Where are Races Won (and Lost)?

Articles from Scientific Conferences

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An analysis of the 1998 World Swimming Championship competition analysis data from Perth indicated that the relationship between the race performance and stroke length was not significant, apart from in the Mens 100 metre freestyle event. It was also evident that average free swimming velocity was related to the race performance for all events. This was to be expected. The race performance in the backstroke and breaststroke was related to both start and turn performance. In the butterfly events, race performance was related to turn performance. In the freestyle sprint events the start performance played a significant role whereas in the middle distance events, the turn performance was significantly related to the race performance. None of turn, finish, or start performance played a significant role in the distance freestyle events. In the individual medley events, turn performance was significantly related to race performance. The order of importance of free swimming velocity in the various strokes on race performance, with the exception of the Mens 200 metre individual medley, was in order backstroke, butterfly, breaststroke and freestyle. The above information is directly relevant to a general competition model. However, individual swimmer competition models may differ significantly from the general model

Introduction

Competition analysis was conducted at the 1998 World Swimming Championships in Perth by the Biomechanics Department of the Australian Institute of Sport. Assistance was provided by staff and students from the School of Biomedical and Sports Science at Edith Cowan University and by students from the Human Movement Department at the University of Western Australia. In total, the analysis involved 30 people and the analysis process continued around the clock for the duration of the championships, utilising a rotation of three analysis groups. The competition analysis was performed for every event on the swimmers who progressed from the heats to the finals in each event. The analysis was performed on both the swimmer's heat and final performances. The information from the analysis was made available to each swimmer analysed in the form of handout sheets. The handout for each swimmer contained an individual analysis sheet, an individual graph of the relationship of stroke rate and stroke frequency to the swimmer's velocity, a graph of the swimmer's velocity throughout the race in relation to that of the first and second place getter's velocity, and a summary spreadsheet for the event that contained the analysis information for all finalist competitors. The handout was provided to each swimmer prior to the next competition session commencing. A comprehensive booklet containing spreadsheets for all finalist performances in each event was provided for every nation that competed. The complete analysis booklet was available to the national swim teams from the morning following the last day of the championships.

The primary purpose of the handout was to provide the coach and the swimmer with feedback as to how well the swimmer competed. The information presented in the handout could be used to identify how the swimmer performed in relation to his or her competition model and this could then be used to fine tune the swimmer's competition model for the final of the event or to perform a total revaluation of the competition model. A total change in the swimmer's competition model would only be attempted between different competition meets where there was plenty of time to train the swimmer to the new model. The information provided from the heats could be used by the coach to make small adjustments to the swimmer's tactics prior to the finals of the event concerned. Probably the best illustration of this was in the 1500 metres Mens Freestyle event at the Atlanta Olympics in which Kieren Perkins only just qualified, by some hundredths of a second, in the eighth spot for the final of the event. The competition analysis from the heat performance indicated that Kieren lost most of his time to the other finalists in the turns. Kieren's coach, John Carew, was made aware of this problem. Even though Kieren was sick with a stomach cramp complaint at the time of the heats, the analysis information identified for Coach Carew that he and Kieren needed to concentrate on the turns in the final. The rest is history as Kieren easily won the gold medal in the 1500 metres Mens Freestyle at Atlanta. Not only is the analysis information from the heats essential for the swimmer's performance to be optimised in the particular competition. The analysis of a final may be used to make effective changes to a swimmer's competition model in the same stroke but over a different distance prior to the heats being conducted for that event.

Competition analysis can best be used to identify where a swimmer's weaknesses exist. It is far more economical to improve a swimmer's performance by eradicating weaknesses than working on the swimmer's strengths. A swimmer's weaknesses or inefficiencies can be identified by examining the competition analysis of the swimmer's performance in comparison to that of swimmers of roughly equal ability. A swimmer's weakness may involve the start, the turns, the finish or the overall free swimming performance. It could also be associated with how the free swimming is performed over the various sections of the race. The swimming velocity is the overall measure of the free swim performance, but the stroke frequency and stroke length are the two major ingredients that result in the swimming velocity that is achieved. It may have been one of either stroke length or stroke frequency that determined whether or not there was a weakness in race strategy or swimming technique. Once a weakness is identified, the swimmer's competition model may be changed by the coach to define a better race stategy. The coach then needs to train the swimmer to the new competition model. Probably the best example of this occurred in the 1500 metres Mens freestyle at the Atlanta Olympics. Although Daniel Kowalski won the silver medal in this event he only managed to beat Graeme Smith of Great Britain by some hundredths of a second. The competition analysis revealed that Daniel lost over seven and a half seconds to Graeme in the turns. This implied that Daniel needed to make up the 7.5 seconds in the free swimming to beat Graeme Smith in the final. The identification of poor turning performance resulted in a revision of Daniel's competition model by the coach to incorporate faster turns. The coach then needed to train Daniel in the turns in order to enable him to perform to the new model during competition.

