NEW RESEARCH APPROACHES ARE UNRAVELLING THE MYSTERY OF PROPULSIVE MECHANISMS IN SWIMMING

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Various explanations regarding how swimmers generate propulsion have been proffered during the last half century. Investigations have been limited by the current technical 'state of the art'. The main limitations have related to the difficulty of directly measuring propulsive and resistive forces and in observing the behaviour of the fluid. The purpose of this presentation is to provide an historical account of how developing methods of analysis are enabling us to unravel the mystery of propulsion in swimming.

Many of the early analyses of propulsion focused on the propulsion produced by the hands. This focus was based on the assumption that the hands were the dominant source of propulsion following various estimates of the contribution of the hand relative to the kick through indirect measurement techniques. Based on the observation that elite swimmers used lateral motions during swimming there was a belief that good swimmers were 'scullers' and that much of the propulsion was generated by lift rather than drag forces as the water flowed across the hand with small angles of attack. The hand was analogised to an aeroplane wing generating lift by the Bernoulii effect.

To assess the veracity of the claim that lift from the hand motions was possibly more important than drag, and to quantify the relative contributions of lift and drag throughout the stroke cycle, several authors conducted controlled experiments in which the hand was set at known orientations of pitch and sweepback angle to the flow. The idea was that once the lift and drag coefficients were known these could be applied to determine the forces produced in actual swimming through quantifying the orientation of the hand and the rate of flow using video-based three dimensional analysis techniques. This indirect approach assumed that the flow was regular, that is. 'quasi static' and that unsteady effects due to irregular and non-laminar the flow would not greatly affect the interpretability of the findings. However, two main factors conspired to minimise the contribution of this approach to knowledge of force production in swimming. The first was that determining the orientation of the hand in actual swimming using video-based three dimensional analysis techniques is very problematic and labour intensive. Second, there was evidence that the actual forces were underestimated. Consequently, there was increasing recognition of other influences such as 'added mass effects' due to accelerations of the limbs relative to the water, and forces associated with the production and shedding of vortices, could not be ignored. Nevertheless, these research approaches had been successful in dispelling the long-standing misconception that skilled swimmers generated force mostly from lift using 'sculling motions'. Attention now turned to considering the role of those unsteady effects.

Development of new technologies in that last 15 years has helped to unravel the mystery of the mechanisms of propulsion in swimming. In particular, researchers at the University of Tsukuba have advocated a 'multi-pronged' approach to yield improved understaning of the mechanisms of propulsion. These include the use of direct force measurement using pressure transducers on the hands or on hand models, the developing software simulation technology of computational fluid dynamics (CFD) and quantification of actual fluid flow via particle image velocimetry (PIV). The researchers have combined these methods with direct force meansurement of the forces generated by limb models driven by programmed robots. The various data sets are input to the to human swimming simulation software (SWUM).

The presentation will conclude with an overview of what we know as a consequence of the research over the last 50 years and some of the questions still to be addressed.