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Stability of behaviour patterns in the 200m breaststroke

Estabilidade dos padrões comportamentais nos 200m do nado peito

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Abstract – The aim of this study was to analyse the stability of the breaststroke technique in five elite swimmers in a 200m event using a qualitative analysis. The codification of the behaviour of each swimmer during the execution of 20 cycles was achieved using an ad hoc observational instrument comprised of a system of categories and field formats to detect the behavioural patterns (T-patterns); software was used for identifying the technical behaviour of stable structures. The results showed that the stability behaviour varied depending on the swimmer, as the variations of codes in each round produced distinct configurations to determine the differences between cycles for the same swimmer. It was concluded that the instrument used in this study plays an important role through the existence of stable behaviour in the breaststroke technique. It was also concluded that there are distinct patterns and behaviours between swimmers during each lap of the race.

Key words: Observational methodology; Swimming; Technical analysis; T- patterns.

Resumo – *O objetivo deste estudo foi analisar a estabilidade da técnica de bruços em cinco nadadores de elite numa prova de 200m usando uma análise qualitativa. A codificação do comportamento de cada nadador durante a execução de vinte ciclos de nado foi alcançado usando um instrumento de observação ad-hoc composto por um sistema de categorias e formatos de campo para detectar os padrões comportamentais (T-patterns); o software foi utilizado para identificar o comportamento técnico de estruturas estáveis. Os resultados indicaram que o comportamento da estabilidade dos nadadores variou de acordo com o nadador, como as variações de códigos em cada ronda produzido configurações distintas para determinar as diferenças entre os ciclos para o mesmo nadador. Concluiu-se que o instrumento utilizado neste estudo desempenha um papel importante, através da existência de um comportamento estável na técnica de nado de peito. Concluiu-se também que existem padrões distintos e comportamentos entre nadadores durante cada percurso de nado.*

Palavras-chave: *Análise técnica; Metodologia observacional; Natação, T- patterns.*

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INTRODUCTION

The technical evolution of image recording and the associated software for monitoring technical execution of athletic actions has become a growing line of research. In the field of physical activity and sport, there are many studies that use the analysis of multi-code event sequences[1–5]. Competitive swimming is one of the most challenging sports in terms of performing scientific research because it involves assessing human beings in an aquatic environment, which is not their natural environment, and other physical principles have to be considered[6]. In recent years, improvement of technological resources has allowed for the development of new theoretical models and patterns of swimming techniques; increased scope and reduced limitations of these models has allowed for the optimisation of individual performance[7–10]. To analyse the athletic movements of a swimmer, the level of swimming from a kinematic perspective and in terms of technical effectiveness should be carried out[11].

The observational methodology used to analyse the situation in terms of behaviour involves the fulfilment of an ordered series of tasks to collect and process data and also presents a significant level of importance to some scientific procedures in the study of technical performance. In competitive swimming, there are some studies that have used these procedures[9,10,12]. According to Anguera et al.[4], there are advantages to using this method, not only because the user can take the procedures from the laboratory and move them into the field, but it can also provide data without interfering with or manipulating the behaviour of the observed subjects. Magnusson[13] considers quantification to be insufficient, stating that it should instead involve the structure of this behaviour expressed through patterns that are apparently hidden to the eyes of the observer, but that do exist and can be detected. Magnusson[13] presents the THEME software as a tool for the detection of regular "temporal and sequential" structures in a data set. A temporal pattern (T-pattern) is essentially a combination of events that occur in the same order, with temporal distances between each other, and that remain relatively invariant in relation to the null hypothesis that each component is independent and is randomly distributed over time.

Bakeman and Quera[14] verify that one of the main reasons for using observational methods is the ability to capture behaviours displayed over time, which allows for the sequential analysis to be carried out.

The breaststroke technique is considered one of the least economic of the four swimming techniques. This issue of economy can lead to early fatigue while swimming. A technical model for diagnosis and counselling in breaststroke, presented in the form of four variants described in terms of higher or lower lumbar hyperextension position and a more or less arched trunk: i) variant very wavy, arched; ii) variant very wavy, slightly arched; iii) variant wavy, slightly arched, and iv) variant without wavy and without rotation. By their very nature, breaststroke techniques feature a number of parameters that are not readily addressed by traditional research, and it was this fact that gave rise to a new trend: quantification of the work done during breaststroke rounds by means of videographic analysis of the detection of temporal structure. This type of study, which takes the time factor into account, has enabled researchers to establish the most suitable training load for each individual swimmer. Among these, we highlight the analysis of T-patterns, which allows for the detection of hidden patterns of behaviour, sequential analysis, and the demand for a significant relationship between behaviours recorded during these sequences.

