The Aerodynamic Assessment of Tandem Paracyclists: A Case Study

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The Paracyclist

Aerodynamic Drag: A Primer

- Aerodynamic drag makes up about circa 94% of the total resistive force that acts on a single cyclist when moving at approximately 50 km/h (Defraeye et al. 2010).

- 60-70% of a cyclists total aerodynamic drag is the rider themselves (Defraeye et al. 2010).

- Drag is measured in ‘CdA’. The lower this value, the more aerodynamic the shape is.

Current state of the literature

- Few studies have evaluated the aerodynamic drag of tandem cyclists (≈ 4) (Mannion et al. 2018$_{x2}$, 2019$_{x2}$).
  - In the studies with practical testing, scale models of tandem cyclists were used.
  - The precision of such experiments when using actual cyclists riding and pedalling a tandem bicycle was assumed (despite the added complexity of two riders pedalling in unison) and is therefore not known.

TANDEM AERODYNAMIC ASSESSMENT EXPERIMENTS 2021

Project Objectives

1) To assess the precision of the use of a wind tunnel in the assessment of tandem paracyclists in-situ.

2) To undertake a case study by implementing a range of drag reducing interventions to elite tandem paracyclists (both male and female teams).

OBJECTIVE 1: ASSESSING THE PRECISION OF THE WIND TUNNEL

- Both one male and one female tandem team took part.
- A time trial track bike (male) and a road time trial bike (male & female) were used for the tests.
- Participants were elite-level paracyclists.
- A ‘closed loop’ wind tunnel was used (with a 2x2.5m cross section & length of 10m) with a ‘blockage ratio’ of 10%.
- 90 secs test periods were undertaken of each bicycle type: Male track TT bike (4 runs) male road TT bike (6 runs) and female road/TT bike (6 runs).
- Air speed was set at 61.1 km/h (male) and 54.8 km/h (female) - consummate with athletes typical race pace. Yaw was set at 0 degrees.

Objective 1: The test environment

OBJECTIVE 2: CASE STUDIES OF APPLIED AERODYNAMIC INTERVENTIONS

A series of arbitrary changes were applied to the tandem teams. These included:

Participants	Intervention
Male Tandem Team	Assessing the impact of wearing gloves (track bike).
	The lowering of pilot, stoker (or both) riders heads (track bike & road TT bike).
	Assessing the impact of a bottle cage (road TT bike).
	Assessing the impact of the pilots handlebar height (track bike).
	Helmet change to rear stoker (track bike).
Female Tandem Team	Impact of the rear stokers saddle height
	Helmet positioning (rotation)

RESULTS: OBJECTIVE 1

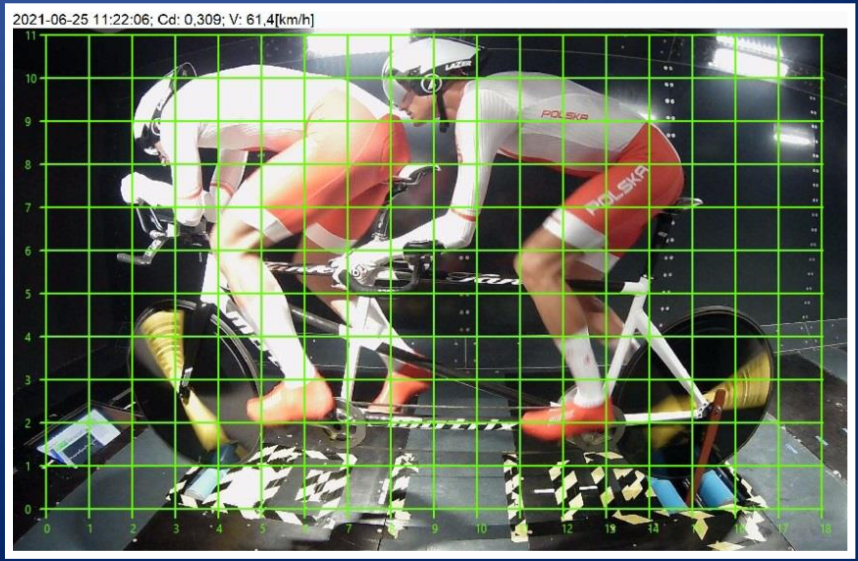
Objective 1: Results

- The male track bike tandem produced a wind tunnel test precision mean C_DA of $0.285^{+/-0.005} m^2$ (CV=1.6%).

