Workshop on Sports Aero- and Hydrodynamics
November 27th, 2020, virtual online meeting

A wind-tunnel case study: Insights into the steady and unsteady aerodynamics of cycling arm position

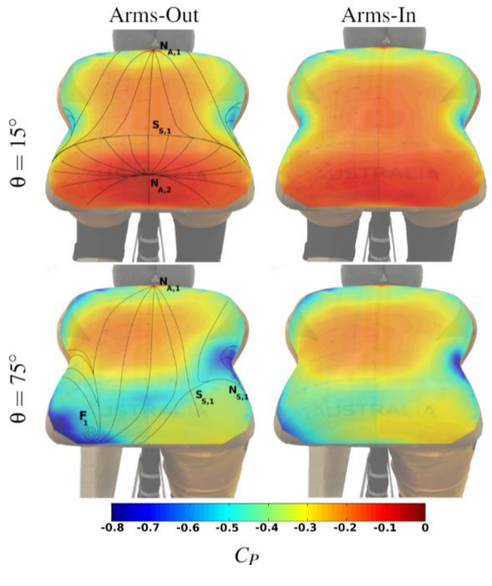
T. Crouch, D. Burton, M. Thompson and J. Sheridan
Department of Mechanical and Aerospace Engineering, Monash University, Clayton, Australia, 3800
timothy.crouch@monash.edu

Abstract

This wind-tunnel case study considers the influence of rider position on the steady and unsteady aerodynamics of a full-scale cyclist mannequin. Quasi-steady experiments are compared for two positions representative of a 'Arms-In' position, with forearms aligned horizontally and close together, and a 'Arms-Out' position, with greater spacing between the forearms as shown in figure 1a. The variation in the aerodynamic drag between the positions is a function of the leg position around the pedal stroke, where leg position is defined by the angle of the crank, θ, relative to the horizontal. The difference in drag between the two positions follows the development of symmetrical and asymmetrical flow regimes that have been shown to exist over the course of the pedal stroke for the cycling geometry under investigation here[1,2]. During leg positions characteristic of the low-drag symmetric flow state, the Arms-Out position has the lowest aerodynamic drag. During leg positions characteristics of the high-drag asymmetric flow state this findings is reversed and the Arms-In position has the lowest aerodynamic drag. When quasi-steady force measurements, recorded in 15° increments around a complete pedal stroke, are averaged over the cycle the variation in aerodynamic performance between the two positions is <1%.

Unsteady surface pressures measured on the torso and hips reveal the impact that arm position can have on the development of large-scale flow structures known to exist for this geometry[1,2]. For the majority of the pedaling stroke, variations in torso surface pressures account for differences in the drag coefficient, but not the complete cycle. Figure 1b compares contours of the surface pressure coefficient for leg positions representative of the low-drag symmetric regime, $\theta = 15^{\circ}$, and the high-drag asymmetric regime, $\theta = 75^{\circ}$, for each arm position. For low-drag leg positions, pressures acting on the back are similar for both arm positions and cannot account for the measured difference in aerodynamic performance between them. For high-drag leg positions, almost all of the variation in aerodynamic drag between the arm positions can be accounted for by differences in surface pressures acting in regions where the large scale flow structures develop. This finding suggests arm position affects multiple mechanisms that determine the magnitude of the aerodynamic loading of cyclists and that different cyclist flow regimes can have varying impacts on the aerodynamic performance of rider position.

(a)



(b)

Fig. 1 Images showing (a) rider positions tested during wind tunnel experiments and (b) contours of the surface pressure coefficient for both arm positions at the low- and high-drag leg positions.

References

[1] Crouch, T. N., Burton, D., Brown, N. A. T., Thompson, M. C. & Sheridan, J. 2014 Flow topology in the wake of a cyclist and its effect on aerodynamic drag. J. Fluid Mech 748, 5–35.

[2] Crouch, T. N., Burton, D., Brown, N. A. T., Thompson, M. C. & Sheridan, J. 2016 Dynamic leg-motion and its effect on the aerodynamic performance of cyclists. J. Fluids & Structures, 65:121–137