MOVEMENT VARIABLES IMPORTANT FOR EFFECTIVENESS AND PERFORMANCE IN BREASTSTROKE

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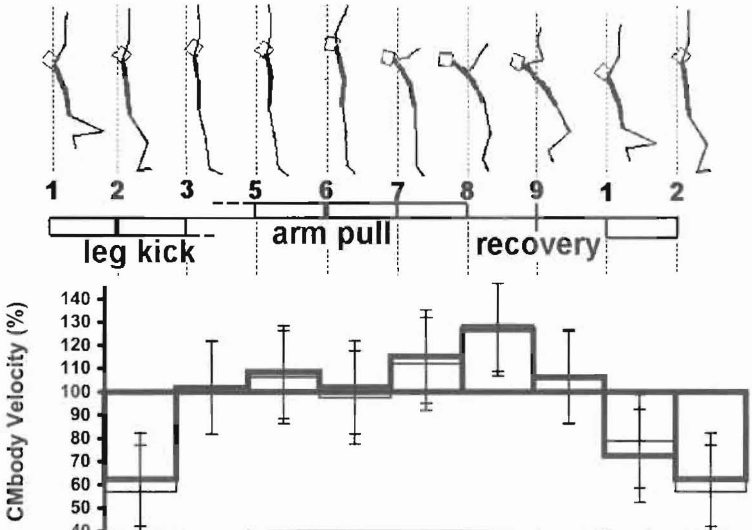
The purpose of this study is to improve diagnosing and advising breaststroke swimmers, based on a movement analysis and a statistical analysis of the two sexes apart. A reference population of 62 international level breaststroke swimmers (37 women and 25 men), from the period after the rule change in 1987, was available. A series of time-space variables was found to be not only relevant for effectiveness (for less velocity variation of the center of mass of the body) but also for swimming performance.

KEY WORDS: breaststroke; effectiveness criterion; CMbody velocity, diagnosis and advice

INTRODUCTION: From the seventies, for diagnosing the four strokes the velocity variation of a fixed point on the trunk was used to derive propulsion, but only during phases without backward or forward segment displacements (Persyn et al, 1975; Persyn et al, 1983). From the velocity change of the CMbody per phase, the difference between propulsion and drag, the resultant impulse, can be calculated during the whole stroke cycle. Van Tilborgh (1987), calculated the velocity change of the CMbody in the stroke cycle within 23 breaststroke swimmers at (inter) national level and estimated that the velocity variation required 25% of the total work delivered. But, with more body waving and trunk rotation a lower % was lost (because of less velocity variation). Consequently, velocity variation of the CMbody was chosen as a criterion for effectiveness to improve technique and performance. Meanwhile the breaststroke rules were changed, which resulted at international level in large individual differences in amplitude of body waving and trunk rotation, the so-called body undulation. The purpose of the present investigation was to detect statistically significant time-space variables relevant not only for effectiveness but also for performance in breaststroke. To allow more individualised diagnosing and appropriate advising, not only the whole population but also the two sexes apart were studied.

METHODS: A reference population of 62 international level breaststroke swimmers (37 women and 25 men), from the period after the rule change in 1987 was available. The recording procedure and a quick video-analysis system, developed by Colman (1991), were used. The movement was recorded on video during the second half of a 20m swim at a 100m swimming pace. A two-dimensional analysis, of a view from the side was conducted and a synchronised front view recording was also needed to correctly delimit some of the phases of the leg kick and arm pull. The video-analysis system includes specific solutions for the reconstruction of the split vision images above and below the water surface, for the correction of the rotating camera, for the identification of the limits of the phase, for digitising trunk flexion and shoulder movements. Global time-space variables were calculated, such as the amount of body undulation and the velocity variation of the CMbody. For digitising, a video player (Sony VP 900P U-matic, 50 fields/s), providing a stable still picture, and an Amiga PC (screen resolution of 640x512 pixels) were used. The computer and video images were overlaid on one screen (using a Rendale Limited Genlock overlay card). Analytical time-space variables were considered from different references of observation: (i) relative to the stroke cycle: the duration of the phases; (ii) relative to the longitudinal axis of the trunk: angles of the limbs, vertical distance of joints (markers) and angles between the different segments; (iii) relative to the water surface: angles of the longitudinal axis of the trunk and of the different segments, and the vertical distance of joints (markers); (iv) relative to a fixed background: paths of hand and foot. Twelve specifically selected instants in one stroke cycle were digitised and nine phases of the leg kick and arm pull were delimited: (Fig. 1: 1-2) legs spreading; (2-3) 1st legs squeezing; (3-4) 2nd legs squeezing; (4-5) 1st arms spreading; (5-6) 2nd arms spreading; (6-7) 1st arms squeezing; (7-8) 2nd arms squeezing; (8-9) 1st arms recovery; (9-1) 2nd arms recovery. The effectiveness was calculated from the difference between the extreme peaks in velocity of the CMbody during the cycle and from the velocity changes of the CMbody from phase to phase (in % of the mean velocity during the stroke cycle). The performance (%) was calculated taking into consideration the performance levels in relation to the curve of the 10 best Americans per age group. All the time-space variables were correlated with the effectiveness criterions and with % performance (Pearson product moment coefficient of correlation (r)). The meaningfulness of r is calculated by the coefficient of determination (r^2), which gives the portion of common association of the factors that influence the two variables. In order to provide more appropriate advice, not only the whole group but also one group per sex were studied. Similar procedures were used in the period of the rule change. For the whole group by Van Tilborgh et al (1988) (but with a smaller number of subjects (N = 23) and of a lower performance level) and for the women and men apart by Colman (1991).

