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THE FRONT CRAWL STROKE:
A REVIEW

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THE FRONT CRAWL STROKE:

A REVIEW

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In dedication to my father

Walter H. Gest

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

The average coach in the field of competitive swimming is amazingly limited in source material upon which he draws the primary components of his activity. Mindful of this situation, the material in this study has been presented for the purpose of aiding coaches and competitors in the front crawl stroke.

In the development of competitive swimming, attention has been focused on the crawl, the fastest of all strokes. In the mechanical analysis and kinesiology of the crawl stroke, the combination of forces forming the propulsive power is being studied and an attempt to construct the most efficient stroke is being made from the results.

Well known are the studies, past and present, of Cureton, Karpovich, Counsilman, Alley, and Heusner. However, the beginning of swimming research dates back to William Fraude in 1872. His study in the field of water resistance involved the use of ship models and various other objects drawn through the water.

Further experiments in water resistance were done on the human body beginning with DuBois Raymond in 1905, F. Houssay in 1912, and G. Liljestr nd and N. Stenstrom in 1912.

In a book published by Jules Amar¹ in 1920 we find the first formula for water resistance as applied to the human body:

$$R = C \times S \times V^2$$

K = A constant equal to from 55 to 73

S = Area in square centimeters of the greatest cross section of the swimmer's body.

V² = Velocity in meters squared.

Karpovich² towed his subjects through the water using a device called a resistograph to measure the resistance. Quoting Froude (1874) and Lanchester (1908), he stated that resistance is caused by skin friction, eddy resistance, and wave-making resistance.

In a later study³ he experimented on the propelling forces involved in the crawl stroke. He stated that the square of the speed of the whole stroke is equal to the sum of the squares of speed developed by the arms and legs separately. The arm-leg ratio in propulsion was found to be approximately 70 per cent arm power and 30 per cent leg power for good swimmers, and up to 77 per cent arm power and 23 per cent leg power for poor swimmers.

¹J. Amar, The Human Motor (London: G. Routledge and Sons Ltd., 1920), p. 243.

²P. V. Karpovich, "Water Resistance in Swimming," Research Quarterly, 4:3 (October 1933), pp. 21-28.

³P. V. Karpovich, "Analysis of the Propelling Force in the Crawl Stroke," Research Quarterly, 6:2 (May 1935), pp. 49-58.

Cureton¹ in 1930, compared the times of various subjects in the crawl stroke with the purpose of finding the weaknesses in the component parts of the stroke. He timed one lap, using legs alone, arms alone, or the complete stroke. He called this procedure "The Stop Watch Method."

Moyle² did research on the relative contributions of the legs and arms to the whole stroke. His correlations for the whole stroke with the arms and the whole stroke with the arms and legs were very high. Thus he showed that the arms contributed the greater per cent to the stroke.

Jeager³ experimented with water resistance as a limiting factor of speed in swimming. He used the standard velocity and the formula , $R = aV^b$.

A study was performed by Tews⁴ on the relationship of propulsive force and external resistance to speed. Because his correlations for resistance and speed were so low, he concluded that the resistance factor was not significant in limiting the speed of the swimmer tested, since the factor of skill was uncontrolled.

¹Thomas K. Cureton, "The Stop Watch Method for Testing Speed," Beach and Pool, 4 (February 1930), pp. 15-19.

²W. J. Moyle, "A Study of Speed and Heart Size as Related to Endurance in Swimming" (Master's Thesis, State University of Iowa, 1936).

³L. D. Jeager, "Resistance of Water as a Limiting Factor of Speed in Swimming" (Master's Thesis, State University of Iowa, 1937).

⁴R. W. J. Tews, "The Relationship of Propulsive Force and External Resistance to Speed in Swimming" (Master's Thesis, State University of Iowa, 1941).

In research both Alley¹ and Counsilman² towed subjects to measure the water resistance. They then tested their propulsive force and by comparison of the difference between these two values were able to evaluate various styles of swimming a stroke.

In measuring the force of propulsion, Fox³ tested the distance his subjects could swim after five complete stroke cycles, beginning from a free dead start in the water.

All of these studies and research work attempted to give direction toward a faster and more efficient stroke. Based on results from a study of water resistance or propulsive force, conclusions were drawn as to what effect a smaller amount of water resistance or a more powerful stroke would have on the swimming speed.

Statement of the Problem

To review and analyze the literature on the competitive front crawl stroke.

