A COMPARISON OF PACING STRATEGY BETWEEN INTERNATIONAL AND PAKISTANI 100-M SWIMMERS

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The purpose of this study was to determine, based on the stroking time recorded in a 100-m swimming competition, whether elite international 100-m swimmers have the same pacing strategy as the Pakistani swimmers or not. Based on a video data, three different levels of performance were analyzed i.e. Finalists (G1, n=32) from the European Championship, 2012; Medalists (G2, n=12) and Non-medalists (G3, n=20) from the Pakistan National Swimming Championship, 2014. For the current analysis each stroking distance was divided into two sections (i.e. before and after the 25m mark). The average speed of each section (ST_1, ST_2, ST_3 and ST_4) was quantified in order to depict pacing strategy. Results showed even-positive pacing (1.75 ± 0.17 m/s) towards the end of the race in G1; whereas, variable speed pacing was observed in both G2 (1.42 ± 0.26 m/s) and G3 (1.21 ± 0.28 m/s). Based on these findings it is proposed to encourage an efficient pace strategy for 100-m swimmers.

KEYWORDS: race analysis, free swim time, elite swimmers.

INTRODUCTION: Minor improvements in performance are of considerable interest, especially when athletes' performances are comparable. A modest improvement can be significant in terms of the overall rankings in swimming. To minimize the effects of fatigue and maximize the performance, different pacing strategies have been designated for a variety of events (Robertson et al., 2009; Lipinska et al., 2016a), in which total effort is managed across a specific exercise session in order to achieve a particular goal in the best knowledge of the likely demands of that certain task (Edwards and Polman, 2012). Six pacing strategies were described by Abbiss and Laursen (2008), which includes negative (speed progression over time), positive (speed retardation over time), all-out (maximal speed possible), even (same speed over time), parabolic-shaped (positive and negative pacing in different segments of the race), and variable pacing (inconsistent or multiple fluctuations). Pacing of elite swimmers has been investigated (Skorski et al., 2014; Lipinska et al., 2016a, 2016b) and results showed parabolic-shaped pacing in top athletes. The importance of pace allocation was also seen in track events (Hart, 1993; Schiffer, 2008), where analyses of 800m running (<110 s) demonstrated a fast first lap and a slight reduction of speed in the second lap (Tucker et al., 2006). But in shorter-duration track events (≤30–60 seconds), a fast start with a progressive decrease in speed until the finish (positive pacing) is considered to be the most successful strategy among elite athletes (Tucker et al., 2006). Therefore, it can be reasonably supposed that to improve final race time, event specific pace strategy should be encouraged.

Race analysis of swimming competitions have mostly considered kinematic and chronological aspects of competitors (Arellano et al., 1994; Thompson et al., 2000). In these studies, stroke kinetics was the major focus, which can vary from one individual to another and therefore is considered a poor predictor of performance (Thompson et al., 2000). Alternatively, athlete's speed in the stroking distances was highly associated to race performance (Arellano et al., 1994; Thompson et al., 2000). To propose an effective strategy, pattern of pacing adopted by international swimmers in a competition should be considered (Foster et al., 2004). Thus, the purpose of this study reported in this paper was to derive a pacing strategy for each split section (ST_1, ST_2, ST_3 and ST_4) in order to achieve a better overall race time.

