DETERMINANT FACTORS RELATED TO THE VARIATION IN HORIZONTAL VELOCITY OF THE BODY CENTRE OF MASS IN BUTTERFLY

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INTRODUCTION: According to Persyn et al. (1995) in the global strokes only the resultant impulse on the body, which is the difference between propulsion and drag forces, can be calculated from one phase to another. Therefore, the horizontal velocity variation of the body centre of mass (CMbody) in a stroke cycle must be calculated.
When the horizontal velocity of the CMbody varies considerably, the swimmer has to overcome during each stroke cycle high hydrodynamic drag forces, due to the high peak velocity.
According to Toussaint (1983), the intracyclic variations are considered to limit swimming performance and depend on the swimmer's skill. Persyn et al. (1989) showed statistically that the amplitude of these variations during certain phases of the stroke are linked to the degree of skill of the swimmer, and that those variations are more critical in the two symmetrical strokes, because of the continuously propulsive and braking resistance impulses.
Other investigations reveal that high level swimmers register small variation values which indicates small CMbody velocity variations around the mean value. According to some consulted authors (Costil et al., 1987; D'Acquisto et al., 1988; Holmer, 1974; Alves et al.; Nigg, 1993) this indicates technical ability, and efficiency and small energetic cost.
Is this paper, which is the result of several studies, our purpose was to: (i) describe the intra cycle CMbody velocity behaviour; (ii) evaluate the determinant factors related to the variation in horizontal velocity of the body centre of mass in butterfly, considering different technical simulations.

METHOD: For this purpose, national level swimmers were filmed using three high resolution video-cameras, two underwater (sagittal and frontal plane) and one above water (frontal plane). The whole body was digitised, for each view, to create a complete stroke cycle. After the filming and digitising procedures the CMbody velocity, during all phases of the stroke cycle (outsweep; downsweep; insweep; upsweep; hand exit; recovery), and the three-dimensional co-ordinates were calculated (DLT algorithm- APAS system).

RESULTS: There were significant correlations ($p<0.05$) between CMbody velocity variation and: (i) hand magnitude velocity during the upsweep (HMVUP) of the stroke (r=-0.95); (ii) hand horizontal velocity during the upsweep (HHVUP) of the stroke (r=-0.96); (iii) vertical velocity during the upsweep (HVVUP) of the stroke (r=-0.79); (iv) hand lateral velocity during the upsweep (HLVUP) of the stroke (r=-0.91); (v) hand magnitude velocity during the insweep (HMVIN) of the stroke (r=0.98); (vi) hand horizontal velocity during the insweep (HHVIN) of the stroke (r=0.96); (vii) hand vertical velocity during the insweep (HVVIN) of the stroke (r=0.91); (viii) BCM velocity during de outsweep (BCMVOUT) of the arm stroke (r=-0,58). The obtained multiple regression (stepwise, 0,05) for the determinant factors related to the BCMVV was:

$$Y=4,517803+5,377747*(MHVIN)-1,725181*(HLVIN)+1,807357*(HVVIN)$$

Thus, the major determinant factors related to the CMbody velocity variation are: (i) those directly related to the high hand horizontal, vertical and lateral velocity during the last phases of the arm stroke (upsweep and exit); (ii) those directly related to the low of hand velocity in all directional components during the most lateral phases of the arm stroke (insweep).

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