Aerodynamics in triathlon: the influence of clothing, helmet selection and position

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Abstract

Aim. To identify how changes to clothing, helmet selection and aerobar extension angle affected aerodynamic drag in a professional triathlete, and to use these findings to guide an individual race set-up.

Methods. One rider completed a sequential wind-tunnel test comprising 37 recorded runs. Position, clothing and helmet comparisons were principally measured at 0° and -10° yaw. Each run contained two recorded measurement points. Body-axis drag area (CdA) and the tunnel workbook's aerodynamic power, normalised to 26.5 mph (42.6 km/h), were compared within each stage of testing.

Results. At a 20° extension angle, the AIR trisuit with pockets recorded 265.3 W at 0° and 242.4 W at -10°. The two-piece outfit required a further 5.5 W and 9.1 W, respectively. The LG P09 recorded the lowest mean drag at both comparison angles in the helmet series. Relative to that series' reference configuration, aerodynamic power was lower by 14.3 W at 0° and 9.9 W at -10°. Raising the extensions from 9.5° to 20° alone produced mixed, small differences. Repeat measurements showed that position and session variability affected the results.

Conclusion. The clearest equipment result was the LG P09 within the tested helmet series. The clothing results favoured the AIR suit with pockets in the initial comparison, but repeats did not support a precise, general garment saving. These findings apply to the rider and configurations tested. They do not establish race-time savings or performance across other riders.

Introduction

In order to understand the aerodynamic effect of race equipment, we have to look at the rider and equipment together. Changing a garment, a helmet or the angle of the forearms alters the shape presented to the airflow. The aim of this study was to identify which of these changes improved my own set-up, while providing useful direction for clothing development. The practical question was simple: could we reduce drag without relying on a position that would be difficult to reproduce?

1. Methods

Rider and equipment

Testing was undertaken at A2 Wind Tunnel on 12 June 2014. The participant was John Polson, a 71 kg professional triathlete with seven years of racing experience. The intended race distance was half Ironman / 70.3. The pre-test form listed a Parlee TTi bicycle, Fizik Arione saddle, aluminium Vuka bars, a Stinger 90 mm wheel and disc wheel, and Gaerne TT shoes. [1, 2]

Test sequence

The session began with a baseline and a repeat at 0° yaw. A second baseline was then established because cadence in the first configuration had been too high. Aerobar extension angles of 14.5°, 20° and 5° were compared with the corrected 9.5° baseline. The extensions were returned to 20° for clothing and helmet testing. [1, 4]

Clothing comparisons included the SCODY AIR trisuit with pockets, Lightspeed trisuit, two-piece outfit, and AIR trisuit without pockets. The pre-test plan identifies the Giro Air Attack as the helmet for clothing testing. The edited clothing workbook identifies runs 8 and 9 as the AIR suit with pockets at 20°, resolving the abbreviated labels in the full tunnel log. Lightspeed and the pocketless AIR suit were subsequently retested. [1-3]

The helmet sequence used runs 20 and 21 as its immediate reference. The next condition is explicitly labelled “same as 10 + Kask helmet”, referring to configuration 10, the pocketless AIR suit. Kask, Rudy Wing 57, Giro Advantage II, LG P09 and POC helmets followed. Kask and POC model names are not specified. The final LG P09 configuration was then measured through a wider yaw sweep. [1]

Measurements and analysis

The workbook contains 37 populated runs and 74 measurement points. The remaining numbered rows are empty template entries. Each reported run mean is the arithmetic mean of its two points. Tunnel speed across run means ranged from 29.68 to 30.01 mph. The workbook reports force normalised to 29.92 inHg and 60°F, with aerodynamic power calculated at an input speed of 26.5 mph. These power values are distinct from the rider's recorded Computrainer power. [1]

Body-axis CdA, expressed in m^2, is used throughout. At non-zero yaw, wind-axis and body-axis values differ; they have not been interchanged. The negative yaw sign is retained from the original workbook. Comparisons use the same yaw and the relevant stage baseline: runs 4/5 for position, 8/9 for clothing and 20/21 for helmets. Positive power differences indicate more drag; negative differences indicate less drag.

