The S-stroke or I-stroke? Elucidating the mechanisms of the ideal crawl stroke

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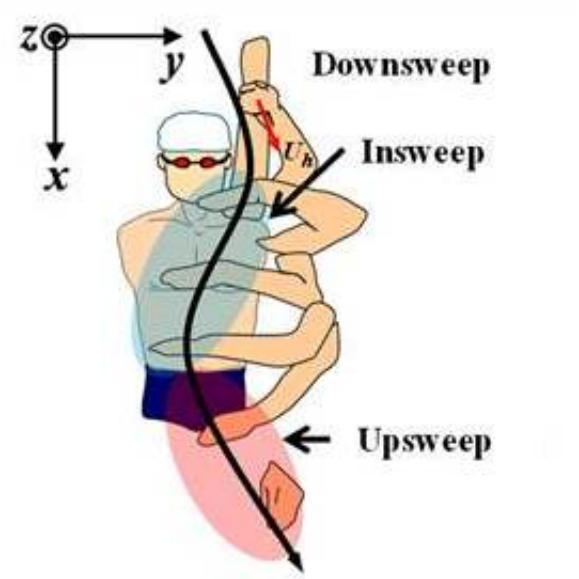

The locus and motions of hand in crawl swimming

The year 2016 is an Olympic year. Developments in high-performance swimwear for swimming continue to advance, along with other areas of scientific research. One area of research has focused on which type of crawl stroke is more effective—when the arm draws a curve in the water (S-stroke) or moves straight (I-stroke)—long a matter of debate in the world of competitive swimming. A research team led by the University of Tsukuba has carefully investigated this matter in terms of fluid mechanics, examining the ideal crawl stroke from every angle, based on the latest measurement and analysis data from Japan and around the

world.

Professor Hideki Takagi, of the University of Tsukuba's Faculty of Health and Sport Sciences, together with Motomu Nakashima of the Tokyo Institute of Technology and fellow joint researchers in Switzerland and Australia, applied the latest fluid measurement and analysis techniques to the action of swimming, particularly the crawl stroke. The team came up with clear evidence of mechanisms that could resolve the debate.

They found that the S-stroke is better suited for swimming middle and long distances where efficiency is required (propulsive power with less physical exertion), while the I-stroke is better for short distances, which depend on speed over efficiency. The mechanisms of propulsive power differ between the two strokes. The vortex pairs generated by the S-stroke, with the arm changing orientation in the water, cause unsteady lift force, while the I-stroke's straight movement causes Kármán vortices that produce drag force.

This research shows for the first time ever how the mechanisms of propulsive power generated by the two stroke patterns differ, particularly in the significant impact of eddy generation on propulsion. The force momentarily generated by the formation of eddies is called the "unsteady fluid force," which has been identified as a mechanism of flight in research on insects and birds. The appearance of the same phenomenon in human swimming, however, is a valuable discovery in that it varies significantly from the quasi-steady state theory of propulsion heretofore hypothesized.

More information: Hideki Takagi et al. Numerical and experimental investigations of human swimming motions, *Journal of Sports Sciences* (2015). DOI: 10.1080/02640414.2015.1123284

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