Scope of the Study

This study will be composed of a comprehensive amount of literature written in the field of competitive swimming with the emphasis placed on the materials

¹Louis Edward Alley, "An Analysis of Resistance and Propulsion in Swimming the Crawl Stroke" (Ph. D. State University of Iowa, Iowa City, Iowa, 1949).

²James Edward Counsilman, "An Analysis of the Application of Force in Two Types of Crawl Stroke" (Ph. D. State University of Iowa, Iowa City, Iowa, 1951).

³M. G. Fox, "Swimming Power Test," Research Quarterly, 23(3):233-237, October 1957.

pertaining specifically to the front crawl stroke. It will include material on the beginning of research in swimming up until the year 1960.

Significance of the Study

To date there has been little effort to combine the literature written on the mechanics of the front crawl stroke. This information would be of value to coaches and competitors in the swimming field. Here they could obtain the major collective works of well known men in this area of swimming.

Limitations of the Study

Some of the thesis, dissertations, and research work done were unobtainable because they were part of unpublished material. The author's subjective judgement was used in securing and evaluating the literature that was used, causing the greatest margin of error. However, a rather exhaustive search for material was conducted over a period of eight months.

CHAPTER II

BODY POSITION

Humans have not been given the streamlined bodies of fish, therefore the human body must be held in a position which maintains a natural streamlined flow. This position is held in order to illiminate the resistance which retards the motion of the swimmer.

In testing the drag of four body positions, Counsilman¹ found that the prone position created the least resistance. He went on to state that the competitive swimmer should minimize excessive roll, as such rolling of the body only serves to increase his resistance, however, a slight roll will permit an easy arm stroke.

According to Bela Rajki², the body, fully stretched, lies on the surface making the slightest possible angle with the surface of the water. This puts the hips somewhat lower in the water so that the feet are in the necessary depth to act effectively. The correct position

¹Counsilman, op. cit., p. 82.

²Bela Rajki, The Technique of Competitive Swimming (Budapest, Hungary, University Printing House, 1956), p. 40

of the head is very important since it effects the position of the whole body. The surface of the water should meet the forehead between the line of the eyebrows and the hair, when the slightly raised head is in the basic position.

The Sheffield¹ infer that the correct shoulder position is in a horizontal line with the surface of the water. When swimming the front crawl stroke the dropping of the shoulders should be at a minimum and should be kept as nearly even as possible.

Balance and control of the body position in the water, Cureton² states, depend upon the following factors:

1. Sense of balance as governed by the semi-circular canal mechanism
2. Kinesthetic sense of position as determined by sensory impressions caused by the pull of ligaments, muscles, and other structures.
3. Pressure sensations of the water upon the body.
4. Anatomical structure
5. Balancing movements as made by the head, arms, and legs.

¹Lyba Sheffield and Nita Sheffield, Swimming Simplified (New York: A. S. Barnes and Company, 1929).

²Thomas D. Cureton, How to Teach Swimming and Diving (New York: Association Press, 1934), p. 200.

In his book, Armbruster¹ breaks the body position down into its component parts. The important components are the following four:

a. The head is carried well up with only the face in the water. The water level will vary, according to buoyancy of the swimmer, from a position just below the eyes to one at the level of the hairline. The eyes are directed forward in a natural position. Being the main aids in the control of the body position, the eyes directed upward or sideward, will easily throw the body out of equilibrium. The chin is also held in a centered position, but not held so far forward that wrinkles appear in the back of the neck.

b. The shoulder blades should be held flat. The upper level of the shoulder is slightly below that of the top of the head. The shoulders are also raised forward in the direction of the movement of the swimmer. Along with the shoulders the upper spine is flexed slightly forward, which places the trunk in a more streamlined position. The whole surface of the thorax and abdomen is flattened, making, along with the other components, the body level parallel with the surface of the water, which allows the water to pass with the least amount of resistance.

¹David Armbruster, Robert H. Allen, and Bruce Harlan, Swimming and Diving (St. Louis: The C. V. Mosby Company, 1958), pp. 77-83.

c. During the competitive splint crawl the hips remain level, but are carried slightly lower than the shoulders and move through the water just below the surface. However, the position that the hips are carried may vary with the weight of a swimmer.

d. The legs are held in a loosely extended position with the ankles and knees passing close by each other in a supple movement.