- The male road TT bike tandem produced a wind tunnel test precision mean C_DA of $0.338^{+/-0.006} m^2$ (CV= 1.8%).

  (Note: *P* between these two states was 3E-07)

- The female road/TT bike tandem produced a wind tunnel test precision mean C_DA of $0.346^{+/-0.009} m^2$ (CV= 2.6%).



Objective 1: Discussion

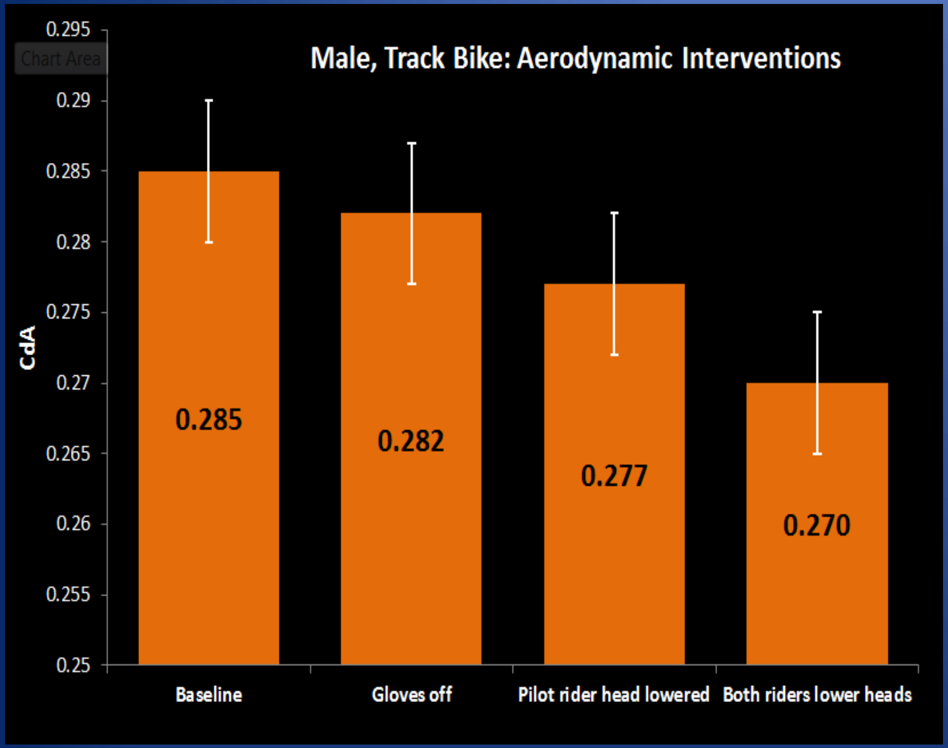
- The level of precision that the male tandem team attained in this study was twice as high than those obtained before by other paracyclists (Dyer & Disley, 2018) but still below the maximum CV of 2% recorded by able-bodied cyclists (García-López et al. 2008).

