RELIABILITY AND SENSITIVITY OF THE NOTIO DEVICE AND AEROSCALE SERVICE TO QUANTIFY CYCLISTS' DRAG COEFFICIENTS IN OUTDOOR CONDITIONS

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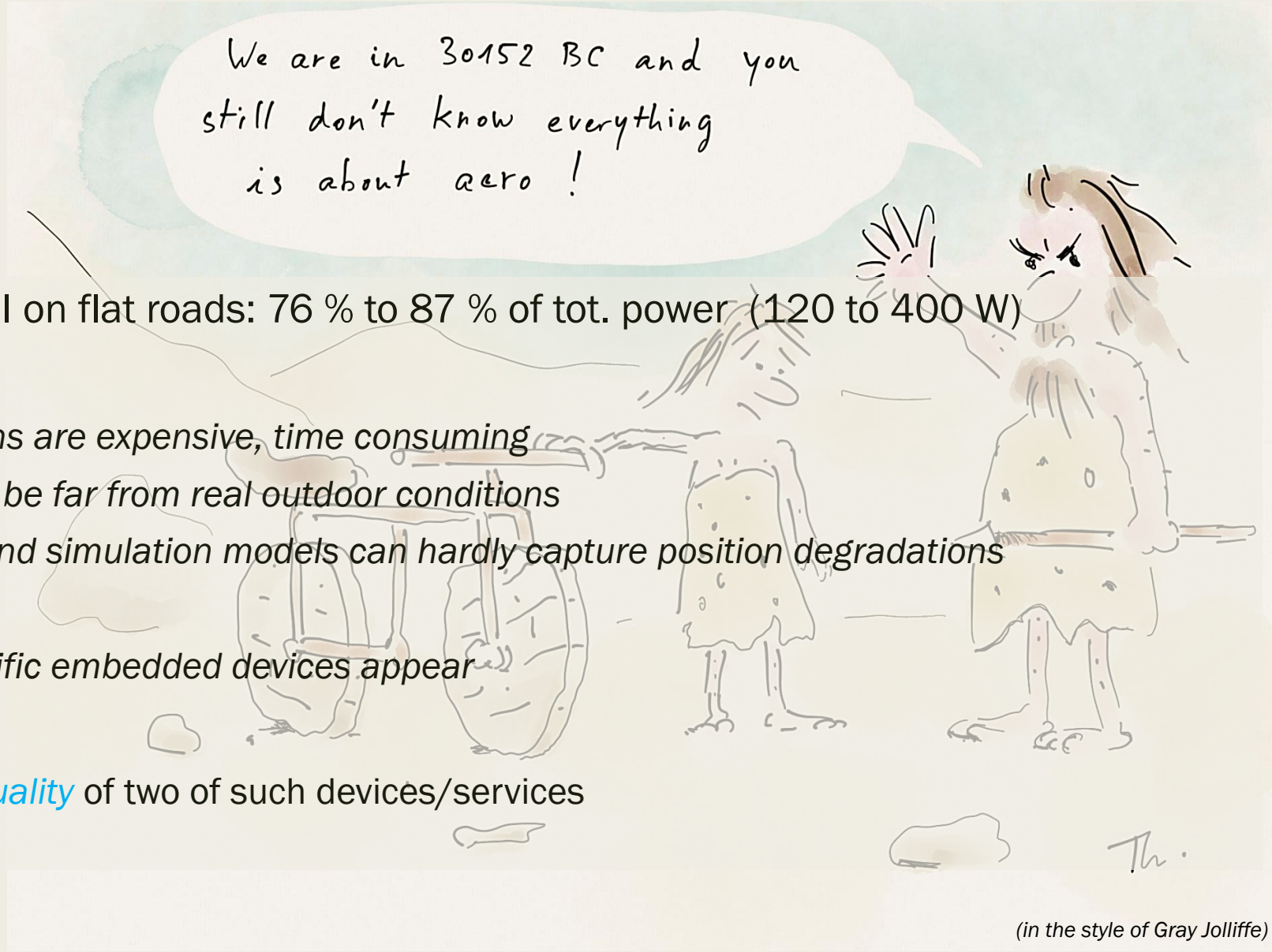
Outline

