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Inter-analyst variability in swimming competition analysis

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Abstract

This paper quantified the inter-analyst variability in the time at which a swimmer reached a certain distance in a race, which is a key measure in swimming competition analysis. Prior to this paper coaches had assumed that differences in these times were solely due to changes in the swimmer's performance. This assumption was tested by asking four trained and experienced British Swimming analysts to calculate the time at which a swimmer reached four distances in ten randomly selected 100 m races. The inter-analyst variability was found to be between 0.02 s and 0.34 s.

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Keywords:swimming; competition; analysis; variability

1. Introduction

Measuring the time at which a swimmer reaches a certain distance is a key requirement in swimming competition analysis. As described by Smith et al. (2002) a widely-adopted competition analysis process is to split a race into contiguous phases (a start, zero or more turns, a finish, and clean swimming between the start, turns and finish) with the boundary between two phases at a certain distance. Coaches identify strengths and weaknesses in a swimmer's performance by comparing the time taken to complete a phase in two or more races and this information is used to inform race tactics and training interventions.

An account of the analysis performed at swimming's premier competition, the Olympics Games, is given by Chatard et al. (2001a-c) and Girold et al. (2001). Twelve video cameras were used to film the semi-finals and finals of the men's and women's 200 m breaststroke and freestyle events. The resulting footage was replayed post-race and the time each swimmer took to complete the contiguous phases described in the foregoing were calculated.

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These times were used to identify differences between the medalists, the non-medalist finalists, and the semi-finalists. Differences of between 0.21 s and 0.32 s in the start and turn phases were found to be statistically significant.

British Swimming, the national governing body for swimming in Great Britain, conducts analysis at competitions such as the Olympic Games, Federation Internationale De Natation World Championships, and its own national championships. They employ four analysts to do this work. As a result the data may be subject to inter-analyst variability. Therefore the purpose of this work was to investigate the inter-analyst variability in the time at which a swimmer reached a boundary between two phases. This research will allow a more informed use of the data, where, up till now, observed differences in the data have been attributed solely to changes in the swimmer's performance.

Nomenclature

HS	An instance in a breaststroke race when the centre of a swimmer's head is on the pool's surface
PB	A boundary between two phases of a race

2. The British Swimming analysis process

A digital camcorder is used to film a race from a position in the stands, with the view panned and zoomed to follow a single swimmer. The captured footage is 50 frames per second and standard definition, i.e. 720 pixels wide by 576 pixels high. After the race the footage is analyzed in proprietary analysis software. Time is calculated from the frame rate. Therefore the time resolution is 0.02 s. Distance is estimated by referring to the colored sections of the floating buoys that separate the pool's lanes: the analyst counts the number of buoys to the nearest change in buoy color, which are usually at 5 m, 15 m, 25 m, 35 m, and 45 m in each lap. Each buoy is approximately 0.085 m wide.

The start phase of a race ends at 15 m, the turn phase is from 5 m before to 10 m after the end of a lap, the finish phase begins at 5 m before the end of the race, and the clean swimming phases occupy the distances between the start, turn, and finish. The swimmer is said to be at a PB when the center of the swimmer's head intersects a line interpolated across the pool's surface at the required distance.

In the clean swimming phase of freestyle and backstroke races the center of the swimmer's head is assumed to be always on the pool's surface. Therefore the analyst calculates the time at which the swimmer reaches a PB by selecting the frame in which the center of the swimmer's head is at the PB's distance. As a result the analyst has to make one choice at each PB.

Maglischo (2002) showed that in the clean swimming phase of breaststroke and butterfly races the swimmer's head moves up and down through the pool's surface in each stroke cycle. So, in most cases, the time at which the swimmer reached the PB cannot be directly measured. Instead it is estimated from the time and distance of two HS. We call these HS_i and HS_j and the time and distance (t_i, d_i) and (t_j, d_j) respectively. We also set the condition that t_i is less than t_j and d_i is less than d_j. A linear estimation is used;

$$t_b = t_i + \left(\frac{d_b - d_i}{S} \right)$$

where S is the mean speed between HS_i and HS_j and (t_b, d_b) is the time and distance at the PB. If d_i and d_j are both less than or both greater than d_b then the estimation is an extrapolation, else it is an interpolation. As a result, for breaststroke and butterfly races, an estimation of t_b requires the analyst to choose HS_i and HS_j, the frame in which the selected HS_i and HS_j occurred, and, for each selected frame, the buoy that is aligned with the center of the swimmer's head. In conclusion, the analyst has to make a total of six choices at each PB.

3. Method

Five 100 m breaststroke races and five 100 m freestyle races were randomly selected from those that British Swimming had already filmed and analyzed. Four of the races were from the 2012 Olympic Games, four were from the 2011 Federation Internationale De Natation World Championships, and two were from national competitions held in 2011 and 2013. Each race was held in a 50 m by 25 m pool and consisted of two 50 m laps.

Four British Swimming analysts volunteered to participate in the study. Each analyst had at least eighteen months of experience in using British Swimming's proprietary analysis software at major national and international competitions. Each analyst was asked to use the proprietary analysis software to estimate t_b at 15 m, 45 m, 60 m, and 95 m in all ten races.

The difference between analysts was quantified using range and standard deviation. Calculations were performed in Microsoft Excel. The intraclass correlation coefficients described by Shrout and Fleiss (1979) were not calculated due to the small number of races included in this study.