The aim of the present research was to study, by means of descriptive and T-pattern analyses, the breaststroke technique used during the 200m event. It was hypothesised that each swimmer would have his own pattern of behaviour, characterised by differences in the gestural stability and by the pace race strategy that each swimmer applied over the 200m event.

METHODOLOGICAL PROCEDURES

The design of the present study was nomothetic, punctual (single moment of collection), and multidimensional, with natural observation units (events and behaviours) and analysis (behaviour patterns). It is nomothetic because the sample consists of five swimmers (n = 5) with one common bond (breaststroke cycles), it is punctual because the acquired data are obtained in a single moment, and it is multidimensional because the behaviour was studied in several dimensions simultaneously.

Subjects

Five male swimmers (age: 23.8 ± 2.6 years; height: 178.6 ± 0.6 m; weight: 73.04 ± 3.32 kg; mean ± SD) volunteered to participate in this study and provided their written consent. They were all national level swimmers with an average personal best result in the 200m breaststroke (147.6 ± 0.041 s corresponding, respectively, to 630.75 ± 69.25 FINA ranking points). The institutional Ethics Committee approved all procedures, which were carried out according to the Helsinki Declaration.

Testing procedure

The experiments were performed in a 50 m indoor swimming pool at a temperature of 27.5ºC and a 75 percent humidity level. Subjects performed a standard warm-up of the 800m front crawl at a medium level of effort after 20 minutes of passive rest. They then performed a 200m breaststroke trial with a push off start at maximum effort.

T-pattern data collection

The swims were videotaped on the sagittal plane with a pair of cameras, providing dual-media frames from both under (SONY D8, EUA, 50 frames*s-1) and above (Sony Mini Dv DCR-HC42E, EUA, 50 frames*s-1) the water surface, along with a periscope Coach Scope (Delphis Swim products). The cameras were placed 25 m from the headwall on a lateral wall of the pool, perpendicular to the line of motion and 6 m away from the swimmer displacement trajectory. One of the cameras was placed at a depth of 30 cm and the other 10 cm above the water level. The images from both cameras were recorded simultaneously and it was possible to follow the swimmer's trajectory and visualise five swimming strokes for each lap.

T-patterns assessment

We used an ad hoc reference. The instrument was configured according to the nature of the research: (i) criteria, (ii) system of codes, and (iii) units of coding. The structure of the observation took individual events by the description of time and order[3], representing one or more specific technical behaviours of hand cycles. In order to prepare the observational instrument, a panel of experts, consisting of graduate students, researchers, and experienced coaches, were consulted to find out what performance indicators should be included in the study. A review of the literature was also carried out.

Box 1. Moments of observation and description of the observational "ad hoc" instrument used

Moments of observation and description of the observational "ad hoc" instrument used – SOCTB	
First propulsive action of arms (FPAA)	Focuses on the aspects of the connection from one cycle to another, particularly in the moment that corresponds to the beginning of flexion until the deepest point that the hands reach.
Second propulsive action of arms (SPAA)	Focuses on the critical aspects of the second propulsive support of the arms, which finishes with the extension of the arms.
First propulsive action of legs (FPAL)	The transitional approach criterion is the maximal flexion of the knees, that the terminus it´sand terminates at the moment in which the angle of the hip/leg is 45°.
Second propulsive action of legs (SPAL)	Focuses on the moment that starts with the angle of the hip/leg at 45° and finishes with the full extension of the same parts
Recovery (R)	Focuses on the moment corresponding to the end of the cycle. Recovery moment that starts with full extension of the legs away from the body until their junction.

For this study, the instrument was set with 431 alphanumeric codes and a total of 44 configurations, used to catalog five swimmers at a length of 20 hand cycles. The reliability of the instrument was calculated using the intra- and inter-observer agreement with the SDIS-GESQ software, and the obtained value of 0.967 was excellent[17]. Each criterion represents a stage of a complete cycle gesture, adding movements and actions that represent the technical conduct, independent of any existing variant. The conduct was in accordance with the temporal characterisation, delimiting the beginning and end of each stage. In each of these stages, key points that were critical to the implementation of the exploratory phase were defined. An alphanumeric code was assigned to each of them. In the following tables, the frequency of the observed events performed and the respective changes over the 200m in all cycles (N) correspond to the 20 observed events, which means that 20 cycles were observed during the 200m breaststroke. In turn, the Stability Index (SI) indicates the stability of the motor gesture that is deciphered by a configuration (Box 1).