- Introduction: motivations, objectives
- Basic idea of these Device
- Notio konect
  - *Experimental conditions and protocol*
  - *Results*
- Aeroscale service
  - *Adaptation of the idea*
  - *Experimental conditions and protocol*
  - *Results*
- Conclusion

Motivations (1/3)

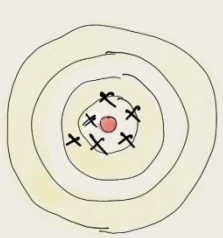


- Aerodynamics is crucial on flat roads: 76 % to 87 % of tot. power (120 to 400 W)
  - *Wind tunnel sessions are expensive, time consuming*
  - *Track sessions may be far from real outdoor conditions*
  - *VE, mathematical and simulation models can hardly capture position degradations*
  - ➢ *Since 5 years, specific embedded devices appear*
- **Objective**: evaluate the *quality* of two of such devices/services

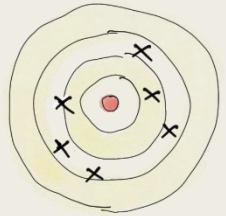
(in the style of Gray Jolliffe)

Motivation (2/3). Quality / qualities?

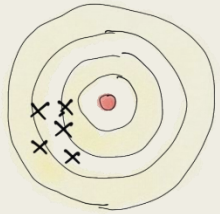
- Usefulness with regards to recreational, regular, elite cyclists?
  - *Accuracy* *(ISO 5725)*
  - *Reliability:*
    - Reliability (engineering): rate of failures/bugs
    - Reproducibility (precision)
  - *Sensitivity: ability to detect small variations*
  - *Response times,*
  - *Ease of use*
  - *Robustness*
  - *. . . (autonomy, size, weight, …)*



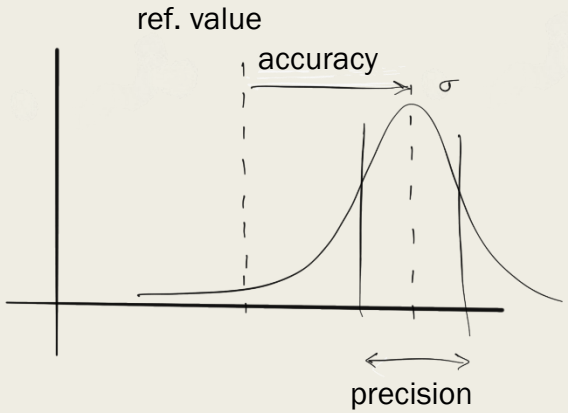
accurate



low accuracy



reliable



sensitive

Motivation (3/3)

- Previous studies

1. Pedro L. V., Yago Alcalde, J., Gil-Cabrera, E. Talavera, A., Lucia, D. Barranco-Gil (2020), Validity of a novel device for real-time analysis of cyclists' drag area, Journal of Science and Medicine in Sport, Volume 23, Issue 4, Pages 421—425.

2. Kordi, M., Galis, G. E., Teun Terra, W. (2021). Reliability and Sensitivity of the Notio Konect to quantify Coefficient of Drag Area in Elite Track Cyclists. European Journal of Sport Science. 22. 1—15.

- Indoor only, Notio Konect only, elite riders only.

[1] concludes for a good reliability (ICC=0.92) and poor sensitivity

[2] concludes for a good reliability (ICC=0.99) and good sensitivity (1.2%)

- **Objective (refined):** evaluate reliability and sensitivity of Notio and Aeroscale, outdoor, for regular and irregular riders.