METHODS: Video recorded data was analyzed for Medalists (G2, n=12) and Non-Medalists (G3, n=20) male swimmers (age: 29 ± 4.09 years; 67.91 ± 10.81 kg; 156.57 ± 10.90 cm) who competed at Pakistan National Swimming Championship, 2014. The data were recorded and analyzed for four strokes (freestyle, backstroke, butterfly and breaststroke) over the distance of 100-m at a 50-m indoor International standard pool. Time recorded in each section by Finalist (G1, n=32) of European Championship, 2012 were obtained from Internet sources, which was publicly accessible at www.swim.ee on 19-09-2014.
An experimental study was designed to analyze the pacing strategy of the Pakistani swimmers and was compared with their International counterparts, with aim to calculate the difference in pacing strategy in each section of the stroking distance. During the 100-m events (freestyle, backstroke, butterfly and breaststroke) five cameras, 6m away (Morales et al., 2010) alongside the calibration markers, were installed at elevated positions to enable split times be recorded. The optical sensor size and resolution of the cameras was 1/2.9" and 3.2 MP respectively, with a frequency of 30 frames per second (Mooney et al., 2015; Nazeer et al., 2016). For the analysis of swimmers, specialized software (Kinovea: 0.8.15) (Bacic and Hume, 2012; Mooney et al., 2015) was used to draw digital interpolated lines, in the video recordings, using each pair of calibration markers placed at predetermined distances (15, 25, 45, 65, 75 and 95 meters) on both sides of the pool. These digital lines bifurcate ST_1 (from the end of the start phase to the mid of the pool), ST_2 (from the mid of the pool to the start of turning phase), ST_3 (from end of the turning phase to the mid of the pool) and ST_4 (from the mid of the pool to the start of the finish phase) and were utilized to measure the speed of the swimmers for each section by the reach of the swimmer's head (Suito et al., 2016). The video was analyzed frame by frame making sure that the on screen stop watch was in synchronization with the official race time. The time between successive frames was 0.033 seconds. The average speed of each section was then compared with the average speed of total stroking distance in order to determine the percentage of effort utilized in each stroke.
Descriptive statistics (means and standard deviations) were calculated for all variables. Relationship of each phase on improvement in final time was calculated for G2 and G3.

RESULTS: Table 1 shows the average speed of each phase where the peak velocities were observed by G1 between the first section (ST_1) with mean values of 2.03 ± 0.05 m/s; 1.81 ± 0.04 m/s; 1.90 ± 0.03 m/s and 1.58 ± 0.04 m/s in freestyle, backstroke, butterfly and breaststroke respectively. Even/ slightly positive pacing was observed in the next three sections of the stroking distance. Whereas, Pakistani Medalists and Non-medalists showed fluctuations in average speed throughout the stroking distance in all four strokes of 100-m swimming events.

Table 1: Average speed (m/s) in each section in each group of 100-m swimmers

Race components	Freestyle			Backstroke			Butterfly			Breaststroke		
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
ST1	2.03	1.83	1.85	1.81	1.98	0.95	1.90	1.28	1.05	1.58	1.73	1.59
ST2	1.98	1.65	1.65	1.75	1.34	1.38	1.88	1.32	1.14	1.58	1.19	1.09
ST3	1.91	1.43	1.09	1.73	1.09	0.84	1.77	1.32	1.04	1.52	1.12	1.08
ST4	1.81	1.48	1.26	1.64	1.46	1.38	1.69	1.39	1.07	1.47	1.15	0.94

Figure 1 shows the pacing strategy of the swimmers with respect to the percentage of effort executed in each section of the stroking distance. The line graph shows a clear variation in pacing for both Pakistani groups as compared to their International counterparts.