To detect temporal patterns, we used the THÉME 5.0 software, as the algorithm for the detection of T-patterns Magnusson[16] developed is based on a binomial probability theory that allows for the identification of sequential and temporal systems of data. The units of codification presented like events according to duration metrics, order, and frequency, representing one or more technical behaviours.

RESULTS

Table 1 presents the characterisation of events and the frequency of occurrences of all swimmers in the first five moments of observation over the 200 metres. Swimmer 1 had no changes in the FPAA, FPAL, and R over the 20 analysed cycles, while in the SPAA, he presented changes in the position of the leg extension (SI, 0.55), flexion (SI, 0.45), and the position of the feet was parallel (SI, 0.55) or discontinuous (SI, 0.45). During the second propulsive action of the legs (SPAL), it was found that the only variation resulted from the comparison of the ankle level to the hip: the ankle may be above the hip (SI, 0.80) or below the hip with no extension (SI, 20).

Swimmer 2 presented the FPAA, FPAL, and R with no changes in the 20 cycles analysed and thus presented overall stability. There was some alteration in the SPAA, where the position of the feet varied between parallel (SI, 0.70) and discontinuous (SI, 0.30). In the SPAL, variation occurred in the level of the head position in relation to the water line – above the water line/intermediate (SI, 0.45) or below the water line (SI, 55).

In Swimmer 3, 100 percent technical stability was observed in the FPAA and R. In the SPAA, there were changes in criteria P5, P6, P7, and C3. The FPAL demonstrated changes in the position of the trunk in the dorsiflex (SI, 0.95) position, as well as in length (SI, 0.05). In the SPAL, it was found that the variations that occurred in the head position relative to the water line were above/intermediate (SI, 0.15) or below (SI, 0.85) and there was a level position of the forearm in relation to the water line, with the arms inclined upward/parallel (SI, 0.05) and angled downwards (SI, 0.95).

Variations in the SPAA were observed in Swimmer 4, in which the position of the legs altered in length (SI, 0.60) and flexion (SI, 0.40) and the position of the feet varied between parallel (SI, 0.60) and discontinuous (SI, 0.40). For this swimmer, changes occurred during the FPAL in the tilt of the forearm in relation to the water line, whereas in the FPAA, SPAL, and R, there were no changes in the total 20 analysed cycles.

Swimmer 5 did not show any changes during the FPAA, FPAL, and R, and the settings were repeated throughout the 20 observed cycles. In the SPAA, there were variations in the position of the legs: they alternated between extension (SI, 0.35) and flexion (SI, 0.65). Finally, in the SPAL, there were variations in the level of the head position relative to the water line, with the head above the water line/intermediate (SI, 0.65) or below the water line (SI, 0.35), and the level of the position of the forearms in relation to the water line, with the forearms inclined upward/parallel with the water line (SI, 0.70) or inclined downwards (SI, 0.30).

Table 1. Characterisation of events and frequency of occurrences in all swimmers.