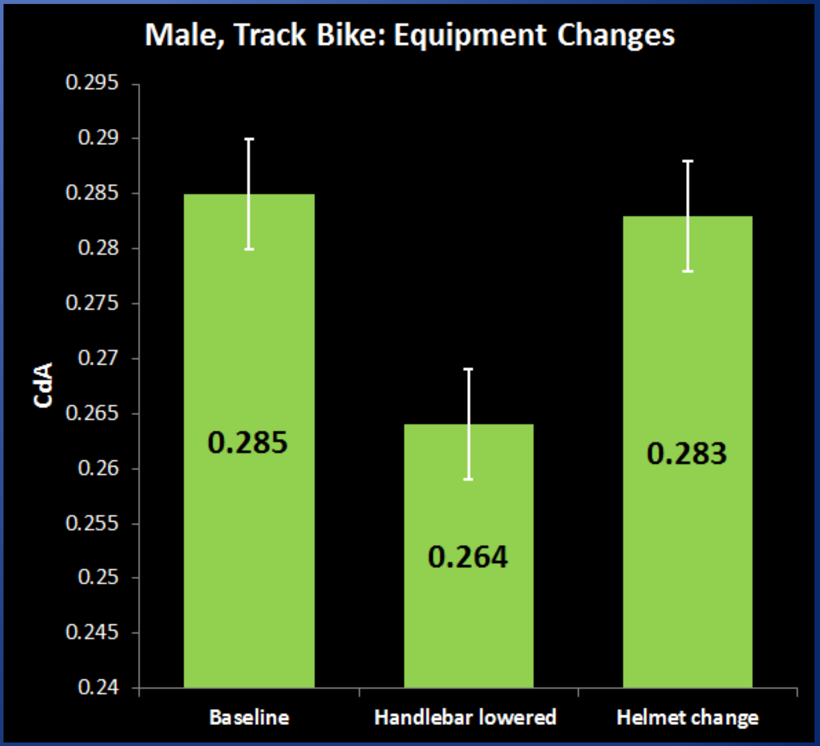
- However, the female tandem team reported a CV that was in excess of this. This may highlight a need for suitable prior experience of riding in a wind tunnel environment or that with some tandem teams, the extra rider and larger bicycle being present over that of a solo rider decreases the precision of the experiment.

- Future testing is required to ascertain its suitability with a greater number, range and abilities of participants.