Armbruster goes on to state that in most individuals the proper alignment of the body position can be checked by drawing a straight line from the midpoint of the shoulder joint through the midpoint of the hip joint, the line being extended backward past the feet. If the body is in proper alignment, this line will pass exactly through a point which is midway between the ankle joints, when the legs are fully spread in the stride position at the end of each beat.

Several other authors of general swimming literature seem to be in agreement with Armbruster's ideas on the body position.

Analysis and Discussion

The material written on the body position is very inadequate in good research work. The statements made in the material are not seemingly backed up by fact and experiment. The only actual research the author found

was done by Counsilman. Armbruster, although still not backed up by research, appeared to have worthwhile information on the body position. The area of the body position in the front crawl stroke is in dire need of more factual research work.

CHAPTER III

LEG MOVEMENT

The swimmer's leg propels him forward in the water with both the upward and downward swing just as the fish's tail propels him forward with each sideward swing.

Cureton¹ experimented with various types of kicks and found the flutter kick to be inferior in maximum momentary impulsive force to the frog kick. He found in his study that 51 per cent of the propulsive drive in kicking comes from hip action. He also found that 48.4 per cent of the total work done in the flutter kick is useless for propulsion, although a part of it serves a purpose by helping to keep the legs horizontal to the surface of the water.

Allen² analyzed the factors involved in the propulsive force of the leg kick in the crawl stroke. The factors taken into consideration were the propulsive force gained from various widths of the leg kick and the proportional amount of propulsion the legs contribute to

¹Thomas K. Cureton, "Mechanics and Kinesiology of Swimming the Crawl Flutter Kick," The Research Quarterly, December, 1930, pp. 87-121.

²Robert H. Allen, "A Study of the Leg Stroke in Swimming the Crawl Stroke" (M. A., State University of Iowa, 1948).

the whole stroke. Using four kicks, narrow (12 inches), medium (18 inches), wide (24 inches), and normal (not specified), Allen found that the normal kick was slightly faster than the narrow kick, which was the fastest of the other three. Another conclusion was that the slower the kick the less it contributed to the propulsion of the whole stroke. Allen also computed the relative contribution of the leg movement from average performance data at various speeds. The factors involved in the computation were the times in seconds of the whole stroke, arm stroke, and leg stroke. He subtracted the time of the arm stroke from the time of the whole stroke with the remainder used as the relative contribution of the leg movement. He found that the leg movement was actually slowing the subject's time for the whole stroke.

Alley¹ made a study of propulsion and resistance in swimming the crawl stroke, using a constant frequency of stroke. The leg component of this study was done with two types of kick, the normal (12 inches) and the short (6 inches). At each velocity for which the surplus-propulsive force was measured, the mean force for the normal kick was greater than the mean force for the short kick.

¹Alley, op. cit.

Counsilman¹ states that the kick raises the legs, fixes the body, and acts a good deal as a stabilizer of the body position, thus giving the swimmer a firmer base from which to work. A theory advanced by Counsilman was that the propulsive phase of the kick may counteract its own resistive phase; so that a swimmer, although not receiving any additional propulsion from his legs, had less to pull with his arms.

The proportionate amount of propulsion contributed by the leg movement as related to the propulsion of the whole stroke was analyzed by Poulos². Using three types of kicks, narrow, normal, and wide, Poulos found the narrow kick to be faster than the other two. Poulos computed the relative contribution of the leg stroke in the same manner as Allen.

Armbruster³, in a completely different context than the previous research studies, states that the leg movement is a forcible and regular oscillation, serving to push the water backward with each upward and downward beat. The movement in the flutter-kick leg action originates at the hip joint and is transmitted through the thigh to the

¹James E. Counsilman, "Theory of the Flutter Kick," Beach and Pool, June 1949, p. 12.

²George L. Poulos, "An Analysis of the Propulsion Factors in the American Crawl Stroke" (M. A., State University of Iowa, Iowa City, Iowa, 1948).

³Armbruster, op. cit., p. 84.

knee joint. In whiplike motion the wave passes from the knee to the lower leg, next to the ankle, and finally to the foot where the wave is then lashed about like the free end of a rope being snapped. At the beginning of the upward leg movement the hip is slightly flexed with the knee and ankle extended. The water is pressed backward with a tremendous driving force, thus propelling the body forward. When the leg finishes its upward beat, the hips and knees are slightly flexed and the ankles are extended. With a small flexion of the hips the water is sent backward. With the extension of the knee the water is driven farther back along the anterior surface of the leg and down over the ankles as the body moves forward. The toes are turned inward in a pigeon-toed fashion during the down stroke in order to contact more water with the tops of the feet. The advantage of possessing large feet and flexible ankles is apparent when the mechanics of the flutter kick are considered.

