Reduction of Velocity Fluctuation and Improvement of Performance by Undulating in Breaststroke

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Introduction

This article compares the undulating and flat breaststroke styles of international level men and women. Knowledge of motion of marine animals, are explored in the light of statistical evidence. The concepts of 'screw-like' and 'dolphin-like' motions help improve performance (Persyn et al. 1975). Because fluctuations in velocity are related to energy consumption, reduction of velocity may be beneficial. Movie A shows a successful 'experimental' swimmer, using screw-like motions with the body.

Before the breaststroke rule change (1987), when the head had to be kept above the water surface, significant correlations were found in 23 breaststroke swimmers at national German level between butterfly-like undulation characteristics (deep leg kick, upward arm spreading, trunk cambering) and fluctuation in velocity of the centre of mass of the body during the stroke cycle (Van Tilborgh et al. 1987). The problem was that considerable weight was forbidden head immersion. Van Tilborgh’s findings influenced a rule change shortly later, allowing the leg kick combined with an upward arm spreading, to achieve an S-like motion help to reduce velocity fluctuations and improve performance (Persyn et al. 1992 (4)).

The undulating breaststroke style is characterised by a deep leg kick combined with an upward arm spreading, to achieve an S-like motion. A score for 'body waving' was calculated from the joint angles shoulder-midpoint trunk-hip-knee-ankle at the instant of greatest waving. A score for 'trunk cambering...

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After the breaststroke rule change, 62 swimmers at international level (37 women, 25 men) were analysed by Colman et al. (1998 (5)).

A specific movement analysis system developed by Colman determined diverse variables of interest, in mass for each of nine phases of the stroke. A score for 'body waving' was calculated from the joint angles shoulder-midpoint trunk-hip-knee-ankle at the instant of greatest waving. A score for 'trunk cambering...
lines connecting shoulder-midpoint trunk-hip-knee at the instant of greatest cambering. Fig. 1 shows the swimmer as in Movie A.

Figure 1: The most dome-shaped, S-shaped and cambered positions of the swimmer shown

From the whole sample, the five most undulating styles in women and the five flattest styles in men were: and C show mean stick figures of these extreme styles. In these styles, the mean body centre of mass velocity per cycle. The considerable difference in range of the velocity between the most undulating and illustrated in mean velocity profiles (Fig. 2). From the changes in this velocity, a criterion of economy can confirmation of propulsion concepts.
In the flattest style variant, the difference between the highest and lowest velocity peaks amounted to as but in the most undulating style variant only 56.5%. In the flattest style variant, peak accelerations occur and feet indicated the possibility of 'screw-like' propulsion. In the most undulating variant, smoother center of mass velocity changes (during dolphin-like trunk rotation above the surface and eel-like body waving below) indicated the possibility similar to those used by marine animals (Persyn et al. 2003 (6)).

In this article, for men and women as separate groups and for the whole sample, correlations were determined (Spearman r) between the diverse movement variables and the change in body center of mass velocity across the whole stroke cycle (Silva et al. 2003 (7), Soons et al. 2003 (8)). Most importantly, correlations between each variable and performance were also determined. The performance score was the within-gender and age percentile score of performance.

**Results**

Significant correlations are indicated for variables in specific phases with whole cycle velocity change, relative to the adjoining phases and with performance (Fig. 3).
Figure 3: Movement variables in phases and phase delimiting instants (see figure 2) typical for mass velocity changes during the stroke cycle or the adjoining phases and relevant for performing level swimmers: 37 women and 25 men. (All correlations are significant). In DESCRIPTION, values for the whole group. Thin lines, smaller numbers and grey arrows specify ISD: indicating a favourable trend of the
depth of the leg kick relative to a fixed background is related to performance for the women and also for the men. The deeper the kick, the better the performance. Depth of the kick is also related to change in velocity during the leg spreading and first part of the squeezing phase relative to the adjoining horizontal leg kick compared to a deep kick.
Movie D and Movie E

The score for body waving (at half way arm spreading) is related to performance for women and for the greater the amount of body waving the better the performance. While there is no significant correlation stroke cycle, there is a correlation between body waving score and change in velocity across the phase the greater the amplitude of body waving, the smaller the fluctuation in velocity.

The higher score for trunk cambering (at the end of the arm squeezing) is related to better performance modestly related to less change in velocity during the stroke cycle (Fig. 3, C-D). The Movies F (instant swimmers with low and high scores for cambering.

Movie F and Movie G

Various scores describing upper and lower trunk angular motion are related to performance for women related to the change in velocity across the phase relative to the adjoining phases (Fig. 3, E-F). These in trunk rotation the better and more economical the performance.

It is also interesting that for the men, as a separate group, the raising of the hands relative to a fixed bac related to better performance (Fig. 3, G). This may require considerable shoulder flexibility and strengh represent a limitation for some men.

Conclusion

A more undulating style, characterised by high scores for body waving and trunk cambering and feat with reduced velocity fluctuations and better performance than a flatter style. However, this is a gene indicate that every swimmer, and certainly every men, should adopt an undulating style. As was ment physically more suited to using a flatter style than an undulating style. For this reason, it is necessary characteristics and technique within style groups to obtain an insight into how to maximise performanc This is the focus of the next articles.
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