The analysis is descriptive. Technical measurement pairs do not increase the participant sample beyond one. No confidence intervals, significance tests or race-time estimates are calculated. Sampling duration, calibration uncertainty, full position coordinates and numerical cadence values are not available in the supplied records. Two abbreviated, anonymous rider summaries in the edited workbook are excluded because their test conditions and underlying measurements are insufficiently documented. [1, 3]

2. Position and clothing results

Extension angle

Extension angle	Runs	0° (W)	-10° (W)	Δ 0° (W)	Δ -10° (W)
9.5° corrected baseline	4/5	264.1	243.3	0.0	0.0
14.5°	6/7	266.9	251.4	+2.8	+8.1
20°	8/9	265.3	242.4	+1.2	-0.9
5°	10/11	267.0	246.3	+2.8	+3.0

Table 1. Aerodynamic power at 26.5 mph. Differences are relative to the corrected baseline at the same yaw. Source: full tunnel workbook. [1]

Raising the extensions to 20° increased aerodynamic power by 1.2 W at 0° and reduced it by 0.9 W at -10°. The 14.5° and 5° settings recorded higher drag at both angles. Although 20° was retained for the rest of the session, the isolated position comparison does not show a consistent advantage over the corrected baseline.

Clothing at a 20° extension angle

Garment / test	Runs	0° (W)	-10° (W)	Δ 0° (W)	Δ -10° (W)
AIR with pockets	8/9	265.3	242.4	0.0	0.0
Lightspeed, first test	12/13	268.2	243.6	+2.8	+1.2
SCODY two-piece	14/15	270.9	251.5	+5.5	+9.1
AIR without pockets, first	16/17	268.1	248.6	+2.8	+6.2
Lightspeed, repeat	18/19	272.2	250.4	+6.8	+8.0
AIR without pockets, repeat	20/21	268.8	244.1	+3.5	+1.7

Table 2. Aerodynamic power at 26.5 mph. Differences are relative to AIR with pockets at the same yaw. Garment labels are reconciled with the edited clothing workbook. [1, 3]

The AIR suit with pockets recorded the lowest mean power at both angles in the clothing comparison. Against the two-piece outfit, the measured difference was 5.5 W at 0° and 9.1 W at -10°. The first Lightspeed test was only 2.8 W and 1.2 W higher than the AIR reference.

The repeats change how strongly we can interpret these differences. Lightspeed increased by 4.0 W at 0° and 6.8 W at -10° between tests. The pocketless AIR suit changed by +0.7 W and -4.6 W. The tunnel log specifically notes a position mismatch around the Lightspeed retest. It would therefore be premature to attribute every difference to the garment, or to conclude that pockets themselves reduced drag.

3. Helmet selection

The helmet series followed the pocketless AIR retest with the extensions at 20°. The immediately preceding runs provide the reference for this comparison. The initial helmet is identified as Giro Air Attack from the pre-test plan; its name is not repeated in the reference run comment. [1, 2]

Helmet	Runs	0° CdA (m²)	-10° CdA (m²)	Δ 0° (W)	Δ -10° (W)
Reference	20/21	0.2636	0.2393	+0.0	+0.0
Kask	22/23	0.2539	0.2322	-9.8	-7.2
Rudy Wing 57	24/25	0.2554	0.2388	-8.4	-0.5
Giro Advantage II	26/27	0.2531	0.2337	-10.7	-5.7
LG P09	28/29	0.2496	0.2296	-14.3	-9.9
POC	30/31	0.2515	0.2394	-12.3	+0.1

Table 3. Body-axis CdA and power difference from runs 20/21 at the same yaw. Power is normalised to 26.5 mph. Lower values indicate less drag. [1]

Lowest recorded drag in the helmet series

The LG P09 recorded 0.2496 m² at 0° and 0.2296 m² at -10°, equivalent to 254.5 W and 234.2 W. These values were 14.3 W and 9.9 W below the reference. The corresponding reduction in body-axis CdA was 5.3% at 0° and 4.1% at -10°. It was the lowest mean result at both yaw angles within this series.

The order behind the LG changed with yaw. At 0°, POC was next, followed by Giro Advantage II, Kask and Rudy Wing 57. At -10°, Kask was next, followed by Giro Advantage II, Rudy Wing 57 and POC. The POC result at -10° was effectively level with the reference, differing by just +0.1 W after rounding. This is a useful reminder that a result at one airflow angle does not establish the same result at another.

Comparison with the corrected starting set-up

Compared with the corrected starting baseline in runs 4 and 5, the LG configuration in runs 28 and 29 was 9.6 W lower at 0° and 9.1 W lower at -10°. This comparison includes the changes made across the session, including garment and extension angle. It must not be added to the helmet-only saving or described as a separate benefit from each component.