RESULTS: In figure 1, the CMbody velocity curves per phase, for female and male swimmers apart, are presented. Men have slightly more velocity variation and primarily from the 2nd part of the recovery to the legs spreading.



	1-2	2-3	3-5	5-6	6-7	7-8	8-9	9-1	1-2
■WOMEN	62	102	108	102	115	127	106	73	62
□MEN	57	102	106	98	112	129	107	79	57

Figure 1. Mean of CMbody velocity in each of the phases delimited in breaststroke.

In this international level group, although very different styles occur, it was interesting to find that a series of time-space variables are relevant for performance as well as for effectiveness (less velocity variation in the total stroke cycle or only in the phase corresponding to the specific time-space variable). These relevant variables are specified in figure 2.

DISCUSSION: Our findings cannot be compared directly with the findings in the available literature (Mason et al, 1986; Maglischo et al, 1987; Maglischo et al, 1988; Mason et al, 1992; Troup 1991, Manley and Atha, 1992), because the technique analysis systems available on the market were used. In these systems the trunk is represented by one line shoulder-hip joint. Consequently the flexible trunk and the moving shoulder girdle cannot be reconstructed and the velocity changes of the CMbody are different (Colman et al, 2000).

	PHASE OR PHASE DELIMITATION → (Reference of observation)	DESCRIPTION (Mean +SD in degrees or % body length)	GROUP	Less velocity var. during stroke cycle	Less velocity var. during corresp. phase	
1 2 3	BEGIN LEG SPREADING TO DEEPEST POINT → (% vert. dist. foot relative to fixed background)	24 3	Whole Women		X	a
5	½ ARM SPREADING → Most S-shaped body position		Whole Women		X	b
	→ (Total trunk rotation angle relative to water surface)		Whole Women		X	c
	→ (Hip highest-lowest relative % dist. to water surface)		Whole	X		d
	→ (Total lower trunk rotation angle relative to water surface)		Whole		X	e
8	END ARM SQUEEZING → (max. uphill trunk relative to water surface)	7 39°	Whole		X	f
	→ (foot most upw. relative to trunk length axis)	5 31	Whole	X		g
	→ (angle upper arm relative to water surface)	-123° 16°	Women	X		h
	→ (% hand backw. relative to trunk length axis)	6 10	Women		X	i
	1ST ARM SPREADING → (% vert.dist. hand relat. to fixed background)	3 4	Men		X	j

Figure 2. Time-space variables relevant for performance and effectiveness.

For the whole group and for the female swimmers, performance and effectiveness are positively related to a deeper leg kick (relative to a fixed background) (Fig. 2, a), to a more pronounced S-shaped body position (Fig. 2, b) and to a larger amplitude in total trunk rotation (Fig. 2, c). The importance of body waving is well explained in the literature of fish swimming (Lighthill, 1969; Alexander, 1977), but not the importance of trunk rotation. For the whole group, women and men together, the amplitude of vertical hip displacement (Fig. 2, d), as well as the amplitude of the lower trunk rotation (Fig. 2, e) are relevant for performance and effectiveness. Furthermore, at the end of the arm pull, the degree of uphill trunk position (Fig. 2, f) and the distance of the foot (relative to the longitudinal trunk axis) (Fig. 2, g) are relevant. Thus, different references of observation are complementary to each other to confirm the importance of the backward trunk rotation. The combination of the two preceding time-space variables determines the amount of cambering the body. For the women only, also at the end of the arm pull, the degree of backward rotation in the shoulder joint of the upper arm (relative to the water surface) (Fig. 2, h) and the amount of backward displacement of the hand (relative to the trunk length axis) (Fig. 2, I) are relevant. The combination of these two time-space variables indicates the importance of a large downward amplitude of the arm pull. For the men only, the upward amplitude of the hand displacement (relative to a fixed background), during the first part of the arm spreading, is relevant. This time-space variable is probably the most important technique change since the rule allowed dipping the head below the water surface.

CONCLUSION: One could expect that, based on time-space variables found statistically relevant for performance and effectiveness in a large number of international level swimmers, a quantitative diagnosing of competitors could be improved.

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