Simulating track cycling in an Olympic event

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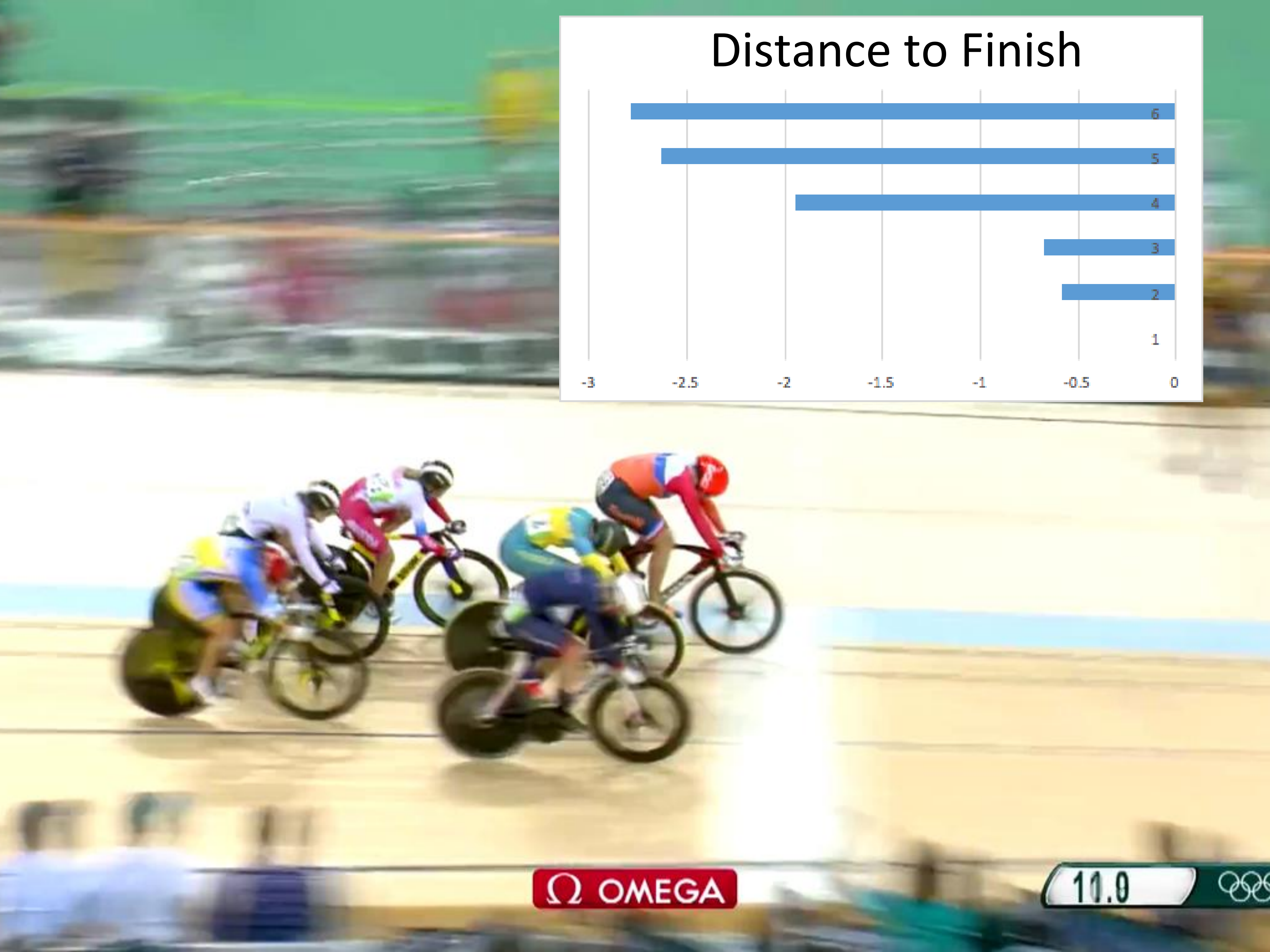
umcg

Elis Ligtlee

Gold Medal Keirin Rio

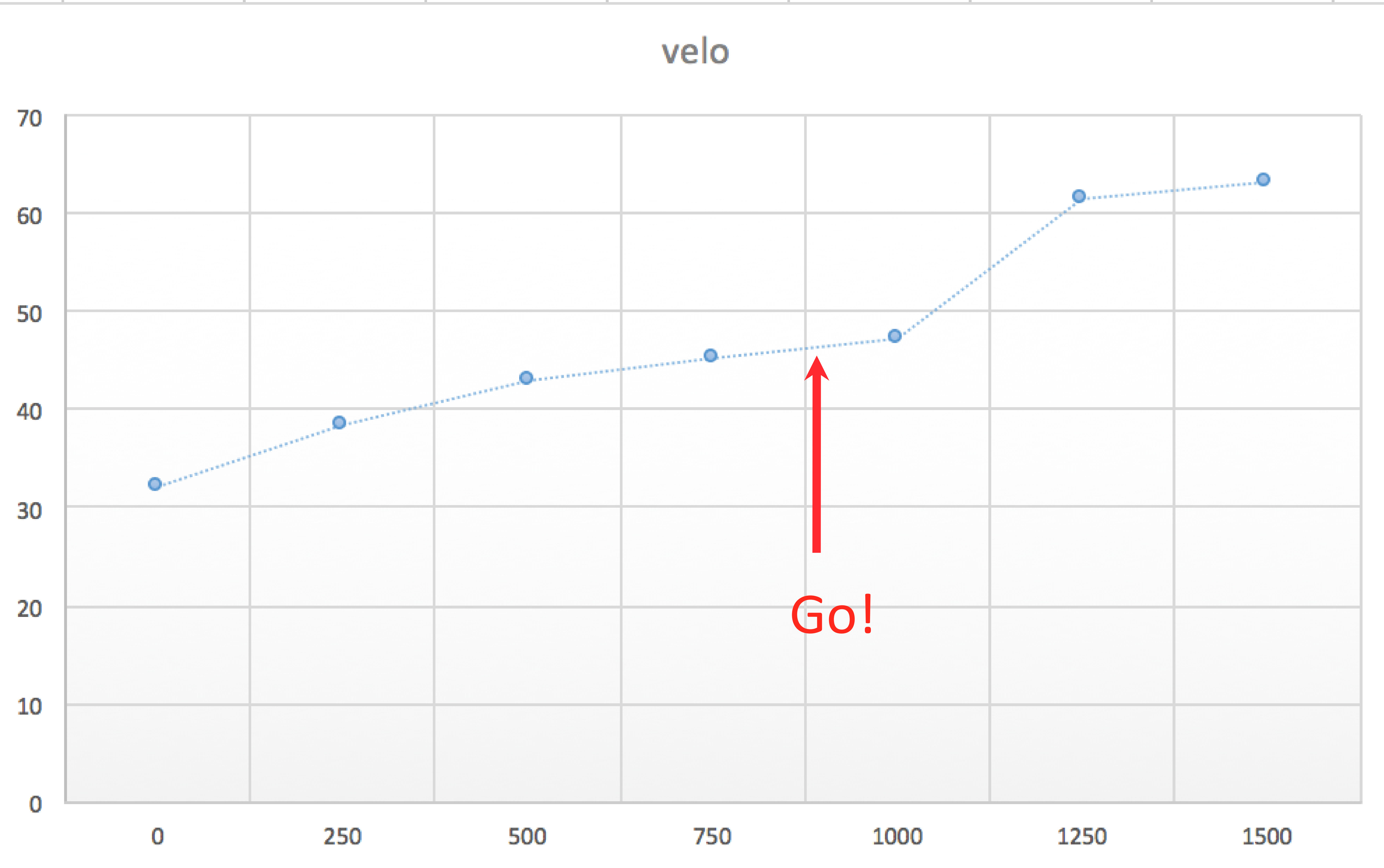

Rio2016
Rio2016
Rio2016
Rio2016


AUSTRALIA
RUSSIA


Distance to Finish
6
5
4
3
2
1
-3
-2.5
-2
-1.5
-1
-0.5
0

difference with silver

- 0.033 sec.
- James was riding 4 km/h faster
- If the finish would have been 16 meter further, Elis would have lost the Gold Medal



velo
70
60
50
40
30
20
10
0
0
250
500
750
1000
1250
1500
Go!

