

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 c

In particular, it may be that, in addition to screw-like motions, ‘dolphin-like’ or ‘eel-like’ motions help improve performance (Persyn et al. 1975 (1)). Because fluctuations in velocity are related to energy co velocity may be beneficial. Movie A shows a successful ‘experimental’ swimmer, using screw-like mot like motions with the body.



Movie A

Before the breaststroke rule change (1987), when the head had to be kept above the water surface, signi swimmers at national German level between butterfly-like undulation characteristics (deep leg kick, up and fluctuation in velocity of the centre of mass of the body during the stroke cycle (Van Tilborgh et al. breaststroke style involving undulation may be more economical than the traditional flat style.

The undulating breaststroke style is characterised by a deep leg kick combined with an upward arm spr position (body waving), and by trunk rotation (trunk cambering). The problem was that considerable w forbidden head immersion. Van Tilborgh’s findings influenced a rule change shortly later, allowing the From then, extreme undulation resulted for some competitors in amazing performance improvements (I

However, most breaststroke swimmers, mainly men, were physically unable to undulate. Colman et al. between physical characteristics and the amount of undulation. ‘Body waving’ was related to specific l cambering’ to specific trunk and shoulder flexibility and to upper limb strength. She advised that swim flexibility and an efficient deep leg kick should train trunk and shoulder flexibility but also upper limb :

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After the breaststroke rule change, 62 swimmers at international level (37 women, 25 men) were analys Evaluation Centre (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 ang -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.

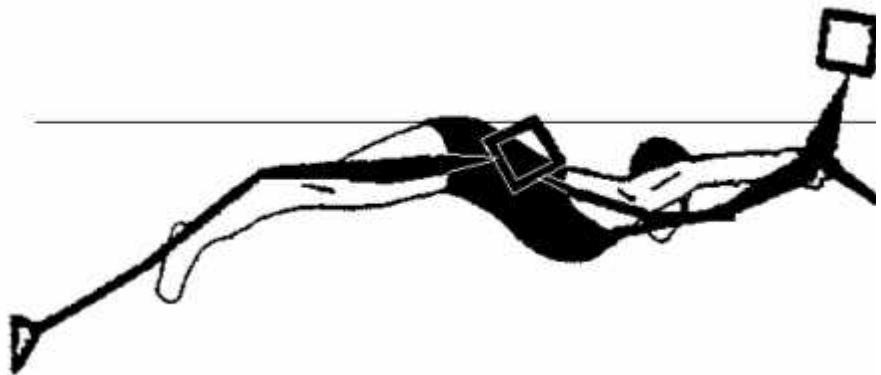
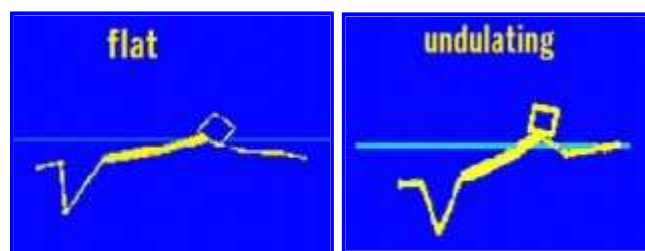
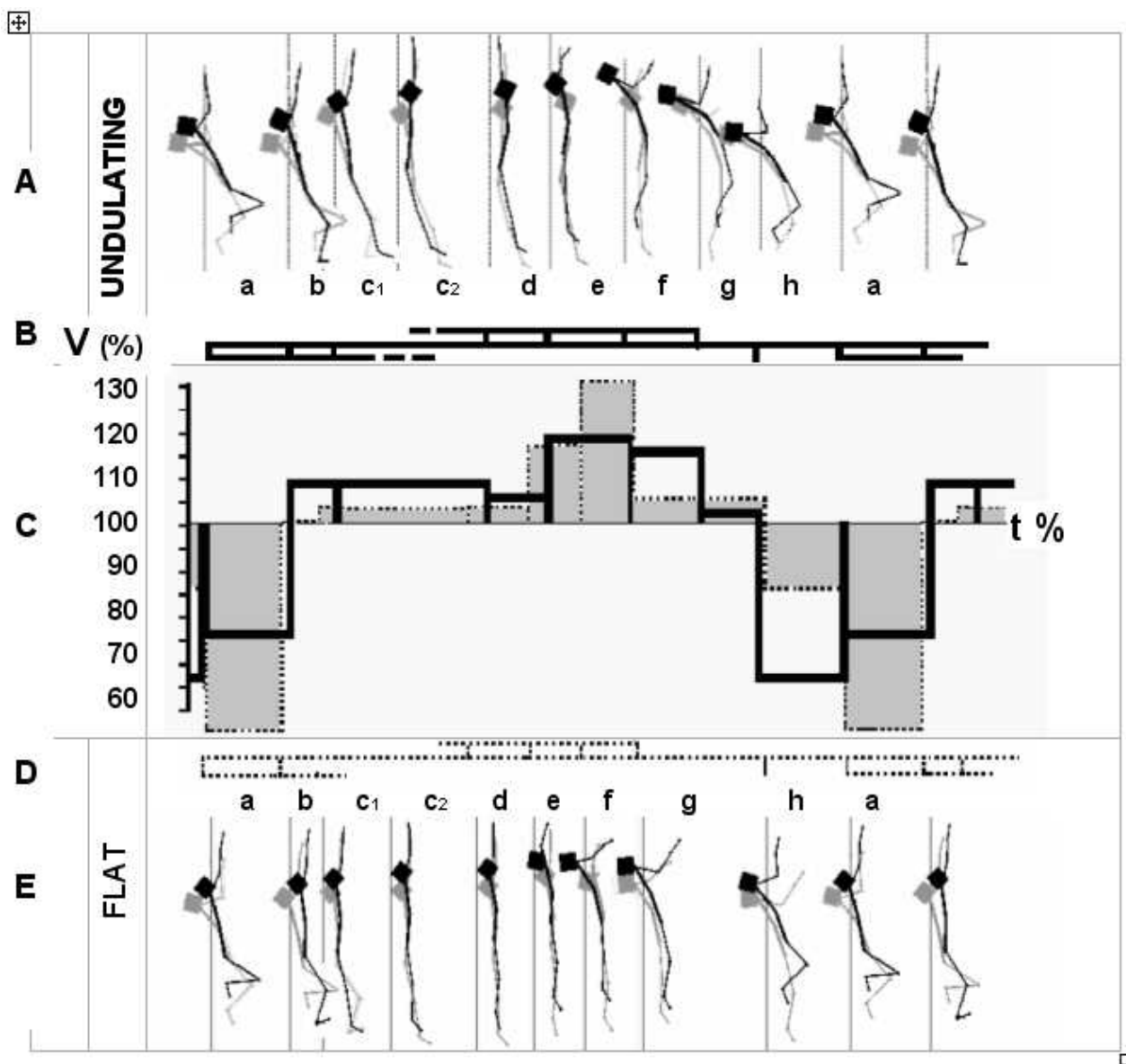


