CHARACTERISTICS OF ELITE SWIM TURN PERFORMANCES

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It is generally undisputed that the turn is of paramount importance in distance and middle distance competitive swimming. Accordingly, there is a need to identify the value of those parameters in the turn that are typical of international elite performance. This will be of vital importance in coaching, to assist swimmers to improve their performance in this aspect of competition. Using the Wetplate analysis system, many elite international swimmers were analysed performing a turn. Selected parameters for elite freestyle, butterfly, backstroke and breaststroke swimming in both genders, that represented the superior turners in each group, were analysed to identify a value for these parameters. A Pearson product moment correlation statistic was also performed on the data to identify those parameters that were of most significant interest in performance enhancement.

KEY WORDS: swimming, competition, turn, analysis, elite, Wetplate

INTRODUCTION: The Australian Institute of Sport developed a unique analysis system called Wetplate in 2006, to analyse the start and turn performances of elite competitive swimmers in a training environment (Mason et al 2012). The system provided immediate computerised quantitative analysis of each swimmer's turn performance along with an above/below water video recording of the swimmer from the 5m mark going into the wall to the 10m mark going out from the wall. The quantitative information supplied for each trial included: overall time on the wall in s, the period the feet were in contact with the wall in s, the depth of the foot plant on the wall and under the water in m, the change in the horizontal velocity of the swimmer's CoG during the time on the wall in ms^{-1}, the peak power generated by the swimmer on the wall in watts/kg of body mass, the force generated against the wall in body weight (Bwt) at peak power output, the projected vertical thrust angle of the swimmer from the wall at peak power output in deg (-ve in a downward direction), the distance from the wall that maximum depth was reached in m, the actual depth of the swimmer at maximum depth in m, the distance from the wall at breakout in m as well as the following times. Time from the 5m mark until wall contact in s, time from wall contact until the 5m, 7.5m and 10m marks were reached in s. The body segment to determine body location in all measurements was the centre of the head. The criterion measure of turn performance was the time taken from the 5m mark travelling into the wall until the 10m mark was reached travelling out from the wall in s. The quantitative information provided by the Wetplate system is used by Australian national team coaching staff to objectively evaluate a swimmer's turns and provide feedback to enhance turn performance. In order for the coach to effectively assess a swimmer's turn technique, the coach must be provided with some suggested ideal parameter values associated with elite turn performance. This paper provides such information so that coaches, technicians and biomechanists are familiar with the biomechanical characteristics of elite swim turns.

METHOD: Since 2006 many of the Australian national swim team members as well as a large number of elite international swimmers have had their turn performances analysed using the Wetplate system. The swimmer's data used in this project was that of the quickest turn for the fastest turners in each stroke, as defined by the time taken from the centre of the head passing the 5m mark on the way into the wall until the centre of the head passed the 10m mark travelling out from the turn . Most of the swimmers whose data was used in this

research were at the level of finalists at world championships and Olympic swim meets. Several of the swimmers were actually world champions and gold medalists in Olympic competition. The data from nine to fourteen swimmers were utilised in each gender category and each of the four stroke categories to be included in the analysis. Most of the parameters were obtained from force measurements on the instrumented turning wall or from digitising the video images of the performance. Both the vertical and horizontal components of force were used to compute the projected angle of the swimmer's thrust when leaving the wall. These two components of force were used to determine the direction of the swimmer's thrust on the wall. Power is the product of force and velocity and both these were derived from the force transducers in the instrumented turn wall. Most of the other parameters were obtained from digitisation of points on the video image. The maximum depth reached and the distance of breakout from the wall in m was obtained from digitisation of the video image. Time at the start of the turn (5m out) (0.0s) and time to reach the 10m mark (in s) was obtained from stationary video cameras (50 fields/s) synchronised with the wall touch signal and located high on the pool wall and facing perpendicularly across the pool at the 5m and10m mark out from the wall.

RESULTS The four summary tables below, list the turn parameter values obtained from the four swimming strokes. Tables 1 and 2 contain the data for males and table 3 and 4 for females. The tables include the mean value and the standard deviation value obtained for each parameter over all turns in the specific gender group. Group sizes were generally 10 in number but there were two with 9 and one with 14. The Pearson product moment correlation coefficient for each parameter is listed to indicate the relationship between that variable and the criterion variable which was Overall Turn Time. The correlation coefficient provides a good indication of the importance of that particular parameter variable to overall turn performance. As the criterion variable in this instance was the time to complete the turn, quicker turns were categorised by smaller numbers in the criterion variable. Correlation coefficient values may range from 1 to -1. The higher the absolute value of the correlation coefficient, the stronger the relationship between that of the parameter in question and the criterion variable.

Table 1
Turn parameter values obtained from the four swimming strokes for males (mean and SD)

Table 1 MALE		Touch to Off. Wall time (s)	Foot Contact Duration (s)	Foot Depth in Water (m)	Change in Velocity (m/s)	Peak Power (W/Kg)	Horz Force at Peak Power (Bwt)	Projection Angle Off Wall (Deg)
Freestyle	Mean	0.26	0.26	0.26	3.92	59.80	1.83	-10
	SD	0.03	0.03	0.06	0.48	12.30	0.25	6
n=11	r	0.01	0.01	-0.18	-0.01	0.08	0.27	0.09
Butterfly	Mean	1.21	0.30	0.31	4.13	64.60	1.93	-4
	SD	0.17	0.04	0.07	0.38	8.60	0.20	4
n=13	r	0.29	0.15	0.04	0.02	0.05	-0.08	-0.11
Backstroke	Mean	0.25	0.25	0.18	3.99	62.50	1.82	-14
	SD	0.04	0.04	0.08	0.20	6.50	0.20	5
n=9	r	0.69	0.69	-0.01	-0.05	-0.81	-0.91	-0.20
Breaststroke	Mean	1.18	0.29	0.32	3.98	58.20	1.73	-2
	SD	0.08	0.04	0.04	0.33	8.10	0.30	4
n=10	r	-0.36	-0.24	-0.89	-0.24	-0.35	-0.24	-0.27