Sprint for Bronze against Katy Marchant
difference: 1.58 m

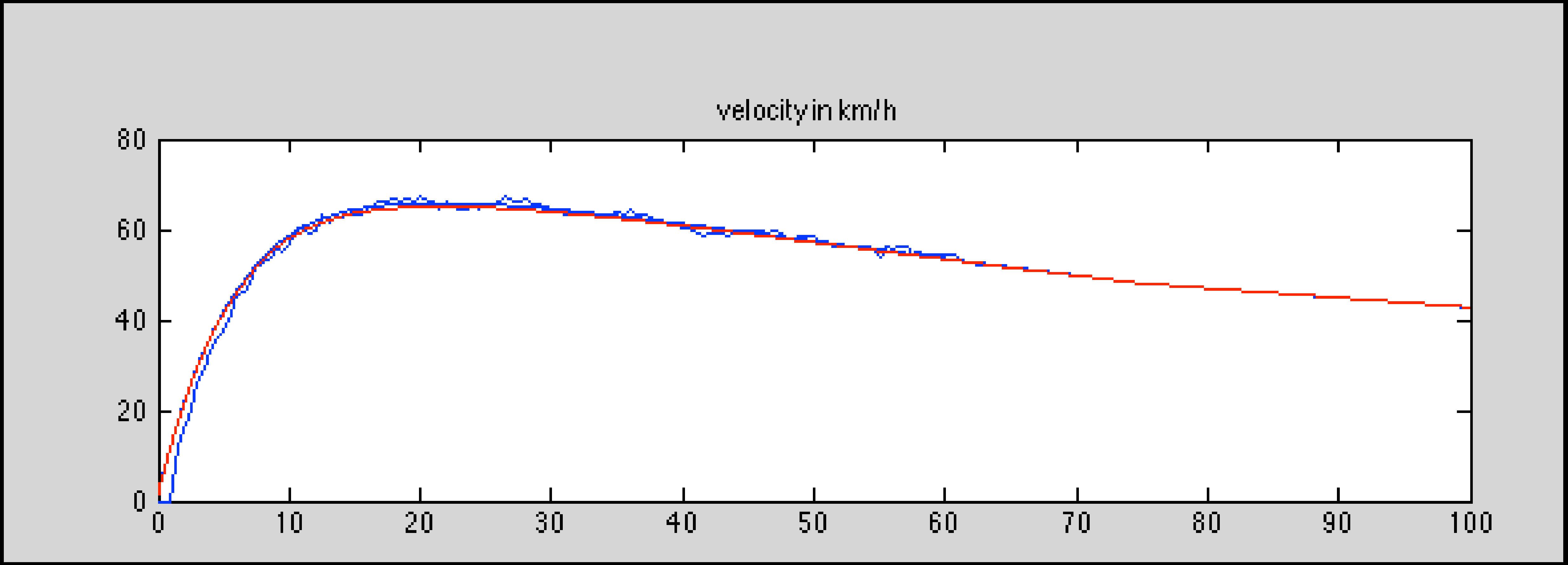
1.85 m
90 kg

1.71 m
67 kg

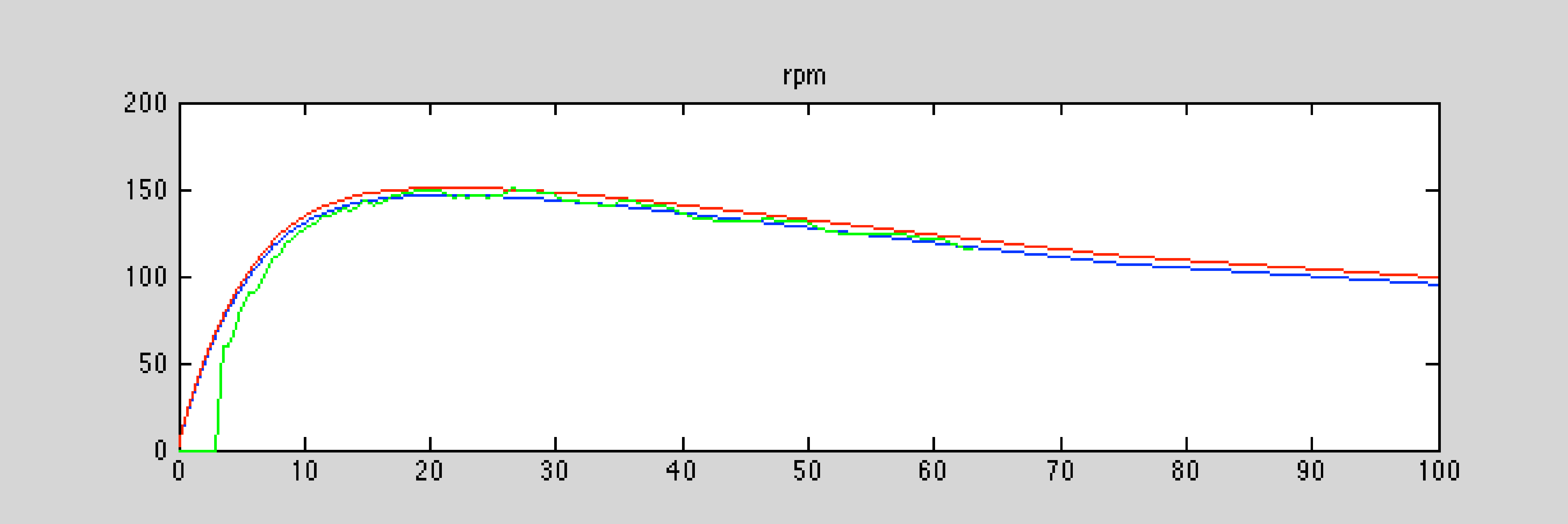

BIORACER


Teun Mulder
1000 m
Rabobank

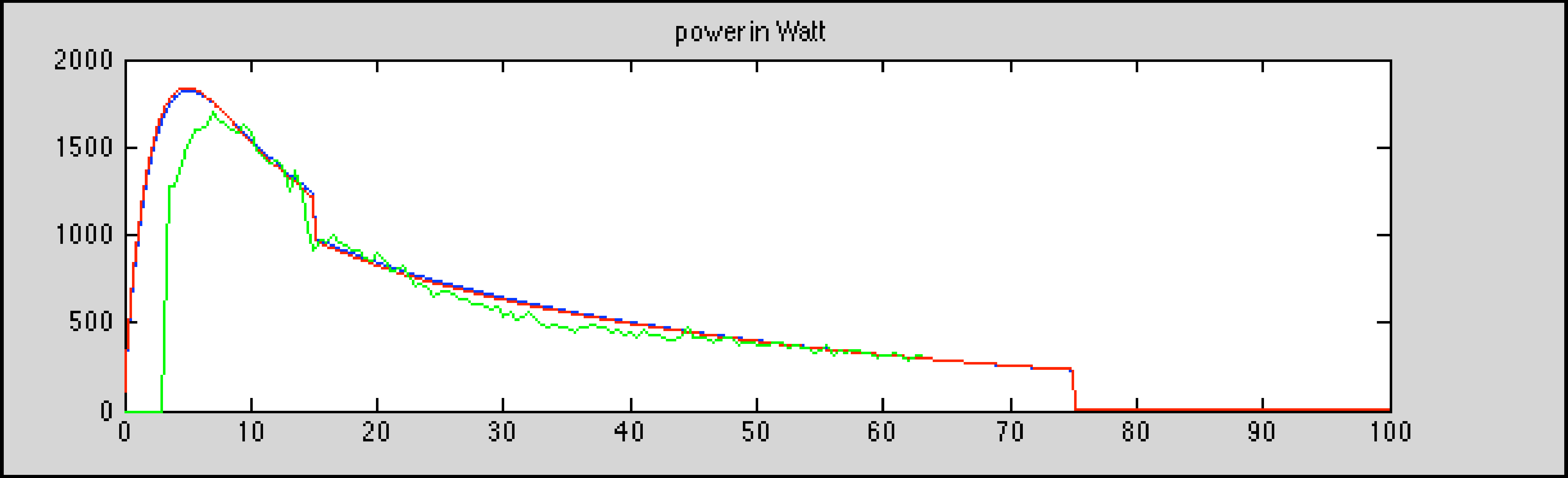
1 km timetrial



1 km timetrial: RPM

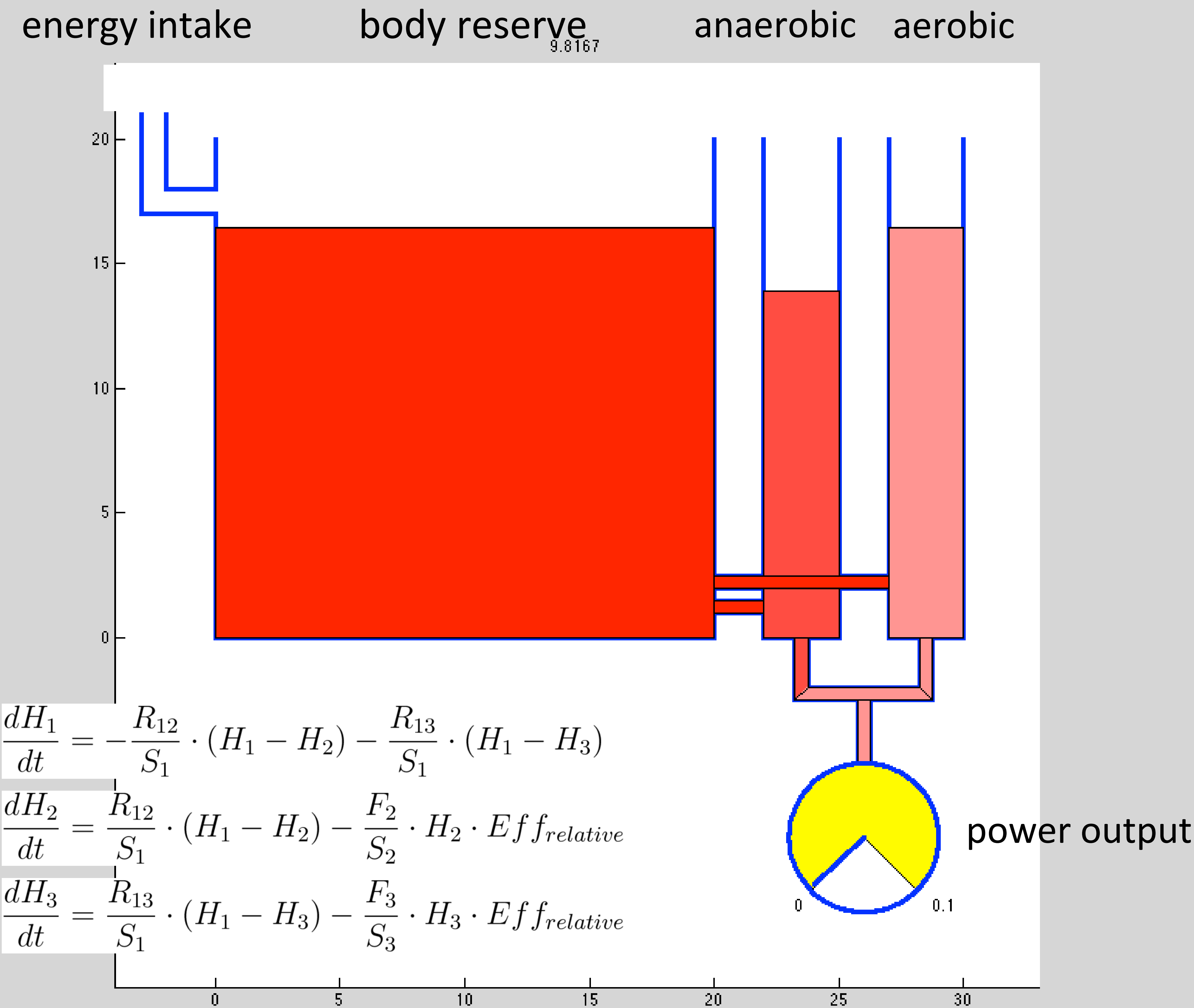


1 km timetrial: power



factors

- **air resistance (CdA)**
- **rolling resistance**
- **mass rider + bike**
- **track (3D)**
- **power delivered**
- **power - rpm function**
- **gear**
- **temperature**
- **air pressure**



$$\frac{dH_1}{dt} = -\frac{R_{12}}{S_1} \cdot (H_1 - H_2) - \frac{R_{13}}{S_1} \cdot (H_1 - H_3)$$

$$\frac{dH_2}{dt} = \frac{R_{12}}{S_1} \cdot (H_1 - H_2) - \frac{F_2}{S_2} \cdot H_2 \cdot Eff_{relative}$$

$$\frac{dH_3}{dt} = \frac{R_{13}}{S_1} \cdot (H_1 - H_3) - \frac{F_3}{S_3} \cdot H_3 \cdot Eff_{relative}$$

Professor had tijd bijna goed

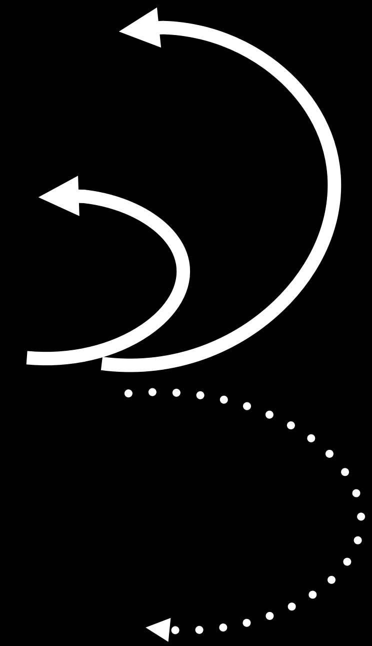
CHORGES • Professor Bert Otten, die als wetenschapper de Belkinploeg helpt met het voorbereiden van tijdritten, had de eindtijd van Bauke Mollema gisteren op een haar na correct voorspeld.

Bij de windkracht- en richting waar Mollema gisteren mee te maken kreeg, rekende de hoogleraar uit dat de renner met een gemiddelde van 35,7 km/u over het traject zou razen. Op Mollema's kilometerteller stond uiteindelijk 35,6 km/u. Door de berekeningen van Otten besloten Mollema en zijn ploegleiders tot een vroege fietswissel. Na de eerste beklimming werd de 'gewone' fiets omgeruild voor een tijdritexemplaar. Mollema: „Dat was een bewuste keuze, daar sta ik helemaal achter. Ik denk dat het me eerder winst dan verlies heeft opgeleverd."

Algemeen Dagblad, 18 juli 2013

factors

- air resistance (CdA)
- rolling resistance
- mass rider + bike
- track (3D)
- power delivered
- power - rpm function
- gear
- temperature
- air pressure

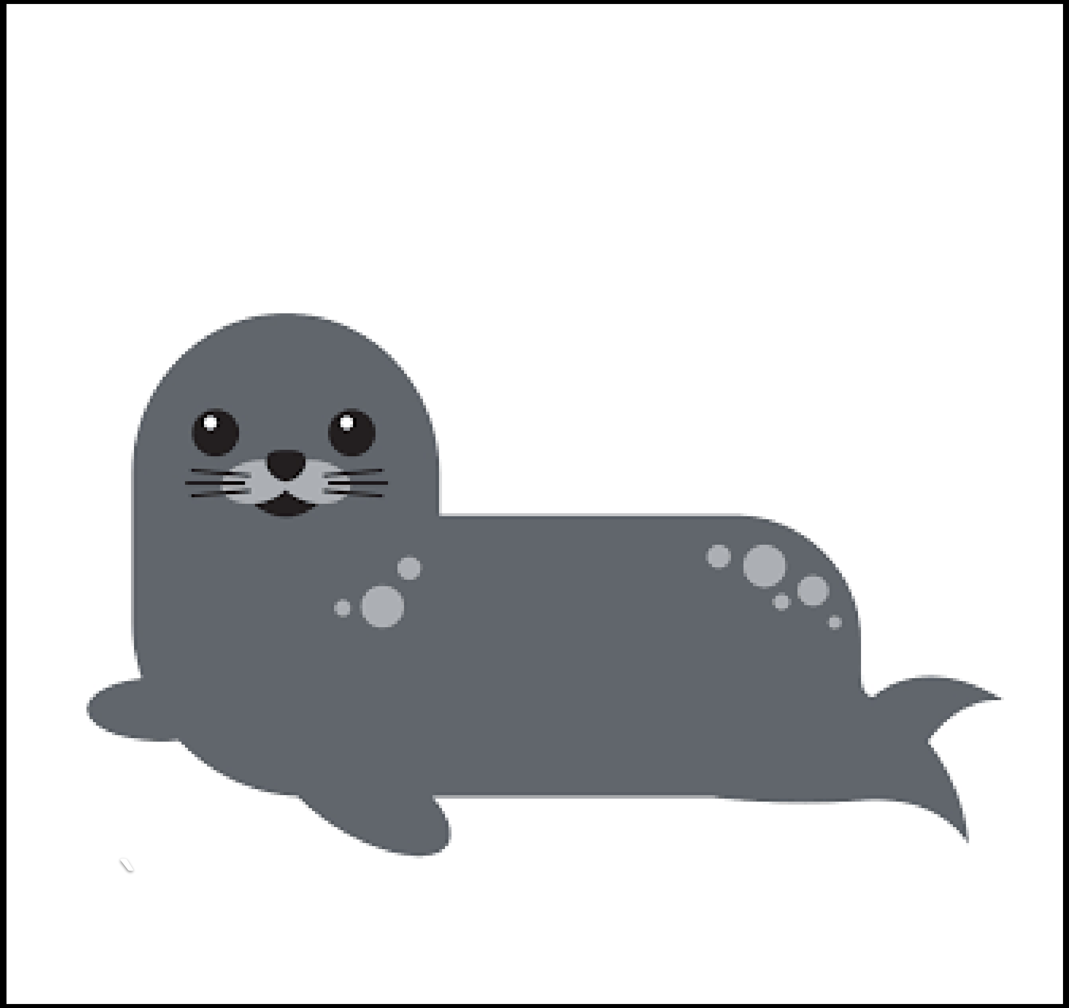


Bassett et al. (Med Sci Sports Exerc 1999; 31:1665-1676)

