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INTRUODOCTION

- Swimming velocity depends on the interaction between hydrodynamic drag force and propelling force.
- Aiming to achieve higher velocities the swimmer should reduce the hydrodynamic drag force resisting forward motion and increase the propelling force.
- In the World Championships held in Rome, in 2009, swimmers used swimsuits produced partially or entirely with industrial polymers, and 43 world records were broken in such time frame.
- Indeed, International Swimming Federation (FINA) banned this type of suits in January 2010, decision involved in great polemic and controversy.
- The manufactures claimed these suits have features such as ultra-light weight, water repellence, muscles oscillation and skin vibration reduction by compression the body (Marinho et al., 2009a).
- Little scientific evidence was reported in main literature about such relationship in this type of polyurethane swimsuits (Neiva et al., 2011).

PURPOSE

- To analyze the effect of wearing a swimsuit on swimmer passive drag.

METHODS

Three-dimensional model

- The three-dimensional surface geometry model was acquired through standard commercial laser scanner Vitus Smart XXL 3D body scanner (Human Solutions Company, Kaiserslautern, Germany).
- The subject of this study was an Olympic level female swimmer (height 1.66 m, weight 55.0 kg, age 23 years-old).
- Care was taken to limit differences in alignment of the individual scans for the two situations, by fixing the position of feet, maintaining similar vertical and horizontal alignment in respective scans and also the stationary pose with control of breadth during the actual moment of acquiring the scan (Lashawnda and Cynthia, 2002).
- The swimmer was scanned in three situations: (i) wearing a standard swimsuit, with no legs; (ii) wearing a last generation swimsuit, with legs and; (iii) with no swimsuit, wearing light underwear (Figure 1).



Figure 1. Female swimmer wearing a standard swimsuit (i), a last generation swimsuit (ii) and, light underwear (iii).

Computational fluid dynamics model

- The numerical simulation of the fluid flow around the three swimmer's models was carried out in Ansys FluentTM 6.3 commercial software (Ansys, Canonsburg, Pennsylvania, U.S.A.).
- The quadrilateral computational domain of 20 m length, 1.5 m breadth and 1.5 m height with inlet at 5 m upstream of the swimmer model was prepared in GambitTM preprocessor (Ansys, Canonsburg, Pennsylvania, U.S.A.).
- The passive drag was determined with the swimmer model at a depth of 0.75 m. Drag force and drag coefficient were computed for a steady flow velocity of 2.0 m/s (Marinho et al., 2009b).

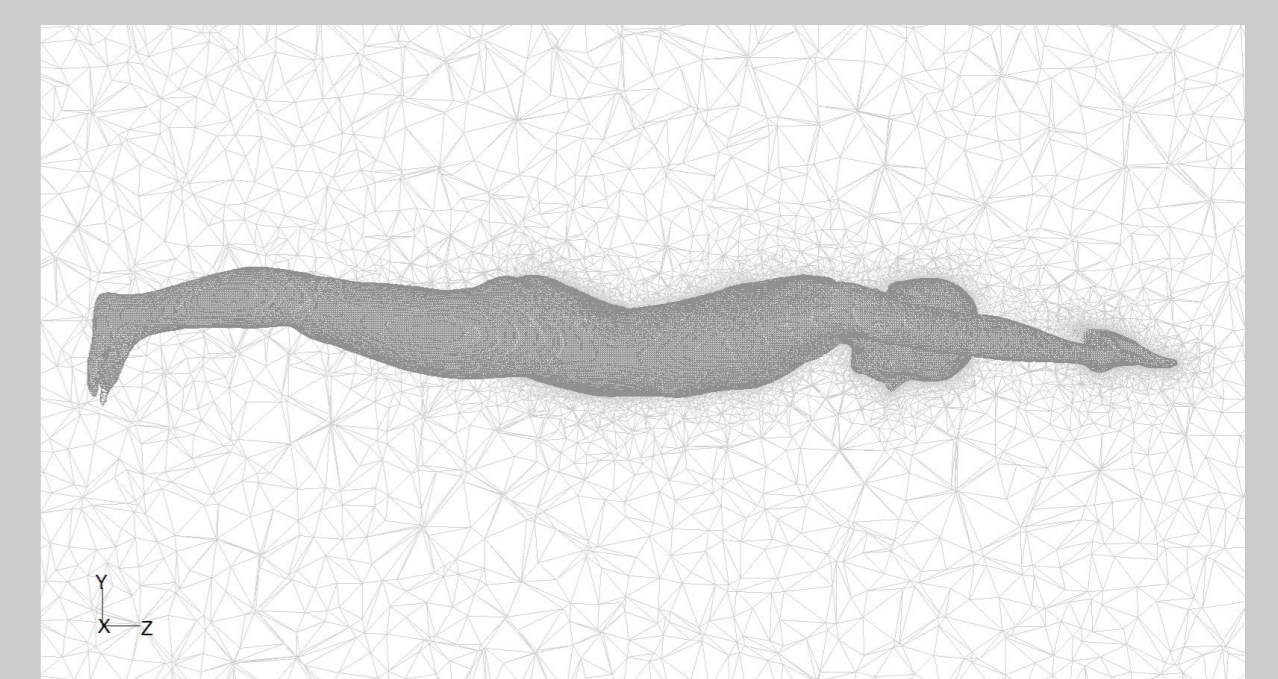


Figure 2. Surface meshing of the swimmer's model.

