Comparative Analyses of Two Methods of Backstroke Starting: Conventional and Whip

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Generally, when a new skill, technique, or style is introduced into a sport, the first attempt to describe the change is by the coach or athlete. The biomechanist will then make a careful review of the mechanics involved, test the principles against the given theory, propose directions for future improvements, or reject the change. This procedure often occurs in the sport of swimming.

During the last decade, techniques of competitive swimming have improved, resulting in several record-producing performances by the swimmers. This improvement may be attributed, in part, to coaches, researchers, and authors like Counsilman (1977) and Maglischo (1982), Hay (1985), Kreighbaum and Barthels (1985), among others. Backstroke swimming techniques have benefited from the investiveness of coaches, swimmers, and researchers. Probably much of the credit for initiating change in technique belongs to the backstrokers of the time. Two examples are Olympic champions John Naber in 1976 with his «head-above-water spin» turn and Rick Carey in 1984 with his «whip» start. These methods of turning and starting have been adopted by many coaches and swimmers.

Even though the Naber turn and the Carey whip start have gained in popularity, little research has been conducted regarding the mechanics of such techniques. For instance, one of the few studies conducted was on the backstroke turns. Benson (1979) filmed two subjects: John Naber executing his unique turn and Peter Rocca (second to Naber in the 1976 Olympics) doing his standard backstroke turn. An elementary comparative cine analysis was made. Benson determined that the Naber turn was more efficient than the standard backstroke turn. Since scientific information about the backstroke whip start is limited, this study was conducted to fill that void and to serve as a basic for further research.

PURPOSES

One purpose of this study was to make biomechanical analyses and a comparison of the «conventional» and «whip» backstroke starts using a computerized program designed to treat digitized cinematographic data. The second purpose was to determine which of the two backstroke starts was faster under simulated racing conditions. The final purpose was to discover the contribution of selected measures of flexibility and power to success in starting proficiency.

PROCEDURES

Two intercollegiate competitive backstroke swimmers, one who preferred the conventional start (CS), and one who used the whip start (WS), were filmed. Also timed comparisons for each start to the 25-yard mark (22.86 m) were obtained from the performances of young swimmers. To determine the value of certain flexibility and power components to either start and time trials, a statistical analysis was made. Only a few of the more important procedures applied to achieve the purposes of this study will be described.

Cinematographical Analyses

The careful use of cinematography produced film of two collegiate swimmers performing the backstroke starts that provided data from which relative mechanical efficiency of the CS and WS for backstroke could be examined.

Cinematography. Exact placement of four 16-millimeter cameras and two video cameras; selection of films, lenses, shutter speed (frames per second); location of lights to provide sufficient above-deck lighting and supplement underwater pool lights; taping of background into grids for proper scaling; application of contrasting targets on articular centers of two subjects; and placement of the electric digital clock were all coordinated according to suggestions from Anderson (1970), Atwater (1970), Benson (1979), Hay and others (1985), (1983), (1975), Miller and Nelson (1973), Noss (1967), Plagenhoef (1971) and Taylor (1971).

Analyses. The films were analyzed from three planes as accurately as possible from projections made on a digitizer tablet. A computer was interfaced with the digitizers so that points, taken from the films by the digitizer's cursor, were automatically entered into a programmed data file representing the x, y and z coordinates for each subject's markings in units of time and according to scale. Using segment lengths, centers of gravity of body segments, and center of gravity of the body as a whole, the computer calculated horizontal and vertical displacement, linear and angular velocities and accelerations, and moments of inertia. Ideas were taken from Adams (1982), Hobie (1980), Preston (1980), Scheuchenzuber (1970), Stratten (1970), Tichy (1981), Wilson (1983) and Walton (1970) for help in creating an analysis program.

Comparison of Starts and Times

To determine which of the two backstroke starts was faster under actual competitive conditions, a study was conducted using subjects from a local swimming team.

Subjects. Nine female and five male swimmers ranked according to the 1986 **United States Swimming Rules & Regulations** were selected for the study. The subjects ranged in age from 12 years to 17 years with a mean age of 14.5 years. Average years of competitive experience was 4.1 years. Each subject gave informed consent before participating.