Basic idea of these devices

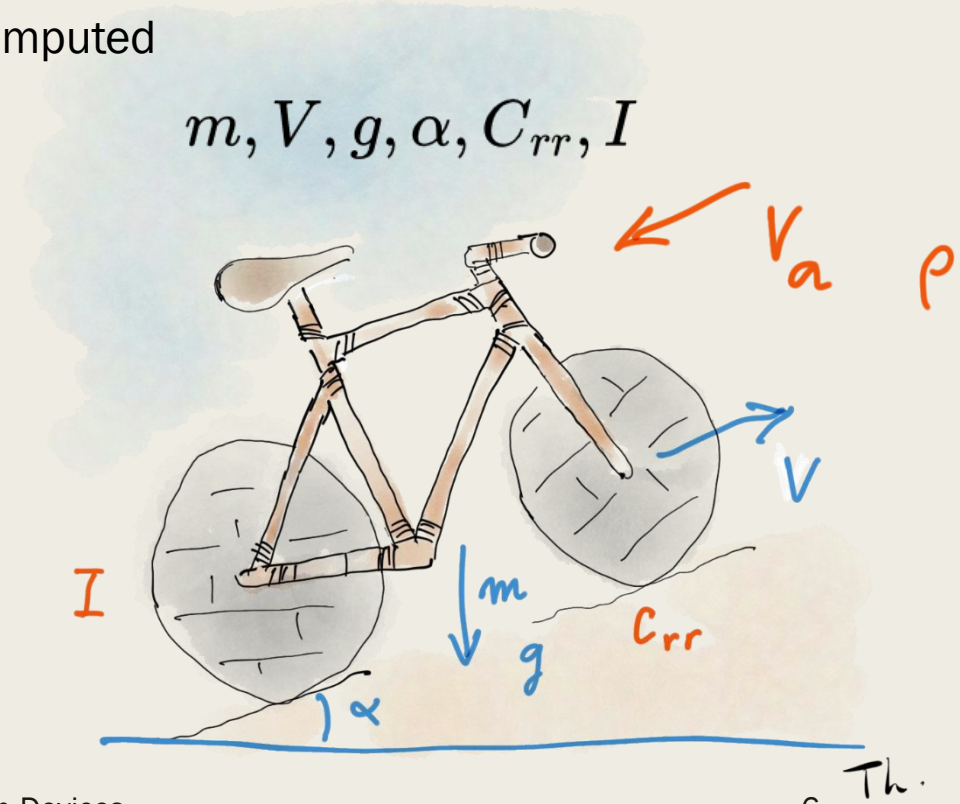
$$TotPwr = Pwr_{aero} + \underbrace{Pwr_{grav} + Pwr_{frictions} + Pwr_{kin}}$$

measured

computed

deduced

$$Pwr_{aero} = \frac{1}{2}\rho C_d A (V + V_a)^2 V$$



Notio Konect Device

- Measures: air speed, temperature, air density, humidity, vibrations.
  - *Pitot tube*
  - *Barometer*
  - *Accelerometer, Gyroscope*
  - *Hygrometer, Thermometer*

- Connected to:
  - *Garmin + sensors measure: velocity, alt.*
  - *Powermeters: Power2max, assioma and shimano P9100*