The analysis booklet which contains information concerning all the swimmers who competed in the finals, could be used to identify the way other swimmers and coaches have developed their competition model. It could also be used to identify general changes that have occurred in competition strategy as a consequence of rule change or technique enhancement. An example of rule change was the revision of the turn rule in the backstroke events to now allow the swimmer to rotate onto the front of the body followed by the tumble turn. How does such a change affect turning speed? An example of technique enhancement is the undulating breaststroke used by many women in preference to the flatter breaststroke. What changes to stroke frequency and stroke length occur as a consequence of such technique enhancement changes?

Apart from the benefit that can be gained by improving the performance of a particular swimmer, the competition analysis information can also be utilised in a statistical analysis to identify the factors that are important to a general model in the various events. Information gained from such research could be used to advantage by the coach through concentrating the swimmer's attention to those aspects of an event that are closely related to the event result. The research project attempted here was to identify those aspects of performance from the competition analysis which were related to the race performance in the various events.

Method

Following the competition analysis being completed, a Pearson correlation statistical analysis was performed on the data using the swimmers' result times as the criterion or dependent variable. The result time obtained by each of the 16 finalists was the best indicator of the race performance of each swimmer and therefore was used as the criterion variable for each event. This research has direct implication to elite performance, as the 16 finalist performances used in this study may be considered to be representative of the fastest 16 swimmers in the world for each event. A number of other variables, obtained for each of the finalist performances, from the competition analysis results were used as independent variables. These included free swim velocity, start time, turn time, finish time, stroke length, stroke frequency and efficiency index. The aim of this project was to identify any relationships these variables may have had with the race performance as determined by the official race time of the finalists. It should be noted here that although correlation statistical analyses may indicate that a significant relationship exists, it does not necessarily imply a cause and effect relationship. For instance just because turn time correlates highly with performance in a particular event it does not imply that turning ability by itself will determine the race result. However, it would suggest that possibly swimmers' abilities to turn quickly may be a significant factor in determining the result of the race. This could possibly be the case as all swimmers may have had similar free swimming velocities and it was the swimmer's ability to turn quickly that determined the race outcome. It should also be noted that the statistical analysis looks at features that are common to the majority of finalists. That is, the result of such statistical analysis relied upon common trends that were displayed by the majority of the swimmers. Another way to put it is that the implications here apply to a general model and not necessarily to particular swimmer's competition model. A single swimmer's performance may be affected by a particular relationship which would not be disclosed by this statistical analysis if the swimmer was significantly different in the way he or she performed compared to the other elite swimmers in the event.

The quality of the start was determined by the time it took in seconds from the starting gun until the swimmer's head passed the 15 metre mark from the starting block. The quality of the turn was determined by the time in seconds that it took from the swimmer's head to pass the 7.5 metre mark from the turning wall on the way in until the head again passed the 7.5 metre mark on the way out. The finish was determined by the time in seconds that it took the swimmer's head to pass the 5.0 metre mark from the finishing wall until the swimmer actually touched the wall. The 50 metre pool is divided into halves in order to examine the swimming velocity in metres per second throughout the race. The swimming velocity is measured in each of the pool's halves throughout the race. However, that part of the swimmer's performance that is considered as part of the start, turn or finish sections is not used in computing the free swim velocity. As well as measure the swimming velocity in the free swimming sections of the race, the stroke length and stroke frequency are also computed in these sections. Stroke length was measured in metres and stroke frequency in strokes per minute. The stroke length was defined as the distance the swimmer's head travelled from right hand entry until the next right hand entry. Stroke frequency was defined as the number of these stroke cycles that would occur in a minute if the present rating was continued. The efficiency index was defined as the product of stroke length and the average swimming velocity during that same section of the race. Efficiency indices can not be compared between strokes. It is debatable whether efficiency indices can be compared between swimmers using the same competitive stroke, however it appears quite meaningful to look at the change in efficiency for a particular swimmer throughout the race or for the same swimmer in different races. The higher the number for the efficiency index, the better was the swimmer's efficiency.