Final set-up

My post-test correspondence identified LG, AIR suit, sunglasses and 20° aero tilt as the preferred combination. The tunnel log identifies the final sweep as LG P09 with the best position. It does not separately record a sunglasses comparison or fully restate the garment specification for that sweep. The evidence supports this as the selected set-up, without assigning an independent saving to the sunglasses or assuming that every component benefit is additive. [1, 4]

4. Yaw sweep and repeatability

The final sweep recorded +20°, +10°, +5°, -5°, -10° and -20° yaw. There is no populated 0° run within this sweep. The earlier LG measurements at 0° and -10° are shown separately below; they are not substituted for a missing sweep measurement. [1]

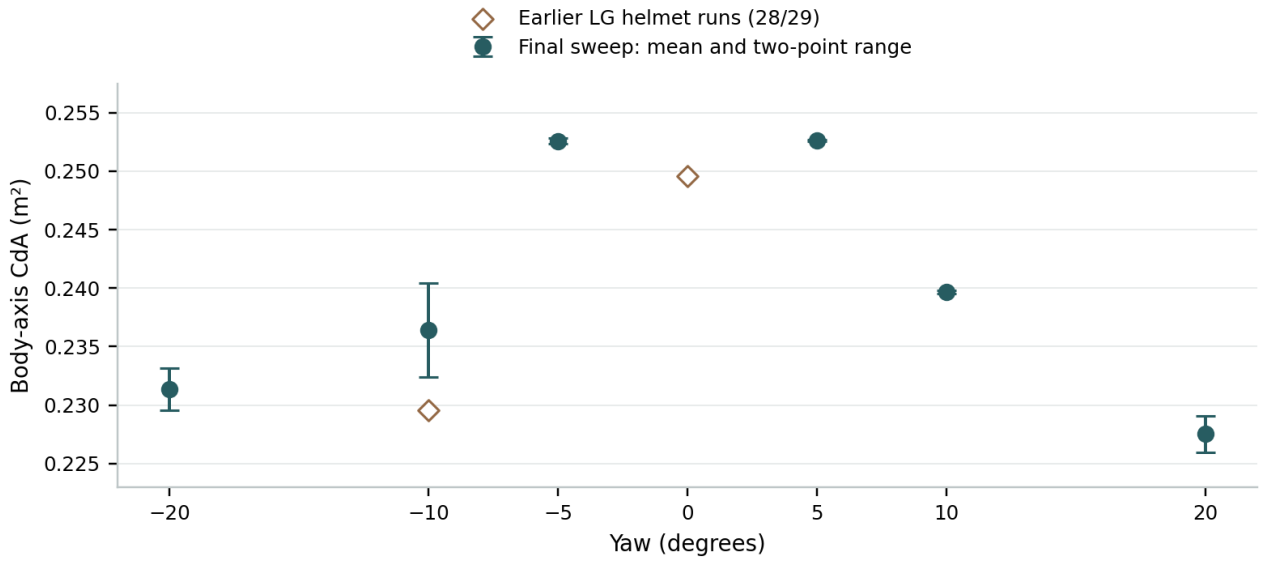

Figure 1. Final yaw sweep, with both recorded points represented by the vertical range. These ranges are not confidence intervals. Earlier LG runs are separate observations. All values are from the full tunnel workbook. [1]

A broader range of airflow angles

Within the sweep, mean body-axis CdA ranged from 0.2275 m² at +20° to 0.2526 m² at +5°. The +5° and -5° means were very close. At 10° yaw, the positive-side mean was 0.0032 m² higher than the negative-side mean, equivalent to 3.3 W in the workbook. At 20°, the negative-side mean was 0.0038 m² higher, equivalent to 3.9 W. With one sweep, these differences cannot establish repeatable left-to-right asymmetry.

Variation within and between runs

The final -10° run recorded 241.1 W, 7.0 W above the earlier LG result at the same yaw. Its two points were 245.2 W and 237.0 W, a spread of 8.2 W. The Lightspeed retest at 0° also showed a 7.2 W spread between points. These are observed ranges, not a calibrated estimate of tunnel error.

The practical implication is that a small difference needs to be reproduced before it becomes a reliable equipment decision. The lower drag at larger yaw angles also cannot be treated as a road saving without accounting for apparent wind speed, wind direction and the amount of time spent at each yaw. No race-weighted yaw average is calculated here.

5. Discussion and practical application

The largest consistent reduction in the helmet series came from the LG P09. This makes it the strongest equipment candidate from the session for my own position. The changing order of the other helmets across yaw reinforces the need to test the rider and helmet together.

For clothing development, the AIR suit with pockets provided a useful reference. It recorded less drag than the two-piece outfit and the other garment conditions at both comparison angles. However, the changes between repeated clothing tests were large enough to affect the ranking and the size of any claimed benefit. The next step should be to reproduce the comparison with the same posture, cadence and helmet, alternating garments and returning to the reference throughout the test.

