# CHARACTERISTICS OF ELITE SWIM START PERFORMANCES

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It is generally undisputed that the start is of paramount importance in elite competitive sprint swimming. Accordingly, there is a need to identify the value of those parameters at the start that are typical of international elite performance. This will enable coaches and skill technicians to assist sprint swimmers to improve their performance in this aspect of competition. Using the Wetplate analysis system many elite international swimmers were analysed performing a start. Selected parameters for five elite freestyle, butterfly, backstroke and breaststroke swimmers for both genders, that represented the best starters in each group, was used to identify the value of these parameters. Even if the coach does not work with sophisticated analysis systems, the information supplied in this paper is of vital importance to identify possible inefficiencies in swim start performance.

**KEY WORDS:** swimming, competition, start, analysis, elite, Wetplate

**INTRODUCTION**: The Australian Institute of Sport developed a unique analysis system called Wetplate in 2006, to analyse the start performance of elite competitive swimmers in a training environment (Mason et al 2012). The system provided immediate computerised quantitative information concerning each starter's performance along with an above/below water video image of the swimmer to the 15m mark. The quantitative information supplied for each trial included: time to leave the block from the start signal in s, centre of gravity (CoG) horizontal velocity upon leaving block in m/s and CoG dive angle trajectory upon leaving the block in deg, overall peak power generated by the swimmer per Kg of body mass in W, peak horizontal force in body weight, peak grab force in body weight, peak absolute force on the kick plate in body weight, distance from the block to where the swimmer's head entered the water in m, the size of the swimmer's entire body entry hole through the water surface in m, the angle that the CoG trajectory entered the water in deg, CoG overall velocity at head entry in m/s, the maximum depth reached under the water in m, breakout distance from the block in m and the time that the head passed the 15m mark from the starting block in s. The quantitative information provided by the Wetplate system is used by Australian national team coaching staff to objectively evaluate a swimmer's start and provide feedback to enhance start performance. In order for the coach to effectively assess a swimmer's start technique, the coach must be provided with some suggested ideal parameter values associated with elite start performance. The objective of this paper was to provide the reader with the characteristics of elite swimmers during the start. The paper provides such information so that coaches, technicians and biomechanists are familiar with the biomechanical characteristics of elite swim starts.

**METHOD:** Since 2006 many of the Australian national swim team members as well as a large number of elite international swimmers have had their start performances analysed using the Wetplate system. The swimmer's data used in this project was that of the quickest start for the fastest starters in each stroke, as defined by the time taken from the starting signal to the time the swimmer's head passed the 15m mark. Most of the swimmers whose data was used in this paper were at the level of finalists at world championships and Olympic swim meets. Some of the swimmers were actually world champions. Five each of the best male and female starters in each of the four strokes was selected to be included in the analysis. Block time is defined as that period of time that has elapsed between the starting signal and when the swimmer's feet actually leave the block, identified by near zero vertical

and horizontal force measured by force transducers within the block. Horizontal velocity off the block is calculated as an integral using the horizontal component of force during the period from the start signal until the swimmer leaves the block and assuming no movement at the time of the starting signal. Both the vertical and horizontal components of force are used to compute the vertical and horizontal velocities when leaving the block. These two velocities determine the angle off the block with –ve indicating a downward direction. Power is the product of force and velocity and both these are derived from the force transducers in the block. Peak power is defined as the maximum point in the power output parameter and measured as per Kg of body mass. Research by (Mason et al, 2006) identified peak power as highly correlated with swim start performance in the swim track start. Peak horizontal force, peak grab force and peak force on the inclined foot plate is identified as the maximum value in each of the three force parameters and obtained from force transducers in the block. Each of these forces is expressed in body weight to enable comparisons between starters of varying mass. Head entry point is defined as the distance from the block to the location of head entry into the water in m. The size of the entry hole is defined as the distance between the forward and backward entry points of the body into the water in m and obtained by digitisation from the video image. The angle of entry of the CoG of the body's trajectory into the water and the velocity of entry is computed using a simple gravitational projectile motion model to calculate the CoG path using the digitised CoG location at the instant of leaving the block, together with the vertical and horizontal velocities of the CoG at that instant and under the force of gravity. The maximum depth reached and the distance of breakout from the block in m is obtained from digitisation of the video image. Time to reach the 15m mark in s is obtained from a stationary video camera (50 fields/s) synchronised with the starting signal and located high on the pool wall and facing perpendicularly across the pool at the 15m mark.

