SWIM TURN PERFORMANCES AT THE SYDNEY 2000 OLYMPIC GAMES

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Swim turn performances of the top 16 finalists at the Sydney Olympics were analyzed to identify the better characteristics of elite performance. Overhead cameras were used to obtain timing, distance and velocity characteristics of the push off and underwater phases of turns. This information supplemented the race analysis data that provided the time for the in phase and out phase of turns. Correlation statistics, using total turn time as the primary criterion measure, were used to examine relationships. The most significant aspect of the turn was the underwater phase. Swimmers that had a longer underwater phase, during the out phase of the turn, in butterfly, backstroke and breaststroke events gained a greater advantage from quicker turns than swimmers with lesser underwater distances.

KEY WORDS: competition analysis, swimming, turns, elite performance, Olympic

INTRODUCTION: Swim turn performance has been studied in depth over the last 20 years to evaluate technique and its relationship to performance. Thayer and Hay (1984) stated that turns comprised up to 33% of total race time in short course competitions and therefore were an important consideration when examining race performance at the elite level.

Research has been conducted in both training (Lyttle & Mason, 1997; Lyttle et al., 1999) and in competition (Chow et al., 1984; Chu, Luk, & Hong, 1999) to evaluate turning technique. Lyttle et al. utilised underwater video and force measurement in such analysis. This enabled the researchers to accurately identify the forces exerted during the swimmer's turning motion. Chow et al. (1984) set up cameras during the 1982 British Commonwealth Games in Brisbane to examine the time, distance and velocity parameters for both the in and out phases of the turn. Distance in was calculated only in the freestyle events and was defined as the distance between the head and the wall at the time that the swimmer's hand entered the water on the last stroke into the wall. Distance out was calculated using the distance between the vertex of the head and the wall at the instant that the swimmer had completed a full stroke cycle after the turn. The time at these locations and average horizontal speed was calculated during the out phase in the freestyle turns. Although Chow et al. (1984) and Chu et al. (1999) were able to use information collected at an international level swimming competition, set distances were not used to determine turn times. Therefore, comparisons could not be readily made between swimmers.

The present study aimed to examine the characteristics of turning technique for elite swimmers and determine important characteristics that could be used to improve turn performance. The turns of finalists and semi-finalists in all strokes and distances for both genders at the Sydney 2000 Olympic Games in swimming competition were analyzed to provide this information.

METHOD: The turns of swimmers in the finals and semi-finals at the 2000 Olympic Games were analyzed by a research group headed by the Australian Institute of Sport Biomechanics department. Stroke length, stroke frequency and interval velocity for each free swimming phase of the race as well as start, turn, and finish phase times, 25 m split times and 50 m split times were computed using the swimming competition analysis program developed at the AIS. The in phase of the turn was the period from the 7.5 m mark out from the wall until wall touch and the out phase of the turn was the period from wall touch back out to the 7.5 m mark. The total turn was the in turn and out turn phases combined together. The pre-turn free swim phase was the period that the swimmer traveled from the 25 m mark to the start of the turn and the post-turn free swim period extended from the end of the turn until the swimmer again reached the 25 m mark. The program used the images from five cameras located on the gantry and split times from the pool's official timing system to compute this information.

Two other Sony TRV-900E cameras involved in the data capture were specifically used to monitor turn performance. Unfortunately, due to obstructions in the viewing field of these cameras, it was not possible to view all eight lanes at both ends of the pool. As a consequence, turns were monitored in lanes 5-8 at the finish end and lanes 1-4 at the non-finish end. The turns were further subdivided into phases using the AIS Biomechanics start and turn analysis computer program that provided the time and distance as the swimmer pushed off the wall and re-surfaced. By digitizing the swimmer's head at these events in the turn, the swimmer's time, distance and velocity for each of the push-off, under water and above water sub phases of the out turn were computed. All measurements used the center of the swimmer's head to represent the swimmer. The on wall time was initiated when the swimmer touched the wall (provided by the official timing) and terminated the moment the feet of the swimmer left the wall. This event was difficult to determine precisely in some races due to splash on the wall. The researchers therefore determined that the underwater time and distance should include the time spent on the wall as well as the time spent under the water after leaving the wall. This was due to inaccuracies that may have occurred because of the difficulty in determining the exact time that the feet left the wall. However, the underwater average velocity was calculated from a location soon after the swimmer's feet left the wall until the swimmer's head re-surfaced.
Statistical analysis involving Pearson Product Moment Correlations were used to determine the relationship for the parameters representing the turn sub phases with the criterion measure, representing the quality of the turn performance. Total turn time was used as the criterion measure. The time, distance and average velocity in each of the sub phases of the turn were the parameters that represented the phases of the turn. The in turn and the out turn phases were also compared with each other as was the free swim velocity prior to the turn with the turn velocity.

RESULTS AND DISCUSSION: The pre turn swim velocity was not significantly related to turn velocity (Table 1). This implies that free swim performance does not necessarily reflect a similar ability in turns.