Results

The independent variables that related highly to performance in the various events are provided below (see also, Tables 1 to 7):

freestyle 50m & 100m

males: In the 50m, only free swimming speed (0.862) had a significant correlation with performance. This was at the 0.01 level of significance and this is not an unexpected observation. In the 100m, free swim velocity (0.792), start time (0.626), turn time (0.635), stroke length (0.640) and index (0.756) all correlated at the 0.01 level of significance with performance. That is, with improved performance, the free swimming speed increased, the start and turn times were reduced, and stroke length and the efficiency index increased.

females: In the 50m, free swimming speed (0.904) was significant at the 0.01 level and start (0.599) and finish (0.585) times were significant at the 0.05 level. That is, as performance improved the free swimming velocity increased and the start and finish times decreased. In the 100m, none of the independent variables correlated with performance.

freestyle 200m & 400m

males: In the 200m, free swim velocity (0.946) and turn time (0.782) were significant at the 0.01 level of significance. In the 400m, free swim velocity (0.893) and turn time (0.783) were significant at the 0.01 level of significance. That is, as performance improved the free swimming speed increased and the turn times decreased for both distances. Free swimming speed in the second 200m (0.823) correlated more highly than the first 200m (0.756) with performance in the longer event.

females: In the 200m, free swim velocity (0.945) was significant at the 0.01 level and turn time (0.587) was significant at the 0.05 level of significance. In the 400m, free swim velocity (0.914) and turn time (0.827) were significant at the 0.01 level of significance. That is as performance improved the free swimming velocity increased and the turn time decreased for both distances. Free swimming speed in the second 200m (0.913) correlated more highly than the first 200m (0.639) with performance in the longer event. Both were significant at the 0.01 level of significance.

freestyle 800m & 1500m

males: In the 1500m, free swimming speed (0.865) was significant at the 0.01 level and efficiency index

(0.721) was significant at the 0.05 level of significance. Performance improved as swim velocity increased and efficiency index increased. Free swimming speed in the second 750m (0.862) correlated more highly than in first 750m (0.758) with performance. Both were significant at the 0.01 level of significance. A sample size of only eight swimmers was used in the analysis.

females: In the 800 m, only free swimming speed (0.800) was significant at the 0.05 level of significance. Free swimming speed in the second 400m (0.906) correlated more highly at the 0.01 level of significance than the first 400m (0.317) at no significant level with performance. A sample size of only eight swimmers was used in the analysis.

butterfly

males: In the 100m, free swimming speed (0.902) was significant at the 0.01 level and turn time (0.499) was significant at the 0.05 level of significance. Performance improved as swim velocity increased and turn time decreased. In the 200m, free swim velocity (0.945) and turn time (0.809) were significant at the 0.01 level of significance. That is, as performance improved the free swimming speed increased and the turn times decreased.

females: In the 100m, free swimming speed (0.975), start time (0.822) and turn time (0.778) were significant at the 0.01 level of significance. Performance improved as swimming speed increased and start time and turn time decreased. In the 200m, free swimming speed (0.926) and turn time (0.806) was significant at the 0.01 level and efficiency index (0.605) and finish time (0.559) were significant at the 0.05 level of significance. Performance improved as free swimming speed increased, turn time and finish time decreased and the efficiency index increased.

backstroke

males: In the 100m, free swim speed (0.606) and start time (0.550) were significant at the 0.05 level of significance. In the 200m, free swimming speed (0.894) and turn time (0.671) were significant at the 0.01 level of significance. That is as performance improved the free swimming speed increased and the turn times decreased for both distances.

females: In the 100m, free swim speed (0.978), turn time (0.960) and start time (0.908) were significant at the 0.01 level of significance. In the 200m, free swim velocity (0.778) and finish time (0.633) were significant at the 0.01 level and start time (0.526) and turn time (0.521) were significant at the 0.05 level of significance. That is as performance improved the free swimming speed increased and the finish, turn and start time decreased.

breaststroke

males: In the 100m, only start time (0.542) was significant at the 0.05 level of significance. That is as performance improved the start time decreased. In the 200m, free swimming speed (0.886) and turn time (0.717) were significant at the 0.01 level and start time (0.499) and finish time were significant at the 0.05 level of significance. That is as performance improved the free swimming speed increased and the start time decreased

females: In the 100m, free swimming speed (0.962), turn time (0.729) and start time (0.650) were significant at the 0.01 level and finish time (0.575) was significant at the 0.05 level of significance. In the 200m, free swim velocity (0.920) was significant at the 0.01 level and turn time (0.503) and and finish time (0.503) were significant at the 0.05 level of significance. That is as performance improved the free swimming speed increased for both distances and for the 100m, the turn, start and finish time decreased and for the 200m the finish and start time decreased.