ntal area (m^2) = 0.0293 x height (m) x mass (kg)^0.425 + 0.0

Mass


TeamNL
speedwear





tsplease
tightspl

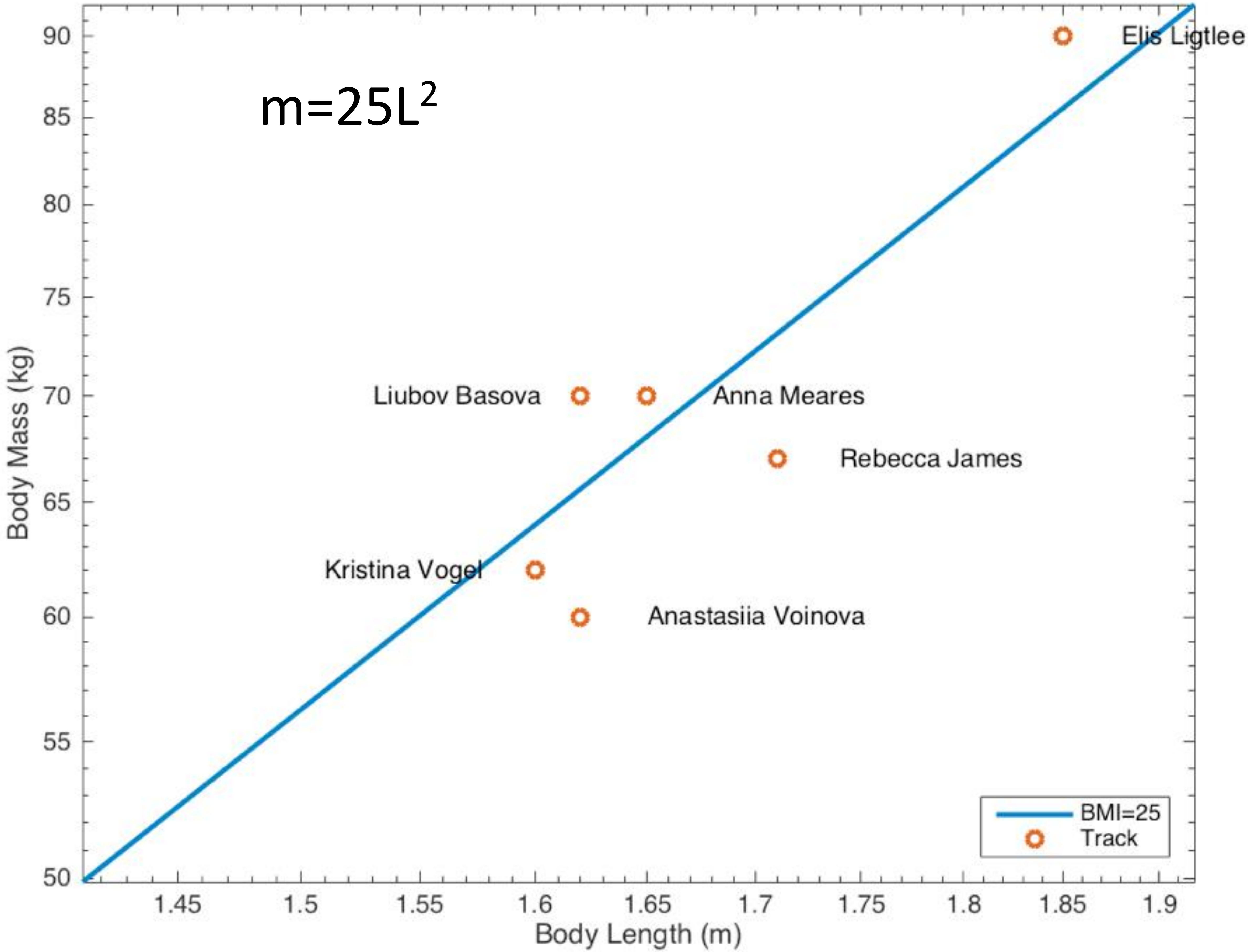

Eur J Appl Physiol (2015) 115:167–176
DOI 10.1007/s00421-014-3002-y

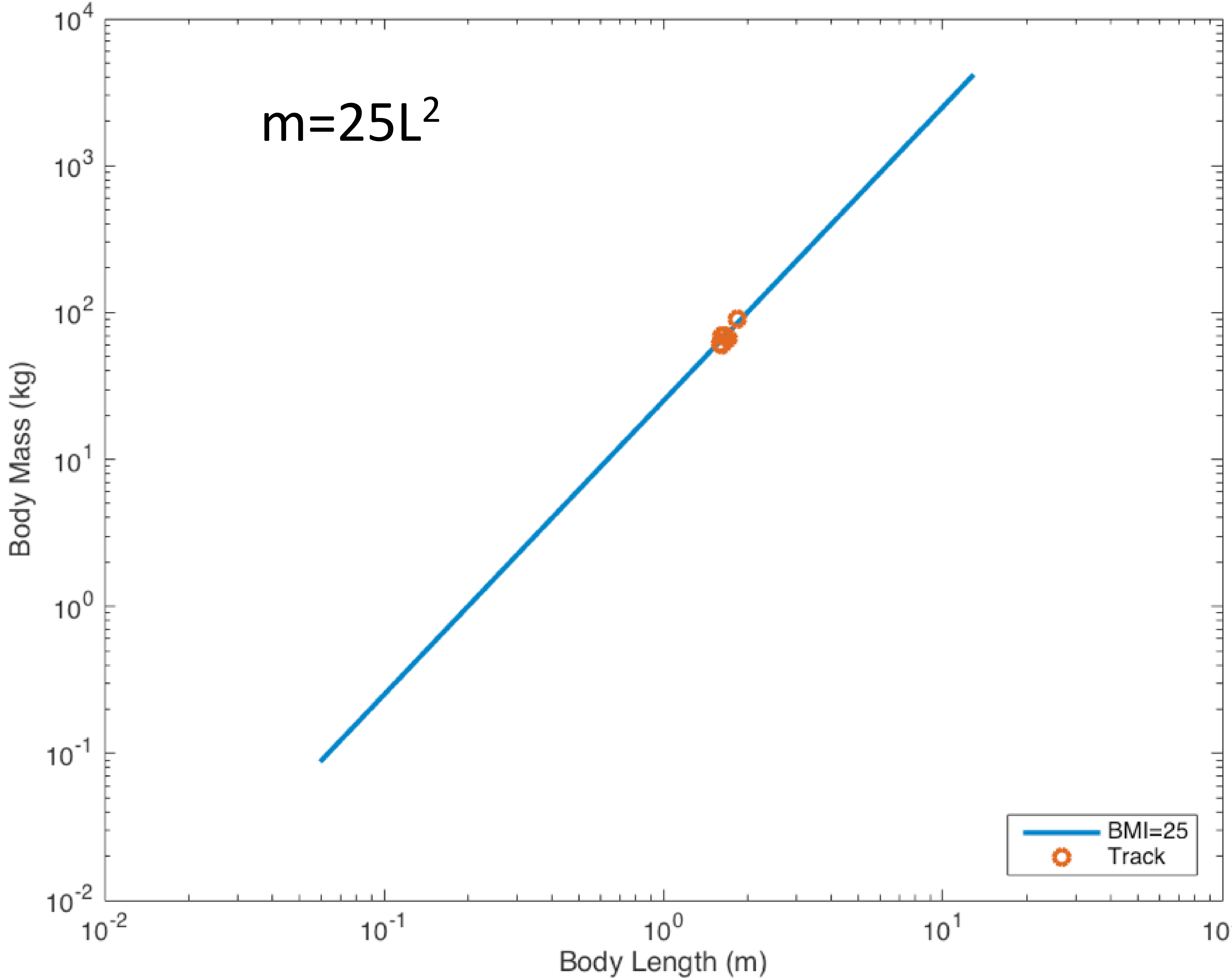
ORIGINAL ARTICLE

Effects of obesity on body temperature in otherwise-healthy females when controlling hydration and heat production during exercise in the heat

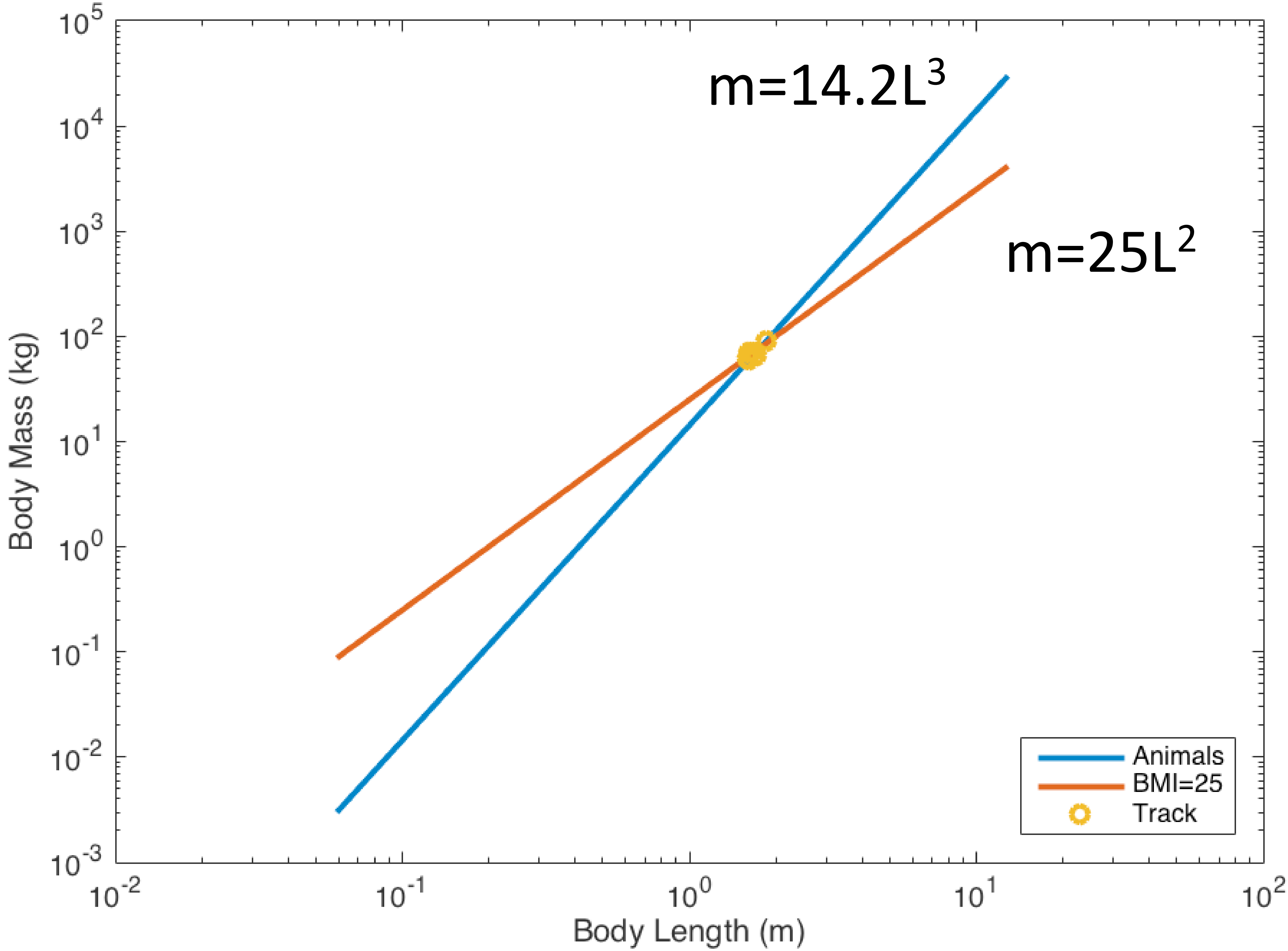
J. D. Adams · Matthew S. Ganio · Jenna M. Burchfield · Andy C. Matthews · Rachel N. Werner · Amanda J. Chokbengboun · Erin K. Dougherty · Alex A. LaChance

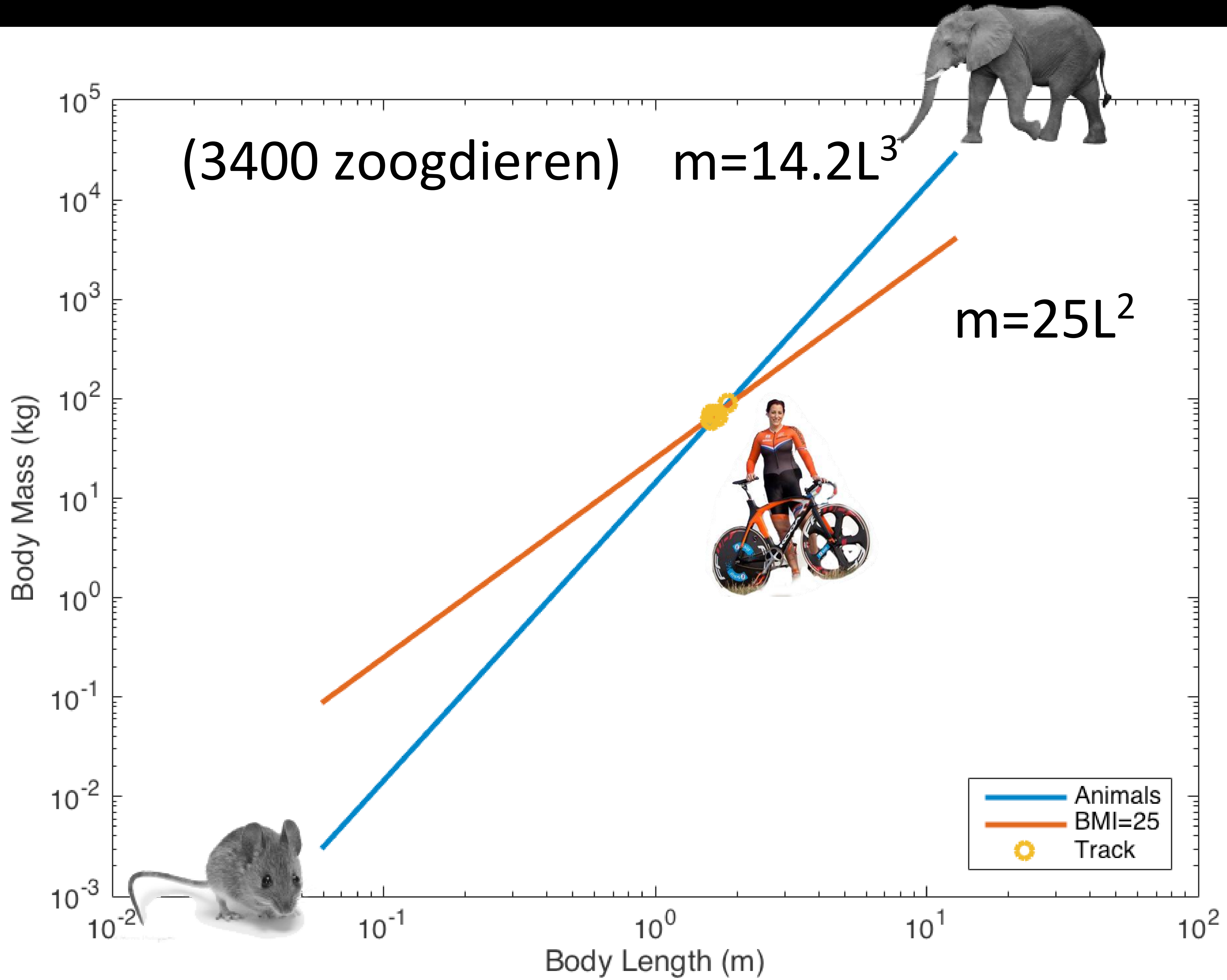
there were no differences in the temperature response between obese and non-obese females exercising in the heat.

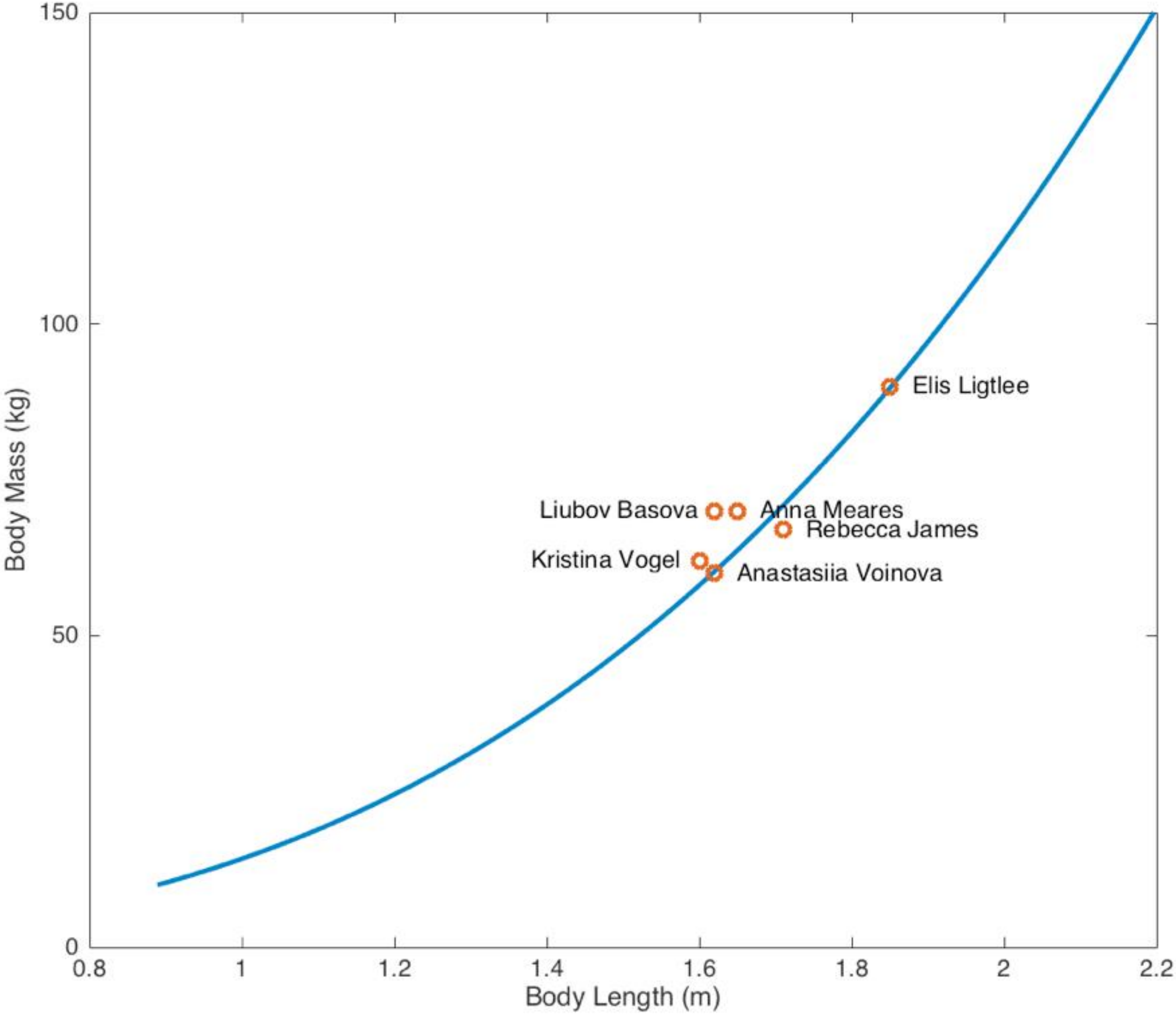

m=25L^2
Elis Ligtlee
Liubov Basova
Anna Meares
Rebecca James
Kristina Vogel
Anastasiia Voinova
BMI=25
Track
Body Mass (kg)
Body Length (m)
90
85
80
75
70
65
60
55
50
1.45
1.5
1.55
1.6
1.65
1.7
1.75
1.8
1.85
1.9