Table I Significant (0.05) Correlations of the Various Turning Phase Parameters with **Total** Turn Time for the Men's Events

Turn	**100 m** Fly (n=9)	**100 m** Back (n=9)	**100 m** Breast (n=10	**100 m** Free (n=9)	**200 m** Fly (n=16)	**200 m** Back (n=16)	**200 m** Breast (n=16)	**200 m** Free (n=16)
Pre Velocity vs. Turn Velocity								
In Turn Time vs. Out Turn Time	-0.77		-0.81					
Underwater Distance vs. Turn Time	-0.88	-0.72					-0.73	
Underwater Time vs. Turn Time	-0.87	-0.83					-0.48	
Underwater Vel vs. Turn Time								
In turn vs. Turn Time				0.84		0.62		0.79
Out turn vs. Turn Time	0.93	0.81		0.91	0.79	0.76	0.94	

There was a significant negative correlation (r = -0.767) between the in turn and out turn times in the Men's 100 m Butterfly and 100 m Breaststroke (r = -0.812). This suggests that the swimmers who were the fastest in leaving the wall were the slowest in the approach to the wall and vice versa. Time and distance for the underwater phase was negatively correlated with total turn time in the 100 m Butterfly, 100 m Backstroke and 200 m Breaststroke events. The underwater average velocity was not significantly related to turn time. This may be a consequence of the underwater velocity being calculated from the time after the feet pushed off the wall, whereas the underwater distance and time also included that period spent on the wall. The only turns that demonstrated significant correlations in the Men's Individual Medley were the turns that included butterfly (Table 2). The in turn and the out turn times were significantly related to total turn time in most events for both males and females.

Table 2 Significant (0.05) Correlation for the Various Turning Phase Parameters with Total Turn Time in the Men's Individual Medley Events

Turn	200 FIB (n=8)	200 BIB (n=9)	200 BIF (n=8)	400 Fly (n=4)	400 FB (n=4)	400 Back (n=4)	400 BB (n=4)	400 Breast (n=4)	400 BF (n=4)	400 Free (n=4)
Pre Vel vs. Turn Vel				0.999						
In Time vs. Out Time	0.68									
Underwater Distance	-0.82			-0.94						
Underwater Time	-0.67			-0.97						
Underwater Velocity					-0.90					
In Turn	0.88			0.91		0.91				
Out Turn	0.95	0.92	0.81		0.99			0.92		

In the women's events, a similar pattern emerged with significant correlations between the in turn time and out turn time for the 100 m Butterfly and 200 m Breaststroke events. Table 3 displays the significant relationships between the underwater phase distance and time parameters in the butterfly and backstroke events. Unlike the men, some significant correlations for the underwater velocity with total turn time existed. For both genders the out phase of the turn was more related to total turn performance than the in turn phase.

Table 3 Significant (0.05) Correlations for the Various Turning Phase Parameters with Total Turn Time in the Women's Events

Turn	100 m Fly (n=8)	100 m Back (n=10)	100 m Breast (n=10)	100 m Free (n=8)	200 m Fly (n=16)	200 m Back (n=16)	200 m Breast (n=16)	200 m Free (n=16)	400 m Free (n=8)
Pre Vel vs. Turn Vel								-0.55	
In Time vs. Out time	-0.75						-0.57		
Underwater Distance	-0.74	-0.79			-0.69	-0.50			
Underwater Time		-0.80			-0.60				
Underwater Velocity					-0.66			-0.52	-0.79
In Turn				0.83	0.74	0.67		0.80	
Out Turn	0.96	0.85	0.85	0.94	0.78	0.91		0.77	

In the Women's Individual Medley events, the parameters associated with backstroke and breaststroke were most related to turn time (Table 4). It was noted that there were significant correlations for all variables in the 400 m butterfly to backstroke turn.

Table 4 Significant (0.05) Correlations for the Various Turning Phase Parameters with **Total Turn Time for the Women's Individual Medley Events**

Turn	200 FIB **(n=10)**	200 BIB **(n=10)**	200 BIF (n= 10)	400 Fly **(n=4)**	400 FB **(n=4)**	400 Back **(n=4)**	400 BB **(n=4)**	400 Breast **(n=4)**	400 BF **(n=4)**	400 Free **(n=4)**
Pre Vel vs. Turn Vel					0.93			0.90	0.96	
In Time vs. Out Time					0.93					0.90
Underwater Distance		-0.76			-0.91				0.88	
Underwater Time		-0.75			-0.89					
Underwater Velocity			0.67	-0.94	0.93		-0.92			-0.99
In Turn		0.70	0.66		0.97	0.99	0.90	0.96		0.95
Out Turn	0.91	0.76			0.99					0.99

CONCLUSION: The analysis of turns at the Sydney 2000 Olympic Games swimming competition, performed by the Australian Institute of Sport Biomechanics Department, identified that the fastest free swimmers were not necessarily the fastest turners and that the most significant aspect of the turn performance was the underwater phase including the action of pushing off the wall. Underwater distance and time were significantly related to the total turn time in the form strokes for both genders. The further the distance and longer the time spent in the underwater phase of the turn, the faster the total turn performance tended to be. This information indicates that at the elite international level, swimmers should try to utilize the underwater phase for as long and as far as the rules permit. A good underwater phase begins by pushing off the wall effectively, then maintaining good streamlining during the glide and at the appropriate time initiating an effective underwater kick to gain the most advantage from the turn. Future studies could examine the depth of the swimmer during the execution of the underwater phase of the turn in relation to performance.

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