Laps	Moments of Observation	Swimmer(SW)	Settings (moles)	N	Stability Index (SI)
Total of four laps	First propulsive action of arms (FPAA)	SW1	1P1,1P3,1P6,1P7,1T1,1T5,1T6,1C2,1C4,1B1	20	1
		SW2	1P1,1P4,1P6,1P8,1T1,1T5,1T6,1C2,1C4,1B2	20	1
		SW3	1P1,1P4,1P6,1P8,1T1,1T5,1T6,1C2,1C4,1B2	20	1
		SW4	1P1,1P4,1P6,1P8,1T1,1T5,1T6,1C1,1C4,1B2	20	1
		SW5	1P1,1P4,1P6,1P8,1T1,1T5,1T6,1C1,1C4,1B1	20	1
	Second propulsive action of arms (SPAA)	SW1	2P1,2P4,2P5,2P8,2T3,2T4,2T7,2C2,2C3,2B2,2B3	11	0.55
		SW1	2P2,2P4,2P6,2P8,2T3,2T4,2T7,2C2,2C3,2B2,2B3	9	0.45
		SW2	2P1,2P4,2P5,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	14	0.70
		SW2	2P1,2P4,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	6	0.30
		SW3	2P2,2P3,2P5,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	10	0.50
		SW3	2P2,2P4,2P5,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	4	0.20
		SW3	2P1,2P4,2P5,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	1	0.05
		SW3	2P2,2P3,2P5,2P8,2T3,2T4,2T7,2C2,2C3,2B2,2B3	1	0.05
		SW3	2P2,2P3,2P6,2P8,2T3,2T4,2T7,2C2,2C3,2B2,2B3	1	0.05
		SW3	2P2,2P4,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	1	0.05
		SW3	2P2,2P3,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	2	0.10
		SW4	2P1,2P4,2P5,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	12	0.60
		SW4	2P2,2P4,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	8	0.40
		SW5	2P1,2P4,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	7	0.35
		SW5	2P2,2P4,2P6,2P8,2T3,2T4,2T7,2C1,2C3,2B2,2B3	13	0.65
	First propulsive action of legs (FPAL)	SW1	3P1,3P3,3P6,3T3,3T4,3C1,3B2,3B4,3B6	20	1
		SW2	3P1,3P3,3P5,3T3,3T4,3C1,3B2,3B4,3B6	20	1
		SW3	3P1,3P3,3P5,3T3,3T4,3C1,3B2,3B4,3B6	19	0.95
		SW3	3P1,3P3,3P5,3T1,3T4,3C1,3B2,3B4,3B6	1	0.05
		SW4	3P1,3P3,3P5,3T3,3T4,3C1,3B1,3B4,3B6	5	0.25
		SW4	3P1,3P3,3P5,3T3,3T4,3C1,3B2,3B4,3B6	15	0.75
		SW5	3P1,3P3,3P5,3T3,3T4,3C1,3B1,3B4,3B6	20	1
	Second propulsive action of legs (SPAL)	SW1	4P1,4P3,4P6,4T2,4T5,4T6,4C1,4B2,4B4	16	0.80
		SW1	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B2,4B4	4	0.20
		SW2	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B2,4B4	9	0.45
		SW2	4P1,4P4,4P6,4T2,4T5,4T6,4C2,4B2,4B4	11	0.55
		SW3	4P1,4P4,4P6,4T2,4T5,4T6,4C2,4B2,4B4	17	0.85
		SW3	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B2,4B4	2	0.10
		SW3	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B1,4B4	1	0.05
		SW4	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B2,4B4	20	1
		SW5	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B2,4B4	2	0.10
		SW5	4P1,4P4,4P6,4T2,4T5,4T6,4C1,4B1,4B4	11	0.55
		SW5	4P1,4P4,4P6,4T2,4T5,4T6,4C2,4B2,4B4	3	0.15
		SW5	4P1,4P4,4P6,4T2,4T5,4T6,4C2,4B1,4B4	4	0.20
	Recovery (R)	SW1	5P2,5P3,5P5,5P8,5T2,5T4,5T6,5C2,5B2	20	1
		SW2	5P2,5P3,5P5,5P8,5T2,5T4,5T5,5C2,5B2	20	1
		SW3	5P2,5P3,5P5,5P8,5T2,5T4,5T5,5C2,5B2	20	1
		SW4	5P2,5P3,5P5,5P8,5T2,5T4,5T5,5C2,5B2	20	1
		SW5	5P2,5P3,5P5,5P8,5T2,5T4,5T5,5C2,5B2	20	1

The Table 1 shows the exact temporal sequences of the motor patterns of each swimmer and is comprised of five different events. The right-hand box shows the full behavioural patterns and the sequence of the technical model of each swimmer; the left-hand box indicates the five moments of observation and the sequences of events; the images in the bottom box show diagrams with reference to the spatio-temporal occurrence of cycles, indicating the number of times that these relationships occur.

Swimmer 1 displayed a single motor pattern. This pattern was repeated 10 times, which means that in the 20 analysed cycles, this swimmer performed the same technical execution in 10 cycles, demonstrating greater stability, particularly at the beginning and at the end (first lap and fourth lap) of the event.

Swimmer 2 presented two complete motor patterns. In the first behaviour pattern, the first five cycles represent a motor pattern; however, the second behaviour pattern presented seven cycles in the last half of the event (third and fourth lap). It seems that this swimmer used one pattern in the first part of the event and changed the pattern in the second part of the event.

The two motor patterns of Swimmer 2 differ only in the C6 criterion (head position relative to the water line - SPAL). The first motor pattern was above the water line/intermediate (4C1), while the second motor pattern placed the head below the water line (4C2).

Swimmer 3 demonstrated two complete motor patterns. In the first behaviour pattern, the first two cycles at the beginning of the event and five cycles halfway through the event represent a motor pattern; however, the second behaviour pattern presented four cycles in the last half of the event (fourth lap). In the last moment of observation, the difference between the first motor pattern of Swimmer 3 and the motor pattern of Swimmer 1 is that the trunk is tilted up/parallel to the water line. The last two events were similar to those that existed in the previous patterns; however, the observed changes were during the second propulsive action of the arms and legs, which in this pattern were inclined downwards/parallel to the water line (2P4), whereas in previous the pattern, the legs were tilted upward (2P3).

