Orginal scientific paper

Vladan Markovic[1] Milomir Trivun[2]
[1]Collage of sport and health- Belgrade
[2]Faculty of Physical Education and Sports University of East Sarajevo
UDK: 797.212.4
DOI 10.7251/SHT1302067M

FREESTYLE SWIMMING STROKE ANALYSIS

SUMMARY

In this paper we analyzed the proper performance of freestyle technique strokes. Phases of strokes were analyzes and graphically displayed. Biomechanical analysis of freestyle technique strokes were done and there were described the most rational ways of performing the technique together with the segments on which it depends on. The rationality of the movement depends on these important segments: stroke length (SL-stroke length), stroke frequency (SR-stroke rate), the number of strokes (Nb movements) surface in which swimmer acts (conditional anthropological dimensions) velocity (the ratio of the length and stroke frequency), continuity of movement (coordination of the legs, arms and breathing).
Key word: *swimming, stroke, technique, frequency*

INTRODUCTION

Swimming is the ability to maintain the body in the water and to move it through the water with the corresponding movements of arms, legs and body. Certain resistance that is significantly different from the movement on the ground appears during the swimming in the water, so it takes some time for the body to adapt to the aquatic environment and master the technique of movement in the water (swimming). The movement in the water is the product of action and reaction, (III Newton's law), i.e. propulsion force (product of muscle contraction of extremities), which moves the body. Well measured strokes (application of propulsive impulses) together with the good hydrodynamics improve the ratio among propulsion and resistance. With the stronger propulsion and smaller resistance, swimmer swims faster. With the more harmonized coordination of movement, swimmer is less tired. Different ways of swimming were developed throughout the time periods and according to them were developed techniques that are used in sports swimming (Zahorijevic 1991). There are four basic swimming techniques: 1.Freestyle technique 2.Breaststroke technique, 3. Backstroke technique 4. Butterfly technique

Freestyle technique

The most famous theorists unanimously concluded that the freestyle technique of swimming is the basis for competitive swimming, which is supported with the factors that the crawl is the most rational, fastest and the most abundant technique on every swimming competition (the 50, 100, 200, 400, 800, 1500 m male, female and two relay 4x100 and 4x200 - male and female). In freestyle techniques body "lies" on the

chest, on the surface of the water near the horizontal, with a minimum angle, so that the head and shoulder area are more set in relation to the caudal area and feet. The face is immersed in the water and placed so that the chin is slightly separated from the chest. Alternately turning the body into right and left side around the lower axis (rotation) can be noted during the swimming. This is a result of the hand movement, which helps in the reduction of resistance and the extension of the stroke.

Footwork is alternating in direction - up and down (propulsive part is emphasized with the movement of foot down; retro-propulsive part is the movement of the feet up). These movements should be rhythmically coordinated, so that the movements are alternately performed - up and down, around the lower body axis. Footwork, although it has a secondary role in the overall propulsion in movement of swimmers (ankle joint flexibility significantly increases the efficiency of the leg), contributes significantly to the correct position of the body and head. Among the freestyle specialists several variants of techniques are noticed, most commonly six-strokes, four-strokes and double-strokes crawl for one cycle of the hand movement (right-left), 2, 4 or 6 feet movement. The work of the hands is cyclic and it achieves maximum propulsion and it has a primary role in the initiation of the body forward. It is characteristic, and necessary for hands to move in curvilinear trajectory (with stroke) in propulsive part of the stroke. That is achieved by bending the arms at the elbow joint (position of active elbow) and its movement under the body.

Phase of freestyle stroke

During the arm stroke two main phases are recognizable (Figure 1): the propulsive - which consists of in-sweep and up-sweep of water and preparation - extraction and transfer of arms through the air (exit and relax), entry into the water, extending of the stroke (entry and stretch) and water abstraction (down sweep to catch).