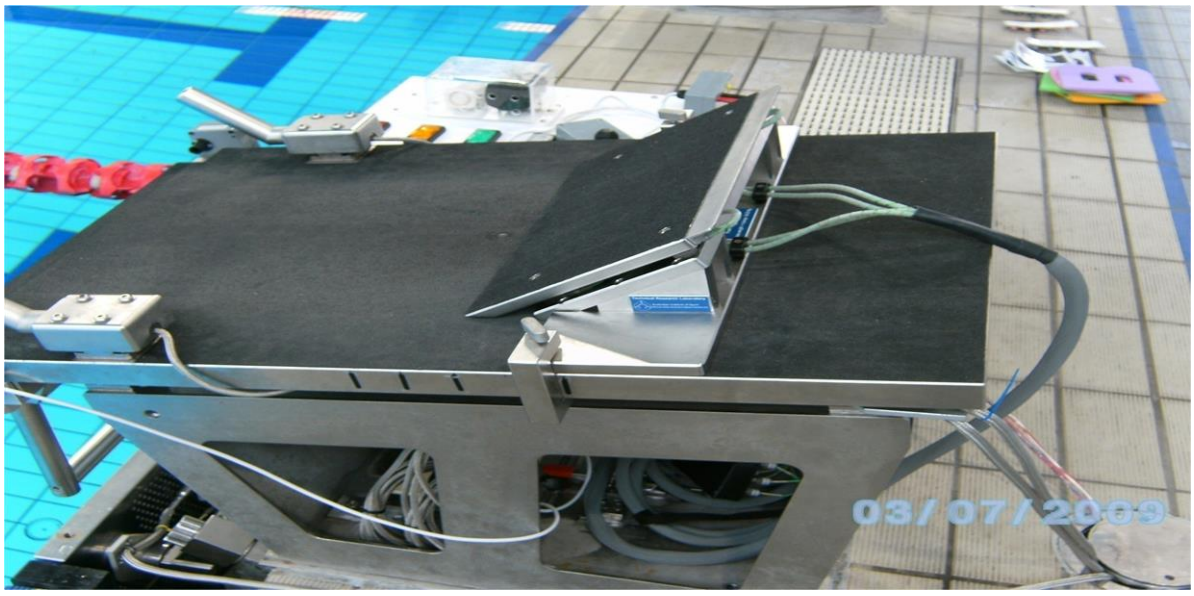


**Figure 1: Wetplate Starting Block with top surface a Kistler force platform and inclined kick plate as a miniature force platform. Hand force is measured by two transducers attached under the front surface of the block.**

**ANALYSIS:** The mean and standard deviation for each of these start parameters was computed for the best five starters for each swimming stroke and each gender.

**RESULTS:** The mean values for the elite male and female start performance parameters in each of the four swimming strokes are listed in the tables below.

**Table 1A, 1B, 2A & 2B:** Lists the characteristics of both male and female elite international swimmers performing the start and broken into the four swimming strokes, using a starting block with the inclined rear kick plate at the swimmer's nominated setting.

| Table 1A MALE | | Time on Block (s) | Take-off Horiz.Vel (m/s) | Dive Angle (deg) | Pk Pwr/kg (W) | Peak Horiz Force (BWt) | Peak Grab Force (BWt) | Peak Ft plate Force (BWt) |
|---|---|---|---|---|---|---|---|---|
| Freestyle | Mean | 0.71 | 4.67 | -11.1 | 63 | 1.37 | 0.93 | 1.75 |
| | SD | 0.04 | 0.63 | 3.3 | 14 | 0.26 | 0.28 | 0.35 |
| Butterfly | Mean | 0.69 | 4.83 | -8.8 | 66 | 1.43 | 0.97 | 1.78 |
| | SD | 0.02 | 0.14 | 2.0 | 6 | 0.20 | 0.16 | 0.48 |
| Backstroke | Mean | 0.63 | 4.02 | -10.5 | 54 | 1.47 | | |
| | SD | 0.06 | 0.61 | 3.8 | 8 | 0.07 | | |
| Breaststroke | Mean | 0.69 | 4.68 | -12.2 | 66 | 1.44 | 0.79 | 1.83 |
| | SD | 0.03 | 0.57 | 4.6 | 9 | 0.27 | 0.23 | 0.24 |