Removing pockets did not improve the recorded results in this session. This does not establish a beneficial effect from pockets themselves. Garment fit, fabric tension and small changes in rider position were not independently measured. Similarly, the retained 20° extension setting should be assessed for repeatability and sustainable riding, because its direct drag comparison with 9.5° was small and mixed.

Limitations

This was a practical development session involving one rider, rather than a randomised comparison across athletes. Test order was sequential. The cadence correction and the documented position mismatch show that control of the rider was imperfect. There was no complete return-to-baseline sequence at the end of testing, and no measurement of long-duration comfort, physiological cost or outdoor performance. Thermal responses were not measured, so aerodynamic findings cannot establish a thermoregulation benefit.

The rider worked in research and design for SCODY. These garment comparisons form part of an internal product-development assessment. All run means are retained in the appendix.

Conclusion

For this rider, the LG P09 at the retained 20° extension setting produced the lowest mean drag in the helmet comparison at both 0° and -10° yaw. The initial clothing comparison favoured the AIR suit with pockets, particularly against the two-piece outfit. Position changes alone produced small, mixed effects. These findings provide a clear starting point for further testing, with the priority on reproducing the preferred set-up and controlling posture and cadence before assigning a fixed performance saving.

Source records

1. A2 Wind Tunnel. **2014-06-12 A2WT-POLSON.xls.** 12 June 2014. Full tunnel export, Coeff and Report sheets; populated runs 1-37.

2. Polson J. **A2 Wind Tunnel Pre-test information.** Pre-test form and prioritised test plan supplied for the June 2014 session.

3. Polson J. **JPWindTunnelData13-6-14.xlsx.** Clothing comparison workbook sent 13 June 2014. Used to resolve garment labels; full export used for run numbering and calculations.

4. Polson J. **ALL the Data.** Email, 13 June 2014. Records the cadence correction, revised clothing baseline and preferred final combination.

Appendix. Complete run means

All 37 populated runs. CdA is body-axis drag area; power is the workbook's aerodynamic power at 26.5 mph. Each row is the mean of two points. Run numbers are from the original full export.

Run	Configuration / recorded change	Yaw	CdA (m²)	Power (W)
1	Initial baseline	0°	0.2595	264.7
2	Initial baseline	-10°	0.2397	244.5
3	Initial baseline, repeat zero	0°	0.2637	268.9
4	Corrected baseline, 9.5°	0°	0.2590	264.1
5	Corrected baseline, 9.5°	-10°	0.2385	243.3
6	Extensions 14.5°	0°	0.2617	266.9
7	Extensions 14.5°	-10°	0.2465	251.4
8	Extensions 20° / AIR with pockets	0°	0.2602	265.3
9	Extensions 20° / AIR with pockets	-10°	0.2377	242.4
10	Extensions 5°	0°	0.2618	267.0
11	Extensions 5°	-10°	0.2415	246.3
12	20° / Lightspeed	0°	0.2629	268.2
13	20° / Lightspeed	-10°	0.2389	243.6
14	Two-piece outfit	0°	0.2656	270.9
15	Two-piece outfit	-10°	0.2466	251.5
16	AIR without pockets, first	0°	0.2629	268.1
17	AIR without pockets, first	-10°	0.2438	248.6
18	Lightspeed, repeat	0°	0.2669	272.2
19	Lightspeed, repeat	-10°	0.2455	250.4
20	AIR without pockets, repeat	0°	0.2636	268.8
21	AIR without pockets, repeat	-10°	0.2393	244.1
22	Kask	0°	0.2539	259.0
23	Kask	-10°	0.2322	236.8
24	Rudy Wing 57	0°	0.2554	260.4
25	Rudy Wing 57	-10°	0.2388	243.5
26	Giro Advantage II	0°	0.2531	258.1
27	Giro Advantage II	-10°	0.2337	238.4
28	LG P09	0°	0.2496	254.5
29	LG P09	-10°	0.2296	234.2
30	POC	0°	0.2515	256.5
31	POC	-10°	0.2394	244.2
32	LG P09, final sweep	+20°	0.2275	232.1
33	LG P09, final sweep	+10°	0.2397	244.4
34	LG P09, final sweep	+5°	0.2526	257.7
35	LG P09, final sweep	-5°	0.2526	257.6
36	LG P09, final sweep	-10°	0.2364	241.1
37	LG P09, final sweep	-20°	0.2314	236.0

Source: 2014-06-12 A2WT-POLSON.xls. Clothing descriptions are clarified by the 13 June summary workbook. Conditions carry forward between changes where indicated by the recorded sequence. [1, 3]