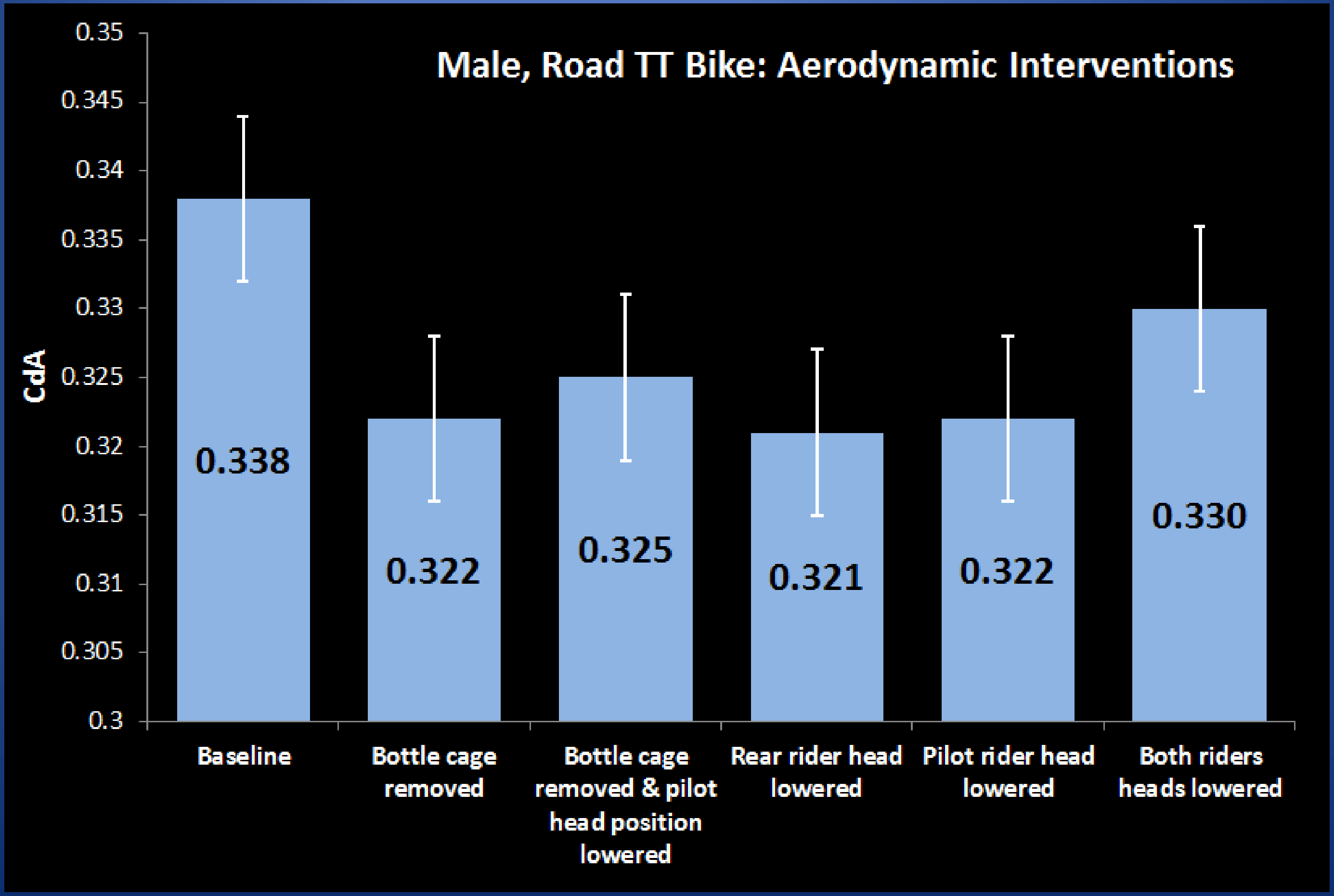
RESULTS: OBJECTIVE 2

Objective 2: Male Aerodynamic Interventions Results

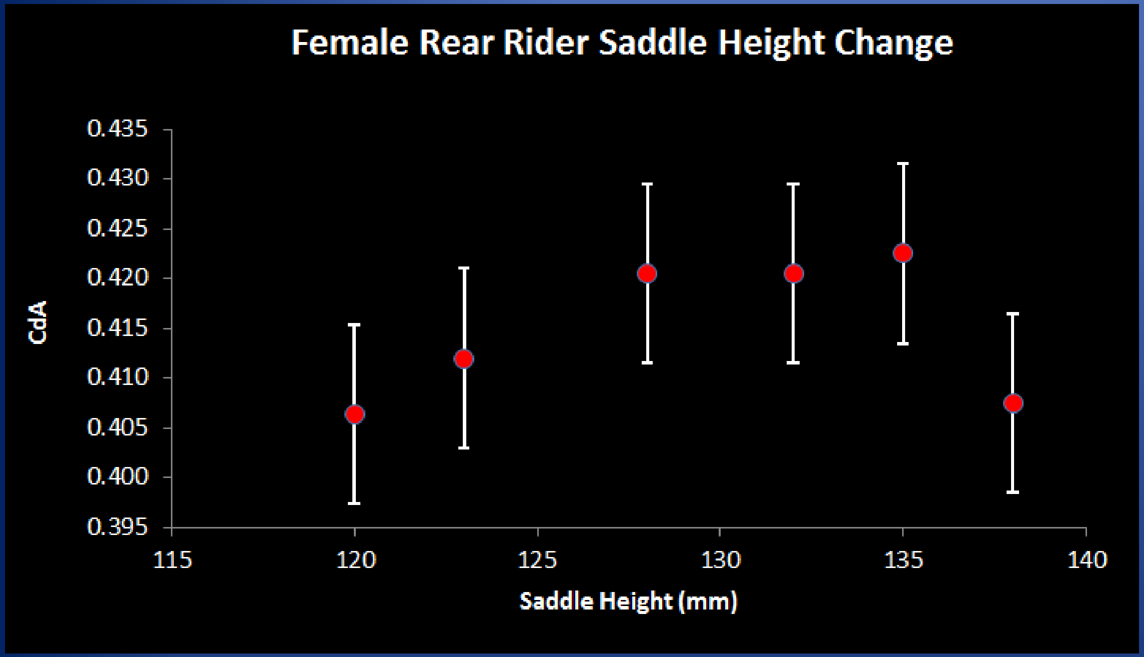


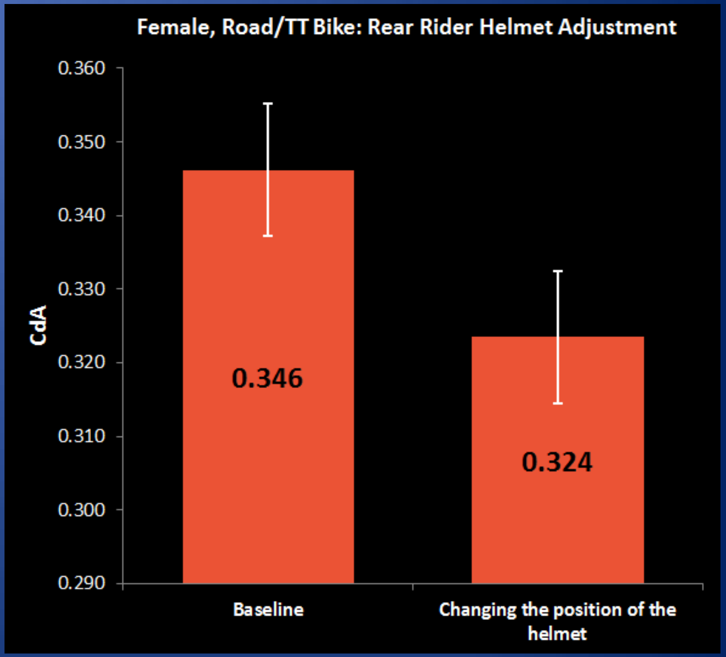


Objective 2: Male Aerodynamic Interventions Results



Objective 2: Female Aerodynamic Interventions Results





Objective 2: Discussion

- All results, (whilst informative) are always relative to the athletes concerned.

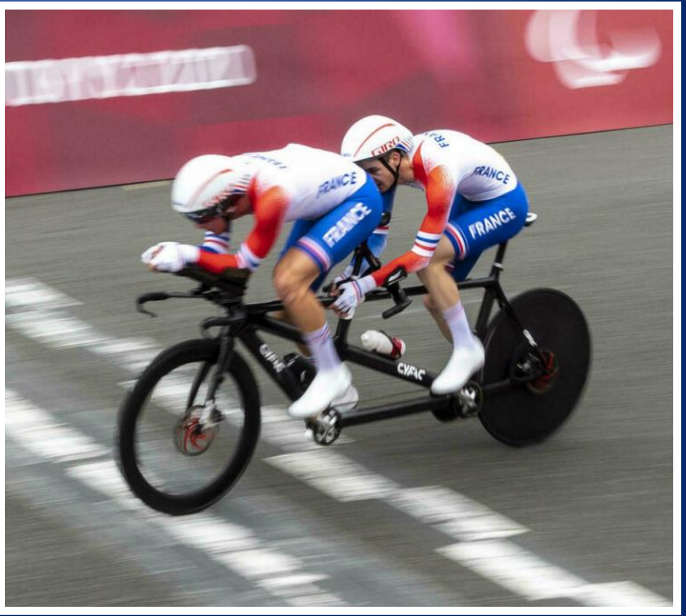
- Some interventions are within the wind tunnel process margin of error. These would require further validation of their efficacy.

What could such gains yield in reality ?

Using the Mywindsock app:

- Applied to a virtual model of the 2021 Paracycling World Championship course using the weather at the time the event was held.
- Assume a power output based upon their actual completion time.
- Apply the 0.017m² maximum drag reduction found on the male road bike by lowering the rear riders head (CdA gain of $0.017m^2$).

<u>Outcome= an advantage of ≈ 35 seconds for their 19 km time-trial event.</u>



Key Limitations of Study

- Obtaining many wind tunnel test runs of the same intervention is often time consuming and can be impractical. Most of the interventions in this study only saw 2 or 3 test runs.
- Interventions are relative to the test participants but create ideas for other tandem teams to try.
- It is not known how wind tunnel experience dictates a riders ability to use it effectively.

Conclusions

1) In the case of elite paracyclists, the use of a wind tunnel is appropriate to assess relative changes in aerodynamic drag.

2) There is scope to improve the overall performance of a tandem team of paracyclists – even when physiological improvement may be not possible.

3) Due to the small participation pool in this study, further study would be needed to assure that a greater type of tandem team could be assessed using this method.