Table 2

Turn parameter values obtained from the four swimming strokes for males (mean and SD)

Table 2 MALE		Dist to Max Depth (m)	Max Depth (m)	Breakout Distance (m)	Time. 5m to Touch (s)	Time. Touch to 5m (s)	Time. Touch to 10m (s)	Overall Turn Time 15m (s)
Freestyle	Mean	3.4	0.50	7.3	2.69	1.68	4.33	7.03
	SD	0.9	0.10	1.8	0.09	0.09	0.15	0.17
n=11	r	-0.02	0.26	-0.19	0.46	0.55	0.86	1.00
Butterfly	Mean	5.9	0.81	11.9	2.58	2.62	5.40	7.98
	SD	1.7	0.22	1.3	0.10	0.09	0.13	0.21
n=13	r	-0.27	0.24	-0.25	0.85	0.67	0.91	1.00
Backstroke	Mean	5.6	0.97	12.2	3.03	1.76	4.65	7.57
	SD	0.9	0.17	2.0	0.13	0.10	0.57	0.37
n=9	r	-0.11	-0.57	-0.76	0.72	0.54	0.79	1.00
Breaststroke	Mean	5.4	0.93	9.3	3.22	2.82	6.50	9.72
	SD	0.7	0.14	1.0	0.14	0.09	0.21	0.29
n=10	r	-0.24	-0.10	-0.05	0.72	0.62	0.89	1.0

Table 3

Turn parameter values obtained from the four swimming strokes for females (mean and SD)

Table 3 FEMALE		Touch to Off. Wall time (s)	Foot Contact Duration (s)	Foot Depth in Water (m)	Change in Velocity (m/s)	Peak Power (W/Kg)	Horz Force at Peak Power (Bwt)	Projection Angle Off Wall (Deg)
Freestyle	Mean	0.27	0.27	0.24	3.66	52.30	1.69	-12
	SD	0.02	0.02	0.06	0.29	6.20	0.16	4
n=10	r	0.10	0.10	-0.09	-0.36	-0.44	-0.22	-0.02
Butterfly	Mean	1.15	0.31	0.28	3.82	50.00	1.53	-5
	SD	0.09	0.02	0.05	0.30	6.30	0.13	5
n=10	r	0.44	-0.42	0.37	-0.65	-0.61	-0.28	0.51
Backstroke	Mean	0.28	0.28	0.19	3.66	49.40	1.56	-14
	SD	0.05	0.05	0.07	0.44	6.80	0.16	3
n=9	r	0.33	0.33	-0.71	0.26	0.11	-0.29	-0.28
Breaststroke	Mean	1.26	0.30	0.31	3.57	45.60	1.52	-2
	SD	0.11	0.05	0.08	0.61	9.70	0.13	5
n=10	r	0.20	-0.60	0.17	-0.31	-0.27	0.02	0.09

Table 4

Turn parameter values obtained from the four swimming strokes for females (mean and SD)

Table 4 FEMALE		Dist to Max Depth (m)	Max Depth (m)	Breakout Distance (m)	Time. 5m to Touch (s)	Time. Touch to 5m (s)	Time. Touch to 10m (s)	Overall Turn Time 15m (s)
Freestyle	Mean	3.3	0.61	7.5	3.03	1.97	4.98	8.00
	SD	0.7	0.15	1.3	0.11	0.09	0.14	0.21
n=10	r	-0.51	-0.44	-0.43	0.80	0.48	0.88	1.00
Butterfly	Mean	3.8	0.60	8.8	2.87	2.88	6.03	8.90
	SD	0.8	0.15	2.3	0.11	0.18	0.32	0.39
n=10	r	0.10	-0.51	-0.54	0.75	0.90	0.98	1.00
Backstroke	Mean	4.7	0.87	10.8	3.41	2.08	5.27	8.68
	SD	0.7	0.15	0.9	0.12	0.12	0.22	0.24
n=9	r	0.08	0.28	-0.20	0.39	0.87	0.92	1.00
Breaststroke	Mean	4.7	0.76	8.5	3.35	3.08	7.01	10.36
	SD	0.6	0.11	0.6	0.20	0.13	0.37	0.45
n=10	r	0.58	0.23	-0.33	0.59	0.62	0.90	1.00

The table cells marked in yellow denote at least a 0.2 significance level: two tailed/non/directional. Those cells that denote the swimmer's times before and after the wall touch are obviously likely to be related to overall turn time. However the other related parameter values, that occurred particularly in the form strokes, provide some insight as to the importance of specific parameters to turn performance. Overall there are not many significant correlations in these tables and this is probably due to the fact that each group of swimmers was very much at a homogeneous elite level resulting in most of the parameters having little variability within the subject cohort.

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 swimmer turn 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 swim start analysis systems such as the new Kistler Pas-S Analysis system. Coaches often require such information when working with swimmers without the use of an analysis system, just to visualise how the swim turn should be performed. The Pearson product moment correlation coefficients in the data tables provide information concerning an indication of the general importance that the particular parameter has to the overall performance of a turn. A similar paper based on the parameters that influence start performance was presented at ISBS2014 (Mason et al 2014). This data in this paper should also dispel many coaching myths about turn performance.

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