4. Results

The inter-analyst variability is summarized in Table 1. The maximum difference between analysts was a range of 0.34 s and a standard deviation of 0.17 s and the minimum was a range of 0.02 s and a standard deviation of 0.01 s.

Table 1. The range (R) and standard deviation (SD) of the time at 15 m, 45 m, 60 m, and 95 m phase boundaries as calculated by four British Swimming analysts for five breaststroke races (BR1-5) and five freestyle races (FR1-5). R and SD are reported in seconds.

Race	N	15 m		45 m		60 m		95 m	
		R	SD	R	SD	R	SD	R	SD
BR1	4	0.02	0.01	0.06	0.03	0.20	0.10	0.14	0.06
BR2	4	0.12	0.06	0.04	0.02	0.28	0.12	0.34	0.17
BR3	4	0.04	0.02	0.04	0.02	0.32	0.16	0.08	0.04
BR4	4	0.22	0.11	0.08	0.03	0.30	0.12	0.12	0.06
BR5	4	0.04	0.02	0.18	0.08	0.20	0.09	0.14	0.06
FR1	4	0.04	0.02	0.06	0.03	0.04	0.02	0.08	0.03
FR2	4	0.04	0.02	0.02	0.01	0.06	0.03	0.06	0.03
FR3	4	0.06	0.03	0.04	0.02	0.12	0.05	0.06	0.03
FR4	4	0.04	0.02	0.02	0.01	0.10	0.04	0.04	0.02
FR5	4	0.02	0.01	0.06	0.03	0.04	0.02	0.02	0.01

5. Discussion

The maximum range in t_b was higher in the breaststroke races than it was in the freestyle races**.** When calculating t_b in freestyle races the analysts had to make one choice at each PB, i.e. the frame in which the swimmer was at the PB**.** However in breaststroke races the analysts had to make six choices when calculating a t_b, i.e. two HS and one frame and buoy for each HS**.** So the larger maximum range in t_b for the breaststroke races probably reflected the larger number of choices that the analysts had to make in the these races.

In the breaststroke races the range in t_b at 60 m was, in general, higher than that at other PB**.** It is not clear why this was the case**.** However one difference between this PB and the others was the absence of a change in buoy colour at 60 m. This may have led to an increase in the choices available to the analysts at this PB when picking the two HS used in the estimation of t_b.

The inter-analyst variability in the freestyle races was less than the statistically significant differences between the medalists, the non-medalist finalists, and the semi-finalists in the start and turn phases of the 200 m breaststroke and freestyle events at the 2000 Olympic Games. However, the variability in the time at 60 m in the breaststroke races was similar in magnitude to these statistically significant differences. As a result, sizeable differences in breaststroke post-turn time may not be solely due to a change in swimmer performance.

6. Conclusion

An inter-analyst variability of up to 0.34 s was found in the time at which a swimmer reached a certain distance in a 100 m race. Variability was, in general, higher for breaststroke races than it was for freestyle races and was highest at 10 m after the turn in the breaststroke races. British Swimming coaches should note that differences in breaststroke post-turn performances of up to 0.32 s could be due solely to inter-analyst differences.

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References

Chatard, J., Caudal, N., Cossor, J., Mason, B., 2001a. Specific strategy for the medallists versus finalists and semi-finalists in the men's 200 m breaststroke at the Sydney Olympic Games. In: 19 International Symposium on Biomechanics in Sports, San Francisco, June 20-26 2001. Last accessed 11 February 2013 at: https://ojs.ub.uni-konstanz.de/cpa/issue/view/ISBS2001.

Chatard, J., Caudal, N., Cossor, J., Mason, B., 2001b. Specific strategy for the medallists versus finalists and semi-finalists in the women's 200 m breaststroke at the Sydney Olympic Games. In: 19 International Symposium on Biomechanics in Sports, San Francisco, June 20-26 2001. Last accessed 11 February 2013 at: https://ojs.ub.uni-konstanz.de/cpa/issue/view/ISBS2001.

Chatard, J., Caudal, N., Cossor, J., Mason, B., 2001c. Specific strategy for the medallists versus finalists and semi-finalists in the men's 200 m freestyle at the Sydney Olympic Games. In: 19 International Symposium on Biomechanics in Sports, San Francisco, June 20-26 2001. Last accessed 11 February 2013 at: https://ojs.ub.uni-konstanz.de/cpa/issue/view/ISBS2001.

Girold, S, Chatard, J., Cossor, J., Mason, B., 2001. Specific strategy for the medallists versus finalists and semi-finalists in the women's 200 m freestyle at the Sydney Olympic Games. In: 19 International Symposium on Biomechanics in Sports, San Francisco, June 20-26 2001. Last accessed 11 February 2013 at: https://ojs.ub.uni-konstanz.de/cpa/issue/view/ISBS2001.

Maglischo, Ernest, W., 2002. Swimming Fastest. Human Kinetics, Champaign, Ill., U.S.A.

Shrout, Patrick, E., Fleiss, Josesph, L., 1979. Intraclass correlations: Uses in assessing rater reliability. Psychological Bulletin 86, 420-428.

Smith, David, J., Norris, Stephen, R., Hogg, John, M., 2002. Performance Evaluation of Swimmers: Scientific Tools. Sports Medicine 32, 539-554.