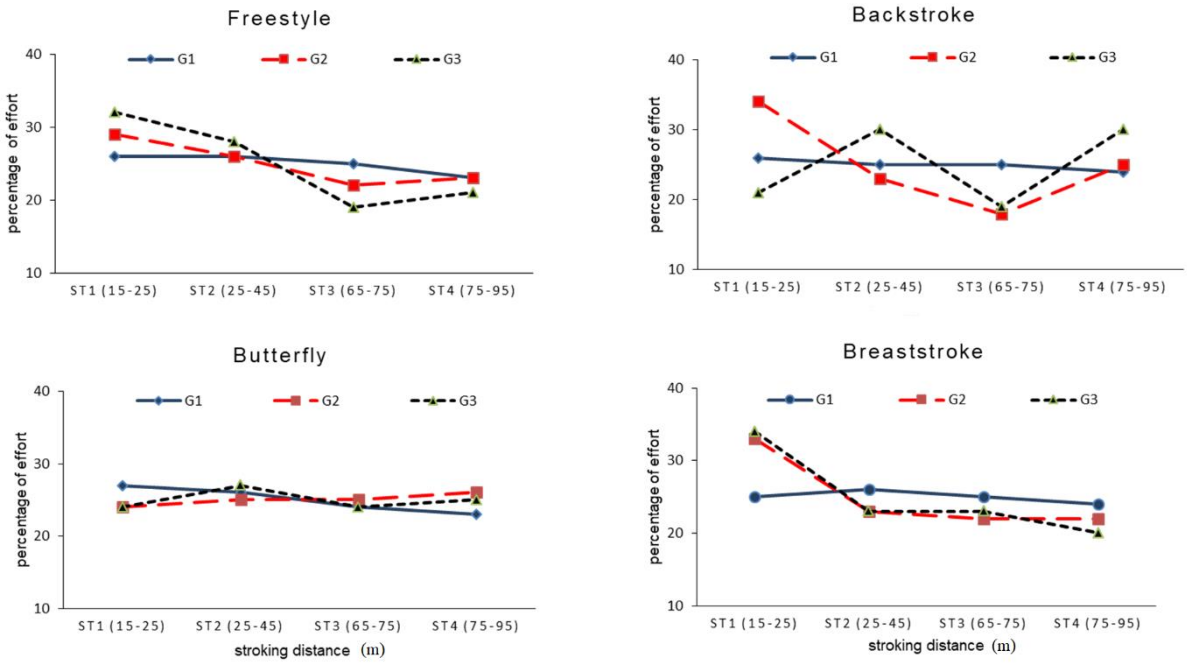

Figure 1: Percentage of effort in each section in four strokes among the 100-m swimmers.

DISCUSSION: Results showed that pacing is one of those significant aspects in 100-m events that can differentiate successful and less successful athletes. Athletes must be aware of their physical capacities, in order to anticipate the strategy to complete the event in the fastest possible time and/or velocity (Abbiss et al., 2016). This research provides athletes and coaches with knowledge required to produce optimal results using an appropriate pacing strategy.

According to our results, three different pacing profiles were observed depending on the swimmers' performance level. These pacing profiles revealed an even / positive pacing for most successful swimmers (International) and variable speed pacing was observed in other less successful groups (Pakistani). The most successful swimmers (G1) adopted a conservative strategy by gaining a maximal speed in the first section and keeping it near to maximal in the next two sections of the stroking distance; the international swimmers were probably able to save some energy for the final spurt (Rodriguez and Veiga, 2017). With this strategy they probably sought to reduce speed fluctuations and prolong maximal speed. In contrast, less successful groups were unable to maintain speed for more than one section and speed fluctuations were notably higher in G3 as compared to G2.

The velocity decrease in the last part of the 100-m swim was less dramatic in the international swimmers, which is the particular challenge of this distance that it has to be done very near to maximal velocity for the duration of 45 to 60 seconds.

These analyses on four strokes is noteworthy for researchers and coaches who are directly involved with the sport of competitive swimming. Since this is the first research that targeted the importance of pacing in stroking distances, other researchers might use this work as reference for future studies in the related area to confirm or challenge these findings. The pacing patterns of this research could be used as a guide for the Coaches and the athletes in context to develop pacing strategies, as this analysis contains the strategies of elite level swimmers who participated in the European Championship 2012. In particular, coaches should consider the differences in pacing by setting training goals.

CONCLUSIONS: The study employed a novel analysis developing a relation between pacing strategy and performance enhancement in 100-m swimmers. The pattern of pacing executed by elite athletes in an international swimming competition is modeled in this study and determined the progression in performance associated with an achievable change (even

pacing) in all sections of the stroking distance. Even pacing in all four sections of the race was associated with an approximate 1.6-5.0% and 1.5–11.6% improvement in total race time for G2 and G3, depending upon the stroke. This method could be beneficial for applied scientific research and provides a quantitative framework to develop an appropriate pacing strategy in other sports as well.

REFERENCES:

Abbiss, C. R., Thompson, K. G., Lipski, M., Meyer, T., & Skorski, S. (2016). Difference in pacing between time-and distance-based time trials in trained cyclists. *International Journal of Sports Physiology and Performance*, 11(8), 1018-1023.

Abbiss, C. R., & Laursen, P. B. (2008). Describing and understanding pacing strategies during athletic competition. *Sports Medicine*, 38(3), 239-252.

