EVALUATION and FEEDBACK IN SWIMMING: HISTORICAL OVERVIEW

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The purpose of this paper was to identify how various swimming service providers from around the world were able to provide evaluation and feedback to swimmers since the early 1970's. It was clear that probably the one particular area that existed through from the 1970's until today was the measurement of active drag and the propulsion generated by the swimmer. The analysis of starts also played a role throughout the entire period. It was not until the late 2000's that the technology was able to provide the tools to produce really comprehensive, immediate feedback analysis of performance.

KEY WORDS: biomechanics, swimming, evaluation, feedback, history

INTRODUCTION: Competitive swimming has been a sport in which there has been more difficulty in providing good quantitative biomechanical analysis feedback than with most land based sports. The reason for this is twofold. Firstly, it was difficult obtaining quality kinematic analysis data in an aquatic environment. Secondly, the propulsive and resistive forces acting on the swimmer are caused by a reaction of the entire swimmer's body with the surrounding water. This has limited the ability of service providers to readily quantify force measurement and body motion. For this reason much of the early aquatics biomechanics was reliant upon subjective analysis which involved reviewing the technique used by swimmers, using underwater video footage of the swimmer's performance. The technique used by better swimmers was regarded as superior and coaches attempted to have their swimmers emulate these actions.

DISCUSSION: In the early 1970's, the concept of lift propulsion, as opposed to purely drag propulsion, was proposed by Doc. James Counsilman. Underwater video footage was used by many service providers to subjectively monitor the swimmer's arm and hand movements in a lateral as opposed to a longitudinal direction. Greater hand and arm propulsive movements across the line of the body inferred greater lift propulsion, as opposed to drag propulsion in which the movement occurred more in line with the longitudinal axis of the body. Using video footage, coaches monitored the arm and hand motion of their swimmers with the aim to increase the more lift propulsion aspects of the stroke. During this period the lift propulsive actions were thought to play a more dominant role in propulsion than is the case today. The 2000 view on this subject, as opposed to that in the 1970's, is that a combination of lift and drag propulsive movements of the hands and arms results in the swimmer's propulsion. The 1970's was also an era in which flumes started to be developed to assist in the scientific monitoring of swimmers.

The mid 1970's to mid 1980's marked an era in which swimmers began to be assessed for active drag and propulsion. Intrastroke velocity variation was monitored from video footage by evaluating the forward and backward movement of the hips with respect to the overall motion of the swimmer's body during each stroke cycle. During this period, better video monitoring techniques were developed that included a combined above /below image of the swimming actions. It was during this period that Rein Haljand from Estonia developed a system for race analysis. The race analysis was able to provide much greater information about a swimmer's performance in a competition setting than could be disclosed from purely lap times. This was because the race analysis separated the competition performance into a start phase, free swimming phases, turn phases and a finish phase, where the result of each phase could be isolated and evaluated.

In the mid to late 1980's and early 1990's linear accelerometry was used to obtain the velocity characteristics of the swimming stroke, including information about intrastroke velocity fluctuations. This was also an era in which both starts and turns were comprehensively analysed from video footage. The measurement of active drag system