| Table 1B MALE | | Entry distance (m) | Entry Hole Diameter (m) | COG Angle of entry (deg) | Entry velocity (m/s) | Max Depth of Head (m) | Distance @ Breakout (m) | Time to 15m (s) |
|---|---|---|---|---|---|---|---|---|
| Freestyle | Mean | 3.12 | 0.72 | 47.00 | 6.84 | -0.88 | 10.32 | 5.83 |
| | SD | 0.18 | 0.15 | 4.11 | 0.44 | 0.22 | 1.75 | 0.18 |
| Butterfly | Mean | 3.13 | 0.60 | 46.30 | 7.00 | -1.15 | 14.01 | 5.79 |
| | SD | 0.18 | 0.14 | 0.95 | 0.11 | 0.06 | 0.28 | 0.09 |
| Backstroke | Mean | 2.46 | 0.71 | 37.50 | 4.44 | -1.35 | 13.96 | 6.50 |
| | SD | 0.21 | 0.20 | 5.67 | 1.43 | 0.15 | 0.63 | 0.30 |
| Breaststroke | Mean | 2.94 | 0.72 | 46.24 | 6.78 | -1.02 | 12.90 | 6.97 |
| | SD | 0.13 | 0.16 | 3.69 | 0.39 | 0.13 | 0.57 | 0.17 |

| Table 2A FEMALE | | Time on Block (s) | Take-off Horiz.Vel (m/s) | Dive Angle (deg) | Pk Pwr/kg (W) | Peak Horiz Force (BWt) | Peak Grab Force (BWt) | Peak Ft plate Force (BWt) |
|---|---|---|---|---|---|---|---|---|
| Freestyle | Mean | 0.71 | 4.56 | -16.4 | 52 | 1.22 | 0.83 | 1.46 |
| | SD | 0.02 | 0.18 | 5.8 | 11 | 0.15 | 0.27 | 0.22 |
| Butterfly | Mean | 0.75 | 4.45 | -16.2 | 51 | 1.11 | 1.08 | 1.30 |
| | SD | 0.03 | 0.27 | 1.6 | 6 | 0.11 | 0.06 | 0.13 |
| Backstroke | Mean | 0.67 | 3.12 | -7.8 | 38 | 1.28 | | |
| | SD | 0.07 | 1.26 | 7.9 | 18 | 0.16 | | |
| Breaststroke | Mean | 0.79 | 4.44 | -16.0 | 51 | 1.20 | 0.78 | 1.46 |
| | SD | 0.07 | 0.12 | 4.5 | 5 | 0.11 | 0.19 | 0.30 |

| Table 2B FEMALE | | Entry distance (m) | Entry Hole Diameter (m) | COG Angle of entry (deg) | Entry velocity (m/s) | Max Depth of Head (m) | Distance @ Breakout (m) | Time to 15m (s) |
|---|---|---|---|---|---|---|---|---|
| Freestyle | Mean | 2.75 | 0.75 | 46.50 | 6.63 | -0.94 | 4.53 | 6.58 |
| | SD | 0.17 | 0.16 | 1.40 | 0.12 | 0.05 | 0.36 | 0.13 |
| Butterfly | Mean | 2.73 | 0.68 | 47.56 | 6.61 | -1.01 | 5.66 | 6.72 |
| | SD | 0.15 | 0.15 | 2.37 | 0.16 | 0.22 | 0.82 | 0.05 |
| Backstroke | Mean | 2.30 | 0.92 | 45.94 | 3.55 | -1.03 | 6.46 | 7.59 |
| | SD | 0.33 | 0.27 | 15.06 | 1.92 | 0.24 | 1.48 | 0.57 |
| Breaststroke | Mean | 2.66 | 0.72 | 47.54 | 6.60 | -0.91 | 5.49 | 7.51 |
| | SD | 0.25 | 0.22 | 1.40 | 0.22 | 0.19 | 1.16 | 0.56 |

**DISCUSSION:** For many years coaches had to rely on just visual video images and superficial times to evaluate the quality of a swim start, from which to identify the changes that were needed to enhance the performance. Since the mid 2000's complex computer aided start analysis systems have begun to evolve to assist the coach in the detection of inefficiencies that occur during the start. Wetplate is an example of such a system. Up until recently, all of the start analysis systems have been developed by sports biomechanists for working with the coaches of elite international swimmers. It is anticipated that very soon commercial start analysis systems will be available to purchase on the open market. Such analysis systems do not instruct the coach with what is needed to be changed in the execution of the swimmer's start in order to enhance the performance. What is provided are objective, quantitative measures associated with the execution of the particular start. It is up to the coach and biomechanist to then identify from these objective measures provided, what is good and what should be changed. It takes many such analyses for a coach and biomechanist to have enough experience to perform this task and the question that always arises is what are the parameters associated with other elite swimmer's starts. This paper attempts to provide such answers.

**CONCLUSION:** The descriptive statistics derived from this study are able to be used by coaches, swimmers and technicians to identify strengths and weaknesses of particular start performances. Without such information it is difficult to ascertain where a swimmer should concentrate their efforts to improve performance when working with the Wetplate and other computerised swim start analysis systems. Coaches often require such information when working with swimmers without the use of an analysis system, just to visualise how the swim start should be performed. This data should also dispel many coaching myths about start performance.

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