Research to improve breaststroke performances with rule changes

Ulrik Persyn [1], Véronique Colman [1], Bart Soons [1] e Antonio Silva [2]
(1) Faculty of Kinesiology and Rehabilitation Sciences, KULeuven (Belgium)
(2) Universidade de Trás-os-Montes e Alto Douro (Portugal)

Persyn, U.; Colman, V.; Soons, B.; Silva, A.; **Research to improve breaststroke performances with rule changes.** Motricidade 2(4): 236-242

submission date: January of 2006
acceptance date: May of 2006

Introduction

Since the seventies, each swimmer, visiting the K.U.Leuven Evaluation Centre, was diagnosed to improve his performances, based on a film or video observation and analysis, using a checklist of faults and a physical profile chart. Presently, a diagnosis can be made by any expert in any pool, when he disposes of the individual's video recordings and a specific PC-program, in addition to the physical profile chart. At a number of Congresses of Biomechanics and Medicine in Swimming, since long before the rule change, permitting to dive with the head below the water durface, special attention was paid to body undulation in breaststroke.

At the Congress in Brussels (1974), e.g., an Olympic finalist in the Games of Munich (1972) was described, who rotated excessively the trunk above the water surface, backward by cambering and forward by launching (as can be observed in dolphins.) This style was assumed to correspond with a more even velocity and more economy (Fig. 1,a) [4]. Another animal-like propulsion concept, below the water surface, was visualised in butterfly, namely body waving (as observed in eels) (Fig. 1,b). By launching and waving, a breaststroke swimmer risked, however, to dive with the head below the water surface, which was not allowed until '87. In the Games of Munich, the usual butterfly-like arm pull, below the body, after start and turns in breaststroke, was often accompanied by a downward butterfly-like leg kick (to maintain the trunk horizontally). This also was not allowed until recently. Instead, a screw-like, up- and downward, more vertical, arm pull was proposed (inspired by penguins) (Fig. 1,c) [5]. Because the amplitude of this pull is wider and propulsion is better directed in the length axis of the body, a higher impulse was generated. However, when swimming at the surface, using this wide, more vertical pull, the swimmer risked also to dive the head below the surface.

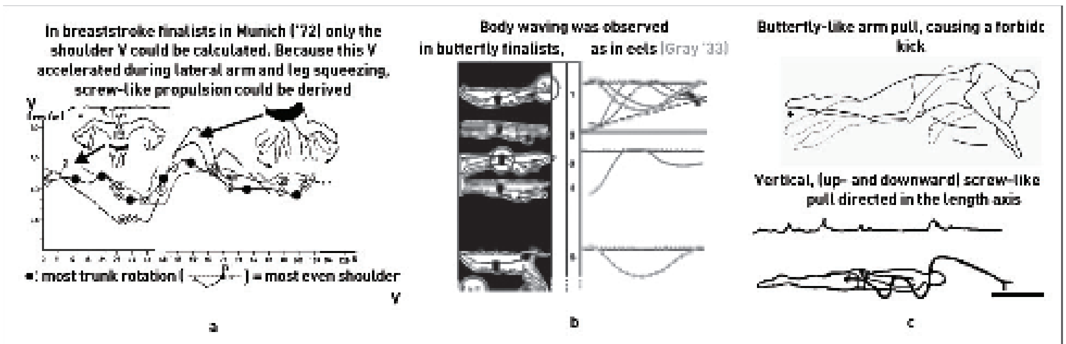


Figure 1: Movement analysis of Olympic finalists ('72) to form hypotheses on propulsion.

At the Congress in Bielefeld (1986), Van Tilborgh introduced a movement analysis system (using 16mm film), measuring trunk mobility and calculating the velocity of the body centre of mass (CMbody). In 23 swimmers at (inter)national level, he found significant correlations between undulation (body cambering and waving) and more even velocity [11]. His findings influenced a rule change (1987), permitting to dive with the head below the water surface and enabling unlimited undulation.

At the Congress in Liverpool (1990), Colman introduced a quick video analysis system. In 35 swimmers at (inter)national level, she found significant correlations between undulation and physical characteristics (body structure, flexibility and strength). In the most undulating and the flattest international level competitors, 9 moments delimiting phases were analysed extensively [1].