Again the author found several other general books and studies that agreed with Armbruster's descriptions and explanations.

Analysis and Discussion

There is an insufficient body of information on the leg action in the crawl stroke to draw sound generalized conclusions. The majority of the research work has been

done on some minute component of the leg movement rather than analyzing the best way to execute the front crawl kick.

In the studies reviewed here, there were several who experimented on the narrow, normal, wide, etc., kick of the crawl stroke. All seemed to find the normal kick superior, however, a swimmer who has executed his "normal" kick for some time will be slowed down by experimental kicks even with practice of them. Therefore, these studies seem to be impractical.

Armbruster has set down logically and clearly the basic mechanics of the flutter kick. This has served as a guide in teaching and coaching swimming. However, it must be recognized that Armbruster's statements are well founded by the current research.

CHAPTER IV

ARM MOVEMENT

Human's arm, unlike the fish's fin, requires skill and coordination in movement through water. The whole stroke would be deficient unless the arm movement was mastered, as the arms provide about 70 per cent of the total power of the front crawl stroke.

Cureton¹ in 1930 worked on two problems which related to arm pull, the direction of the pull, and the length of the levers. He first attempted to measure static forces involved by having a subject, strapped to a plinth, pull upon a scale. He concluded that the maximum force was exerted when the arm passed 120° flexion at the elbow joint. In the same experiment, Cureton then measured the pull in three different positions and with three different lengths of levers. He found that the pull in the midline of the body exerted the maximum force. Optimum results were obtained when Cureton shortened the lever to fifteen inches with the 120° flexion at the elbow joint.

In one of Karpovich's² many studies he developed the formula, $V_w^2 = V_a^2 + V_l^2$, where V_w refers to the velocity of the

¹Thomas Cureton, "Mechanics of Swimming the Crawl Arm Stroke," Beach and Pool, 4:60, May 1930.

²Peter V. Karpovich, "Swimming Speed Analyzed," Scientific American, 42:224-225, March 1930.

whole stroke, V_a represents the velocity of the arms alone, and V_l represents the velocity of the legs alone. From this he could obtain the propulsive force from the arms of a good crawl stroke swimmer, which turned out to be approximately seventy per cent.

While attempting to determine the relation between the crawl arm stroke and the application of force, photographic analysis was used by Lola Osborne¹. She states the following: "The force applied during the arm pull in the crawl is applied irregularly, but mainly at two points. In the case of the speed swimmer, the greater force is applied when the arm has passed from 68° to 95° through the pull. In the case of the endurance swimmer, the force is also applied at two points. It is applied when the pulling arm has passed from 25° to 45° through the cycle.

Campbell² conducted a study to determine the relationship of arm and shoulder strength to speed and endurance in the front crawl stroke. On the basis of the correlation coefficients he found from the apparatus, he was able to conclude that the arm strength was more highly related to speed in swimming rather than endurance.

¹Lola L. Osborne, "A Method of Analysis of Swimming Strokes with Relation to the Application of Force" (M. A., University of California, Los Angeles, California, 1941), p. 85.

²Cameron R. Campbell, "A Study of the Relationship of Arm and Shoulder Strength and Endurance in Free-style Swimming" (M. A., State University of Iowa, Iowa City, Iowa, 1948), p. 23.

Allen¹ concluded from his survey of related literature that the arm movement is of greater importance than the leg movement in propulsion.

While analyzing the propulsive factors in the front crawl stroke, Poulos² found the long arm, the arm pulling through past the hip, stroke to be superior to the short arm, pulling through just to the hip, stroke, which was in a distance of ten yards.

Alley³ studies propulsion and resistance in swimming the crawl stroke, using a constant frequency of stroke. He tested two types of arm pull, the "normal" arm stroke, in which the arm was pulled through the water with the elbow held straight, and the bent-arm stroke, in which the elbow was held at an angle of approximately 90°. The mean for the surplus-propulsive force using the "normal" arm stroke was greater than the mean for the bent-arm stroke. As the velocity became greater than zero, there was a decrease in the amount of surplus-propulsive force of the whole stroke and the arm stroke alone, which was greater than could be attributed to resistance. This was no doubt due to the decreased effectiveness of the stroke and the increase in the total resistance.

¹Allen, op. cit., p. 25.

²Poulos, op. cit., p. 10.