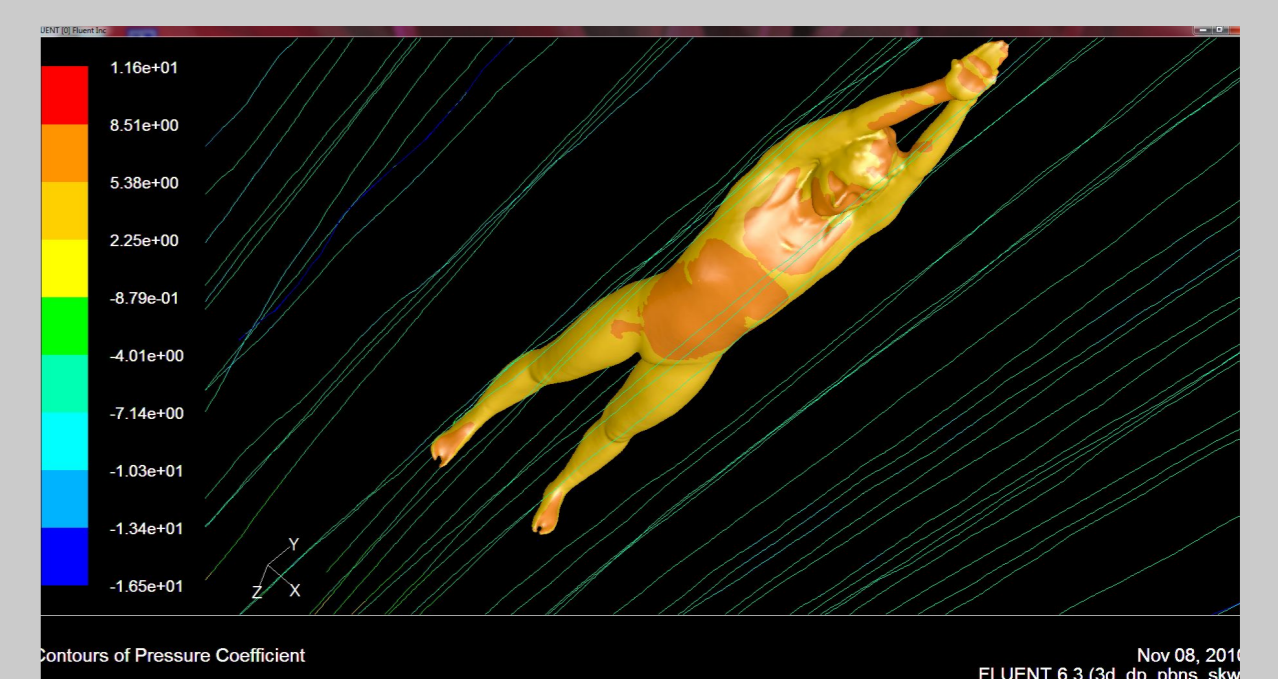


Figure 3. Pressure contours around the swimmer's model.

RESULTS

- Table 1 shows the drag coefficient and drag force values of each swimsuit condition. The percentage and the absolute values of total drag due to skin friction and pressure drag are also presented.

Swimsuit condition	Drag coefficient			Drag force (N)						
	Total Drag	Pressure drag	Friction drag	Total Drag	Pressure drag	Friction drag				
Stand. suit	0.325	0.270	83.08%	0.056	16.92%	76.23	63.20	82.91%	13.03	17.09%
New suit	0.323	0.266	82.35%	0.058	17.65%	75.82	62.31	82.18%	13.51	17.88%
Underwear	0.453	0.397	87.64%	0.056	12.36%	105.84	92.74	87.62%	13.09	12.38%

Table 1. Drag coefficient and drag force values and contribution of pressure and skin friction drag for the total drag to each swimsuit condition: (i) standard swimsuit; (ii) new generation swimsuit and; (iii) underwear.

DISCUSSION

- The results pointed out that there is an advantage of wearing a swimsuit on swimming performance, although minor differences were obtained between a standard suit and a new generation swimsuit.
- The swimmer model with no swimsuit (underwear) presented the highest values of hydrodynamic drag compared to the models wearing swimsuit, which gives rise to higher drag of about 40%.
- There is very low variability of friction drag parameters compared to their pressure counterparts among the tested situation, which indicates that the main influence of swimming suits, both full body and conventional suits, seems to be on pressure drag, probably due to selective compression of body volume.
- Minor differences were obtained between a standard and a high-tech swimsuit.

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