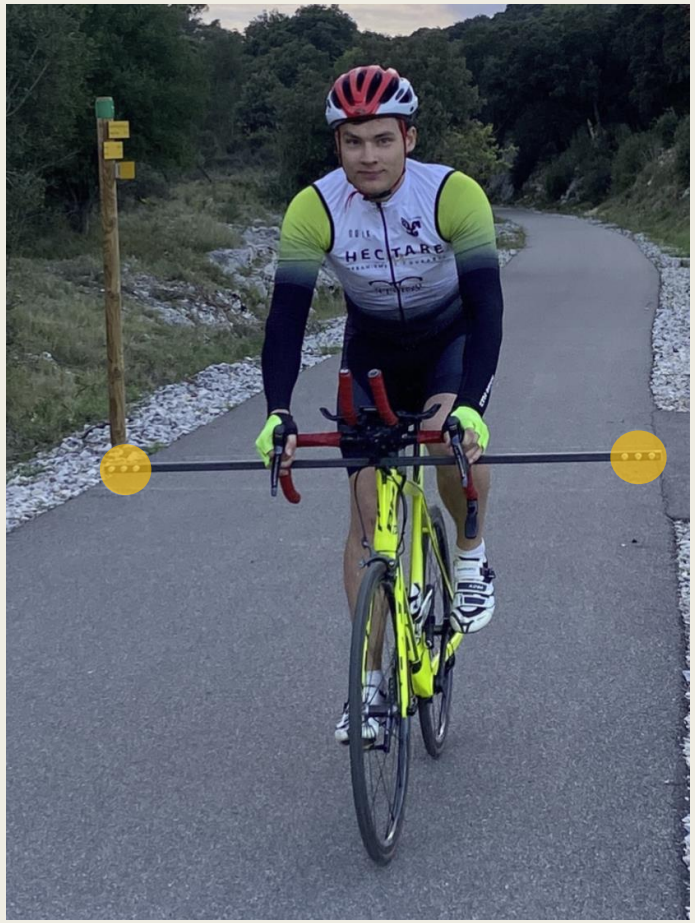
- Data processed by: Golden Cheetah Notio

Experimental conditions. Protocol

- 3 cyclists: 2 irregular (24 yo), 1 regular (52 yo). 170 cm, 188, 194 cm.
- 3 bicycles.
- 2 Garmin (1000, 1030). 2 Notio Konect.
- 3 x 5 runs.
- Run: 3 km forward + 3 km backward. => more than 110 km.
- Straight, flat road.
- Constant Speed ≈ 30 km/h, Cadence $\approx 85\ rpm$, 80 < pwr < 280

- Runs 1: no disc (but bar)
- Runs 2: 12 cm discs
  + 0,023 m² CdA
  + 7 %
- Runs 3: 15 cm discs
  + 0.037 m² CdA
  + 13 %

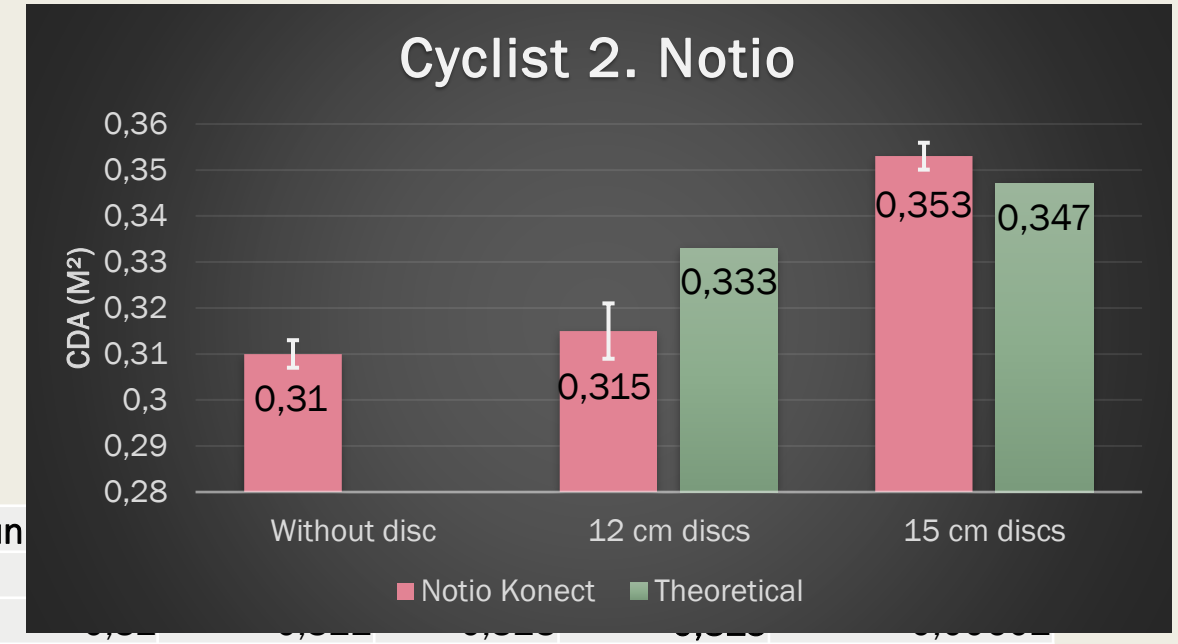
- Constraints: same day, approx. same temp., no car.