At the Congress in St-Etienne (2002), Silva and Soons presented statistical data of 62 swimmers at international level. This population was divided in 4 style groups (N= ± 16), based on the maximum waved and cambered body positions: an undulating and a flat group were formed again, as well as two intermediate groups, one typified by most waving and least cambering and another vice versa [8,9]. In each style group and in the 2 gender groups, a series of movement variables in various phases of the stroke cycle were statistically relevant for velocity change of the body centre of mass (and thus for propulsion) and even for performance.

Presently, the expert needs selecting for each individual 9 moments in the stroke cycle from a side view video recording, while his physical profile chart remains necessary. The 9 video moments of each individual are overlaid on 9 mean stick figures (delimiting the phases) of their best corresponding style group, to locate faults [9].

Research steps

a. Propulsion concepts in the extreme undulating and flattest styles (nineties)

Methods

The first 10 years after the rule change in '87, while the style evolution was not yet stabilized, 65 (inter)national level competitors were digitised and analysed for diagnosis. Based on the 7 moments in the stroke cycle, taken to define undulation, the majority of styles could be classified in a group, but not all. However, various groups were too small for statistical analyses.

At international level, 5 individuals classified in the flattest style group (all men) and 5 in the extreme undulating style group (all women) were examined extensively [2,3]. To allow comparing propulsion (concepts) in the 2 genders and in different age groups, the mean velocity of the CMbody in the selected phases during the stroke cycle was calculated as a % of the mean swimming velocity (Fig. 2).

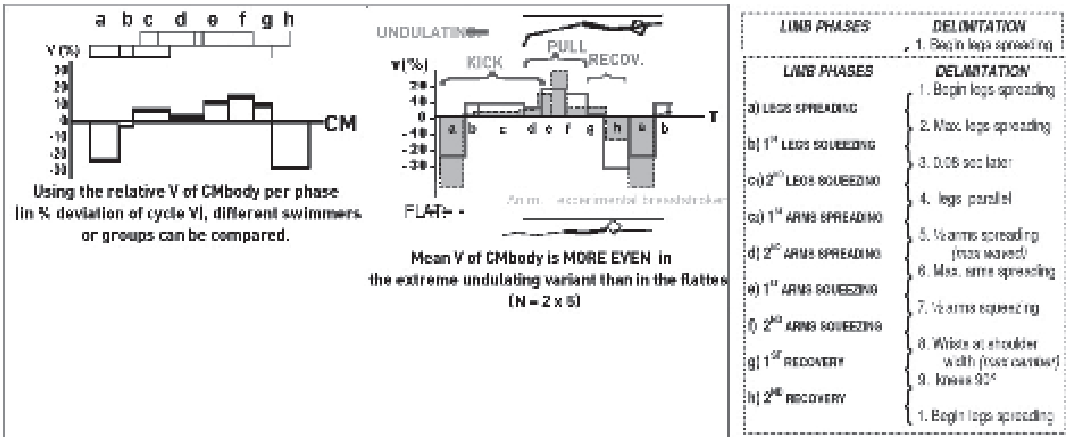


Figure 2: Very different %V of CMbody in the two extreme variants

Results

The difference in % velocity of the CMbody between the slowest and fastest phases of the extreme undulating style group was 24% less than in the flattest style group. This confirmed findings of Van Tilborgh, even before the rule change, that undulation resulted in a higher mechanical effectiveness. Less energy is lost to overcome the inertia of the body.

Considering the very differing velocity changes of the CMbody in the two extreme style groups, very different propulsion concepts were deduced. Due to the animal-like locomotion in the most undulating style, with the participation of the whole body (moving above and below the water surface), not only velocity peaks in the fastest and slowest phases are levelled off but more phases in the cycle are propulsive.

b. Movement variables relevant for propulsion and for performance in the 2 gender and in 4 different style groups (since 2000)

Methods

10 years after the rule change, the evolution of the breaststroke styles was stabilizing, apparently. In the year 2000, 62 recent breaststrokers at international level were digitized and analysed for diagnosis. (The mean performance of, e.g., 100m men was 1'03", while the world record was ±1'00".)