Figure 1: The most dome-shaped, S-shaped and cambered positions of the swimmer shown

From the whole sample, the five most undulating styles in women and the five flattest styles in men were identified. Movies B and C show mean stick figures of these extreme styles. In these styles, the mean body centre of mass velocity and the mean velocity per cycle. The considerable difference in range of the velocity between the most undulating and flattest styles is illustrated in mean velocity profiles (Fig. 2). From the changes in this velocity, a criterion of economy can be confirmed of propulsion concepts.



Movie B and Movie C



LIMB PHASES	DELIMITATION
a) LEG SPREADING	Begin legspreading
b) 1 ST LEG SQUEEZING	Max. leg spreading
c ₁) 2 ND LEG SQUEEZING	½ leg squeezing
c ₂) 1 ST ARM SPREADING	Begin arm spreading (arms parallel)
d) 2 ND ARM SPREADING	Fingers highest or ½ arm spreading
e) 1 ST ARM SQUEEZING	Max. arm spreading
f) 2 ND ARM SQUEEZING	½ arm squeezing
g) 1 ST RECOVERY	End arm squeezing (hands should. width)
h) 2 ND RECOVERY	½ leg recovery (knees 90°)
	Begin legspreading

Figure 2: The mean centre of mass velocity profile per phase in the most undulating (A) and flat E: Mean stick figures (delimiting phases) of the 5 most undulating styles (women) and the 5 flat timing of selected limb phases.

(in % of the stroke cycle) C: Mean centre of mass velocity per phase (in % of the mean velocity undulating; grey zone: flattest)

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 occurred and feet indicated the possibility of 'screw-like' propulsion. In the most undulating variant, smoother cephalic 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 for diverse movement variables and the change in body centre of mass velocity across the whole stroke cycle to the previous and subsequent phase) (Silva et al. 2003 (7), Soons et al. 2003 (8)). Most importantly, competitive performance were also determined. The performance score was the within-gender and age percentile score 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).



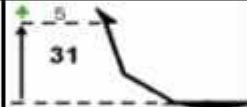




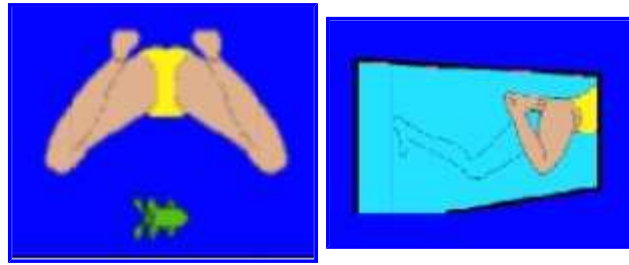
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	PHASE(S) OR PHASE DELIMITATION → (Reference of observation)	DESCRIPTION (Mean +SD in degrees or % body length)	GROUP	Less velocity change during adjoining phases
A	BEGIN LEG SPREADING TO DEEPEST POINT → (vertical distance in % of body height of foot relative to fixed background)		Whole Women	.45 .51
B	½ ARM SPREADING (most waved) → Most S-shaped body position		Whole Women	.30 .37
C	END ARM SQUEEZING (most cambered) → (foot most upward relative to trunk length axis)		Whole	
D	→ (max. uphill trunk relative to water surface)		Whole	.27
E	TRUNK ROTATION → (Total trunk rotation angle relative to water surface)		Whole Women	.39
F	→ (Total lower trunk rotation angle relative to water surface)		Whole	.46
G	1ST ARM SPREADING → (vertical distance in % of body height of hand relative to fixed background)		Whole Women Men	.46 .63

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 performance 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 1SD: indicating

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 phases. 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 1 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 back related to better performance (Fig. 3, G). This may require considerable shoulder flexibility and strength represent a limitation for some men.

Conclusion

A more undulating style, characterised by high scores for body waving and trunk cambering and feature with reduced velocity fluctuations and better performance than a flatter style. However, this is a general indication that every swimmer, and certainly every man, should adopt an undulating style. As was men 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 performance. This is the focus of the next articles.

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