Facilities and equipment. The 8-lane, 25-yard competitive pool at Brigham Young University (BYU) was used for time trials. The pool, the height and grip standards of the starting blocks, and the electronic, completely automated Colorado Timing System met the rule requirements, as set forth by the 1986 National Collegiate Athletic Association (NCAA) **Swimming and Diving Rule Book.**

Instructional strategies. The subjects were taught and learned the two starts by the whole method. No attempt was made to break down the skills into individual parts, nor were props, such as poles or hula-hoops, used. Each start was first introduced by showing a high-speed film clip and video tape of the start in its entirety. The two starts were then demonstrated by collegiate swimmers who were specialists in the respective starts. Each training session was spent actually practicing the entire start with periodic emphasis given to key concepts. All subjects continued to train with their club throughout the course of the study and were asked not to spend any other time practicing backstroke starts.

Time trials. The trials ran for a duration of nearly seven weeks with approximately 100 trials performed for each start.

The swimmers were randomly assigned to one of two groups. Group 1 began with the CS, while Group 2 began with the WS. Seven 45-minute sessions were devoted to each start. Swimmers were then timed for seven 25-yard backstroke sprints. This procedure was then repeated with Group 1 doing the WS and Group 2 doing the CS.

Anthropometric Measurements

In addition to determining if a significant difference existed between the mean starting times of the CS and WS was an interest in learning if any physical attributes, such as flexibility and power, were related to performance.

Flexibility. Three warm-ups were given for each of the four tests of flexibility and the average of the next three trials was recorded. The subjects were given adequate time to stretch before the test and were reminded frequently to stretch slowly and smoothly. Four measures of flexibility were recorded: 1) Shoulder flexion (SF) was measured with the subject lying prone on the floor with the chin touching the floor. The swimmer, with the arms fully extended and fingers locked together, attempted to lift the arms as high off the floor as possible. The height achieved was measured with a meter stick and recorded. (2) Plantar flexion (PF) was measured with the swimmer in a sitting position on the floor, legs extended, feet together. The swimmer pointed the toes as far as possible and the distance from the floor to the big toe was measured and recorded. (3) Lower back flexibility (LBF) was measured with the swimmer lying prone on the floor, chin on the floor, hands behind the back and the feet secured. The swimmer attempted to hyperextend the back. The distance from the floor to the highest point of the shoulder was measured and recorded. (4) Hamstring flexibility (HF) as well as lower back flexibility was tested using the sit and reach test. In this test, the swimmer sat with the legs fully extended in front and the knees pressed against the floor. The feet were placed against a stool to which a meter stick was attached and the swimmer attempted to reach as far forward as possible. The swimmers were reminded to keep the knees in contact with the floor and bouncing was discouraged.

Measures of Power. The two tests selected as indicators of power were: 1)

The vertical jump has been used by Counsilman (1977) as a measure of power for over 25 years. He also believes that those swimmers with a high VJ score for their age group and sex make better sprinters and those with a lower VJ score would make better distance swimmers; 2) The Biokinetic Swim Bench has been a valuable research tool in swimming. Costill, Sharp and Troup (1981) found a .93 correlation between the SB and performance times at 25 yards and a .89 correlation at 100 yards.

Statistical Treatment. To determine the relationship of the six independent variables (measures of power and flexibility) to the dependent variable (difference in starting times) a multiple linear regression was performed. The measures selected were suggested by the researcher to be related to success in swimming and the question as to their relationship in performing a backstroke start was investigated. The multiple linear equation used was:

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$$

where b_0 = mean effect, x_1 = shoulder flexibility (SF), b_1 = regression of SF with performance time, x_2 = plantar flexion (PF), b_2 = regression of PF with performance time after the variance due to SF has been removed, and so on. The purpose of the multiple regression was to predict as much variance as possible in the dependent variable with the fewest number of independent variables. Regression computations were performed by computer program: Minitab (2), Correlation and Regression, on a BYU VAX 8600 Computer.

RESULTS AND DISCUSSION

The major project of this study was the biomechanical analyses and comparisons between the backstroke CS and WS. Two sub problems involved statistical treatment of time trials and the effect of selected anthropometric measurements on performance of the two backstroke starts.

Biomechanical Analyses and Comparisons

The following chart gives a comparison of the data which was digitized and computerized from film made of the backstroke CS and WS for the entire body. Data was also treated for movement of body parts, such as head, trunk, and limbs, but are not included in this paper.

