SWIM START PERFORMANCES AT THE SYDNEY 2000 OLYMPIC GAMES

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The starting performance of finalists and semi-finalists in the swimming competition at the 2000 Olympic Games was analyzed. Start times were shown to consist of between 0.8% and 26.1% of the overall race time depending on the event. The start time was then broken into various phases to determine the significance of each phase on the overall start time. It was shown that the most significant variables in determining a fast start time were the underwater distance and time for both the male and female events. However, individual differences were found for all events so coaches must take these into account when training the start phase of a race with their swimmers.

KEY **WORDS:** competition analysis, swimming, starts, elite performance, Olympics

INTRODUCTION: Over the last five years, competition or race analysis has become a regular feature in most international calibre swim meets. Swim start information from the race analysis has generally been limited to providing the time it takes for the swimmer to reach a set distance after the start signal (15 m in the Australian competition analysis) and possibly the time the swimmer takes to leave the blocks. Although each swimmer has a unique start distance for each start, a set distance is used to define all swim starts in competition analysis in order to enable comparisons to be made between swimmers. The international rules for swimming competition dictate that swimmers must re-surface from the under water phase of starts by the 15 m mark from the wall in all strokes. This makes the 15 m mark an ideal location to set the finish of the start phase distance.

Swimming starts have previously been researched by many scientists looking at the differences in the grab versus the conventional start (Bloom et al., 1978; Nelson & Pike, 1978; Havriluk & Ward, 1979). Others have reported on the importance of the start in its contribution to the overall race performance (Mason & Cossor, 2000). Bloom et al. (1978) measured the reaction time as the time of the first visible movement after the starting signal but included a movement time, which was the time a swimmer's feet left the block. The flight phase was defined as that period between the swimmer leaving the blocks until the time that the swimmer's hands reached the predetermined 10 foot mark (Bloom et al, 1978). Havriluk and Ward (1979) measured a response time that was defined as the time from the starting signal until when the swimmer left the block, but also divided this into two separate phases – reaction time and movement time. Mills and Gehlson (1996) also measured flight time in their analysis of starts but did not define this phase.

A more detailed analysis of the start in elite competition would lead to a better understanding of the techniques used by the best starters in each event. Therefore, this study set out to determine and define the various sub phases of the start in a swimming race in which time, distance and velocity parameters could be measured easily and accurately in a competition environment. The relationship between these parameters and overall start time would then be examined.

METHOD: Competition analysis was conducted at the Sydney 2000 Olympic Games by the Australian Institute of Sport (AIS) Biomechanics Department using the Australian Format for the presentation of the results. Five Sony TRV-900E cameras were located on the gantry directly above the pool and were used to gather data for the competition analysis. Information derived from these cameras included stroke length, stroke frequency, interval velocity and start, turn and finish times, as well as the 25 m split times (Mason & Cossor, 2000).

To examine the start, critical pieces of information were examined including:

- the time that it takes for the swimmer to leave the block,
- the time and distance that the swimmer is in flight,

- the time and distance traveled under the water
- the time taken to reach the predetermined set distance

Two additional cameras located at approximately 5 m from either start end of the pool were used to monitor this information. Only lanes 5-8 at the 100 m start end and lanes 1-4 at the 50 m start end were analyzed due to the obstruction of views from this position. The starts were divided into sub phases using the AIS start and turn analysis computer program. All cameras operated at 25 frames per second with the analysis utilizing 50 fields per second.
The time that the swimmer left the block and the time and distance information of the swimmer's head was collected when the swimmer entered the water and re-surfaced during the start. Leave block time was the time between the starting signal and the time when the swimmer's feet left the blocks. This information was provided by the official competition timing system. The flight phase was defined as that interval between leaving the blocks and the head making contact with the water. The underwater phase was defined as the interval between head contact with the water and the head re-surfacing. The above water phase consisted of the interval from head resurface until the center of the head reached the 15 m mark. Total start time was calculated as the time from the starting signal until the time the swimmer's head passed the 15 m mark.
Pearson Product Moment Correlation statistics were used to determine the relationship of the various starting sub phases with the total start time (the criterion measure).

RESULTS AND DISCUSSION: Men's Events: Time Spent Leaving the Block. In the Men's competition, the only events that displayed a significant positive correlation, for the leave block time with the 15 m start time, were the 100 m Butterfly and 400 m Individual Medley events. These correlations indicated that the slower the time to leave the blocks, then the slower was the 15 m start time. Leave block time would obviously be more crucial in the sprint events than the distance races.
Time and Distance Traveled Underwater. Underwater distance was negatively correlated at a significant level for the 200 m Butterfly, 100 m Backstroke and 100 m Freestyle races (Table 1). Therefore, as the distance of the underwater phase increased, the 15 m start time decreased. A similar significant negative correlation was displayed for the time of the underwater phase with the 15 m start time in the 100 m and 200 m Butterfly events, 100 m Backstroke and 100 m Freestyle events. In the 200 m Butterfly and 100 m Freestyle events significant negative correlations were found for the underwater distance and time parameters with total start time.
Underwater Velocity. A significant negative correlation was also displayed between the underwater velocity and the 15 m start time in the 100 m Backstroke and 100 m Breaststroke events. This would suggest that the greater the underwater velocity that a swimmer maintained in these events, the faster their total start time.
Start Velocity. A significant correlation was also seen in the 200 m Freestyle race for the post start velocity with the 15 m start time. This indicated a tendency for the faster starters to 15 m to also be able to maintain higher post start free swim velocities.
Women's Events: Time Spent Leaving the Block. In the women's 100 m Breaststroke event, the leave block time displayed a significant positive correlation with the time to reach the 15 m mark. Swimmers that took longer to leave the blocks also took a greater time to reach the 15 m mark.