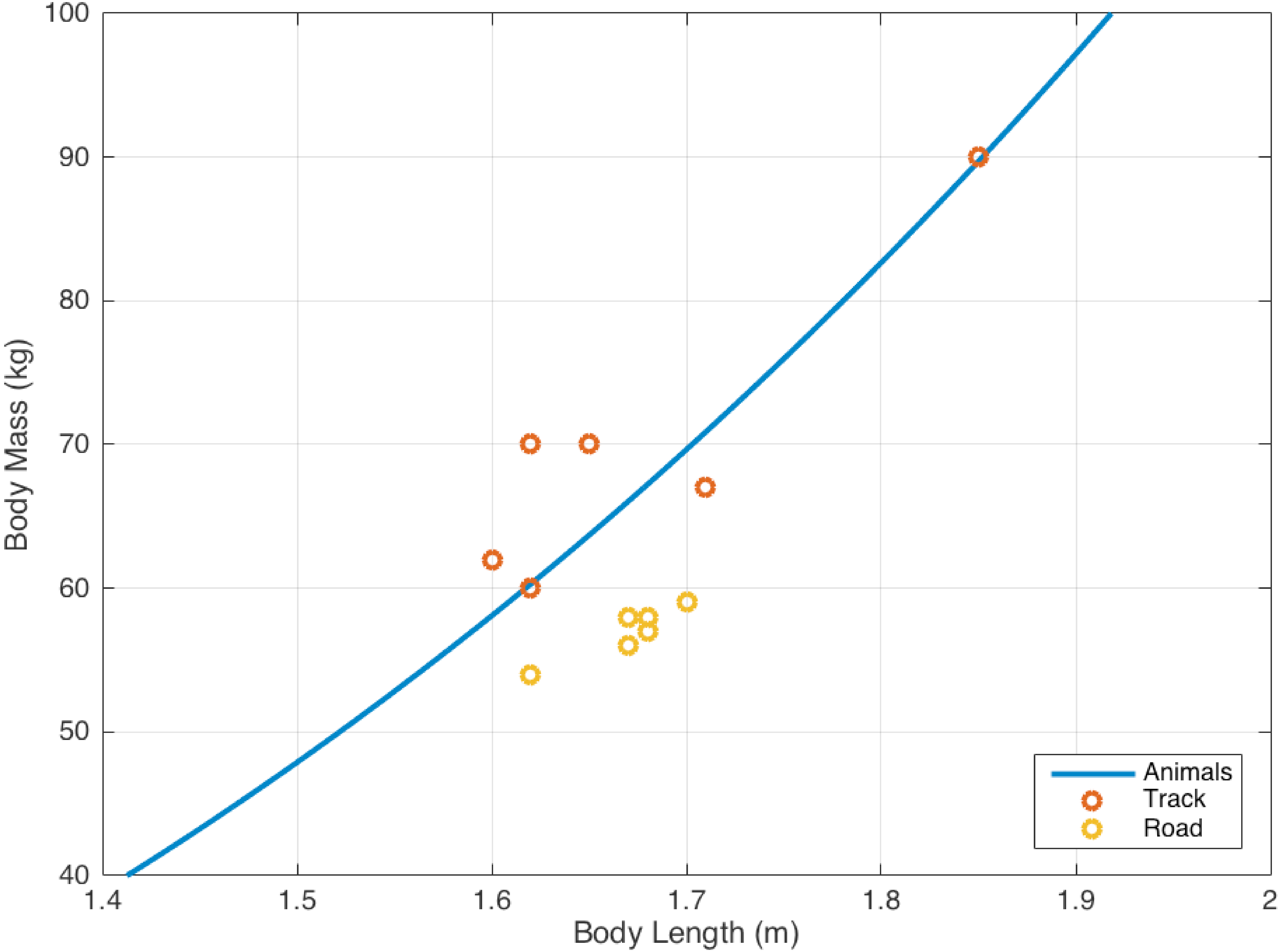
m=25L²
Body Mass (kg)
Body Length (m)
BMI=25
Track


m=14.2L^3
m=25L^2
Body Mass (kg)
Body Length (m)
Animals
BMI=25
Track


(3400 zoogdieren)
m=14.2L3
m=25L2
Body Mass (kg)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-2
10^-1
10^0
10^1
10^2
Body Length (m)
Animals
BMI=25
Track



150
100
50
0
0.8
1
1.2
1.4
1.6
1.8
2
2.2
Body Mass (kg)
Body Length (m)
Elis Ligtlee
Liubov Basova
Anna Meares
Rebecca James
Kristina Vogel
Anastasiia Voinova



Body Mass (kg)
Body Length (m)
Animals
Track
Road
100
90
80
70
60
50
40
1.4
1.5
1.6
1.7
1.8
1.9
2

250 m with start 50 km/h
1.85 m 90 kg P=1400 W CdA=0.35

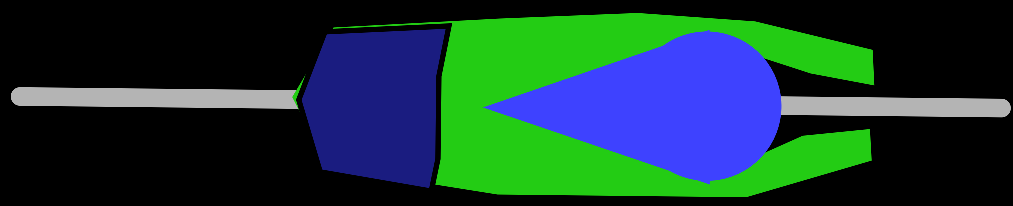
mass (kg)	CdA	power (W)	difference at finish
87 kg	0.346	1400	1.21 m
87 kg	0.346	1384	0.50 m

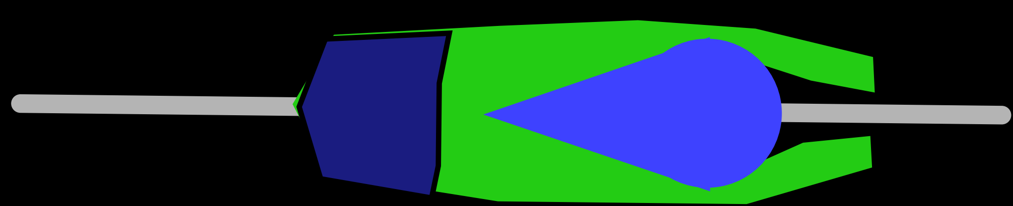
250 m with start 64 km/h

1.85 m 90 kg P=1400 W CdA=0.35

mass (kg)	CdA	power (W)	difference at finish
87 kg	0.346	1400	0.63 m
87 kg	0.346	1384	0.11 m

Air Resistance






2 x velocity

2 x more collisions per second

2 x more impulse per collision

4 x more air resistance

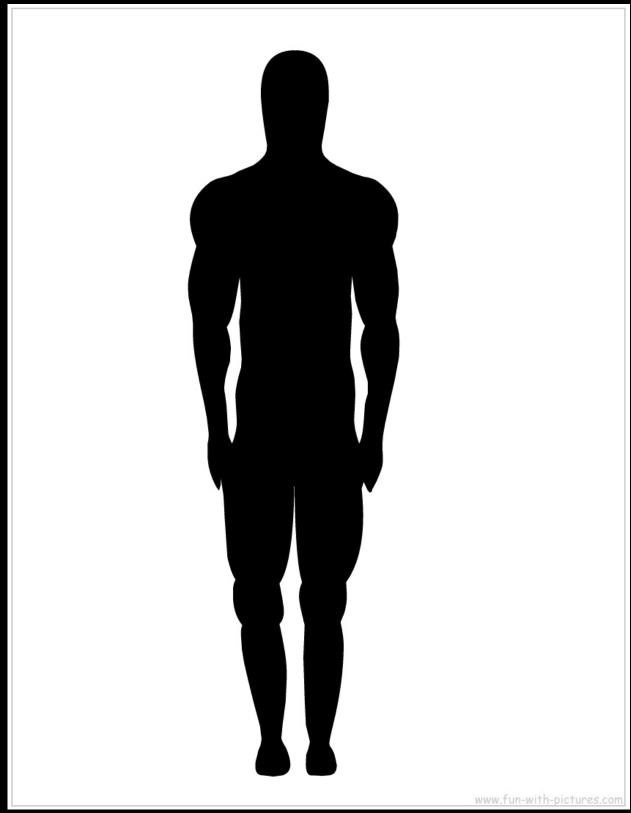
8 x more power needed = force x velocity