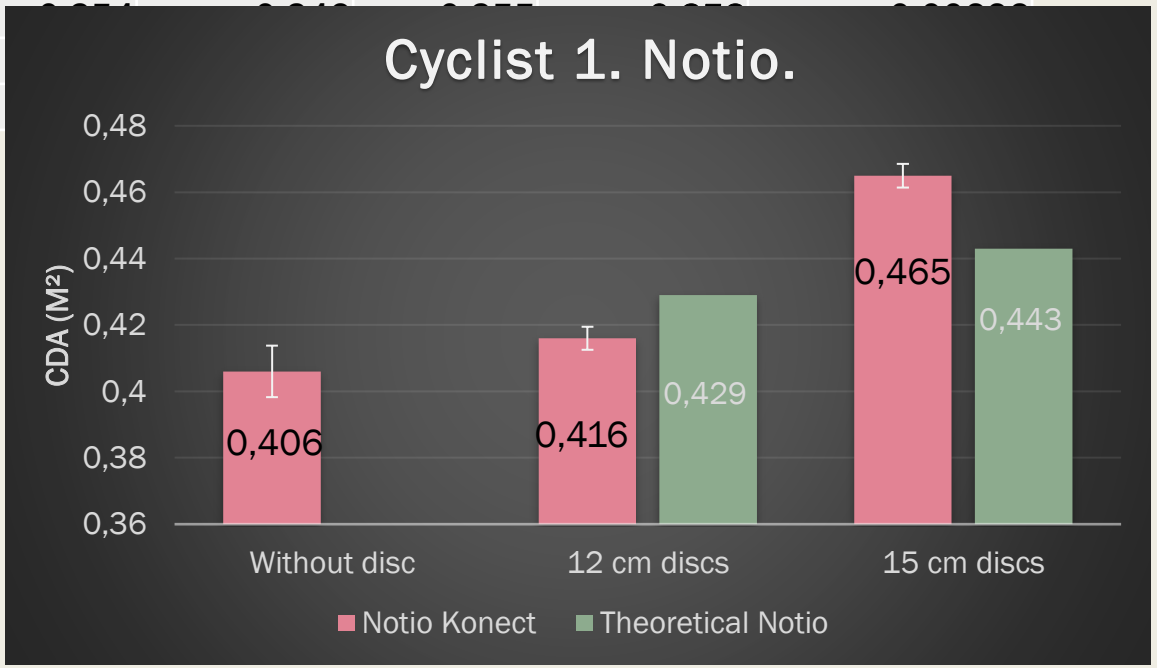


Notio results

Cyclist 2. CdA (m^2). Regular.

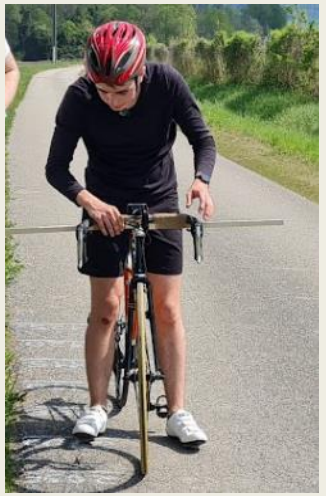
	run 1	run 2	run
Without disc	0,309	0,307	
12 cm Discs	0,316	0,311	
15 cm Discs	0,351	0,356	
		ICC	

