THE DEVELOPMENT OF AN ANALYSIS SYSTEM TO ASSIST IN THE CORRECTION OF INEFFICIENCIES IN STARTS AND TURNS FOR ELITE COMPETITIVE SWIMMING.

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The purpose of this paper is to provide the reader with information concerning the purpose, the structure, the capabilities and the analyses provided by the Wetplate computer programme and its associated data capture equipment. Since its development and its success in helping coaches eliminate technique inefficiencies in elite swimmers' starts and turns, coaches have been bringing their swimmers from all over Australia in increasing numbers to take advantage of Wetplate's attributes. The presentation will provide examples of how the Wetplate analysis has been able to assist in the performance enhancement of elite Australian swimmers.

KEYWORDS: swimming, starts, turns, analysis, technique coaching.

INTRODUCTION: Sprint races in competitive swimming are often won by hundredths of a second and in distance events by less than a second. Better starters are often 0.5 s better than poorer starters over the 15 m length that denotes the starting distance. Races in competitive swimming have a turn every 50 m in long course events and every 25 m in short course events. In the 1500 m long course event, there are 29 turns and 59 in the short course event. Small time differences in tenths of a second per turn occur frequently between better turners and not as good turners. Thus it becomes obvious how important it is for competitive swimmers to get the most out of every start and turn as that may make a considerable difference where they place in a race. Through competition analysis, it has been disclosed that in the 1500m event at the 2000 Sydney Olympic Games, Kieren Perkins who finished second actually swam faster in the race than Grant Hackett who won the gold medal. Grant actually won due to his outstanding performance in the turns. Daniel Kowalski who finished second to Kieren Perkins in the 1500 m event at the 1996 Atlanta Olympic Games lost over 7.5 seconds in his turns to Graeme Smith who came in third. Daniel only just beat Graeme at the finish but had to make up the time that was lost in turns, during the free swimming phases of the race. Prior to the 2008 Olympic Games in Beijing the prospective relay participants in the Australian Swimming Olympic Squad had several camps at the A.I.S., primarily to look at performance in relay changeovers. Compared to the results obtained by the Australian Swim team at any previous Olympic Games, the Beijing Olympics saw the first time Australia won a medal in all 6 swimming relay events. In 50m sprint events it is often the case that the fastest starter will win the race. Generally at the elite level it is not swimming speed that wins races but rather the better technicians in starts and turns. Generally, improving performance in starts and turns will not require additional energy consumption as performance in starts and turns is more technique rather than energy based. As a consequence of the importance of starts, turns and relay changeovers in elite competition, the Australian Institute of Sport (A.I.S.) needed to provide the Australian swim coaches with a means of biomechanical analysis to assist in the performance enhancement in these aspects of swim competition.

The purpose of developing the Wetplate Start and Turn Analysis System was to accelerate the learning process in refining a swimmer's performance in these skills. This only became possible after the introduction of machine vision cameras and modern high speed computers. The system was intended to provide the coach with an immediate feedback capability as well as the ability to readily and easily compare the performance in two separate trials.

METHODS: The A.I.S. completed the developed of a start, turn and relay changeover analysis system in 2006 to assist in the performance enhancement of Australian elite swimmers. As the analysis system incorporated a force platform that was used as a turning