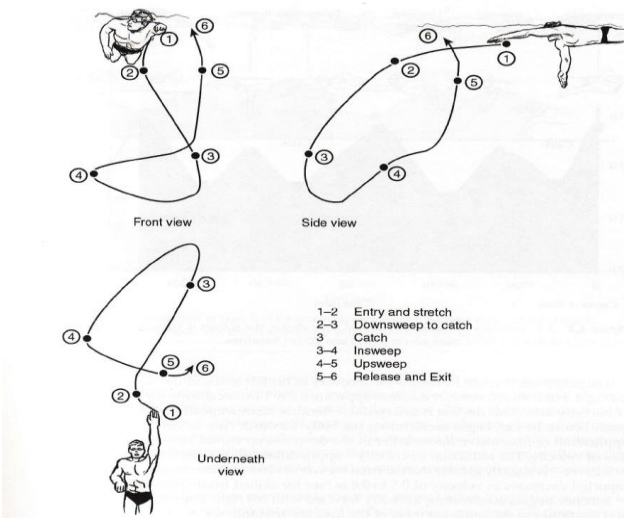

Figure 1. Phases of freestyle technique

Freestyle arm stroke starts by entering the right arm in the water and by the beginning of the rotation of the body with high shoulder position through a phase "entry to stretch", while the left arm starts phase of water intake - down sweep to catch (Figure 2).

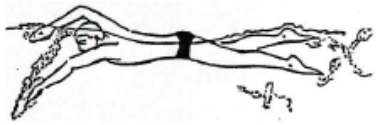

Figure 2.Down sweep to catch phase

The right hand entered the water, the rotation is continued, and the left hand is rapidly accelerating the movement in relation to the right hand and enters the propulsive phase of drawing – in sweep phase (Figure 3).

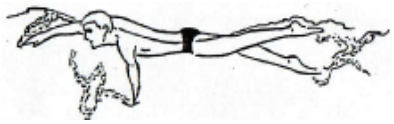

Figure 3.In sweep phase

The right hand gives direction of the body, it helps rotation of the body which extend the moment of movement and avoids frontal resistance that arose caused by the thrust force of the left hand (which is in up sweep phase). Head is turning because of the breath, left leg with the downward movement balance motion of left hand upward (Figure 4)

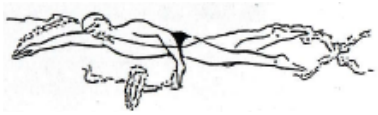

Figure4. Up sweep phase

During the passive part of the left hand stroke (relax phase) body rotates to the end point on the left side, the head is slowly returning to the starting position and the right hand is preparing for the beginning of the stroke (Figure 5).

Figure 6.Retro-pulzive part of the freestyle technique stroke

Left arm is fully immersed in the water, and the head is in the axis of the body. This is a fundamental aspect the stroke - the head is immersed in the moment when the hand enters the water (Figure 7). Pay attention to the angle that forms an arm (about 90 degrees).

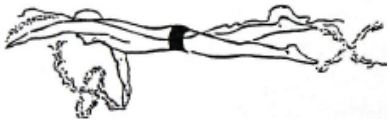

Figure 7.Preparing for the start of the left hand stroke in freestyle technique

Right hand accelerates as it enters the propulsive phase and the left is correct, maintaining direction and balance (Figure 8).

Figure 8.In sweep phase of right hand at freestyle technique

Bubbles that are formed around the left hand indicate that there is a thrust (down sweep), which raises the body, circular bubble behind the right arm signifies the end the stroke, i.e. where propulsion is carried out (Figure 9).

Figure 9.Phase of left hand water intake and right hand up sweep at freestyle swimming technique

The hand has the slowest moving at the beginning of the stroke. Speed of the hands at this point is approximately equal to the speed of body movement. Entry of the hands in the water that is too fast reduces the speed of the swimming. During the entering of the hands in the water and during the first part of the stroke, the elbow is above the wrist. The high position of the elbow ensures strong leverage and high body position. At the half performance of the stroke (in sweep phase) elbow should be bent up to 90 ˚. After hand entering in the water, it moves downwards and outwards to a little more

than shoulder width, to the point where it changes direction towards the inside (down sweep to catch phase). From this phase, the hand speeds up its movement. The acceleration of the hand is producing the additional force that allows the athlete to move a greater distance with each stroke. While the hand speeds up creating additional propulsive force, the other hand enters into the water with a much lower speed. Entering of the hands in the water should be slow otherwise it would disrupt the moment of movement of the other hand. The body rotates around its axis, improving hydrodynamic position in the water and avoiding frontal resistance. At the beginning of the stroke, body rotates at the side of the front arm and at the end of the stroke to the opposite side. The arm rests at the passive part of the stroke, elbow has a high position and the forearm is transmitted slowly forward (like a pendulum), in a semi-circle, to the point where a hand is of 5-10 cm in front of the face. Then the hand enters in the water at an imaginary extension line of the arm. While the hand stretches out a swimmer allows the body to continue the movement, using the movement of movement gained with the previous stroke. The passive part of the stroke should be controlled especially as it affects the hydrodynamic body position and balance. The second part of the passive stroke is when the hand slides forward through the water in front of the face and help better the rotation of the body (Figure 10).