³Louis E. Alley, "An Analysis of Resistance and Propulsion in Swimming the Crawl Stroke," Research Quarterly, 24:253-270, October 1953.

The effectiveness of the bent-arm stroke and the straight-arm stroke in the execution of the front crawl arm stroke was compared in a study by Harris¹. In his study Harris quoted McCloy from his lectures: "A mechanical analysis of the two strokes shows the straight-arm stroke to be less efficient than the bent arm stroke. McCloy has shown that as the arm moves backward at a speed which is less than the forward speed of the body. The faster the tempo of the arm stroke, relative to forward speed, the higher up on the arm is the line that marks the junction of the lower portion of the arm, which propels, and of the upper part of the arm that resists. It is easier, therefore, to perform the bent-arm stroke at a fast tempo than the straight-arm stroke." Harris found the following results:

1. The straight-arm stroke, arm pulled through a semi-circle, produced the greatest amount of surplus-propulsive force at each velocity and tempo tested.
2. With the bent-arm stroke, arm follows a path closely parallel to the body, it was possible to swim at a faster tempo than with the straight arm stroke.
3. The bent-arm stroke at the "all-out" tempo produced the greatest number of points of surplus-propulsive force recorded at the 1.94, 2.61, and 3.12 feet per second velocities.

¹Archibald J. Harris, "An Analysis of the Straight Arm Stroke and the Bent-Arm Stroke in Swimming the Crawl" (M. A., State University of Iowa, Iowa City, 1952), p. 87.

Since the bent-arm stroke can be used at a faster tempo, it should be the more effective stroke, when a maximum tempo is required. Therefore, Harris concludes, the straight-arm stroke should be the most effective at normal tempos.

In the study that Counsilman¹ performed in 1951, it appeared from the data presented that the continuous stroke is superior to the glide stroke for competitive swimming. This superiority may be attributed to the fact that it contributes more propulsive force and there is less fluctuation of this force. The above fact that the continuous stroke created more force at a given tempo might also give rise to the opinion that it requires more energy to accomplish this increase. The continuous stroke appeared to create more resistance, since the body rolled slightly more. This might also lead to the assumption that the glide stroke requires less energy to accomplish a given speed and as a result, would be the choice for longer races. That the glide stroke requires less energy for a given tempo than the continuous stroke is unlikely, however, since the glide stroke arm pull is faster and fast movements require more energy than do slower ones. Also to be considered is the possibility that more of this thrust in the glide stroke

¹James Counsilman, "An Analysis of the Application of Force in Two Types of Crawl Stroke," op. cit.

is used to overcome inertia than is necessary in the continuous stroke. The efficiency of the strokes on the basis of energy output could only be determined by a study of that factor by such a method as oxygen consumption technique.

For the purpose of analysis, states Armbruster¹, the front crawl arm stroke may be classified into seven components: entry, support, catch, pull, push, release, and recovery. The arm must enter the water in such a manner that it is immediately placed in the most favorable position for a forceful stroke by taking hold of as much water as possible. For support the arm and hand serve to propel the swimmer forward as soon as they enter the water and continue this propulsive action until they are removed for the recovery. During the supporting phase, the arm is pressing downward and backward causing the catch. At the end of the catch the arm has gained traction in the water and has been brought into position for the most propulsive phase of the arm stroke, the pull. The transitional movement from the pull to the push is accomplished by drawing the upper arm toward the body so that the arm can be drawn powerfully backward. At the completion of the push the arm is lifted from the water

¹Armbruster, op. cit.

causing the release. The action of the arm from the release to the entry is termed the recovery. The correct arm action sustains the body balance, as well as, affords a continuous propulsive force which maintains steady forward progress.

Analysis and Discussion

There seemed to be more worthwhile material written on the arm movement than on that of the previous chapter. However, here again, it was noticed that, in reading over the literature written, a pattern seems to develop. The pattern developed, in most instances, is the subjects being tested seem to follow the style they have already established for themselves. If this variable could be eliminated the results obtained would be more meaningful.

CHAPTER V

COORDINATION OF ARMS AND LEGS

In the crawl stroke the cadence of the legs is faster than that of the arms. This motion, at first, appears to be unnatural, since it is unlike any that is used by man while walking and running. In walking and running the arms serve to counterbalance the driving action of the legs by swinging in the opposite direction as the legs. The legs and arms thus move to a 1 to 1 ratio, however, in the crawl they move in a 3 to 1 ratio. The legs perform 3 beats to each arm movement, or 6 beats to each complete cycle of both arms.