(MAD) was developed and used to evaluate the active drag of swimmers over a full range of swim velocities. Various large competition analysis systems began to evolve in Canada, Australia and Japan to monitor the performance of swimmers in competition. The Information from such systems had coaches concentrating their attention to the swimmer's race plans.
The early to mid 1990's were again characterised by evaluation of active drag and propulsion. Competition or race analysis systems were utilised in competitions to not only provide information about times and velocities during the various phases of the race, but also stroke lengths and stroke frequencies during the free swimming aspects of races. This information was then included by coaches as part of the swimmer's race model to be implemented in racing. Coaches would develop and refine the race model with analyses from progressive swim meets for each swimming stroke and distance that their swimmer competed. It was during this period that portable race analysis systems began to evolve that could be taken away by national swim teams to overseas competitions. The strong swimming nations began to depend more and more upon the analysis from their own portable systems as the larger analysis systems were not always in operation at international meets. Although these portable systems were able to assess all the parameters obtained by the larger analysis systems, the portable systems were limited in that they could only perform analysis on a single swimmer per race. As the information concerning the overall performance in starts and turns became available from the race analysis, there was a need to more accurately evaluate starts and turns in the training environment. This resulted in the development of start and turn analysis systems that involved more than just plain underwater video footage. Such systems could be used in a training environment to analyse each swimmer's start and turn performance. As well as start and turn video footage, such systems provided time on the block for starts and time on the wall for turns, as well as the times and velocities to various distances out from the block or wall.
In the late 1990's interactive software became available to assist in the diagnosis of inefficiencies in the swimming stroke. The coordination of swimming actions was being examined with regard to reducing intrastroke velocity variation. It was believed that a reduction of intrastroke velocity variation would reduce power requirements for the swimmer and therefore allow the swimmer to swim at a higher velocity with a similar power output. Passive drag, active drag and propulsion were again being monitored. Much of that monitoring was being assessed along with measuring pressure differentiation across the hand. The velocity perturbation method of assessing active drag had been established by Sergei Kolmogorov and was being used to determine the active drag of swimmers at their maximum swimming speed. Emphasis was also placed on the evaluation of starts and turns in the training environment. The Australian Institute of Sport (A.I.S.) had a system whereby force transducers were incorporated into the starting block and the turning wall. As well as data obtained from video cameras, the force data was also used in assessing starts and turns. The effect of breathing, the effect of body position and the degree of undulating body movements were monitored with respect to swimming efficiency. Swimmer's passive drag was measured as an indicator of the active drag characteristics of the swimmer. The effect of body roll on the in sweep hand velocity was evaluated with respect to swimming speed. Large competition analysis systems operated in most major swim meets and coaches examined the relationship between stroke length and stroke frequency. Toward the finish in races, the stroke length of the swimmer tends to fall off and the stroke frequency increases. Coaches were attempting to ascertain when in their swimmer's race the drop off point was most likely to occur and modify this to obtain a faster race time. This was an era in which the new race suits began to appear. Service providers attempted to assess the effectiveness of the different suits on their swimmer's performances.
From the early to mid 2010's much servicing concentrated on the starts and turns. In the starts, the leave block time and 15m time were examined in reference to type of start (Grab versus Track start). The turns were examined in relation to the time on the wall, the in swim time from 5m out until contact, and the outswim time from wall contact to the swimmer passing the 10m mark. Instrumentation to monitor the intrastroke velocity fluctuations was developed and was being used in an attempt to reduce such fluctuations. In this time period,

the affect of the different suits on performance was evaluated to try and identify the most beneficial suit for a particular swimmer.

The mid to late 2010's was an era in which competitive swimming was thrown into turmoil as a consequence of Speedo developing the Lazer Racer suit. It became clear during the Beijing Olympics that the LZR provided a distinct advantage over Speedo's competitor suits, due to the increased compression in the swimmer's body caused by the suit and as a consequence of reduced drag by eliminating stitched seams exposed to the oncoming flow of the water. Service providers attempted to quantify the advantage that these new suits provided. The different swim suit manufacturers attempted to refine their suits even further and non porous materials began to be used in the manufacture of suits in order to trap air in the suit and make the swimmer more buoyant. This in itself produced faster race times. Aquatic sports scientists were involved in the process of helping in the development of the suits for the various swim suit manufacturers. During the world championships in 2009, the situation became so explosive that the national swimming bodies demanded that something be done to reduce the performance effect of the suits. This resulted in new FINA by-laws about suit manufacturing that was implemented to reduce the overall effect of the swim suit on performance. This era also saw the effect of new technologies on the development of equipment to monitor performance. Such technology involved a miniaturisation of pressure transducers that could monitor pressure at various parts of the body including across the hand, accelerometers, gyroscopes and GPS sensors. It also involved the use of faster computers with greater amounts of accessible memory that could now process huge amounts of data in real time. Gigabyte Ethernet cameras that could film at higher speed rates with greater resolution and with images that could be captured by computers in real time also became available in the development of systems to monitor swimming performance in a training environment.

From the late 2010's until the present time, service providers attempted to look at the flow characteristics of the water around the body during swimming. The methods used involved attaching tuffs of material to parts of the body, the use of dye flow patterns around the swimmer in flumes, the use of "particle image velocimetry" and finally the use of Computational Fluid Dynamics to isolate the various propulsive actions of the swimmer. The pattern of breathing in the stroke cycle was evaluated against performance and the gains to be made with controlled breathing over breathing every stroke. The introduction by FINA of the Dolphin Kick in the breaststroke start and turn resulted in service providers attempting to identify for each swimmer, the preferred place in the start and turn that the kick should be employed. Similarly, with the introduction of the new FINA approved starting block with the inclined kicker, service providers attempted to indentify the most advantageous location for the kick plate and where the body should be located over the block for the various swimmers they were assisting. Active drag and propulsion continued to be an area which involved looking at the swimmer's propulsive actions in relation to the velocity profile of the swimmer. Comprehensive start and turn analysis systems were developed to provide immediate feedback to swimmers. Evaluation of a swimmer's starts and turns was again an important area of servicing. With new technology now available both kinematic and kinetic analysis of starts and turns was examined with more sophisticated feedback systems. The A.I.S. developed a system called Wetplate that was capable of comprehensively analysing starts, turns and relay changeovers and providing the analysis information as almost immediate feedback to the coach and swimmer on pool deck.

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