2x as tall

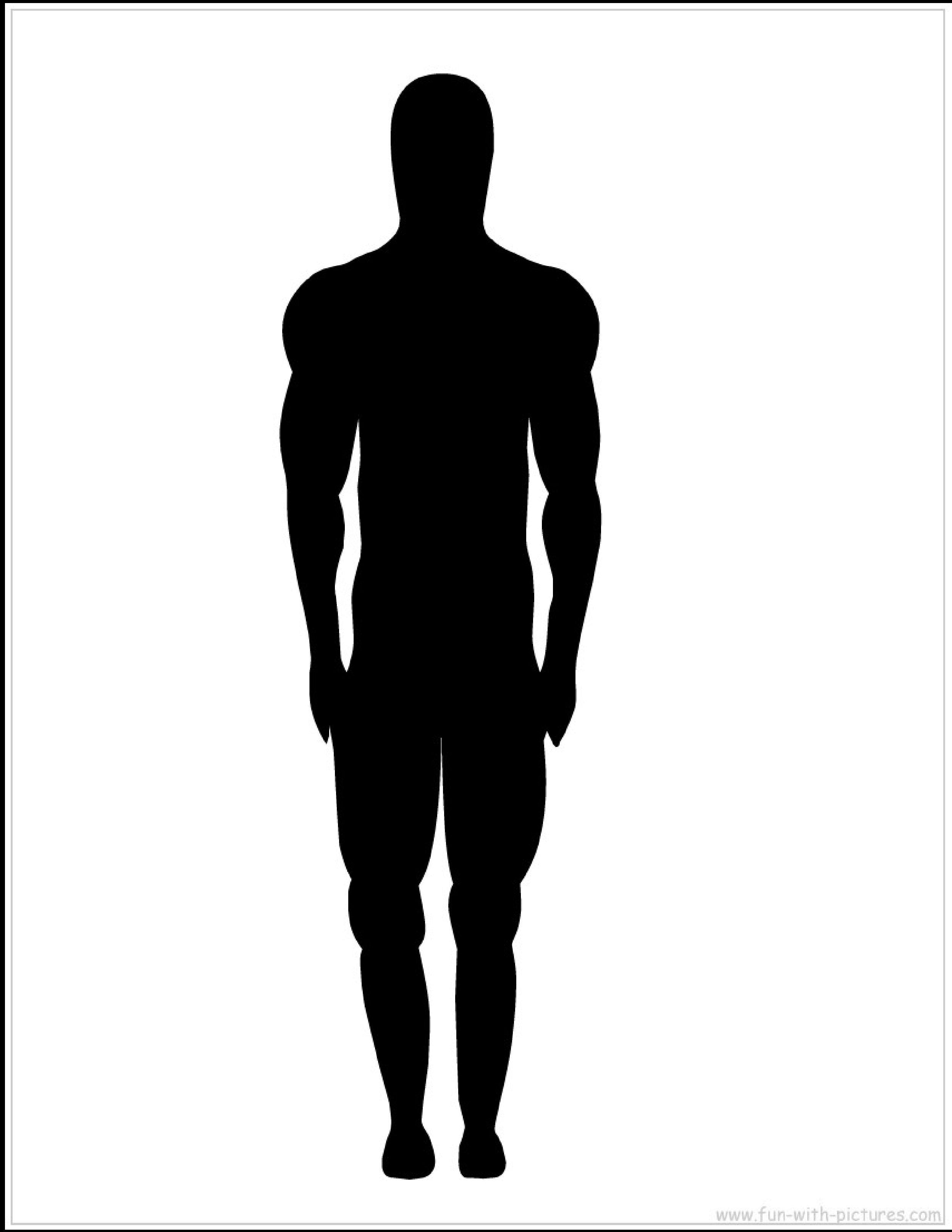
4x as strong

8x mass

8x power



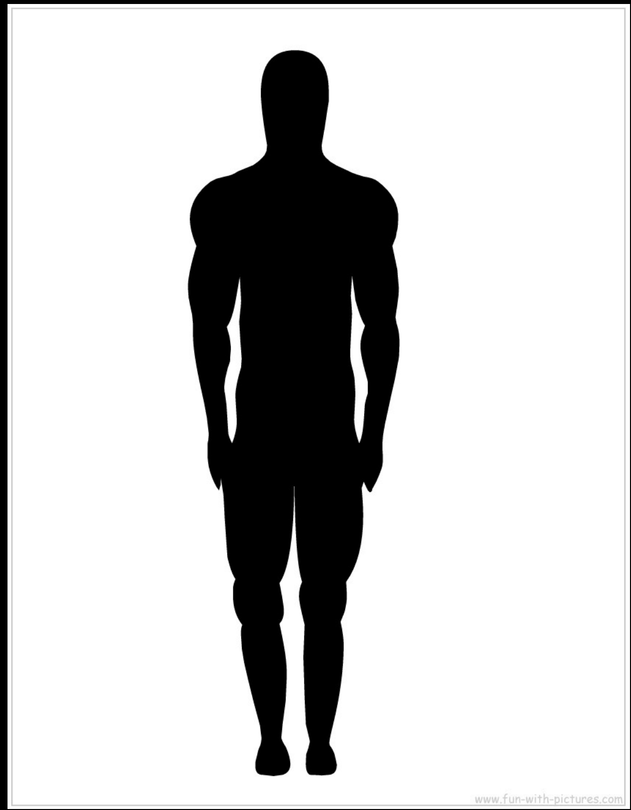
available



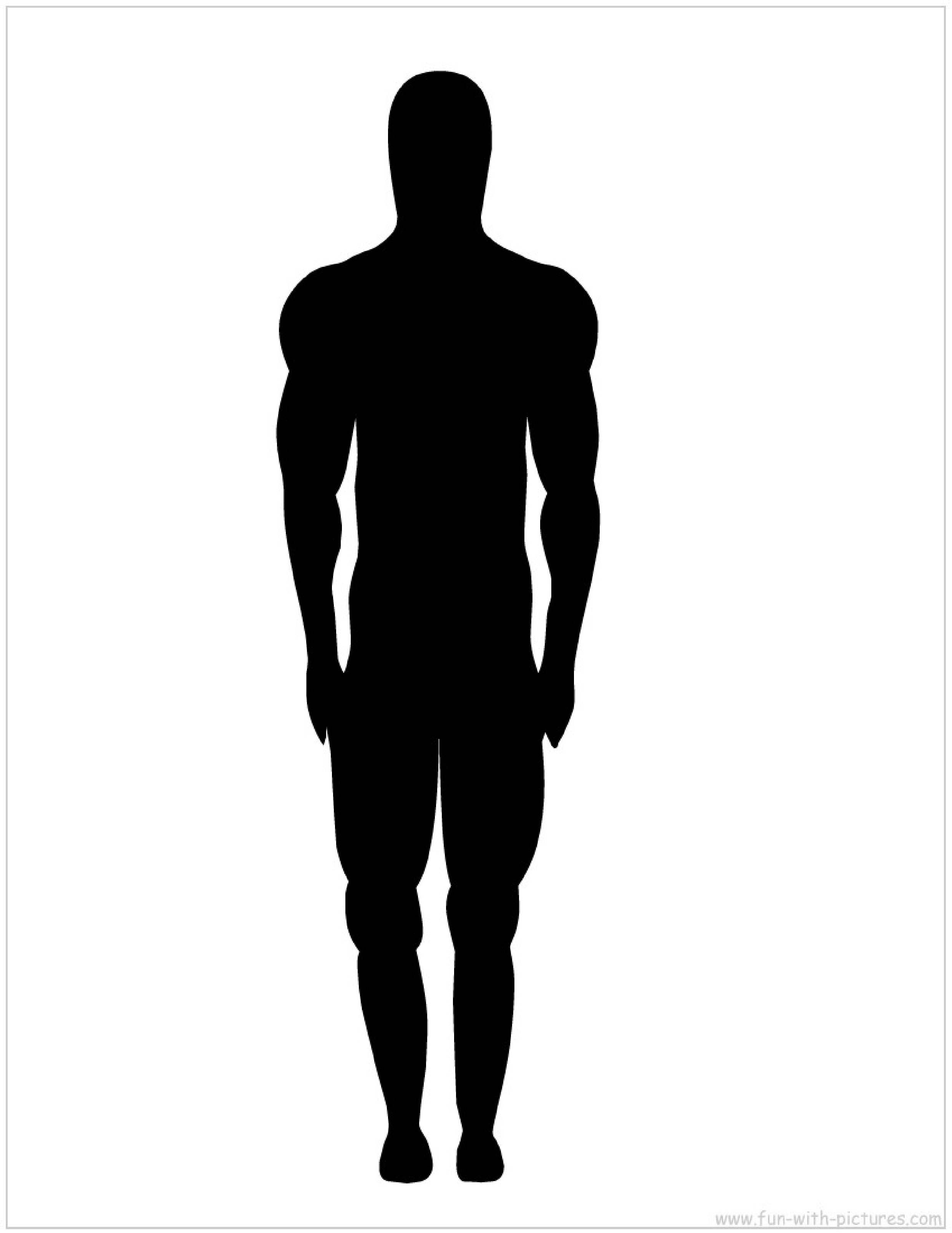
2x as tall

4x air resistance

8x power

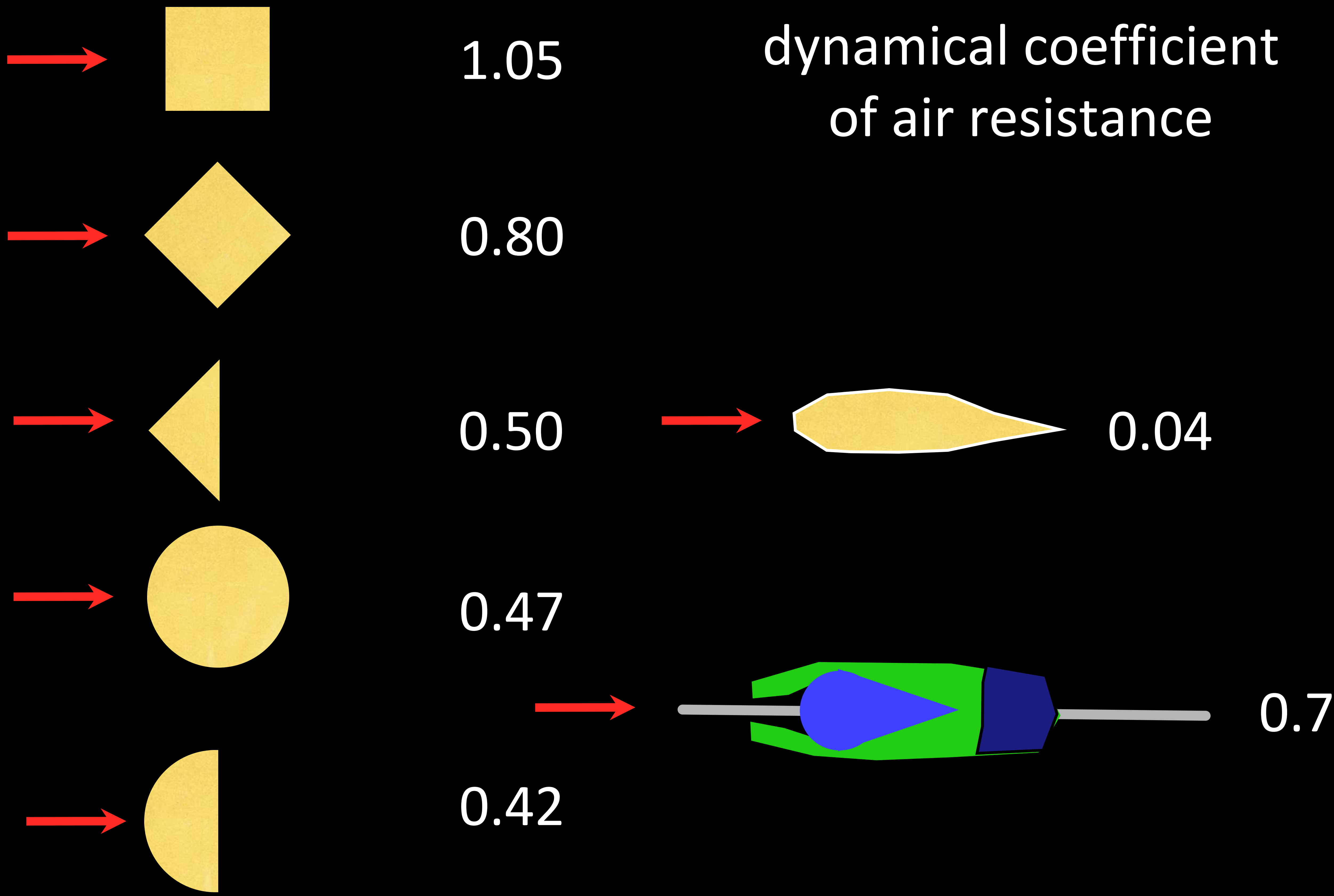


needed

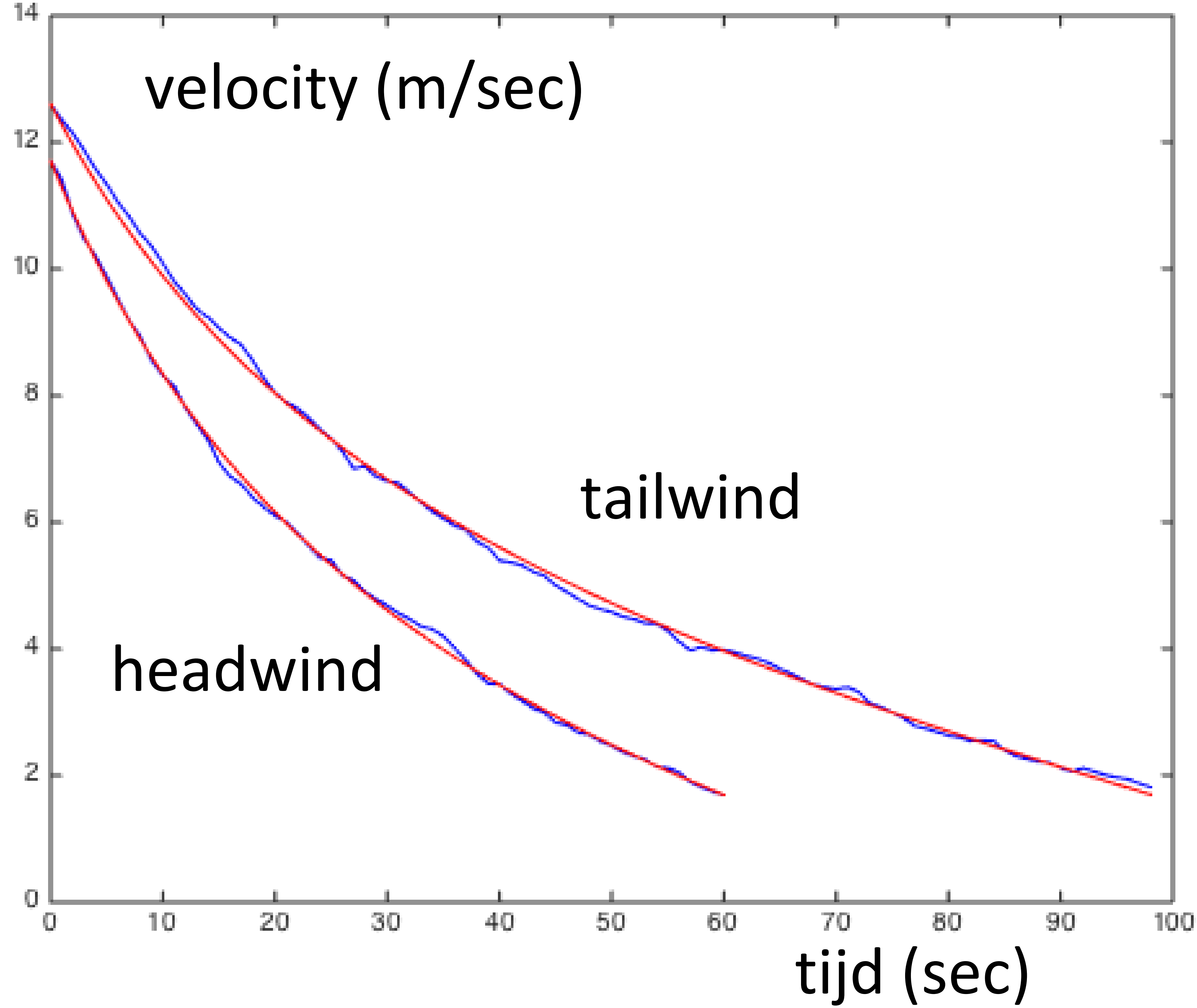


Jean Robic (1.61 m)

Johan Vansummeren (1.97 m)


dynamical coefficient
of air resistance
1.05
0.80
0.50
0.47
0.42
0.04
0.7

Graeme Obree

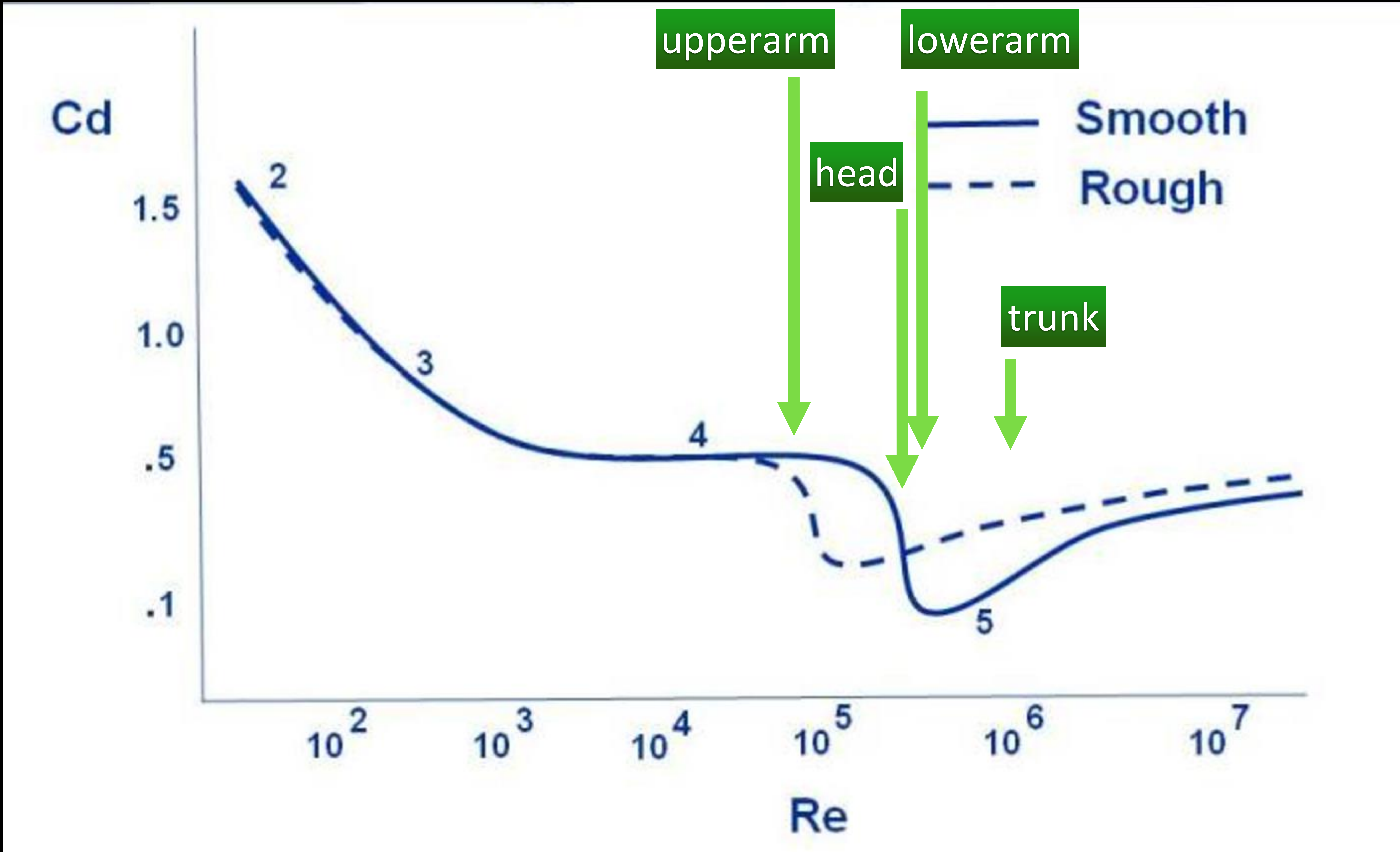


velocity (m/sec)
tailwind
headwind
tijd (sec)
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60
70
80
90
100