While analyzing the propulsion factors in the front crawl stroke, Poulos¹ combined the fastest type of leg kick, the normal width of the swimmer, and the fastest type of arm movement, the long-arm pull, to use as the whole stroke. The author's graphs revealed that the closer the velocity with the arms alone corresponded to that of the total stroke, the less the legs contributed to the propulsion of the whole stroke. Poulos indicated that an increase from a six beat kick to an eight beat kick increased the velocity

¹Poulos, op. cit.

of the swimmer. However, this resulted in a narrower leg kick and a longer arm pull in order to maintain the correct coordination. Increasing the leg action beyond eight beats per stroke cycle tended to cause too slow an arm action.

In a study made by Alley¹ he found at each velocity for which the surplus-propulsive force was measured, the mean for the whole stroke using the normal kick, 12 inches in width, and the normal arm stroke, in which the arm was pulled through the water with the elbow held straight, was greater than the mean for the other types of strokes. The sum of the effective-propulsive force of the arms alone and the kick was not the equivalent of the effective-propulsive force of the corresponding whole stroke.

Alteveer² states that there is a very noticable lag between the pulling of both the arms. If the swimmer could maintain a constant leg propulsion this drop of speed would probably be reduced. However, many top swimmers definitely neglect their leg movement.

The arms and legs must be well coordinated in their independent execution, states Cureton³. In addition, a very

¹Alley, "An Analysis of Resistance and Propulsion in Swimming the Crawl Stroke," op. cit.

²Robert J. G. Alteveer, A Natographic Study of Various Swimming Strokes (Springfield, Massachusetts: Springfield College, 1958).

³Cureton, How to Teach Swimming and Diving, op. cit. p. 223.

definite balance and timing are required in the execution of the whole stroke. Of greatest importance is the timing which permits continuous propulsion.

Rajki¹ agrees that in the front crawl the correct and commonest ration of arm and leg action is one complete arm cycle for six leg beats. For the correct synchronisation of arm and leg movement each should bridge the relative dead points of the other. The preceding sentence is the most important statement made here. The correct synchronisation of arm and leg movement ensures the even glide of the body.

An analysis by Armbruster² of the mechanics of the six-beat crawl stroke reveals that it is as truly balanced as is the counterbalancing action of the arms and legs in walking. The part of the stroke that is performed with the most regular rhythm is the leg action. Although the arms also move in cycles, their rhythm is a peculiar one, as during one complete arm cycle each arm is out of the water during the remaining two thirds of the cycle. The legs move upward and downward in uniform periods and each upward and downward beat of the legs marks a certain regular phase of the stroke. Each component commences with the instant

¹Rajki, op. cit. p. 42.

²Armbruster, op. cit. p. 94.

the legs are completely spread in the stride position at the end of each beat.

Analysis and Discussion

A percentage of coaches are very weak on carefully analyzing the elements of coordination in the execution of the whole crawl stroke. Cureton¹ states, much more research needs to be placed in this area.

The majority of the researchers found, when analyzing the coordination of the arms and legs, there was a reserve of surplus propulsion during a phase in the cycle of the front crawl stroke. Also found was a lack of surplus-propulsive power at a different phase in the cycle.

It is the opinion of the author, more work should be done in utilizing this reserve propulsive power in the phase of the cycle which lacks it. This would mean further research should be done in experimenting with different timing combinations.

Of major importance again, such a study would mean the controlling of the swimmer's normal stroke so it would not influence the experimental strokes.

Here in lies some of the questions that are now left unanswered.

CHAPTER VI

BREATHING

Expert swimmers who have skillfully mastered breathing and relaxation of the abdominal muscles seldom have difficulty in breathing when under the exertion of swimming at great speed. If the breathing is not mastered the leg kick and arm rhythm may be disturbed.

Rajki¹ states the commonest method of breathing is a single inhalation during one complete arm cycle. In correct inhalation the turning away of the head should, to a certain extent, be made independent of the arm stroke. The head turns sideways when the arm corresponding to the side of breathing reaches the end of the push, and the other arm reaching forward in the line of the head waits, offering support and securing the balance of the body during breathing. The short and quick inhalation is completed when the forward swinging arm comes level with the shoulders. The head is now returned with a quick movement into a straight position in such a rhythm that it should be completed before the forward swinging arm touches the water. The swimming style described here is short distance crawl, however, the middle

¹Rajki, op. cit. p. 42.

and long distance crawls do not differ fundamentally, only in the alteration of the ratio which is caused by the slower rhythm.