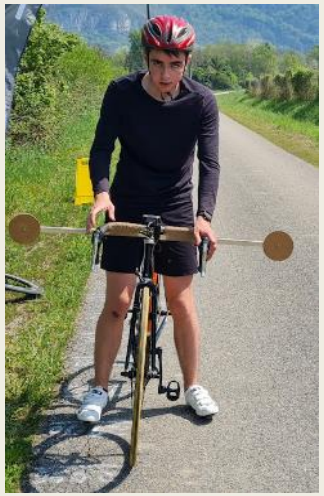




Aeroscale
Experimental conditions. Protocol

- 1 cyclist: irregular (24 yo), 170 cm.
- 1 bicycle. (2 sets of wheels)
- **No powermeter required** and no bike computer
- Aeroscale device.
- 3 x 5 runs at incremental speeds.
- Run: 150 m forward + 150 m backward.
- Straight road., flat (3 cm of elevation)
- Initial speed: 15 to 35 km/h, cadence = 50—60 rpm





- Runs 1: no disc (but bar) Runs 2: 12 cm discs Runs 3: 15 cm discs

  + 0,023 m² CdA *+ 0.037 m² CdA*

  7 % *13 %*

- Constraints: same day, approx. same temp., no car.

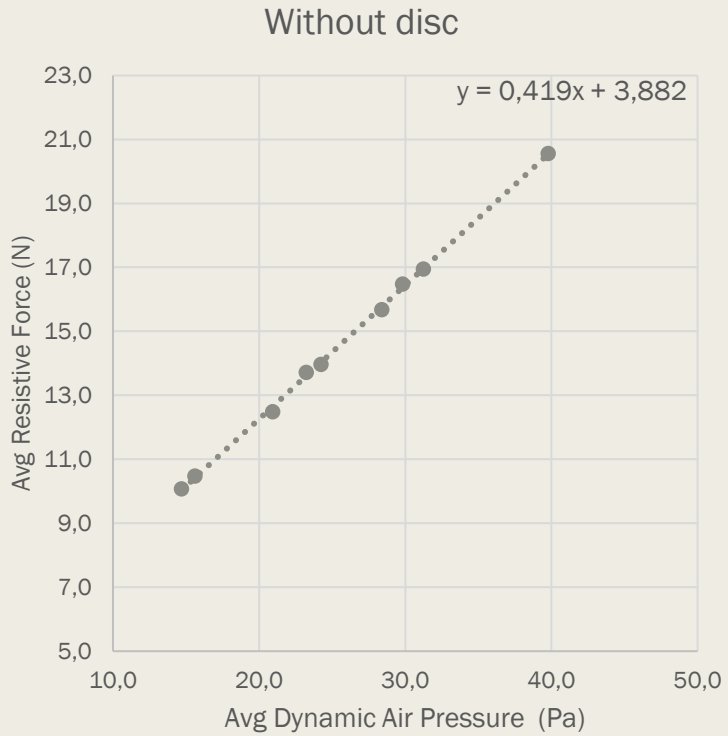
Aeroscale adaptation of the initial idea