Arellano, R., Brown, P., Cappaert, J., & Nelson, R. C. (1994). Analysis of 50-, 100-, and 200-m freestyle swimmers at the 1992 Olympic Games. *Journal of Applied Biomechanics*, 10, 189–199.

Bacic, B., and Hume, P. (2012). Augmented Video Coaching, Qualitative Analysis and Post-Production using Open Source Software. In, "30th Annual Conference of Biomechanics in Sports." Conference Proceedings Archive 1(1): 363–366. Melbourne: Austraila

Edwards, A., & Polman, R. (2012). Pacing in sport and exercise: A psychophysiological perspective. Sports and athletics preparation, performance and psychology. New York, NY: Nova Science Publishers.

Foster, C., de Koning, J. J., Hettinga, F., Lampen, J., Dodge, C., Bobbert, M. et al. (2004). Effect of competitive distance on energy expenditure during simulated competition. *International Journal of Sports Medicine*, 25, 198–204.

Foster, C., Snyder, A. C., Thompson, N. N., Green, M. A., Foley, M., & Schrager, M. (1993). Effect of pacing strategy on cycle time trial performance. Medicine and Science in Sports and Exercise, 25, 383–388.

Garland, S. W. (2005). An analysis of the pacing strategy adopted by elite competitors in 2000 m rowing. *British Journal of Sports Medicine*, 39, 39–42.

Hart, C. (1993) 400 meters training. Track & Field Quarterly Review, 93: 23-28.

Lipinska, P., Allen, S. V., & Hopkins, W. G. (2016a). Relationships between pacing parameters and performance of elite male 1500-m swimmers. *International journal of sports physiology and performance*, 11(2), 159-163.

Lipińska, P., Allen, S. V., & Hopkins, W. G. (2016b). Modeling parameters that characterize pacing of elite female 800-m freestyle swimmers. *European Journal of Sport Science*, 16(3), 287-292.

Mooney, R., Corley, G., Godfrey, A., Os-borough, C., Quinlan, L. R., and Ó Laighin, G. (2015). Application of video-based methods for competitive swimming analysis: a systematic review. *Sports and Exercise Medicine*, 1(5), 133-150.

Morales, E., Arellano, R., Famia, P., & Mercades, J. (2010). Regression analysis model applied to age-group swimmers: study of stroke rate, stroke length and stroke index. Biomechanics and Medicine in Swimming XI, 129-132. In, P.L. Kjendlie, R.K. Stallman and J. Cabri (Eds.). pp 127-129. Oslo: Norwegian School of Sport Sciences.

Nazeer, M. T., Akhtar, T., Nawaz, U., & Mayo, Z. A. (2016). Comparison of 50 meters freestyle race component time analyses of pakistani and international swimmers. *Science International*, 28(2), 1205-1211.

Robertson, E. Y., Pyne, D. B., Hopkins, W. G., & Anson, J. M. (2009). Analysis of lap times in international swimming competitions. *Journal of Sports Sciences*, 27(4), 387-395.

Rodriguez, L., & Veiga, S. (2017). Effect of the Pacing Strategies on the Open Water 10km World Swimming Championships Performances. *International Journal of Sports Physiology and Performance*, 1-19.

Schiffer, J. (2008). The 400 metres. New Studies in Athletics, 23(2), 7-13.

Skorski, S., Faude, O., Caviezel, S., & Meyer, T. (2014). Reproducibility of pacing profiles in elite swimmers. *International Journal of Sports Physiology and Performance*, 9(2), 217-225.

Suito, H., Nunome, H., and Ikegami, Y. (2016,). Relationship Between 100-m Race Times and Start, Stroke, Turn, Finish Phases at the Freestyle Japanese Swimmers. In, "33rd International Conference of Biomechanics in Sports, Conference Proceedings Archive." 33(1): 1224-1227.

Thompson, K. G., Haljand, R., & MacLaren, D. P. (2000). An analysis of selected kinematic variables in national and elite male and female 100-m and 200-m breaststroke swimmers. *Journal of Sports Sciences*, 18, 421–431.

Tucker, R., Lambert, M. I., & Noakes, T. D. (2006). An analysis of pacing strategies during men's world-record performances in track athletics. *International Journal of Sports Physiology and Performance*, 1(3), 233-245.