Cureton¹ found that swimming causes interference with breathing. This is because the leg movements and arm movements limit the mobility of the abdomen and thorax, respectively. The crawl stroke requires fast and shallow breathing if a breath is taken each cycle.

Every ordinary turning of the head for breathing increases the resistance about one half a point for a speed of five feet per second, observed Karpovich². He has also observed that lifting the head or body (hydroplaning) invariably increases the resistance.

Swimmers, states Counsilman³, should use a limited amount of roll so that an easy arm stroke will be permitted and so there will be proper application of propulsive forces, and sufficient roll to permit proper breathing. The swimmer should breath on the side of the weaker arm for breathing creates resistance. Therefore, a swimmers stronger arm will tend to keep the stroke in better coordination.

¹Thomas Cureton, How to Teach Swimming and Diving (New York: Association Press, 1934), p. 190.

²Karpovich, op. cit., pp. 49-58.

³James Counsilman, "An Analysis of the Application of Force in Two Types of Crawl Stroke" (Ph. D., State University of Iowa, Iowa City, Iowa), p. 82.

Armbruster¹ states some common errors resulting from faulty head-turning mechanics. Lifting the chin forward and sideward to get air results in dropping the opposite elbow and shoulder, which causes the opposite arm to slide laterally, and disturbs the leg balance, with the propulsive force being dissipated. Turning the head in the same rhythm and cadence as the arms results in rolling the body. Not fully recovering the head results in loss of body balance. Opening the mouth with the lips stretched back too far results in strangulation due to water entering the mouth. Moving the head out of its longitudinal axis results in a loss of symmetric arm and leg movement and disturbs the body balance, thus, propulsive force is lost. Breathing on one side only results in the neck and shoulder muscles becoming cramped, loss of balance, and the inability of the swimmer to see the field on both sides during a race.

Analysis and Discussion

A review of the literature has concluded material on how and when to turn the head in breathing, however, from a basic research point of view nothing much has been accomplished.

Counsilman's suggestion of breathing on the swimmer's weak side, so the coordination of the stroke won't be thrown

¹Armbruster, op. cit. p. 104.

off, seems to be of merit. However, to the author's knowledge, it is not backed up by research.

Research, therefore, should be done in this area rather than some other area already covered.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The development in the technique of swimming the front crawl stroke has evolved from the trial and error method of experimentation, states Armbruster¹. The criterion of success with the innovations attempted was and is the increase in speed of the swimming stroke. The constant lowering of records is an indication that the mechanics of the front crawl stroke still can be improved. The author feels C. T. Wilson² sums up mechanical analysis by his statement: "A mechanical analysis of any particular movement in swimming, from the simplest phase to the composite stroke, may always be made in terms of the basic physical concepts of direction, force, and time."

A coach reviewing the literature on the mechanics of the front crawl stroke would have difficulty deciphering research phraseology. The author suggests the conclusions of this literature should be written for the average coach's comprehension, since the findings are usually for a coach's use.

¹Ibid. p. 22.

²Collin T. Wilson, "Coordination Tests in Swimming," Research Quarterly, 5:83, December 1934.

Perhaps the biggest error in the research work done is with the control groups. In experimenting with the various innovations, the swimmers complete the testings much better the style or way they have always swam them, which is only natural, However, some method to correct this situation is essential to obtain an accurate picture of each experiment attempted.

A few men, who have been in the swimming field a long time, have developed and improved upon the various strokes, yet, in the strict sense of the word, they are not backed up nor often recognized by research. The author feels that both research and long term observation have their place in the field of swimming.

The possibility of more material and research work compiled on swimming is conceivable, however, it is not available in published form. This is definitely a weakness in this field. If more coaches and researchers would take time to publish their material, it would undoubtedly benefit all of those who are interested. There has not been enough work done on the front crawl stroke. With the attention focused on the crawl, because of its faster speed, there should be many sources available for information concerning the mechanics of the stroke.

BIBLIOGRAPHY

Allen, Robert H. "A Study of the Leg Stroke in Swimming the Crawl Stroke." M. A., State University of Iowa, Iowa City, Iowa, 1948.

Alley, Louis Edward. "An Analysis of Resistance and Propulsion in Swimming the Crawl Stroke." Ph. D., State University of Iowa, Iowa City, Iowa, 1949.