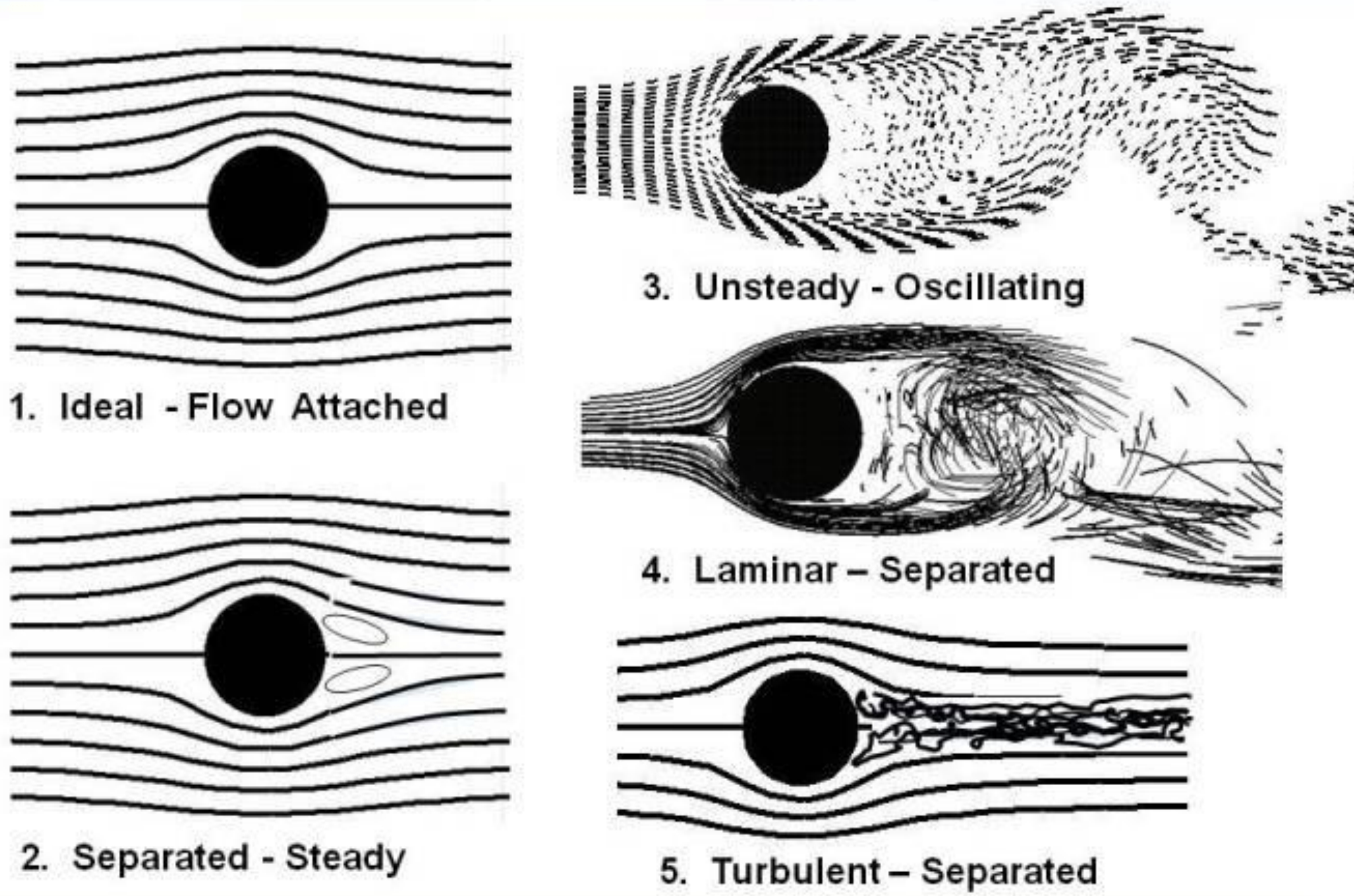
Reynolds Number

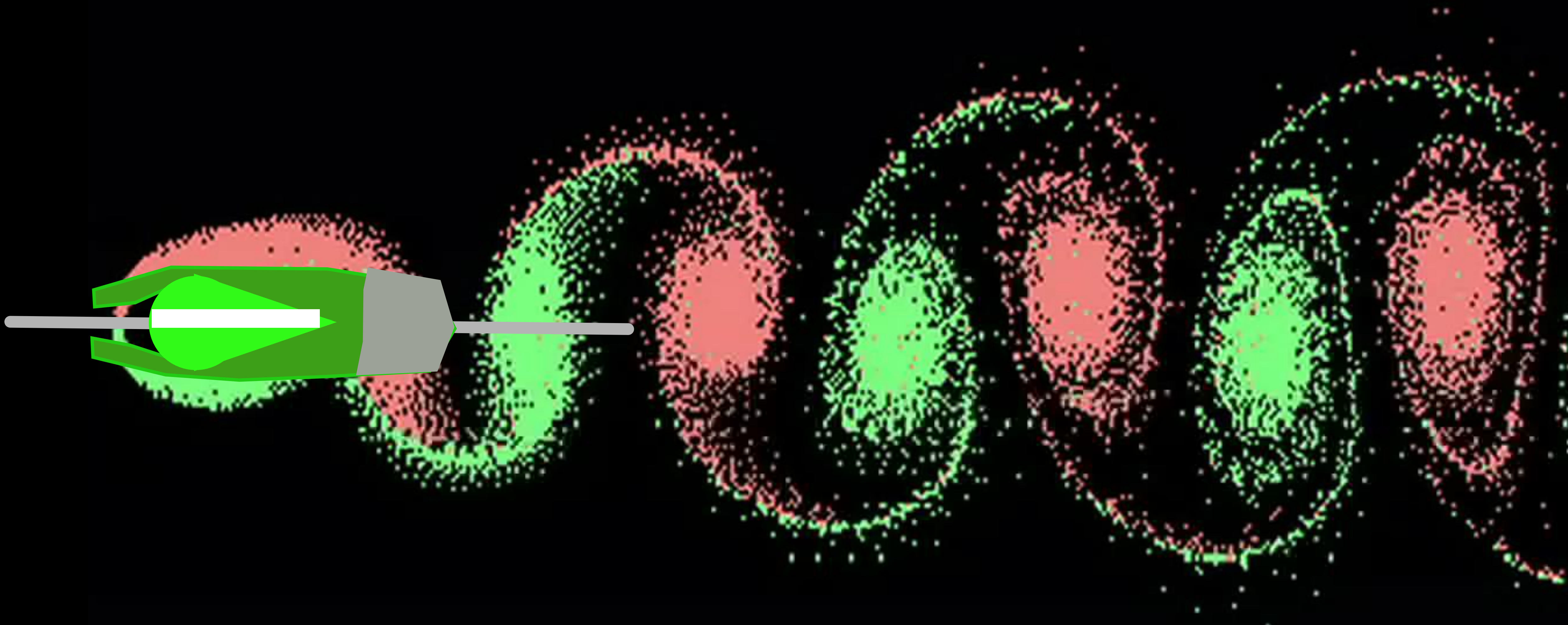
- Re = V * rho * l / mu
- V: velocity
- rho: air density
- l: length of the object
- mu: viscosity of the medium

reynolds numbers at 60 km/h



Flow Past a Cylinder





$$\rho\left(\frac{\partial u_i}{\partial t}+u_j\frac{\partial u_i}{\partial x_j}\right)=-\frac{\partial p}{\partial x_i}+\frac{\partial T_{ij}}{\partial x_i}$$

$$\frac{\partial \rho}{\partial t}+u_j\frac{\partial \rho}{\partial x_i}+\rho\frac{\partial u_j}{\partial x_j}=0$$

Navier Stokes Equations and Continuity Equation

$$\rho\left(\frac{\partial u_i}{\partial t}+u_j\frac{\partial u_i}{\partial x_j}\right)=-\frac{\partial p}{\partial x_i}+\frac{\partial T_{ij}}{\partial x_i}$$

$$\frac{\partial \rho}{\partial t}+u_j\frac{\partial \rho}{\partial x_i}+\rho\frac{\partial u_j}{\partial x_j}=0$$

density acceleration pressure viscosity

Navier Stokes Equation and Continuity Equation

For OS X or Linux

Open Source

CFD modelling is computer simulation of air or fluid movements using Computational Fluid Dynamics (CFD)


sky
sky
adidas
adidas


poc


2016


Rabobank


KOGA
Rabobank
KOGA
Rabobank

Elis Ligtlee
in her
BMX time

!

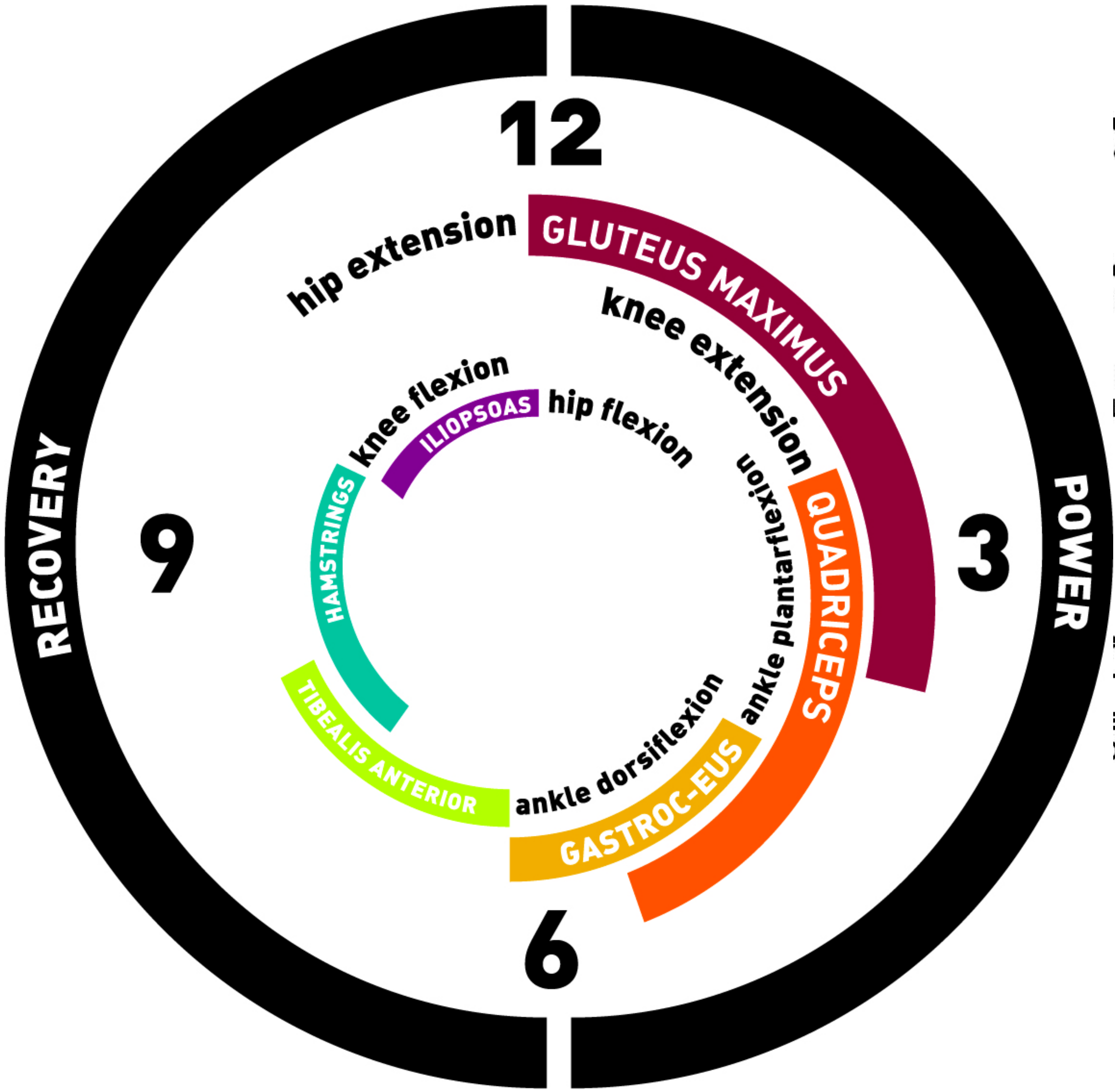
250 m with start 50 km/h
1.85 m 90 kg P=1400 W CdA=0.35

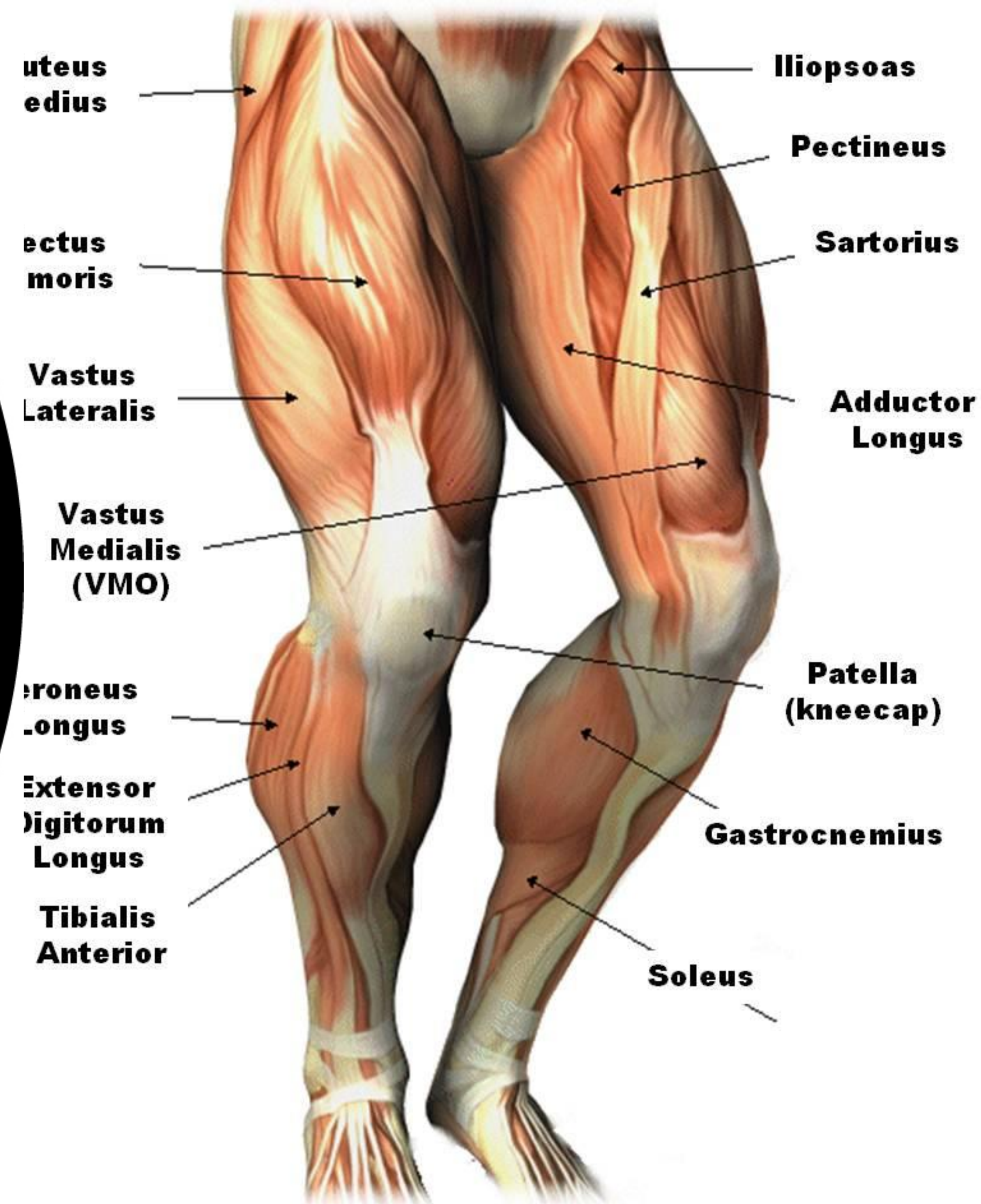
CdA(m^2)	power (W)	difference at finish
0.336	1400	1.60 m