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wall, was mounted in a vertical direction, and was partly submerged under the surface of the water, the analysis system was called Wetplate. Wetplate is comprised of a starting block whose top surface is a modified 900 mm by 600 mm Kistler force platform. The force plate is angled, as per FINA regulations, down in the direction of the pool water. Under the front edge of the platform is located a bar that is gripped by the swimmer's hands during starts. The bar is instrumented on either side of the handle so as to measure the grip force exerted by the hands during starts. There is also an inclined kick plate that sits on top of the top surface of the start block force platform that is used by the rear foot during starts. The inclined plate setup is compliant with FINA regulations. The inclined plate also is instrumented with 4 triaxial force transducers in the formation of a miniature force platform. The inclined plate is able to be moved up and down the starting block, to replicate its placement on a normal starting block (Figure 1). The turn wall is also a modified Kistler 900mm by 600mm force platform that fits into a section of the pool end wall that is normally filled with a dummy plate. The front surface of the instrument wall has a multitude of holes so as to minimise much of the force signal exerted by the wave which travels in front of the swimmer and has much of its force dissipated through the holes. All the force exerted by the hands and feet are measured directly on the turn wall. Because all but 300mm of the 900mm length of the wall is located under the water the instrumented wall is only able to stay in the water for up to eight hours. For backstroke starts there are handles that attach to the main force platform that in turn are attached to the starting block. The force exerted by the hands and arms to raise the body out of the water during backstroke starts is measured by the force platform acting as the top surface of the starting block. The turn wall is utilised to measure the force exerted by the feet and legs during the backstroke start. Signals from all force transducers are transferred by way of cables to the computer via amplifiers and an analogue to digital board.

Figure 1: Wetplate starting block including a Kistler force platform with kick plate.

There is also a start button that triggers the start signal and is initiated by the starter who stands behind the starting block. The signal from this button is also transferred by an electrical pulse to the Wetplate computer via the analogue to digital board. A box which is located beside the starting block has a number of indicator lights for the visual indication of events that have occurred. These indicator LED lights are primarily there to display the instant of an event during the visual playback of the trial. The LED lights display an indication of events including: the start signal, when the swimmer left the block, when the front wall was touched in turns and when the relay touchpad has been activated by the incoming swimmer, swimming into the wall during relay changeovers. The LED indicator receives its signal concerning the leave block time through the reconnection of a red LED beam across the front of the start block. The swimmer's feet block the beam prior to the swimmer leaving the block. Four Gig E Pulnix Machine vision cameras are used to provide visual feedback of a trial. All cameras are synchronised to run at 100 frames per second. The cameras cover the lateral or side view from behind the start block out to the 15 m mark from the wall. One camera films from above water to capture the above water activity during a start and turns. The other

three cameras cover the entire underwater view from the turn wall out 15 m from the wall. When viewing the visual display, all four cameras provide what appears to be a continuous image on the computer screen (Figure 2). There is both a magnetic timing system and a video camera timing system used to identify when the swimmer's head passes through the 5 m, 7.5 m, 10 m, 15 m and 20 m marks from the wall.
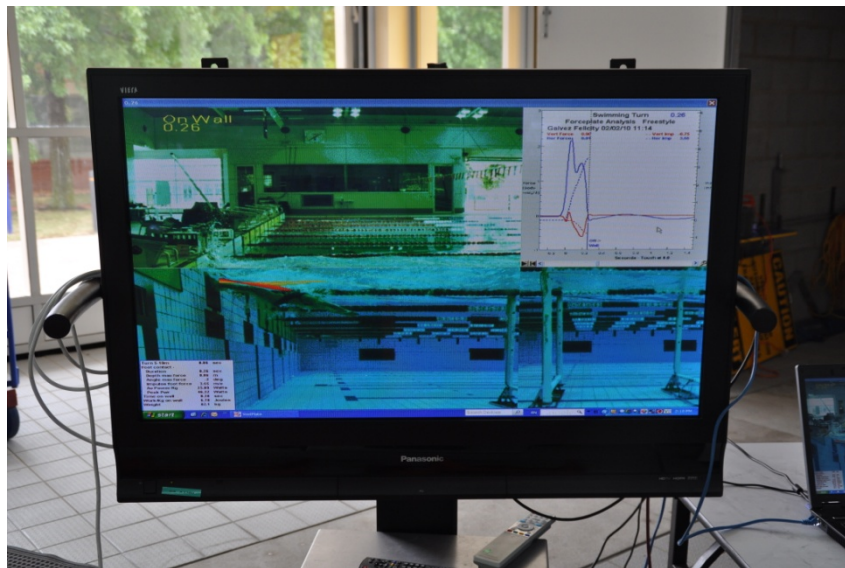

Figure 2: Wetplate plasma screen showing footage from the 4 GigE cameras of a turn analysis with associated force curve of a swimmer.