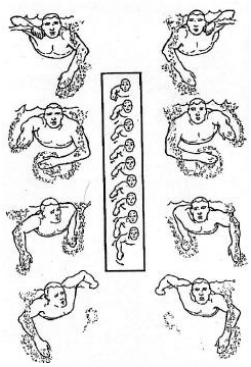

Figure 10.Freestyle technique (frontal side)

Rationality of freestyle technique

The best swimmers today generally use spiral stroke, because the aim of the swimming is to catch as much water as it is possible. (Figure11). This way the path of the hand and arm is extended, which leads to a longer propulsive phase. Freestyle stroke technique is performed in the "S" pattern, and for good propulsion you need to have good sense. Research study found that in all the techniques of swimming stroke is not performed in a straight line, but it consists of a series of small strokes (sculling) or differencing direction pulse, while the hand goes to a curved path across the imaginary direction line of the body. Stroke shaped in the form of “S” consists of three movements. After entering the water a handful goes a little outward (preparatory movement for better water intake). After that, it changes direction and moves inward (phase of operation and pulling of the water). Stroke ends when hand overpasses hips. Outward and inward movements under the hull produce strong impulses of propulsive force, although the overall speed of hand movement is changed during the stroke (Figure 5). Swimming is conditionated by the significant rotation of the hand and forearm in combination with continuous adjustment and high elbow position. Also separating the thumb of the hand (Alulae effect) and by placing a handful and forearm, from the top of the little finger to the tip of the elbow (the crescent), we enhance the maintenance of the flow around the wrist and forearm. The stated position of the arm prevents the sinking of the body and keeps it in the flat position,

which with the force of stroke creates flow circulation necessary to create efficient propulsion.

Figure 11.”S”stroke

Analysis of freestyle stroke elements

Swimming is a cyclic movement and its speed can be calculated as the product of stroke length (S) and its frequencies (F).

V = SXF

Just at a glance, we can conclude that the maximum speed is achieved at the maximum length and maximum stroke frequency. However, if the length of the stroke is grater, longer break must be made in order that body crosses a longer path, which also reduces the frequency of stroke. . This leads us to the conclusion that the speed is achieved at the optimal combination of frequency and length of stroke. It was determined that the better swimmers have greater frequency of stroke and more shallow stroke due to the high position of the elbow but they have longer out-sweep phase, that is have greater length of stroke (SL-stroke length) than the average swimmers (Craig & Pendegrast, 1979; Keskinen, E 198for dissipation during some work).

The rationality of the movement depends on important segments:

-Length of stroke (SL-stroke length)

-frequency of stroke (SR-stroke rate)

-Number of strokes (Nb movements)

-surface in which swimmer acts (conditioned by anthropological dimensions)

-velocity (the ratio of the length and frequency of strokes)

-continuity of movement (coordination of the legs, arms and breathing)

If we look at the analysis of swimming at the Olympic Games in Athens in 2004 and the achievement of the Olympic winner Pieter Van den Hoogebanda (Fig.12.), It can be concluded that the result partly depends on the optimal relation of the length, number and frequency of strokes that is individual and describes the style of each individual swimmer, but it also depends on other factors as well: racing tactics, the technical sophistication of start and turn element and freestyle swimming technique, training, motivation ...etc.

