THE ANALYSIS OF PRESSURE DRAG AND SKIN FRICTION DRAG DURING THE GLIDING IN SWIMMING

Marinho, D.1, Reis, V.1, Sousa, L.2, Leal, L.2, Alves, F.3, Vilas-Boas, JP3., Machado, L.4, Rouboa, A., Silva, A.5

1: UBI (Covilhã, Portugal), 2: UTAD (Vila Real, Portugal), 3: CIDESD (Portugal), 4: FMH-UTL (Lisbon, Portugal), 5: FADEUP (Porto, Portugal)

Introduction: In human swimming, the total drag is composed of the skin friction drag, pressure drag and wave drag. The relative importance of each component to the overall hydrodynamic drag is controversy issue. Therefore, the aim of this study was to analyse the relative contributions of the skin friction drag and the pressure drag for the total drag during the gliding, using numerical simulation techniques.

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Methods: The numerical simulation analysis consisted of the use of a three-dimensional mesh of cells that simulates the flow around the considered domain. We used the k-epsilon turbulent model (Moreira et al., 2006) implemented in the commercial code Fluent® and applied to the flow around a three-dimensional model of a male adult swimmer in a gliding situation, in ventral position with the arms extended at the front. The simulations were applied to different flow velocities, between 1.6 m/s and 2.0 m/s and the coefficient of drag (CD) was computed to each one of the applied velocities. Moreover, the CD was decomposed into pressure and skin friction drag by Fluent® software.

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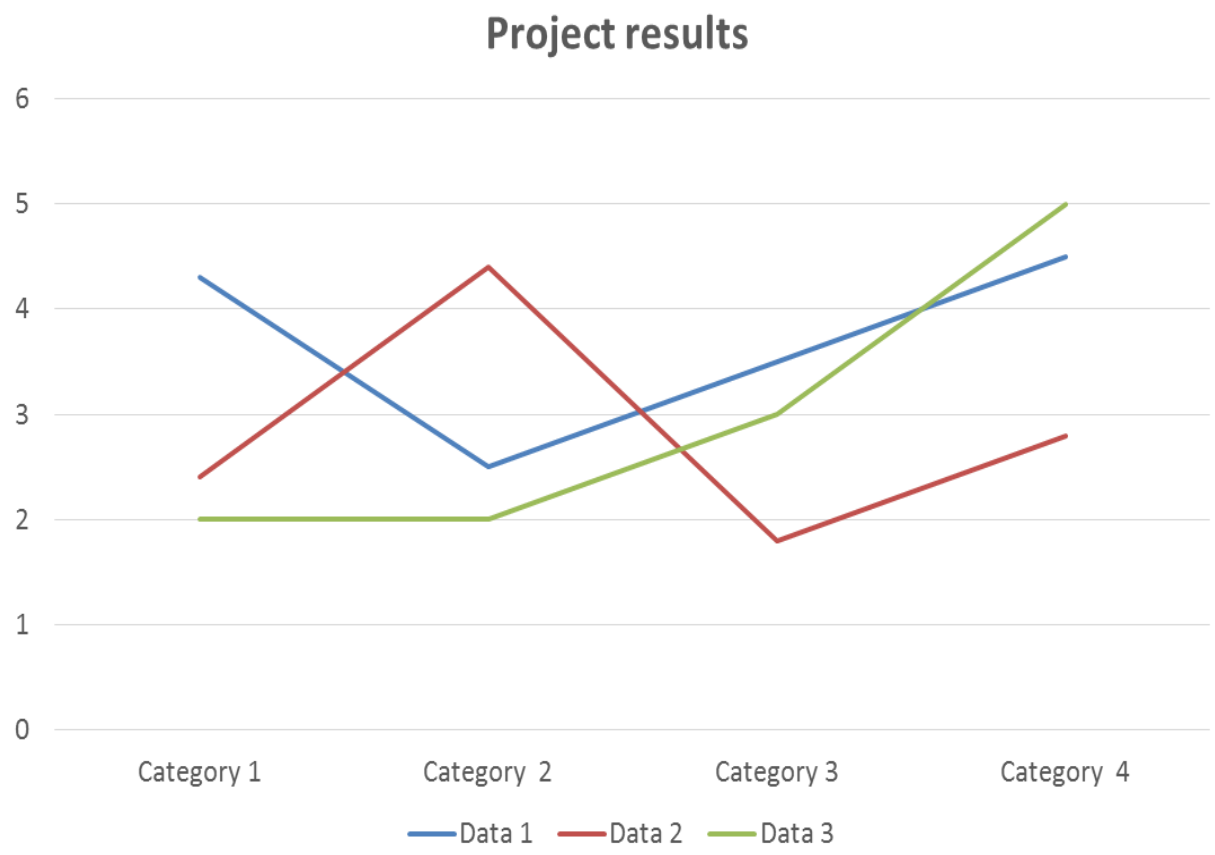

Results: Velocities of 1.6, 1.7, 1.8, 1.9 and 2.0 m/s produced, respectively, CD values of 0.48, 0.475, 0.432, 0.431 and 0.428. The pressure drag was the main responsible for the total drag, with a percentage of about 87%, while skin friction drag contributed to about 13% for the total drag during the underwater gliding.

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Discussion: In both gliding positions the swimmer CD decreased with the velocity.
The inverse relationship between the CD and the velocity found in the present study seems to correspond to what happens in experimental situations in the human body totally submersed (Jiskoot and Clarys, 1975; Lyttle et al., 2000).

The computed drag forces components showed that the pressure drag was dominant. Nevertheless, skin friction drag was by no means negligible. However, these values are based on the swimmer model's surface having a zero roughness. Another different situation could happen if the swimmer were at the water's surface. The contribution of the skin friction drag would be reduced due to the reduction in the wetted area and the generation of wave drag (Bixler et al., 2007).