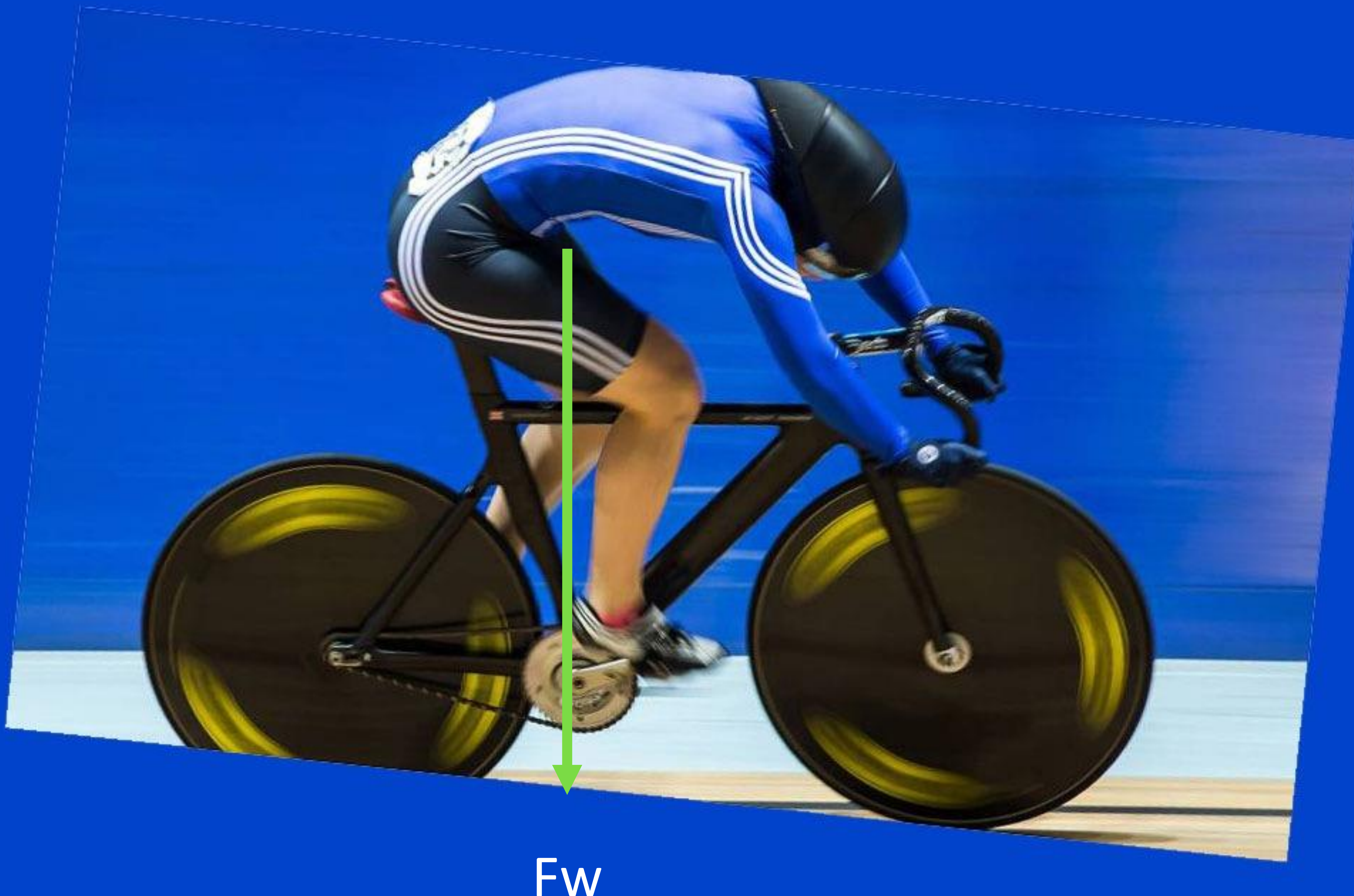
Sprint for Brons against Katy Marchant
difference: 1.58 m

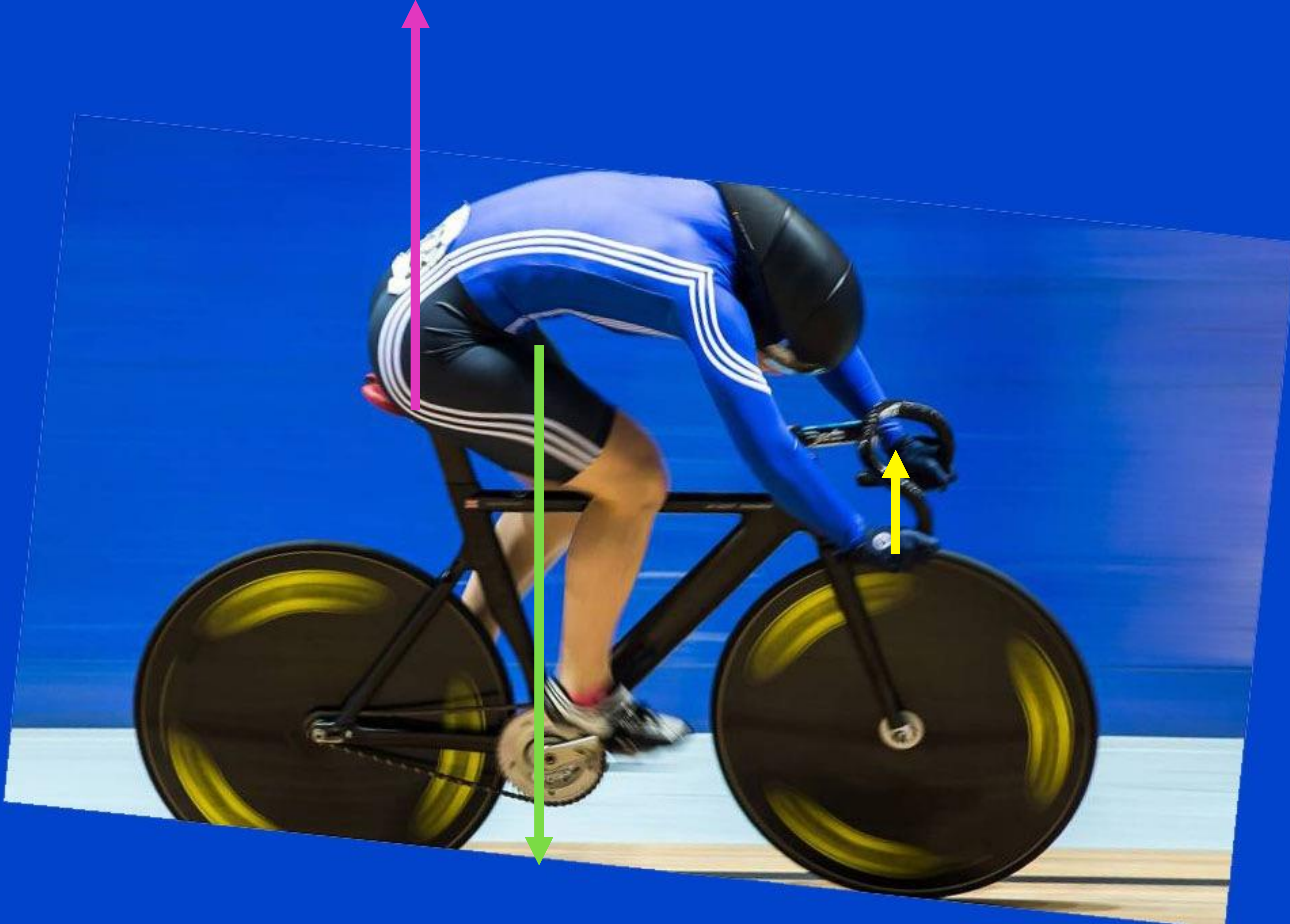

uci
RACER
RACER
sport

equiv SPEED
50 KM/H

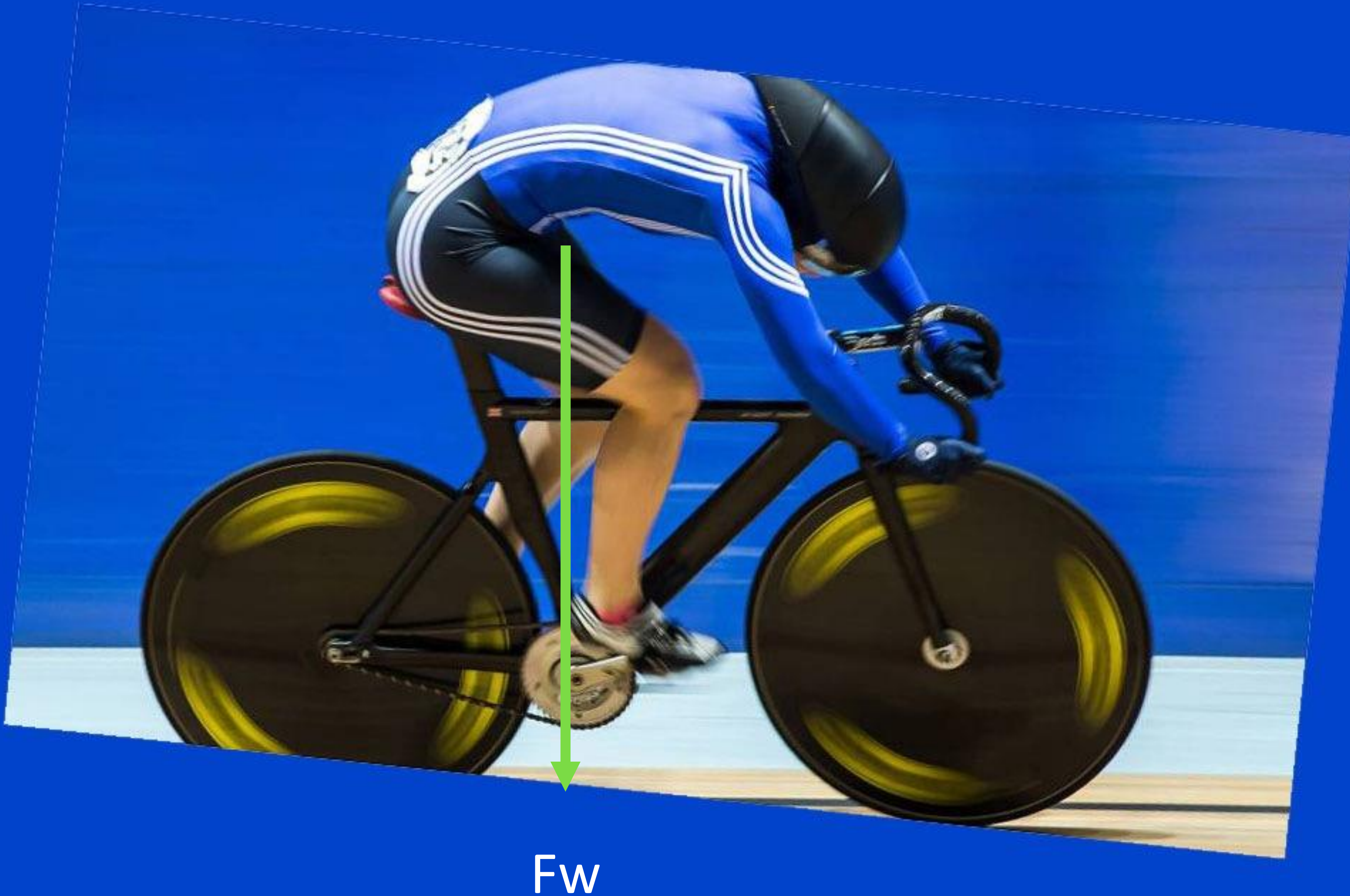

12
3
6
9
RECOVERY
POWER
hip extension
GLUTEUS MAXIMUS
knee extension
QUADRICEPS
ankle plantarflexion
GASTROC-EUS
ankle dorsiflexion
TIBEALIS ANTERIOR
HAMSTRINGS
knee flexion
ILIOPSOAS
hip flexion

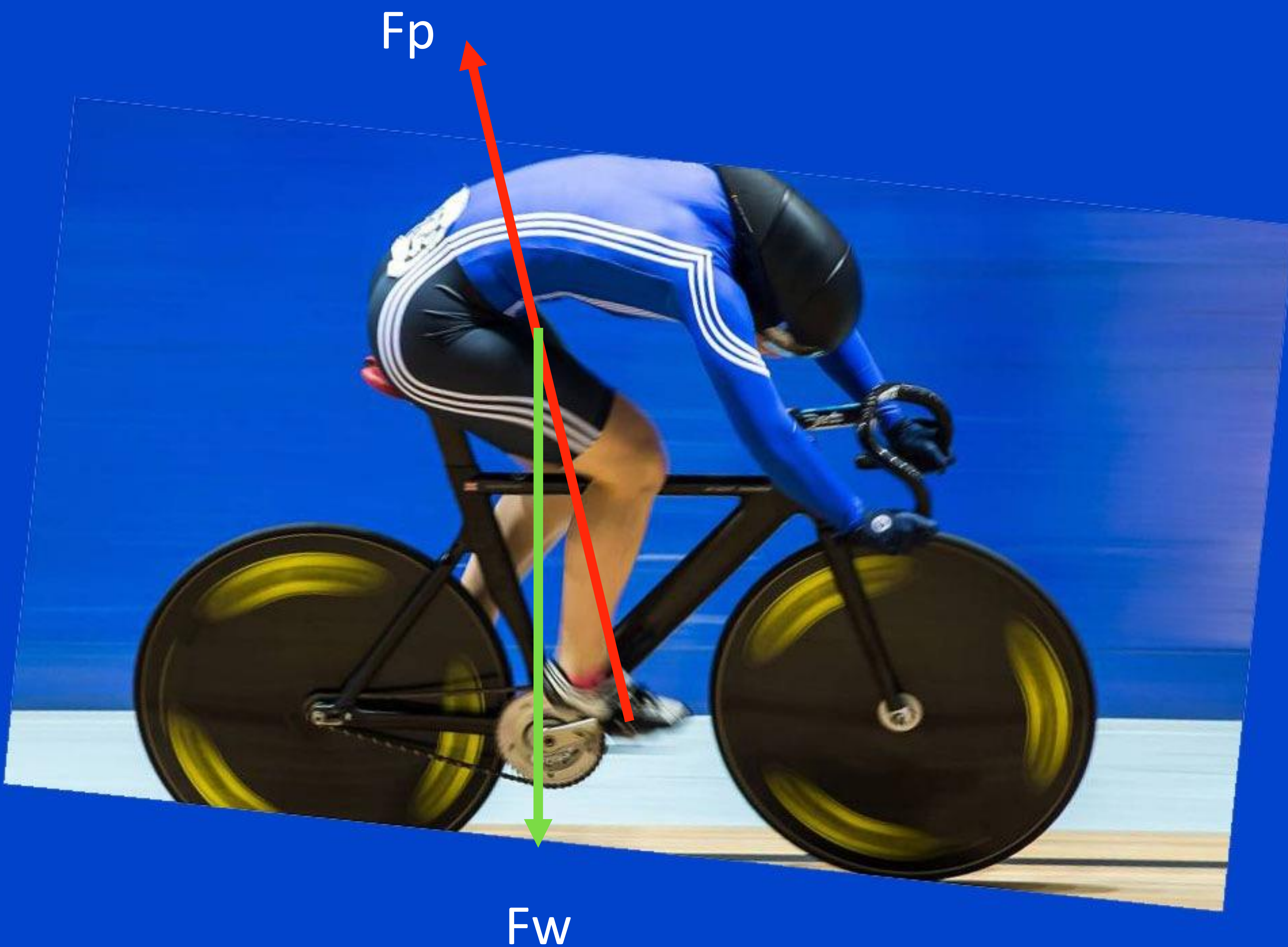

uteus
edius
ectus
moris
Vastus
Lateralis
Vastus
Medialis
(VMO)
eroneus
Longus
Extensor
Digitorum
Longus
Tibialis
Anterior
Iliopsoas
Pectineus
Sartorius
Adductor
Longus
Patella
(kneecap)
Gastrocnemius
Soleus