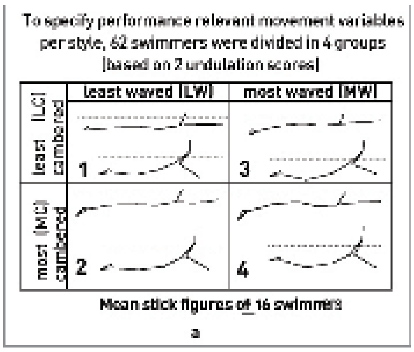
Based on 9 specific moments (delimiting phases), in this population a statistical study was made. Most of the movement variables relevant for CMbody velocity change (indicating propulsion), and even for swimming performance were related to waving or cambering. To simplify further grouping, only the maximum cambered and waved body positions were taken as criterions (Fig.3,a). This population was not only divided in 2 gender groups [8] but also in 4 equal style groups (N = 4 x ±16) were formed (genders mixed) [9]. The preceding most undulating and flattest style groups (N=2x5) could now be expanded and two intermediate style groups were composed (the most waving and least cambering swimming and vice versa.) This manner of grouping had already been found in previous studies [6].

As in the whole population, in the 2 gender groups and in the 4 style groups, the movement variables relevant for CMbody velocity change and for performance were calculated.

Results

In the expanded undulating and flat style groups (N = 2 x ±16), the same trends in % velocity changes of the CMbody per phase were found as in the two extreme styles from the previous study (N = 2 x 5) [1] (Fig.3,b). Moreover, per style group, a number of movement variables still correlates significantly with performance [9] (Fig.3,c-d). Consequently, many of these relevant movement variables, indicating animal-like or ship-like locomotion, reinforced hypotheses regarding specific propulsion concepts [7].

In Fig. 4, 9 mean stick figures, delimiting the phases, of the women group and a style group (undulating) are given. Performance relevant movement variables (angles, amplitudes…) are specified by arrows on the stick figures; the direction shows the change in technique corresponding to better performance [8,9].



The 9 mean stick figures in the *women and the undulating style group* are rather similar (Fig. 4), as well as the *men and the flat style group*. In addition, the relevant movement variables correspond.

For example, in *the women and the undulating style group*, a deep leg kick (Fig. 4: A3 and B3), combined with a forward head inclination, prepares a downward trunk inclination (Fig 4: A5 and B5). During the maximum waved position, legs kept deep, combined with an upward arms spreading and a downward trunk inclination (Fig. 4: A5 and B5), remain relevant for performance.

When cambering, a large backward rotation and a large vertical displacement of the head (Fig. 4: A8 and B8) also remain relevant for performance. Moreover, when cambering, a small angle between upper arm and upper trunk is relevant (Fig 4: B8).

c. Developing of a semi-quantitative kinesiological diagnosis system for the renewed breaststroke.

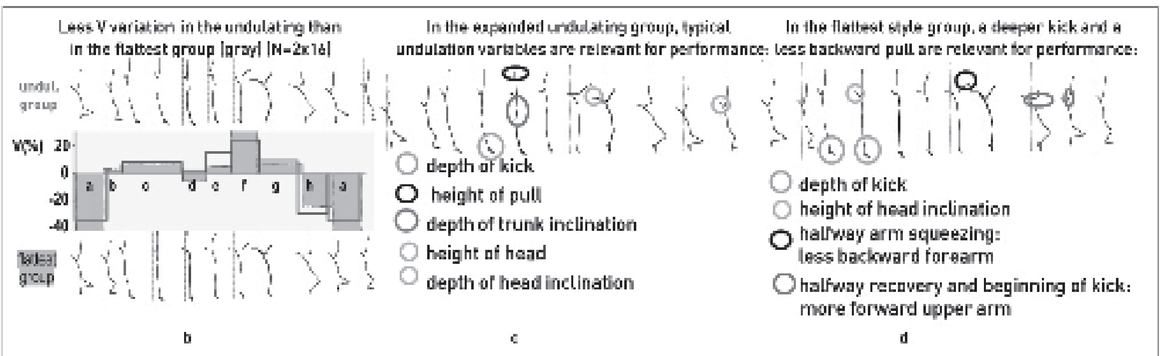


Figure 3: Movement variables statistically relevant for performance in the flat and undulating breaststroke style groups.

