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Leaving it All in the Pool: From Fundamental Fluids Experiments to Real-Time Coaching Tools

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Abstract

The science of swimming has come a long way since the seminal study by Thevenot (1696). Experiments by van Houwelingen, *et al*. (2018) and computational studies by von Loebbecke & Mittal (2012) represent the state-of-the-art not just in swimming research, but in the broad field of fluid dynamics as well. It is now possible to study in great detail everything from the vortex wake of a swimmer's hand moving through the water to the force balance of a swimmer's dolphin kick, *cf*. Wei, *et al*. (2014). Yet, the challenge exists on how to effectively transition this level of science and technology to a toolset that can be used by a swim coach (who generally has at best a rudimentary understanding of fluid physics) in real time.

This presentation starts with and overview of work done with USA Swimming to develop advanced, fluid dynamics based training and analysis tools for current and future Olympic swimmers. This includes objectives, methodologies and outcomes of measurements of flow around swimmers. Movies of PIV flow measurements and time resolved force measurements around swimmers, including Beth Botsford and Megan Jendrick 1996 and 2000 Gold Medalists in the 100 meter back and 100 meter breast, respectively, will be presented. A sample DPIV vector field from a video of Megan's breaststroke is shown in Figure 1 to the right. Work with Ariana Kukors, 2012 Olympian, 2009 World Championships gold medalist and world record holder in the 200 IM will also be presented.

The second part of this presentation will include preliminary work done on the dynamics and energetics of swimmers. An example appears in Figure 2 below. This will set the stage for a somewhat scientifically heretical view that the coach and swimmer don't necessarily need to know or understand the flow physics to swim faster. Rather, what is most important to them is the mechanics and timing necessary for fast swimming. Thoughts on how to transition these measurments into a practical coaching tool will be discussed.

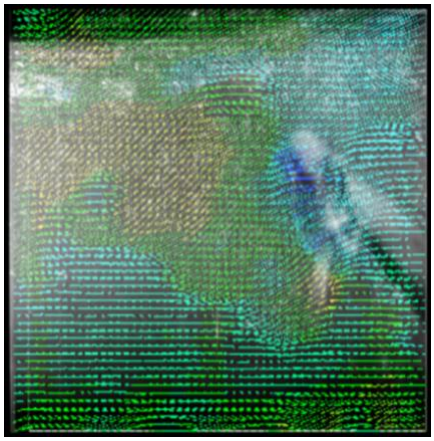

Fig. 1: Instantaneous DPIV vector field showing flow generated by Megan Jendrick's breaststroke kick. Note the dark blue vectors pointing away from her foot.

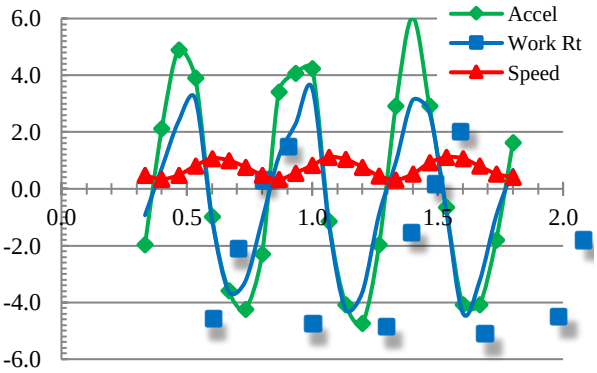

Fig. 2: Time traces of speed, acceleration, and rate of work associated with Ariana Kukors' dolphin kick.

References

Thevenot, M. 1696 The art of swimming. *Nabu Press*.

van Houwelingen, J., Antwerpen, R.M., Holten, A.P.C., Grift, E.J., Westerweel, J. & Clercx, H.J.J. 2018 Automated LED tracking to measure instantaneous velocities in swimming. *Sports Engineering*, **21,** 419 – 427.

von Loebbecke, A. & Mittal, R. 2012 Comparative analysis of thrust production for distinct arm-pull styles in competitive swimming. *Journal of Biomedical Engineering*, **134 (7)**, Paper: 074501.

Wei, T., Mark, R. & Hutchison, S. 2014 Fluid dynamics of competitive swimming. *Annual. Review of Fluid Mechanics*, **46**, 547 – 565.