individual medley

males: In the 200m, free swimming speed (0.884), turn time (0.848) and finish time (0.759) were significant at the 0.01 level of significance. That is as performance improved the free swimming speed increased and the turn and finish times decreased. Of the strokes only the freestyle free swimming speed (0.666) was significant and this was at the 0.01 level of significance. In the 400m, free swimming speed (0.919), turn time (0.920) were significant at the 0.01 level and start time (0.568) and finish time (0.536) were significant at the 0.5 level of significance. That is as performance improved the free swimming speed increased and turn, start and finish times decreased. Of the strokes involved, the backstroke (0.790), the breaststroke (0.724), the butterfly (0.671) at the 0.01 level and the freestyle

(0.597) free swimming speeds at the 0.05 level of significance correlated with performance.

females: In the 200m, free swim speed (0.938), turn time (0.738) and finish time (0.654) were significant at the 0.0l level of significance. That is as performance improved the free swimming speed increased and the turn and finish times decreased. Of the strokes involved, the backstroke (0.812) and the butterfly (0.672) at the 0.01 level and the breaststroke (0.584) and the freestyle (0.576) free swimming speeds at the 0.05 level were significant. In the 400m, only free swimming speed (0.932) was significant at the 0.01 level of significance. That is as performance improved the free swimming speed increased. Of the strokes involved the backstroke (0.899), the butterfly (0.876) and the breaststroke (0.698) correlated with performance at the 0.01 level of significance.

Table 1 Significant Correlations with Independent Variables: Freestyle

Distance	Gender	Free Swim	Start Time	Turn Time	Finish Time	Stroke Length	Stroke Freq	Eff Index
50m	Male	**(0.86)						
50m	Female	**(0.90)	* (0.60)		* (0.59)			
100m	Male	**(0.79)	**(0.63)	**(0.64)		**(0.64)		**(0.76)
100m	Female							
200m	Male	**(0.95)		**(0.78)				
200m	Female	**(0.95)		* (0.59)			* (0.59)	
400m	Male	**(0.89)		**(0.78)				
400m	Female	**(0.91)		**(0.83)				
800m	Female	* (0.80)						
1500m	Male	**(0.87)						* (0.72)

Note ** indicates 0.01 level of significance
* indicates 0.05 level of significance

Table 2 Significant Correlations with Halves of the Race: Freestyle

Distance	Gender	First Half Swim Speed	Second Half Swim Speed
400m	Male	**(0.76)	**(0.82)
400m	Female	**(0.64)	**(0.91)
800m	Female		**(0.91)
1500m	Male	**(0.76)	**(0.86)

Note ** indicates 0.01 level of significance
* indicates 0.05 level of significance

Table 3 Significant Correlations with Independent Variables: Butterfly

Distance	Gender	Free Swim	Start Time	Turn Time	Finish Time	Stroke Length	Stroke Freq	Eff Index
100m	Male	**(0.90)		* (0.50)				
100m	Female	**(0.98)	**(0.82)	**(0.78)				
200m	Male	**(0.95)		**(0.81)				
200m	Female	**(0.93)		**(0.81)	* (0.56)			* (0.61)

Note ** indicates 0.01 level of significance
* indicates 0.05 level of significance

Table 4 Significant Correlations with Independent Variables: Backstroke

Distance	Gender	Free Swim	Start Time	Turn Time	Finish Time	Stroke Length	Stroke Freq	Eff Index
100m	Male	* (0.61)	* (0.55)					
100m	Female	**(0.98)	**(0.91)	**(0.96)				
200m	Male	**(0.89)		**(0.67)				
200m	Female	**(0.78)	* (0.53)	* (0.52)	**(0.63)			

Note ** indicates 0.01 level of significance
        * indicates 0.05 level of significance

Table 5 Significant Correlations with Independent Variables: Breaststroke

Distance	Gender	Free Swim	Start Time	Turn Time	Finish Time	Stroke Length	Stroke Freq	Eff Index
100m	Male		* (0.54)					
100m	Female	**(0.96)	**(0.65)	**(0.73)	* (0.58)			
200m	Male	**(0.89)	* (0.50)	**(0.72)	* (0.62)			
200m	Female	**(0.92)		* (0.50)				

Note ** indicates 0.01 level of significance
        * indicates 0.05 level of significance

Table 6 Significant Correlations with Independent Variables: Individual Medley

Distance	Gender	Free Swim	Start Time	Turn Time	Finish Time	Stroke Length	Stroke Freq	Eff Index
200m	Male	**(0.88)		**(0.85)	**(0.76)			
200m	Female	**(0.94)		**(0.74)	**(0.65)			
400m	Male	**(0.92)	* (0.57)	**(0.92)	* (0.54)			
400m	Female	**(0.93)						