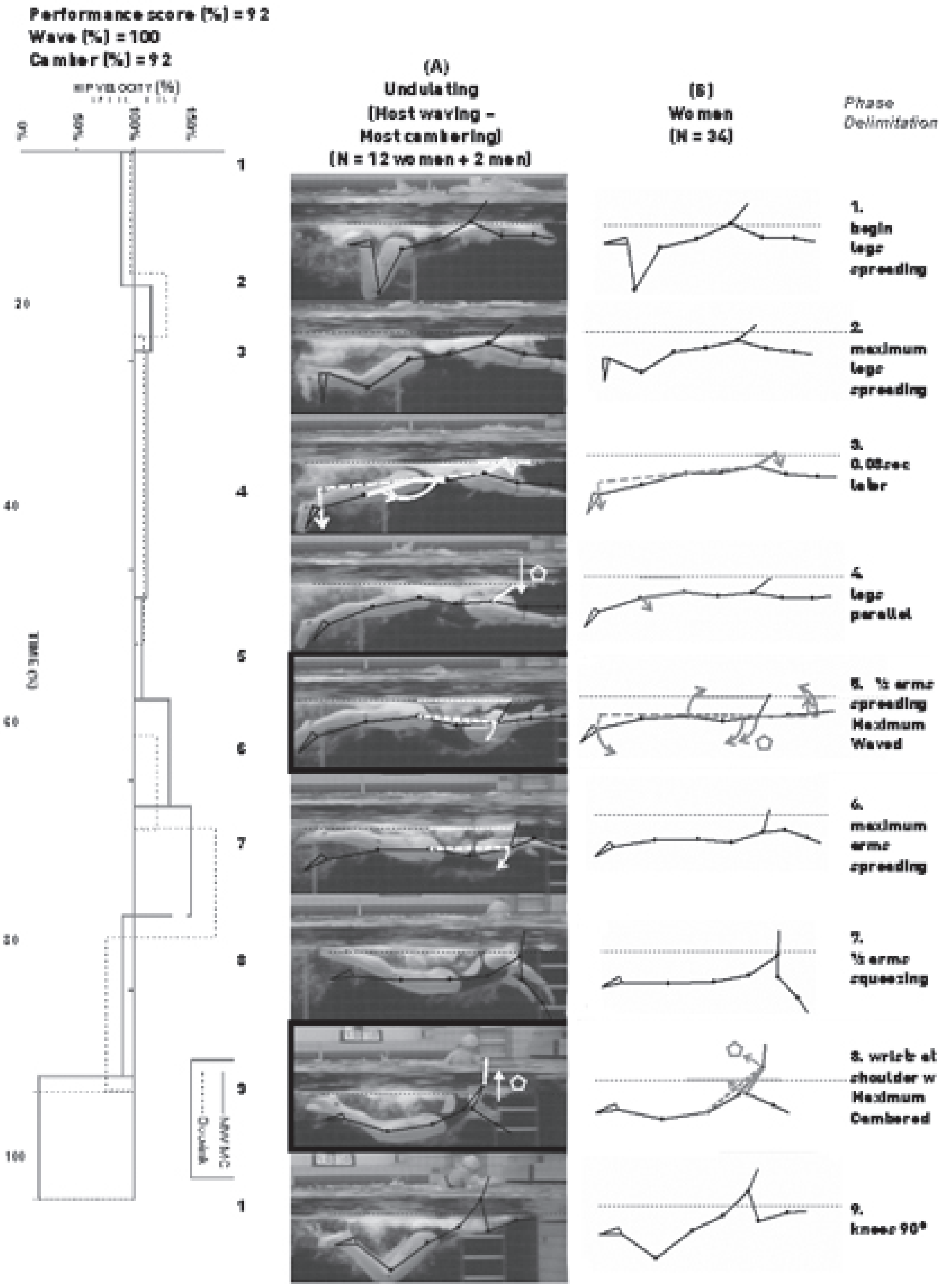


Figure 4: Semi-quantitative diagnosis system for one case in the undulating style group. At the left, the nine moments are confronted with the V_{HIP}. (full lines: mean; dotted lines: individual).