Swimmer 4 showed one motor pattern, presenting five different events numbered from 1 to 5, as was the case in the patterns of the other swimmers. Thus, it appears that the standard motor pattern is performed in the first four cycles of the stroke. Finally, Swimmer 5 displayed one motor pattern (Table 1); in the 20 cycles studied, this swimmer performed the same technical execution in six cycles, and demonstrated greater stability in the 6th, 9th, 10th, 11th, 12th and 18th cycles.

According to the schematic representations obtained for the different swimmers, it was found that three swimmers adopted a technical stroke model that is close to the variant, "very wavy, arched" (Swimmers 2, 3, and 4), and the remaining two swimmers adopted "wavy, slightly arched" and "very wavy, slightly arched" variants (Swimmers 1 and 5), according to Colman et al.[15].

DISCUSSION

The present study fills an important gap in the field of swimming research, as the temporal structure of the breaststroke technique has not previously been studied in the 200m event.

The aim of this study was to describe the breaststroke technique in the 200m event by means of the analyses of T-patterns. The main findings were that each swimmer adopted his own motor pattern behaviour; however, there were some individual indicators of behaviour stability during the 200m event. The presented data highlights the potential of the motor patterns in performance analysis and motor skills in swimmers.

Characterisation of events and the frequency of occurrences in all swimmers

Of the five moments of observation over the 200m event, the results indicate that those that experienced the least amount of change were the FPAA, FPAL, and R, which had greater gestural stability. The moments that experienced the most changes were the SPAA and SPAL, which had less gestural stability.

These data are consistent with the statements of Chollet et al.[18], Barbosa et al.[6], and Seifert et al.[19], who reported that swimmers adjust their techniques with wide variations in velocity because of the greater drag components of the forward movement during underwater recovery of both arms and legs. It is also due to their capability of limiting the drop of velocity during the critical phases of movement by remaining streamlined (FPAA, FPAL, and R) and by having a high propelling efficiency (SPAA and SPAL). Previous studies on the performance of elite swimmers[12,20] show that greater gestural stability leads to better athletic performance.

Temporal sequence of motor patterns

According to Sarmento et al.[21], the number, frequency, and complexity of the detected patterns indicate that the athletic behaviour is more synchronised than the human eye can detect. The existence of complete motor patterns across the sample places value on the observation instrument developed, making it feasible and reliable for use in similar conditions.

In this study, Swimmers 1, 4, and 5 presented one motor pattern and Swimmers 2 and 3 showed two different motor patterns, where in the first part of the event, they used one pattern and in the second part of the event, they changed that pattern. It seem that, according Thompson et al.[22] , the swimmers drop off more from the first to the second half of 200m events than do freestyle and backstroke swimmers. First of all, the split during the first 100m includes a turn and the split during the second 100m does not, which might explain the changes in motor patterns. Second, the breaststroke technique involves large intra-cycle velocity fluctuations[6,19], which are greater compared to those of any other competitive stroke.

In this study, three different breaststroke styles were identified: variant "very wavy, arched" (Swimmers 2, 3, and 4), variant "wavy, slightly arched" and "very wavy, slightly arched" (Swimmers 1 and 5), according to Colman et al.[15]. These variants in swimming techniques are all associated with a more or less horizontal position of the trunk but with different levels of energy expenditure. At slow velocities, the highest intra-cyclic velocity fluctuations were observed in the undulated style with overwater recovery of the arms.

One limitation, given the purpose of this study, verified that the aquatic environment led to obtaining images that were not always perceptible, which determined the application of the observational methodology. Another limitation of the study was that the swimmers adopted swimming techniques that were appropriate for their own biophysical characteristics, which made it difficult to compare the motor patterns between swimmers.

CONCLUSION

In conclusion, each swimmer adopts his own motor pattern behaviour, since each one adjusts his swimming technique characteristics differently. Therefore, it would be useful to apply the observational methodology described here to other swimming strokes in which swimmers are differentiated according to their gender, as this would enable the study of any potential differences in temporal structure according to the degree of performance. A further point is that although our swimmers were all elite swimmers, it would be interesting to compare the temporal structure across age groups in situations of real competition (not simulated), thereby improving the quality of the technical evaluation of swimmers.

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