Chart 1

Comparison of Elementary Data Selected From 16 mm Film of Two Subjects Performing the Conventional (CS) and Whip (WS) Starts for Backstroke

PHASE	CS	POSITION	WS
Start to	.21 sec	Loss of hand contact	.28 sec
Take-off	.43 sec	Time of force application	.47 sec
		CG displacement	
	29.6 cm	Horizontal (backward)	14.2 cm
	3.6 cm	Vertical (upward)	4.8 cm
	38.6 cm	Height of CG	42.8 cm
Take-off	3.02 m/s	Velocity	3.67 m/s
	29 deg	Angle	44 deg
Flight	.36 m	CG Height	.48 m
	1.89	CG Distance	2.13 m
Entry	23 deg	Angle	31 deg
	.46 m^2	Area	.18 m^2
	.80 m	Depth	1.22 m
Under Water	1.57 m/s	Velocity at 7 meters	1.98 m/s
	2.22 m/s	Velocity at Break-out	2.48 m/s
	10.1 m	Distance at Break-out	11.9 m

As can be noted from the chart, the primary differences between the two starts were that the WS had a greater take-off angle, higher and longer flight path, steeper entry angle with less frontal resistance, faster entry velocity, greater underwater depth, longer submerged time, and a faster break-out velocity than the CS. The greater underwater depth and longer submerged time is not necessarily a disadvantage. Larsen (1981) determined that the drag coefficient drops rapidly as the body goes below the surface. This phenomenon occurs because as the body goes beneath the surface, gravity wave generation rapidly goes to zero. Larsen also determined that the coefficient of drag approaches zero for depth-to-length ratios of .2 to .4. Thus, a swimmer 1.8 meters in height would need to reach a depth of approximately .7 meters to benefit from reduced drag. These findings have important implications for the backstroke start: keeping the body stretched as long as possible tends to reduce drag; gliding at depths of greater than approximately .2 of the swimmer's length would greatly reduce the drag during the glide phase; and, the gliding velocity after a start can be 50-60 percent higher than swimming velocity and is limited by the pool depth.

Time Trials

The results clearly show that with equal learning time, the WS is faster than the CS. Ten of the 13 subjects in the study had faster times with the WS.

Statistics. Mean starting times were 16.62 ± .57 seconds for the WS and 17.01 ± .66 seconds for the CS with a mean difference of −.387 ± .188 seconds, the calculated t-ratio was −2.06, which, with a 2-tail test, was significant at the .061 level. To assess the relationship between the performance in the WS and the CS a Pearson's Product-Moment Correlation Coefficient was computed for the performance of the 13 subjects. The computed coefficient of 0.963 was significant at the .01 level. This indicates that approximately 93% of the variation in one start could be predicted from the other start. The faster subjects in one start were also faster in the other start.

Learning and conditioning. The subjects had limited experience with the conventional start and none with the whip start. The relatively short time of six hours spent in learning and conditioning for the two starts produced notable results and lend support to the superiority of the whip start.

Safety precautions. It is important to emphasize that with the increased depth required for successful completion of the whip start, precautions be taken in shallow water pools. The whip start should be modified with an earlier pike to slow vertical displacement. If the mechanics of the dive are introduced properly and the start is practiced and performed only in deep water, then the whip start should prove to be a safe and faster alternative for the majority of swimmers who try it.

Flexibility and Strength Testing

When viewing the WS in comparison with the CS, there *appears* to be more lower back flexibility required, a need for additional upper body strength, and a greater demand for leg power. However, the results from the devised tests and statistical model do not support this assumption.

Statistics. No significant relationships existed between any of the shoulder, lower back, hamstring and ankle flexibility measurement variables and performance in the WS. A relatively strong relationship (r

= .89) existed between the swim bench and the vertical jump and each correlated with performance times for both starts, .83 and .77, respectively. Incidentally, this supports the idea of these tests being relatively good indicators of power.

Value. Statistically speaking, none of the physical characteristics addressed in this study could serve as reliable predictors of success in performing the WS. Therefore, it does not appear that any of the physical attributes examined are pre-requisites for success in performing the WS.

SUMMARY

The skill needed to learn the WS might deter some athletes from trying or using it. However, with proper analysis and instructional scheme, the start can be learned effectively in a relatively short period of time. The WS takes no superior physical attributes and success, as exemplified, can be achieved by a majority of the swimmers.

Even though only two swimmers were used for cinematographical analysis, there are strong reasons that can be argued in defense of the WS. Several reasons have been previously discussed and three of them are here emphasized. The entry acceleration due to gravity, decreased profile drag due to body position, and resultant depth of glide all lend credence to the idea that mechanically speaking, the WS is more efficient.

Since little improvement has been made in actual swimming velocities over the last 10 years and record times continue to be achieved, it is reasonable to assume that part of the credit for the records must go to starts, turns, and conditioning. Therefore, it behooves a coach and swimmer to give consideration to the WS.

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