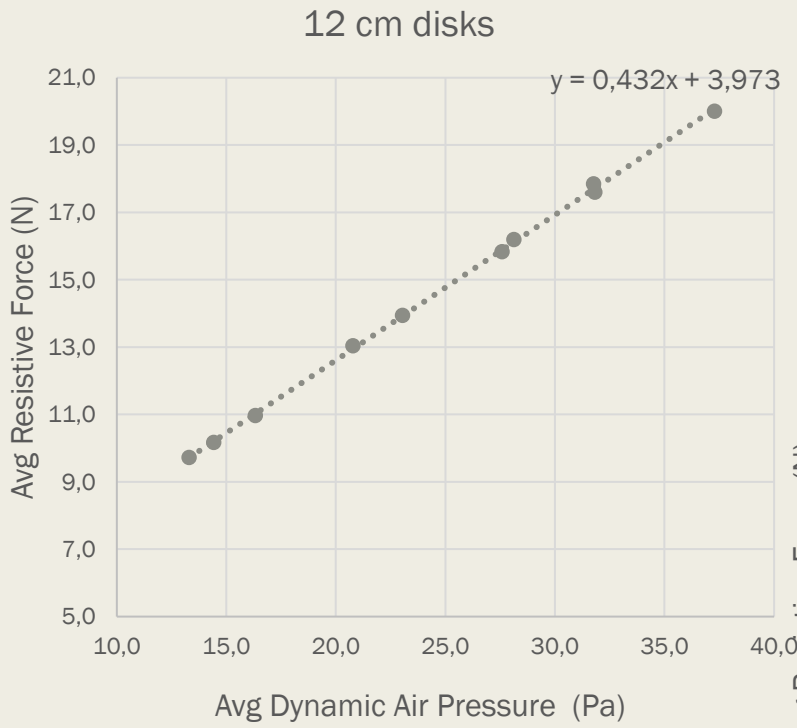
$$TotPwr = Pwr_{aero} + Pwr_{grav} + Pwr_{frictions} + Pwr_{kin}$$

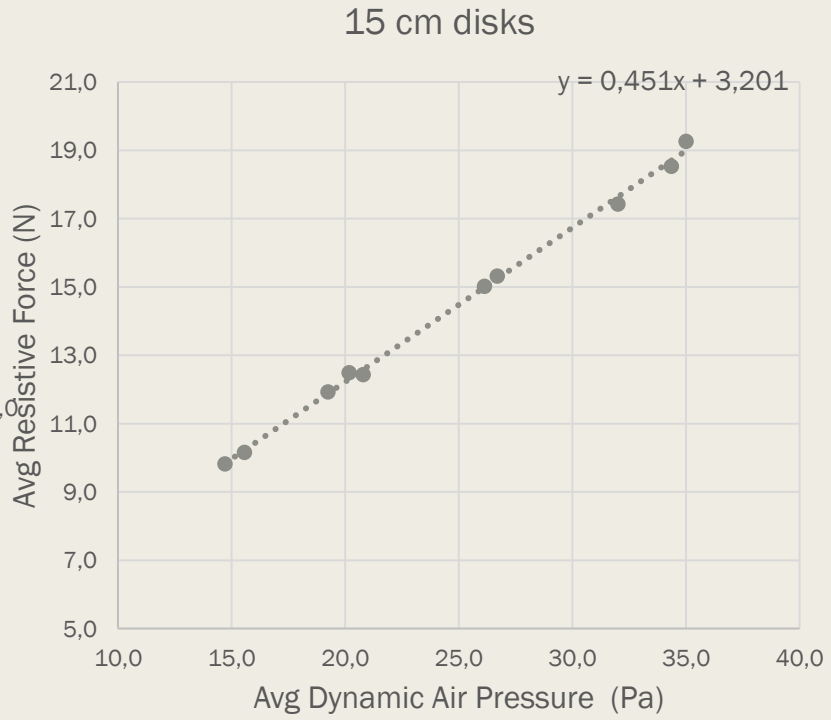
$$\frac{TotPwr - Pwr_{kin} - Pwr_{grav}}{V} = C_d A \frac{1}{2}\rho(V + Va)^2 + Crr \times mg$$

$$\begin{aligned} F_{res} &= C_d A \times DynPressure + Crr \times mg \\ y &= a\,x + b \end{aligned}$$