Methods

To evaluate technique, the expert needs a video recording from side view (below and above the water surface), synchronised with a front view. For each individual, 9 moments in the stroke cycle from the side view are selected. (In addition for a kinesiological evaluation, a physical profile chart is necessary).

A quick digitizing procedure on PC was developed (in visual basic 5-0), to reconstruct angles in order to estimate the most corresponding style group, based on:

- the maximum waved position: from the joints ankle-hip-shoulder and hip-shoulder-wrist,
- the maximum cambered position: from the joint knee-hip-middle-trunk and hip-middle trunk-shoulder.

In figure 4, an application, the 9 video moments of one female individual are overlaid on the 9 mean stick figures of the most appropriate style group and also compared with the 9 mean stick figures of the women gender group. From these mean stick figures, including the performance relevant movement variables, per style group and per gender, faults can be located in specific moments.

Immediately after the discussion, the report is printed, ready to be given to the coach.

Conclusion

Beginning in the seventies, each swimmer, visiting the K.U.Leuven Evaluation Centre, was diagnosed based on a film or video observation and a checklist of faults, as well as on a physical profile chart. In the eighties, to evaluate breaststrokers at international level, a specific digitizing system for movement analysis, developed by Colman, was used. This quantitative system, however, was time demanding and the success depended for a large part on the expertise of the researchers themselves, gained from the investigation of the most undulating, average undulating and flattest styles.

Because in 62 recent breaststrokers at international level, numerous movement variables were relevant for the propulsion (concept) and for performance, a quick semi-quantitative kinesiological diagnosis system could be made operational for use in any pool by a well trained expert.

References

1. Colman V; Daly D; Desmet S; Persyn U. (1992) Relation between physical characteristics and undulation in the breaststroke, in Maclaren D; Reilly T; Lees A (eds), *Swimming science VI* (Biomechanics and medicine in swimming), London: E & FN SPON, 365-370.

2. Colman V; Persyn U. (1993) Trunk rotation, body waving and propulsion in breaststroke. *J Human Mov Stud*. 24:169-189.

3. Colman V; Persyn U; Daly D; Stijnen V. (1998) A comparison of the intra-cyclic velocity variation in breaststroke swimmers with flat and undulating styles. *J Sports Scienc*. 16:653-665.

4. Persyn U; De Maeyer J;Vervaecke H. (1975a) Investigation of hydromechanics determinants of competitive swimming strokes, in Lewillie L; Clarys JP (eds), *Swimming II (International series on sport sciences 2)*, Baltimore (Maryland): University Park Press: 214-222.

5. Persyn U; Vervaecke H, (1975b), A model for a functional evaluation of full-synchronization data in the crawl stroke, *Hermes (Leuven)*. 9(5):425-435.

6. Persyn U, Colman V. (1999) What are the best breaststrokers doing now? R. Sanders and J. Linsten (eds.) *Applied proceedings of the XVII International symposium on biomechanics in sports: swimming*. ISBS 1999. Perth Western Australie, 33-45. (http://www.sportscoach-sci.com/).

7. Persyn U, Colman V, Soons B. (2003) New combination of hydrodynamic concepts in swimming, *Biomechanics and Medicine in Swimming IX*. Publications de l'Université de St. Etienne. 7-14.

8. Silva A, Colman V, Soons B., Alves F, Persyn U. (2003) Performance relevant time-space variables for breaststroke: sex differentiation and whole group. *Biomechanics and Medicine in Swimming IX*. Publications de l'Université de St. Etienne, 295-300.

9. Soons B, Silva A, Colman V, Persyn U. (2003) Specific movement variables important for performance in different breaststroke styles, *Biomechanics and Medicine in Swimming IX*. Publications de l'Université de St. Etienne, 179-184.

10. Soons B, Colman V, Persyn U. (2006) Development of a multi-media system for kinesiological evaluation of swimming by experts in any pool. *Biomechanics and Medicine in Swimming X*.

11. Van Tilborgh L; Willems EJW; Persyn U. (1988) Estimation of breaststroke propulsion and resistance resultant impulses from film analysis, in Ungerechts B; Wilke K; Reischle K (eds), *Swimming science V*. Champaign: Human Kinetics, 67-72.