Analysis of the Aerodynamics by Experimental Testing of an Elite Wheelchair Sprinter

Tiago M. Barbosa[a,b,c], Pedro Forte[c,d], Jorge E. Estrela[b,c], Eduarda Coelho[c,e]

[a]Nanyang Technologic University, Singapore; [b]Polytechnic Institute of Braganca, Portugal; [c]Research Centre in Sports, Health and Human Development, Portugal; [d]Univesity of Beira Interior, Portugal; [e]Univesity of Tras-os-Montes and Alto Douro, Portugal

Introduction

Background: One concern for wheelchair sprinters is the head's alignment racing.

This misalignment may increase significantly the resistance acting upon the athlete albeit, evidence on this is scarce in wheelchair racing.

A feasible way to gather insight on the effects of misalignments in the aerodynamics is the cost-down technique.

Aim: To compare the resistive forces acting upon an elite wheelchair sprinter keeping different body positions.

Methods

Subject:

- T52
- European medallist
- National record holder (100 & 400m events)
- Ranked 2nd in the world

Procedures: 3x(8x400m) @ several speeds, randomly assigned.

Each set was performed adopting one of three body position (Fig 1).

Fig. 1. The three body positions adopted by the wheelchair racer.

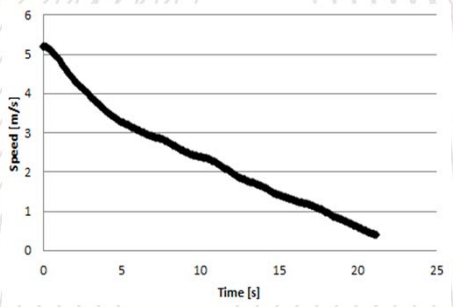

Fig. 2. The speed-time plot coasting-down over one trial.

Resistive forces: The speed decay (f=33Hz) was measured by Doppler-effect (Stalker-Pro, Stalker Radar, TX, USA) coasting-down in the final straight before the finish line (Fig 2).

Surface area of the sprinter plus chair was measured by a photogrammetric technique using a digital camera (DSC-T7, Sony, Tokyo, Japan) and an image measurement software (Udruler, AVPSoft, USA) [1].

Resistive forces were estimated by a simplified deceleration method [2].

Mechanical energy & power: Energy and power were then estimated [2] for the race he broke the 400m national record.

Results

Resistive forces: Aerodynamics is higher in the upright than racing positions. Between the latter ones, pointing the trailing edge of the helmet upwards imposes the highest resistance (Table 1).

Table 1: Comparison of coefficient of rolling friction (CR) and effective surface area (ACd) of an elite wheelchair sprinter in different positions.

	Upright position	Racing position with neck in flexion	Racing position with neck in hyperextension
CR [dimension.]	0.0019	0.00489	0.00618
ACd [m^2]	0.1747	0.1482	0.1456

Mechanical energy & power: The head misalignment can account at least 2% more in the power delivered (Table 2).

Table 2: Comparison of power to overcome drag (Pd), power output (Ptot), energy cost (C) and external mechanical power (Pext) of an elite wheelchair sprinter in different positions.

	Upright position	Racing position with neck in flexion	Racing position with neck in hyperextension
Pd [W]	26.62	22.59	22.19
Ptot [W]	630.71	602.55	620.31
C [J/m]	100.14	95.67	98.49
Pext [W]	113.59	108.51	111.71

Conclusions

The resistance acting upon the sprinter is different according to his position on the chair.

Slight changes in the head position over the race can affect by almost 2% the power delivered.

References

[1] Morais JE et al. J Hum Kinetics 2011;28:5-13.

[2] Candau RB et al. Med Sci Sports Exerc 1999;31:1441-7.