Separate to the Wetplate analysis visual image from the four Gig E cameras, there is another image also provided. This image is videoed by cameras that film from a moving trolley that travels along the side of the pool and which is powered by a golf buggy (Figure 3). The image stays level with the swimmer. This provides a split image that combines the view from two cameras, one above and one below the surface of the water. At the present time it provides only analogue video signals which are combined to produce a single video image using an analogue video mixer. There is in addition to the side on footage, an image of the trial from above using another analogue camera. These analogue cameras are soon to be replaced with machine vision Gig E cameras.

Figure 3: Filming trolley pulled by modified golf cart using two filming cameras (1 above & 1 below the water surface).

RESULTS: The Wetplate computer collects the information from all sources and provides the completed analysis within minutes of the trial being conducted. The computed analysis

data information is stored on the A.I.S. network so that feedback can be conducted elsewhere, but is usually presented on a large plasma screen with the analysis being controlled by a laptop computer on the pool deck behind the starting block and away from the Wetplate capture computer (Figure 2). At the same time, the Wetplate capture computer may be collecting information from another trial, enabling several swimmers to be tested during the one session. When viewing the Wetplate analysis, the visual information from the machine vision Gig E cameras is always available to be displayed. Other kinetic and kinematic analysis information can also be provided by way of switching it on or off via a selection tab. The other analysis information included in the kinetic analysis is the time history of the vertical force, horizontal force, grab bar force, rear plate force and resultant velocity of the centre of gravity (CoG) of the swimmer in both the vertical and horizontal directions. As well as the force graph, a power graph may also be displayed. The force vectors may be displayed over the visual image of the swimmer on the starting block or turning wall during the visual replay of the trial. As the indicator time line moves along the graph, the visual image is incremented accordingly, a frame at a time either manually or automatically. Once the swimmer leaves the block, the force graph is replaced by a displacement velocity graph which indicates the velocity and displacement from the wall in sequence with the visual image being displayed. Also displayed on the visual image is the leave block time and the velocity achieved during starts and the impulse achieved during turns. In starts, the distance of entry out from the wall, the size of the entry hole as well as the angle and velocity of entry are superimposed over the visual display. During the underwater phase of the start or turn, the time, displacement and depth are provided at the location of maximum depth as well as time and displacement at break out. A theoretical trajectory of the swimmer's path is also provided. There is also an information box which provides information concerning each trial. For starts this includes: Time to 15 m, Time on block, Take off horizontal velocity, Take off vertical velocity, Angle of CoG on leaving block, Average acceleration, Average power and Peak power. For turns it includes: Turn time, Foot contact duration, Foot contact depth at maximum force, Direction of maximum force, Average power during foot contact, Peak power during foot contact as well as total time on the wall. One of Wetplate's greatest attributes is its ability to display the analysis of two trials at the same time, synchronised by starting signal for starts or by wall contact for turns. This then provides a comparison between the one athlete at different times or of two different athletes.

DISCUSSION: This paper has discussed the purpose, the structure, the capabilities and the analysis that is provided by the Wetplate computer programme. Wetplate provides a very advantageous environment when the coach provides the feedback to the swimmer. The two major attributes of the Wetplate programme are its ability to provide a comparison analysis of two different trials on the one screen and its capability to provide almost immediate feedback. The immediate feedback enables the coach to identify inefficiencies and try various solutions as well as to objectively assess the effectiveness of these solutions from future trials.

CONCLUSION: This paper provides an example of a modern specific biomechanical analysis tool used in elite competitive swimming and how it is able to provide performance enhancement information for elite swimmer's starts and turns. In relay changeovers the initiating point is the touch on the wall by the incoming swimmer and other than that, the remainder of the changeover analysis is similar to the start analysis.