virama, L. O. A., Naviri, S., & Noralisa. (2021). Development of agility test construction: Validity and reliability of karate agility test construction in kata category. International Journal of Human Movement and Sports Sciences, 9(4), 697–703. https://doi.org/10.13189/saj.2021.090413

Yudhistira, D., & Tomoliyus. (2020). Content validity of agility test in karate kumite category. International Journal of Human Movement and Sports Sciences, 8(5), 211–216. https://doi.org/10.13189/saj.2020.080508

Yulianto, W. D., & Yudhistira, D. (2021). Content Validity of Circuit Training Program and Its Effects on The Aerobic Endurance of Wheelchair Tennis Athletes. 9(c), 60–65.