100 m FREESTYLE FINAL MEN								
Firs name	Neethling	Iles	Magnini	Schoeman	Van den Hoogenband	Karpalov	Draganja	Thorpe
Name	Ryk	Salim	Filippo	Ronald Mark	Pieter	Andrey	Duje	Ian
Final time (sec)	48,63	49,30	48,99	48,23	48,17	49,30	49,23	48,56
Fligth time	1.06	1,12	1,00	1.05	1,18	1,10	1,09	0,95
Time first movement	3,83	3,12	4,12	4,28	3,92	3,96	3,45	3,42
Time 15m	5,52	5,96	6,00	5,44	6,00	6,00	5,76	5,92
Time 1st 25m	10,40	10,64	10,68	10,16	10,76	10,68	10,48	10,72
Time 2nd 25m	12,65	12,54	12,96	12,44	12,51	12,92	12,73	12,95

Time 1st 50m	23,05	23,18	23,84	22,60	23,27	23,60	23,12	23,57
Time 75m	35,28	35,44	35,96	34,80	35,28	35,80	35,52	35,72
Time 3rd 25m	12,23	12,26	12,12	12,20	12,01	12,20	12,31	12,15
Time 4th 25m	13,35	13,86	13,03	13,43	12,89	13,50	13,71	12,84
Time 2nd 50m	25,58	26,12	25,15	25,63	24,90	25,70	26,02	24,99
% 1st 25m/Final time	21,39	21,58	22,21	21,07	22,34	21,66	21,29	22,08
% 2nd 25m/Final time	26,01	25,44	26,45	25,79	25,97	26,21	25,86	26,46
%3rd 25m/Final time	25,15	24,87	24,74	25,30	24,93	24,75	25,01	25,02
% 4th 25m/Final time	27,45	28,11	26,60	27,85	26,76	27,38	27,85	26,44
Time 7,5m before turn	4,09	3,90	4,08	3,80	3,91	4,08	3,93	3,93
Glide time 1st turn	2,32	2,40	2,76	2,37	2,37	2,16	1,93	3,37
Time 7,5m after turn	2,91	3,14	3,16	3,04	3,21	3,16	2,99	3,07
Turn time(15m)	7,00	7,04	7,24	6,84	7,12	7,24	6,92	7,00
Time last(7,5m)	3,75	4,14	3,71	3,87	3,77	3,90	3,99	3,64
Start stroke rate	57,69	61,86	58,82	57,69	70,59	63,83	63,16	62,50
Stroke rate 1st 25m	55,56	60,43	53,48	53,86	55,90	60,19	55,05	56,03
Stroke rate 2nd 25m	52,96	57,75	48,29	50,00	51,61	52,63	49,03	46,83
Stroke rate 3rd 25m	50,47	54,84	53,07	50,63	51,39	51,61	49,03	47,16
Stroke rate 4th 25m	49,05	54,68	51,02	50,51	50,18	48,31	46,27	45,78
Stroke length 1st 25m	2,21	2,12	2,30	2,36	2,25	2,13	2,31	2,23
Stroke length 2nd 25m	2,32	2,10	2,45	2,43	2,37	2,26	2,43	2,51
Stroke length 3rd 25m	2,23	2,10	2,21	2,26	2,32	2,25	2,30	2,45
Stroke length 4th 25m	2,23	1,98	2,21	2,17	2,29	2,26	2,33	2,49
Nb movements 1st 50m	33	38	32	31	33	35	33	33
Nb movements 2nd 50m	39	44	39	40	39	40	39	34
Total movements	72	82	71	71	72	75	72	67

Figure 12.Analysis of results and competitive elements in the final race of the 100 m freestyle at Olympics in Athens 2004

CONCLUSION

Children should be taught about identification and manipulation of the flow at an early age. Young swimmers should be aware that the functional position of palms and hands are important aspects of swimming techniques. There is no need to burden the swimmers about the various expressions such as thrust, the ideal angle of attack and the path of strokes movement. With a basic information and display, talented swimmers who will quickly acquire the skills of efficient implementing of flow could be extracted. Educated swimmers can improve the technique when they become aware of the flow. Learning to create the feeling and recognition of the ideal generated flow of water gives the athlete feedback about the effectiveness of its strokes.

Good trainer should be able to accommodate all these observations about efficient performance techniques and movements in the water to individual abilities of swimmers. People differ, differ in size, shape, and therefore in the mythology and they move differently in the water. Some floating around easily, others do not, some are the more hydro dynamic, some quickly accept the presented concepts and have developed a tactile sense tempo, some are in a better condition…For this reason, qualified and experienced trainer will discuss all of these features before deciding which style of his swimmers he will improve.

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