Alley, Louis Edward. "An Analysis of Resistance and Propulsion in Swimming the Crawl Stroke." Research Quarterly, 24: 253-270, October 1953.

Alteveer, Robert J. G. "A Natographic Study of Various Swimming Strokes." M. S., Springfield College, Springfield, Massachusetts, 1958.

Amar, J. The Human Motor, London: G. Routledge and Sons Ltd., 1920.

Armbruster, David, Robert H. Allen, and Bruce Harlan. Swimming and Diving, St Louis: The C. V. Mosby Company, 1958.

Bengston, Edwin J., and Alan A. Butter. "An Analysis of the Back Crawl and Crawl Arm Strokes." M. S. Springfield College, Springfield, Massachusetts, 1956.

Callander, Audrey E. "An Analysis of the Newer Techniques of Swimming." M. Ed., Ohio University, Athen, Ohio, 1939.

Campbell, Cameron R. "A Study of the Relationship of Arm and Shoulder Strength and Endurance in Free-style Swimming." M. A., State University of Iowa, Iowa City, Iowa, 1948.

Child, E. The Art of Swimming and Diving, London: Thorsons, 1951.

Counsilman, James E. "Theory of the Flutter Kick." Beach and Pool, June 1949.

Counsilman, James E. "An Analysis of the Application of Force in Two Types of Crawl Stroke." Ph. D. State University of Iowa, Iowa City, Iowa, 1951.

- Cureton, Thomas. "Mechanics and Kinesiology of Swimming the Crawl Flutter Kick," The Research Quarterly, December 1930.
- Cureton, Thomas. "Mechanics of Swimming the Crawl Arm Stroke." Beach and Pool, 4:60, May 1930.
- Cureton, Thomas. "The Stop Watch Method of Testing Speed." Beach and Pool, 4:15-19, February 1930.
- ✓ Fox, M. G. "Swimming Power Test." Research Quarterly. 28(3):233-237, October 1957.
- Goss, G. "Swimming Analyzed." The Author. Northampton, Massachusetts.
- ✓ Handy, J. "Six-beat Crawl." Scholastic Coach. 20:30, December, 1950.
- Harris, Archibald J. "An Analysis of the Straight Arm Stroke and the Bent Arm Stroke in Swimming the Crawl." M. A., State University of Iowa, Iowa City, Iowa, 1952.
- Jeager, L. D. "Resistance of Water as a Limiting Factor of Speed in Swimming." Master's Thesis, State University of Iowa, Iowa City, Iowa, 1937.
- Karpovich, Peter V. "Swimming Speed Analyzed." Scientific American, 42:224-225, March 1930.
- ✓ Karpovich, Peter. "Water Resistance in Swimming." Research Quarterly, 4(3):21-28, October 1933.
- Karpovich, Peter. "Analysis of the Propelling Force in the Crawl Stroke." Research Quarterly, 6(2):49-58, May 1935.
- Moyle, W. J. "A Study of Speed and Heart Size as Related to Endurance in Swimming." Master's Thesis. State University of Iowa, Iowa City, Iowa, 1936.
- Osborne, Lola, L. "A Method of Analysis of Swimming Strokes with Relation to the Application of Force." M. A., University of California, Los Angeles, California, 1941.
- Poulos, George. "An Analysis of Propulsive Factors in the American Crawl Stroke." M. A., State University of Iowa, Iowa City, Iowa, 1949.

- Pulley, Frances C. "The Relationship of Speed Swimming and Buoyancy to Form in the Execution of the Front Crawl Stroke." M. S., Smith College, Northampton, Massachusetts, 1955.
- Rajki, Bela. The Technique of Competitive Swimming. Budapest, Hungary: University Printing House, 1956.
- Runquist, K. C. "Teaching Arm Action for the Crawl Stroke." Journal Health, Physical Education, and Recreation, 28:42, December, 1957.
- Sheffield, Lyba and Nita. Swimming Simplified. New York: A. S. Barnes and Company, 1929.
- ✓Tews, R. W. J. "The Relationship of Propulsive Force and External Resistance to Speed in Swimming." Master's Thesis, State University of Iowa, Iowa City, Iowa, 1941.
- Wetmore, R. C. "Experimental Data Applied to the Crawl and Breast Strokes." 11., Athletic Journal, 33:30, November 1952.
- ✓Wilson, Collin T. "Coordination Tests in Swimming." Research Quarterly. 5:83, December, 1934.

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