Note ** indicates 0.01 level of significance
        * indicates 0.05 level of significance

Table 7 Significant Correlations with Strokes: Individual Medley

Distance	Gender	Butterfly	Backstroke	Breaststroke	Freestyle
200m	Male				**(0.67)
200m	Female	**(0.67)	**(0.81)	* (0.58)	* (0.58)
400m	Male	**(0.67)	**(0.79)	**(0.72)	* (0.60)
400m	Female	**(0.88)	**(0.90)	**(0.70)	

Note ** indicates 0.01 level of significance
        * indicates 0.05 level of significance

Discussion

all events As was expected, in most events for both genders, the average free swimming velocity correlated highly with the race performance. That is, the faster you swam, the most likely you were to win in all events. This occurred because of the physical fact, that most time in each event was spent in the free swimming phases of the race. The analysis of the data suggested that stroke lengths, stroke frequencies and efficiency indices were very much an individual factor rather than generally applicable to all swimmers and an examination for the group did not indicate that any significant relationship existed between them and with the race performance.

freestyle n the sprint events for both genders, there was a slight relationship between starting performance and race performance. For distances longer than a sprint, the starting performance did not significantly affect the race performance. The turn performance in the sprint events indicated only a slight relationship with the race performance. The turn performances in the middle distance events played a most significant role in the race performance. This was not the case for the long distance events where the turn performance was not significantly related to the race result. The quality of the finishes were only significant in the 50 metre sprint. The stroke length was only significantly related to race performance in the Mens 100 sprint as was the efficiency index. In the case of the long distance events, the race performance was more highly related to the free swimming velocity in the second half of the race as opposed to the first half of the race.

butterfly In both genders and for both distances, turn performance was related to race performance. There was however a more significant relationship between turn performance and the race performance in the longer distance. The start performance was only significant in the Womens 100 metre distance event.

backstroke In both genders and for both distances, start performance played a significant role for this stroke. It was however more significant at the shorter distance. Turn performance was also significantly related to the race performance and this was more significant in the longer distance.

breaststroke In both genders and for both distances, start performance was significantly related to the race performance for this stroke. It was however more significant at the shorter distance. Turn performance was also significantly related to the race performance and this was more significant in the longer distance event. The finish performance appeared to be more significantly related in this stroke than in any of the other strokes.

individual medley Start performances were not significantly related to the race performance. Both turn performance and finish performance were significantly related to the race performance for both genders, with the exception of the Womens 400 metre Individual Medley. Of the four strokes, the backstroke free swim velocity was most significantly related to the race performance in the individual medley events. The order of significance for free swim velocity of the various strokes with overall race performance was backstroke, butterfly, breaststroke and freestyle. This did not hold true for the Mens 200 metre individual medley event where the freestyle swim velocity was the only stroke that was significantly related to the overall race performance.

Conclusion

Many people believe that the total race performance is related to the stroke length of the swimmer, with the better swimmers having longer stroke lengths. The analysis of the World Championship competition analysis data indicated that stroke length, stroke frequency and the efficiency index was not significantly related to the race performance apart from in the Mens 100 metre freestyle event. It was also evident that average swimming speed was related to the race performance for all events, but this was to be expected. The race performance in the backstroke and breaststroke were related to both start and turn performance. In the butterfly events, race performance was related to turn performance. In the freestyle sprint events the start performance was significantly related to overall race performance. In the middle distance events, the turn performance was significantly related to overall race performance. None of turn, finish or start performance were significantly related to overall race performance in the distance freestyle events. In the individual medley events, turn performance was significantly related to race performance. The order of importance of various stroke free swimming velocities on race performance, with the exception of the Mens 200 metre individual medley was, in order of significance, backstroke, butterfly, breaststroke and freestyle.

From experience in dealing with competition analyses, I have found that all independent variables collected in competition analyses can relate to the overall race performance when dealing with a particular swimmer. While it is important to understand the implications of the general competition model on overall performance, an individual swimmer's performance is related to:

1. The ability of the coach to determine the most effective competition model for the swimmer.
2. The coach and swimmer ensuring that appropriate training occurs to achieve the competition model.
3. Ensuring that the swimmer swims to the model in competition.

Using the competition analysis for the swimmer concerned is an important ingredient in determining the most effective competition model for the swimmer. The results of the competition analysis can also be used for assessing whether the swimmer performed to the model derived for the swimmer.