Table **1** Significant **(0.05)** Correlations Between the Various Starting Phase Parameters with **15** m Total Start Time for Men.

Men Start	**100** rn Fly (n=10)	**100** rn Back (n=10)	**100** m Breast (n=11)	**100** m Free (n=10)	**200** m Fly (n=10)	**200** rn Free (n=9)	**400 m** IM (n=4)
Leave Block Time	0.629						0.928
Flight Dist							
Flight Time							
U/W Dist.		-0.843		-0.665	-0.886		
U/W Time	-0.602	-0.650		-0.614	-0.737		
U/W Vel.		-0.818	-0.734				
Post Swim Velocity						-0.634	

Time and Distance Traveled Underwater. The underwater distance, time and velocity displayed a significant negative correlation with the 15 m start time in the 200 m Butterfly. In the 200 m Breaststroke event there was also a significant negative correlation for the underwater distance and velocity with the start time to 15 m. Similar to the men's events, those swimmers who spent a longer time and traveled a greater distance underwater had faster 15 m start times.
Time Spent in Flight. Flight distance and flight time displayed a significant positive correlation and underwater distance and velocity displayed a significant negative correlation with the 15 m start time in the 100 m Backstroke. In other words, the further out that the swimmer entered the water and the longer it took before entry, the slower was the overall start. On the other hand, the further that the swimmer traveled underwater and the greater average velocity attained during this phase, the faster was the start. The 200 m Individual Medley event analysis also indicated that the further the distance attained in the flight phase, the faster the 15 m time.

Table **2** Significant **(0.05)** Correlations Between the Various Starting Phase Parameters with the **15** rn Start Time for the Women's Events

Women Start	**100** m Back (n=11)	**100** m Breast (n=10)	**200** m Fly (n=9)	**200** m Breast (n=9)	**200** rn Free (n=11)	**200** rn IM (n=10)	**400 m** Free (n=4)
Leave Block Time		0.711					
Flight Dist	0.662					-0.667	-0.936
Flight Time	0.751						-0.929
U/W Dist.	-0.646		-0.942	-0.651	-0.653		
U/W Time			-0.895		-0.605		
U/W Vel.	-0.894		-0.699	-0.780			
Post Swim Velocity							

The freestyle events only showed significant correlations in the 200 m and 400 m events. The 200 m Freestyle demonstrated a significant, negative correlation for the underwater distance and time with the 15 m start time. The start time in the 400 m events were most related to the flight time and distance. In the lesser distance events faster entry times were related to the swimmer reaching the 15 m mark faster.
The underwater phase was a major contributor to superior start performance. An indication of the time and distance contributions is provided in Figure 1. From this it can be seen that the

ratio of the underwater distance to start distance is greater than the ratio of the underwater time to start time in the longer events. In events where both the men and women showed significant correlations with the start time, the men were able to utilize the underwater phase of the start better than the women.

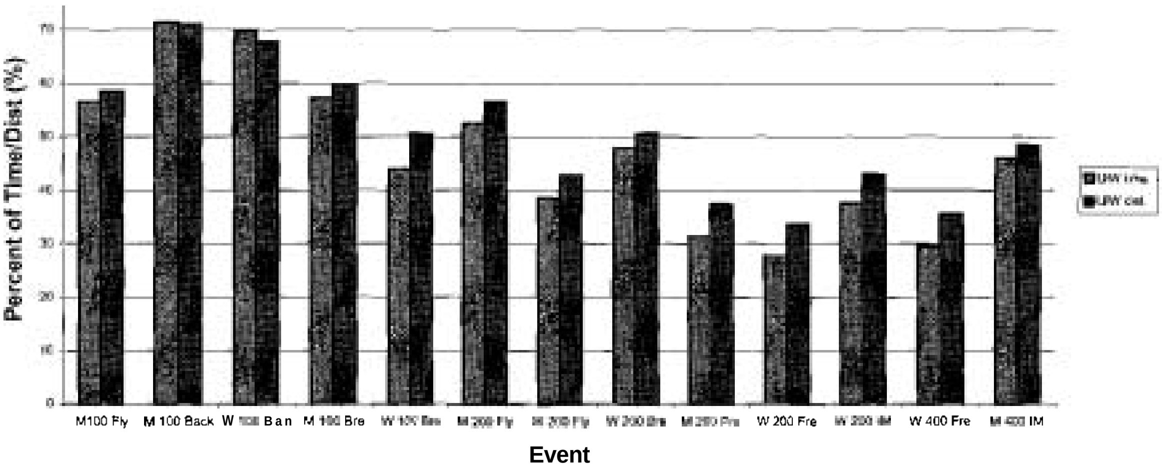

Figure **1 -** Underwater distance as a percentage of total start distance and underwater time as a percentage of total start time.

CONCLUSION: There are various parameters that are used to examine performance in the Australian swimming competition analysis and these include the overall start, turn and finish times as well as stroke length, stroke frequency and free swim velocity for each 25 m race section. A more detailed analysis of the start phase was believed to be necessary in order to determine the sub phases within a start that most influence the overall starting time. The level of importance of the underwater phase as a percentage of the 15 m start time was also highlighted (Figure 1). By examining the influence of the time and distance parameters for the leave block phase, flight phase, underwater phase and above water phase in relation to the 15 m start time, it was possible to determine using correlation statistics that the underwater phase of the start had the greatest influence on the time of the race start phase. Future studies should examine the maximum depth that a swimmer reaches during their dive phase and how this influences the 15 m start time. Larger sample sizes in future would also increase the possibility of finding more significant correlations.

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