ESTABLISHING ERRORS IN STROKE TECHNIQUE OF THE FRONT CRAWL

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Recent research in swimming biomechanics has provided the coach with a wealth of information on skilled stroke technique (Counsilman, 1969, Maglischo, 1982, Schleihauf, 1983; 1986). This detailed information on the technical atmbutes of skilled performers provides invaluable evidence to the coach for use in the stroke correction process. However, information on skilled performance alone does not completely address the problems of coaches who work with average level swimmers. In order to work effectively with swimmers, the coach needs to know about the errors in stroke technique that the swimmer needs to avoid as well as the models of stroke technique that should be emulated.

The purpose of this paper is to document the errors in stroke technique which were observed in a sampling of 17 "average" college swimmers (all were enrolled in an advanced swimming class). Data on the swimmers in the college sample were compared to identical data collected on the 1984 and 1988 US Olympic Swimming Teams (USOT), as provided by the US Swimming Federation. Clear differences in movement style were observed between portions of the college sample and the USOT data. Movement styles which appeared both biomechanically inefficient (from the point of view of forward hand force production) and which deviated from the common trends observed in the USOT sample were identified as stroke errors. The stroke errors found to be most prevalent in the college sample were reported.

METHODOLOGY

Video Collection Procedure

Subjects were videotaped with front and side view cameras. The 25 yard pool was set up for data collection under the following configuration. Two cameras were put at the shallow end of the pool. One was placed at the wall, in front of the swimmer's path and the second camera was placed perpendicular to the first camera, yielding a side view. The swimmers swam 2-4, 25 yard trials (with 30-120 seconds rest after each trial). The pass with the best centered data (with respect to the camera field of view) trial was used for three diminsional analysis.

Hand and arm body landmarks were digitized for a complete underwater arm pull for each subject. Given X, Y. Z coordinates, hydrodynamic data was computed. The resulting data on the college sample were compared to identical data on the elite sample. Selected biomechanical measures were computed for each swimmer and sample means and standard deviations were computed for each measure. When the statistical data were computed a degree of variability was established and swimmers who fell outside that range were considered to have biomechanical errors. The data used to established these flaws were:

1. Total Resultant Force - The total hand force generated by the swimmer from hand entry to hand exit.
2. Effective Resultant Force - The amount of force aimed in the forward direction.
3. Angle of pitch - The angle the hand makes with the curvilinear line of motion.
4. Lift and Drag forces - The forces the hand produces in which a resultant force arises.
5. Time for completion of the arm pull.

Errors in Technique

Differences were found between the college and USOT sample. the most obvious errors in the college sample appeared during the finishing sweep phase of the arm pull. The performance of elite swimmers was used to serve as a guide to evaluate the arm motions within the college sample.

The following steps were followed in the evaluation of stroke flaws in the college sample:

1) Stroke index measures were derived from the kinematic / kinetic data collected for each subject. These stroke index measures were adapted from those previously published (Schleihauf, 1983). Each measure was originally derived to highlight biomechanically important features in the stroke. In general, the stroke index measures were designed to quantify the style variations observed between the elite and college samples. For example, the Angle of Pitch Index was derived to measure the average angle of hand pitch during the finishing sweep phase of the arm pull.

2) The stroke index measures which showed the clearest differences between the samples were singled out for further study. Stroke errors were defined on the basis of two criteria:

a) The movement style observed in the college sample was different from that observed in the elite sample, and
b) The movement style observed in the college sample produced propulsive force data which were less effective than that observed in the elite sample (i.e., the hand force vectors were not aimed forward, or the hand force vectors were smaller than those produced by elite swimmers).

3) The mean and standard deviation for each stroke index was computed for each

swimmer (both elite and college samples). Members in the college sample who had a stroke index measure which fell 1.7 standard deviations away from the elite mean were singled out for membership in a "stroke error" sub-group.

4) For the purposes of this paper, the three stroke error sub groups with the largest membership were singled out for complete analysis and discussion. The following sections of this paper discuss the three most prevalent stroke technique errors observed in the college sample:

a) Stiff wrist finish.

b) Hand Slide on the Finish.

c) Weak emphasis.

RESULTS & DISCUSSION

Stiff Wrist Finish

A recurring factor found within the sample was what was termed "stiff wrist finish" (Schleihauf. 1978). Swimmers who demonstrated stiff wrist finish, did not continuously adjust their hand angles of pitch throughout the arm pull. As a result. the swimmer could not produce forward propulsive forces at critical points throughout the stroke.

Swimmers who exhibited stiff wrist finish within our sample had:

A) A sustained wrist angle during the critical range of motion yielded a high angle of pitch (API = 48) resulting in decreased lift production (SI = 65). The occurrence of a fixed wrist angle is of considerable value to coaches because a fixed or flexed wrist angle during the finishing sweep can be seen without the use of video data.

B) A decrease in propulsion was documented due to the maladjusted hand position. For our study a 15% loss of propulsion was recorded.

Stiff wrist finish was documented among 28% of the college sample. signifying a pervasive presence. This could be sign cant for coaches, because it indicates to the coach that this is an error that could be present among their respective swimming community.

Hand Slide on the Finish

As a swimmer performs each arm pull the application of forces occurs non-uniformly in pulses. These forces occur in increasing magnitude as the stroke progresses, ending with the largest pulse during the finishing sweep (Schleihauf, 1974). Yet, for those who "slide", this large pulse of force is not efficiently employed. In some cases, the large pulse does not even occur during the critical range of motion. Lateral displacement of lift forces develop and allow the body to decelerate. Lift forces also diminish and the swimmer's forces are not used efficiently.

A swimmer who "slides" through the water, maintains the necessary increases in hand velocity during the finishing sweep. However, the hand is positioned with the palmar surface in a parallel position to the sagittal plane of the body during the critical range of motion. From this study the following may be concluded:

A) Swimmers who slide will most likely have low angles of pitch. This low angle of pitch will direct lift forces inefficiently.

B) To detect sliding, one can look from a side view, and watch for the pinky edge of the hand leading through the finishing sweep phase.

C) The consequence of sliding is a large decrease in propulsion. The results of our study yielded a 25% loss when compared to the elite sample.

Weak Emphasis

Swimmers considered to have weak emphasis performed sculling motions but were characteristically flawed with the largest production of force occurring earlier in the arm pull. They were unable to create the large pulse of force during the critical range of motion. From the data, the prime factors of weak emphasis were:

A) Swimmers with weak emphasis had early peak force production (60%) when compared to elite swimmers.

B) The weak emphasis sample had a lower peak force distribution (1.68) when compared elite swimmers (2.38) by 30%.

C) A low angle of pitch was documented.

D) A low Effective Propulsive Index (48%) verified that swimmers with weak emphasis practically throw away the forces during last one third of the motion. The consequence of weak emphasis was a 57% loss in propulsion. This is clearly an error of great magnitude.

Weak emphasis is not just a hand position error. It is a dynamic error and careful attention should be focused on the hand velocity with respect to the last one third of the arm pull.

CONCLUSION

From the results of this study an order of priority can be established for the stroke correction process based upon the prevalence of errors subgroups among the college sample. It can be determined that this order of priority considers the most inefficient subgroup as the largest subgroup of the entire sample. For the purposes of this study, the order of priority follows:

1) Stiff Wrist Finish (28%)
2) Hand Slide on Finish (24%)
3) Weak Emphasis (24%)

It is the intent of this study that the information revealed will help physical educators with invaluable information. The information provided is aimed to enhance the swimming community at large by establishing a knowledge base of how "average" swimmers perform. Currently there is little, if any information concerning the performance of non-competitive average swimmers.

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