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Partial contribution of rolling friction and drag force to total resistance of an elite wheelchair athlete

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Introduction

In wheelchair racing, the main sources to loose energy are the rolling friction and the drag force.

The aim of this research was to model the partial contribution of rolling friction and drag force to total resistance of an elite wheelchair athlete.

Methods

Subject: The subject was a male athlete that competes in the T52 category, holds the national records at the 100m and 400m events. He was also ranked 2nd in the world at the 400m race at the time of this research (season 2013-2014).

Rolling resistance: It was calculated for a range of speed (fig 2) based on non-linear speed dependency and from visco-elastic models as:

$$F_R = c_a + c_b \quad (1)$$

$$F_R = \mu_R \cdot m \cdot g + k_f \cdot m \cdot g \cdot v^2 \quad (2)$$

Where F_R is the rolling friction, c_a and c_b the rolling friction coefficients for linear and non-linear velocity dependency, μ_R the coefficient of rolling friction (μ_R = 0.01), *m* the mass of the athlete and wheelchair combined, *g* the gravitational acceleration, k_f the coefficient of speed influence on the rolling resistance (k_f = 5x10^{-6} m^2/s^2) and *v* the velocity.

Drag force: It was computed for the same range of speeds (fig 2) as:

$$D = 0.5 \cdot \rho \cdot v^2 \cdot S \cdot C_D \quad (3)$$

Where *D* is the drag force, ρ the air density (being 1.2041 kg/m^3 at 20º C and sea level), *v* the velocity, *S* the frontal surface area and C_D the coefficient of drag (assumed to be 0.7).

The *S* was measured with a photogrammetric technique (fig 1) [1].

Figure 1: Photogrammetric technique.

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Figure 2: Range of speeds analysed.

Results

There is a higher contribution of the F_R at slow paces, but the role of D increases with speed (fig 3).

Racing between 5.32 and 6.83m/s, the F_R and D ranged between 76.31-66.39% and 23.69-33.61%, respectively.

Racing at the world record pace, F_R would represent 65.11% and D 34.89%.

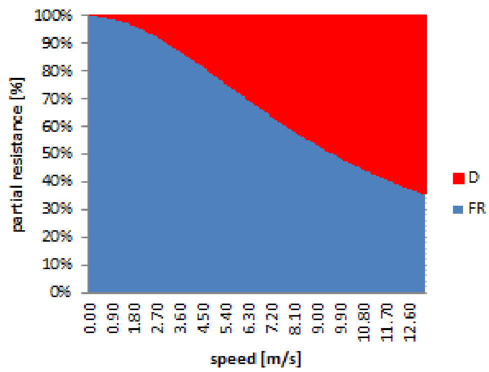

Figure 3: Partial contribution of rolling friction (F_R) and drag force (D) to total resistance between 0 and 13m/s, in wheelchair racing.

Conclusion

As a conclusion, tailored solutions should be designed in order to reduce both rolling friction and drag force in Paralympic athletes because both external forces play determinant roles in their performance.

References

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