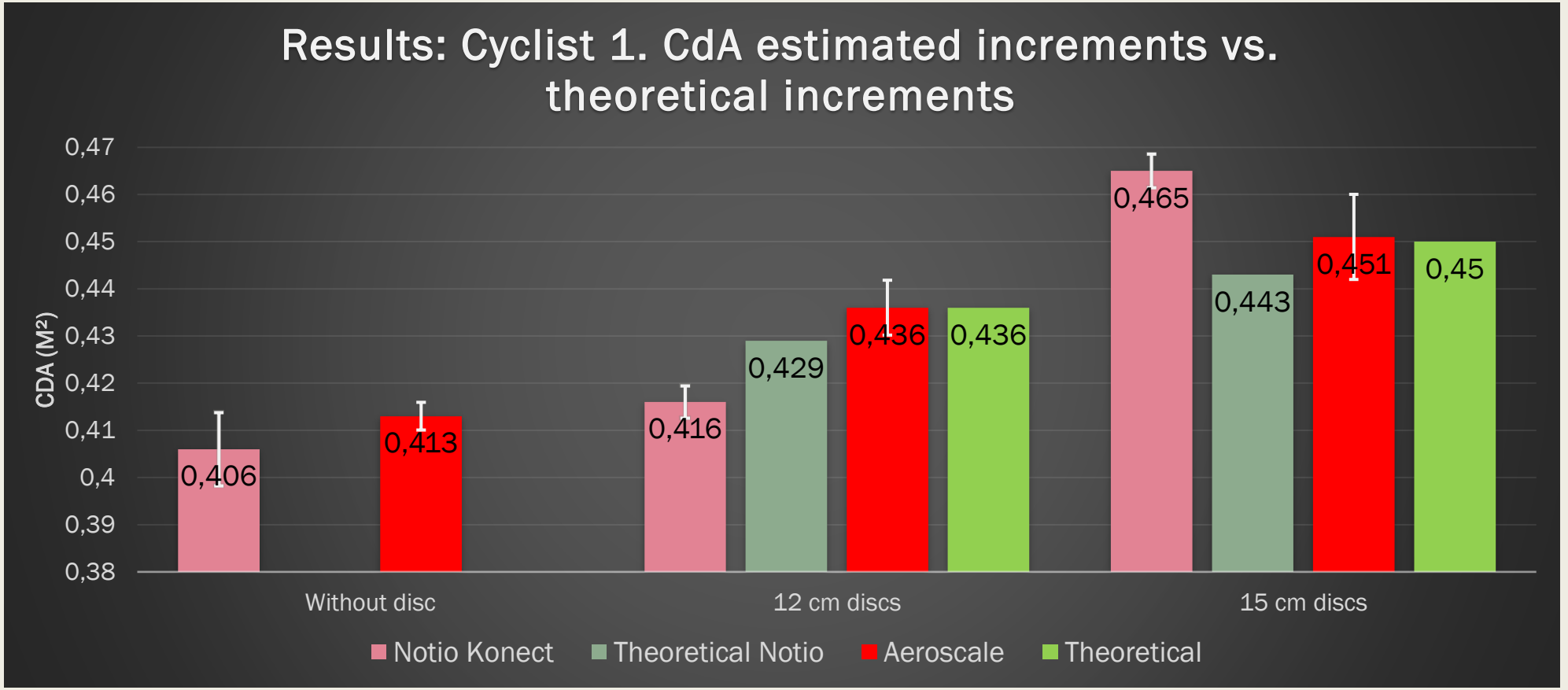
Aeroscale results







Results


Results: Cyclist 1. CdA estimated increments vs. theoretical increments
CDA (M²)
0,47
0,46
0,45
0,44
0,43
0,42
0,41
0,4
0,39
0,38
0,406
0,413
0,416
0,429
0,436
0,436
0,465
0,443
0,451
0,45
Without disc
12 cm discs
15 cm discs
Notio Konect
Theoretical Notio
Aeroscale
Theoretical

Conclusion

- Notio and Aeroscale are both precise
  - *(ICC = 0.97, $\sigma = 0.003$ or 1%)*

  "In Notio and Aeroscale, we trust"

- Sensitivity:
  - *Notio can hardly detect variations < 5 %*
  - *Aeroscale detects variations < 0.5 %*

- "Real-time" notio promise: irrealistic

(in the style of Gray Jolliffe)

Thank Notio & Aeroscale engineers.
Thank you for your attention