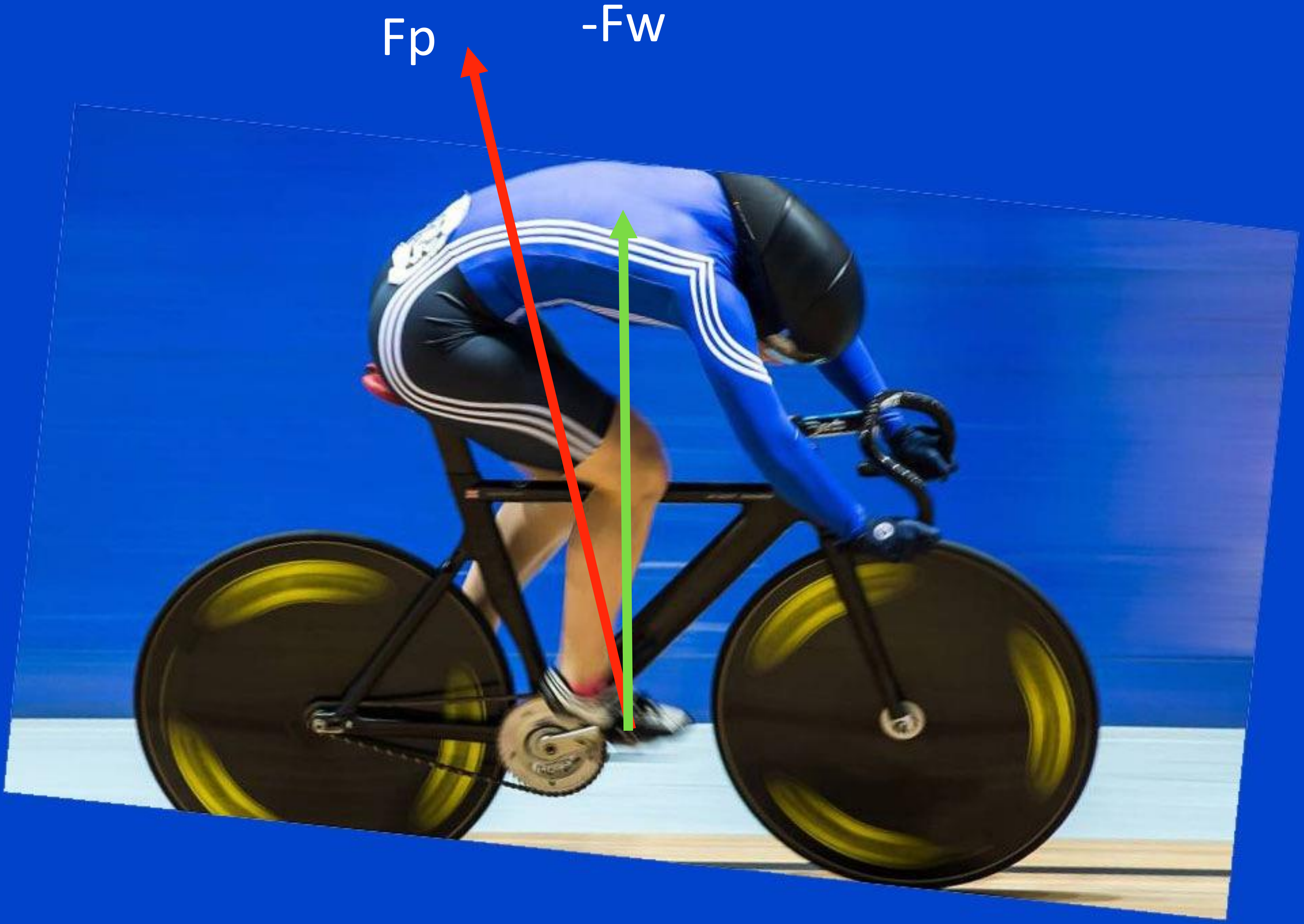

Fw

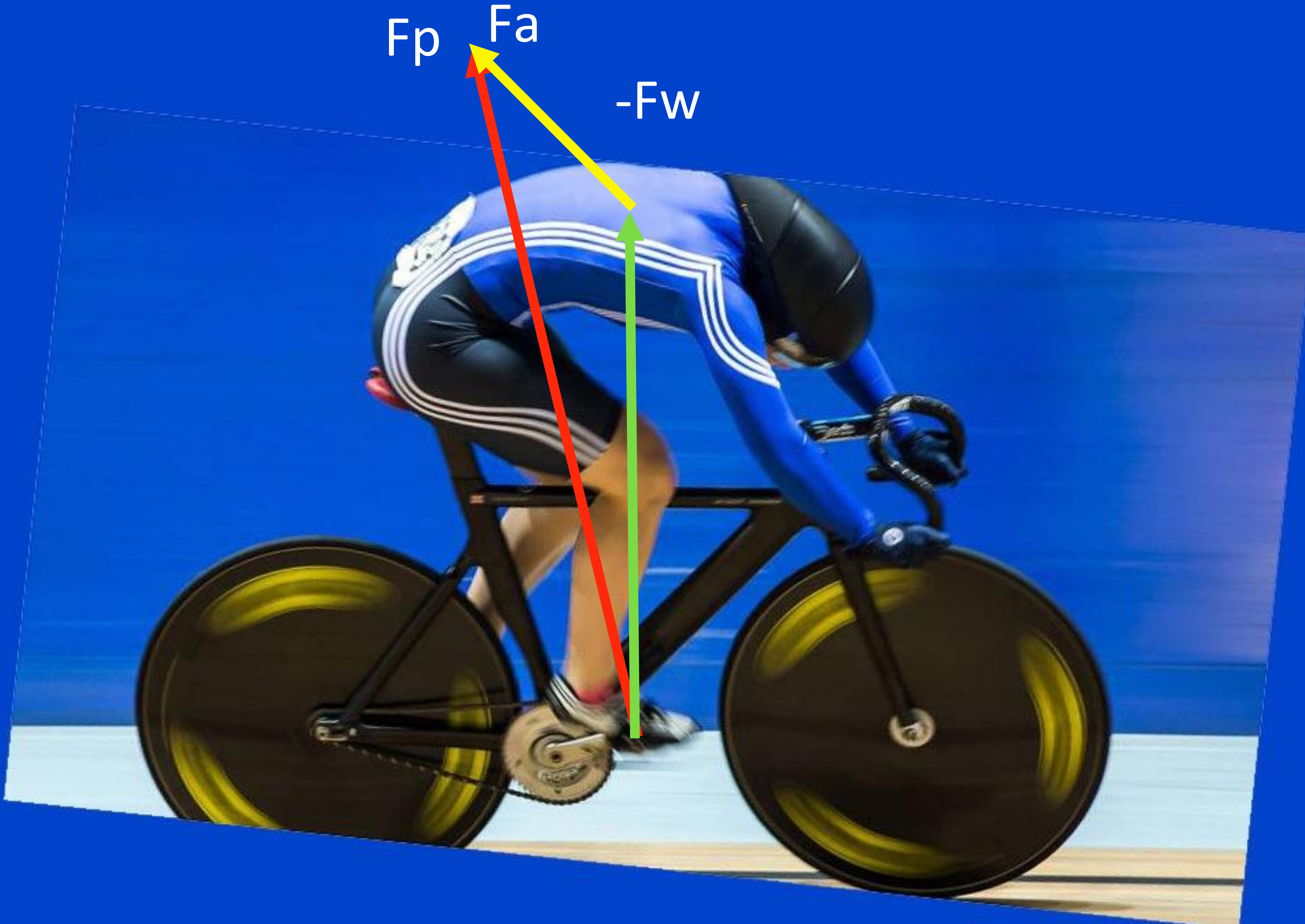


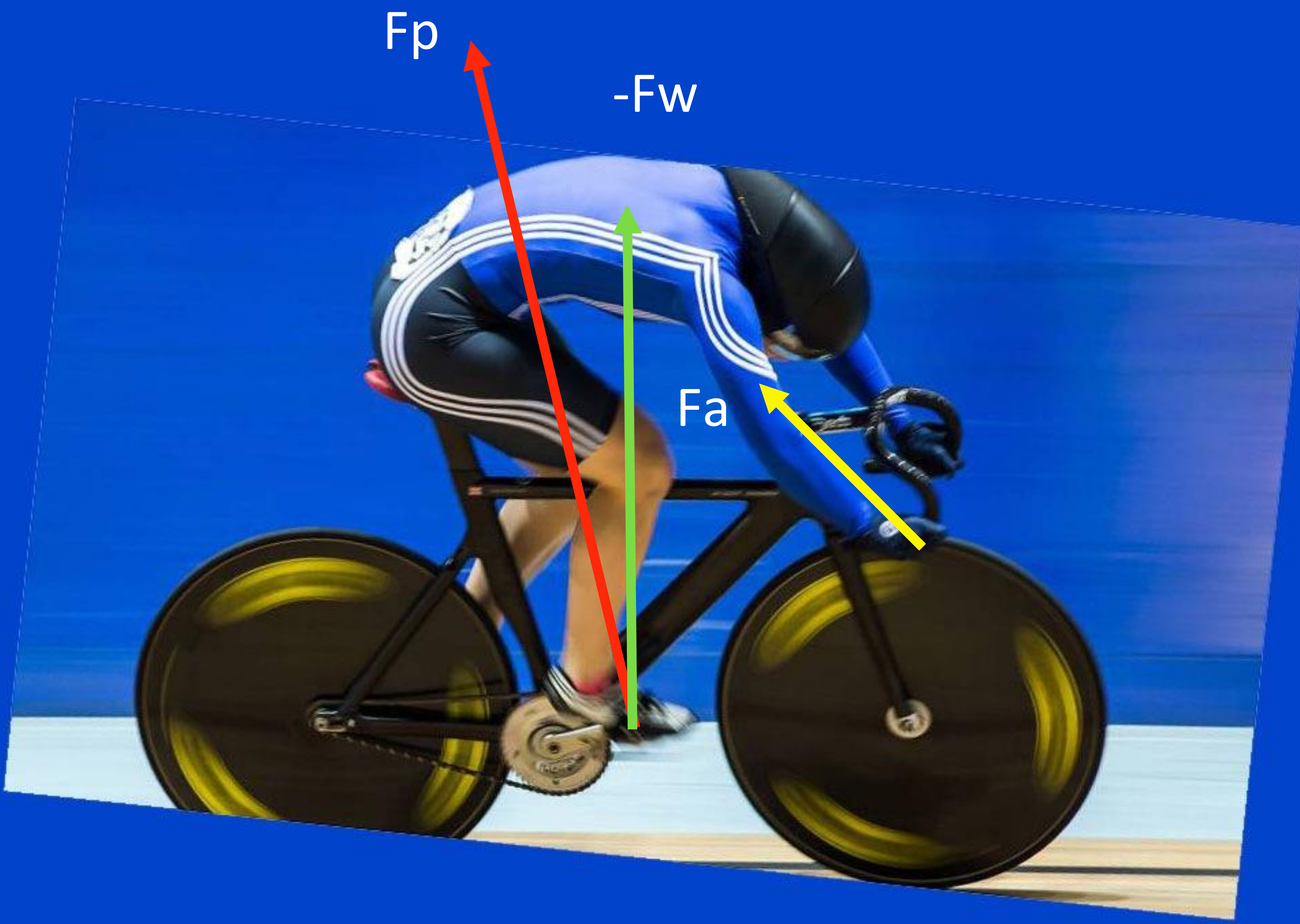
Fw


Fw


Fp
Fw


Fp
-Fw

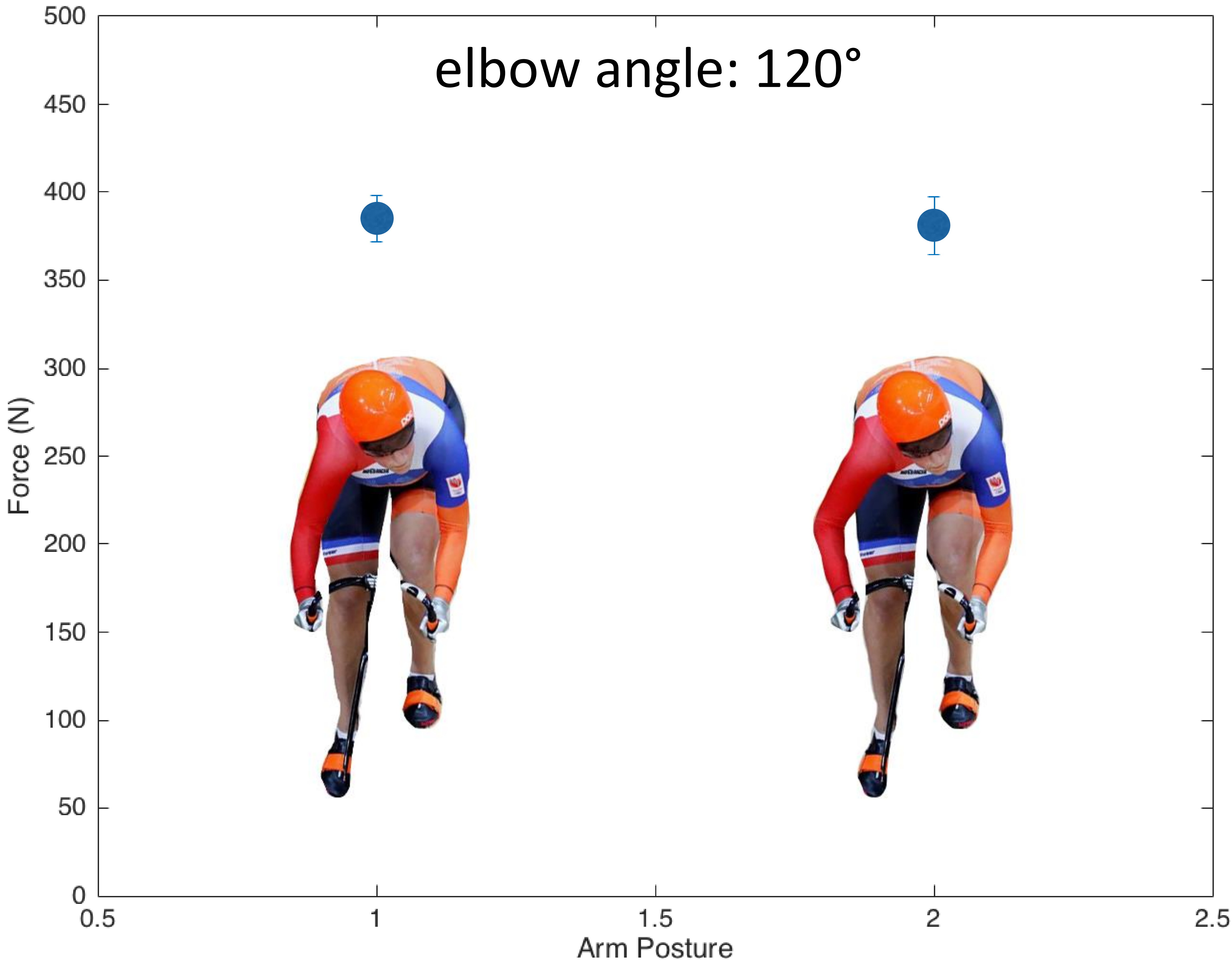

Fp
Fa
-Fw


Fp
-Fw
Fa

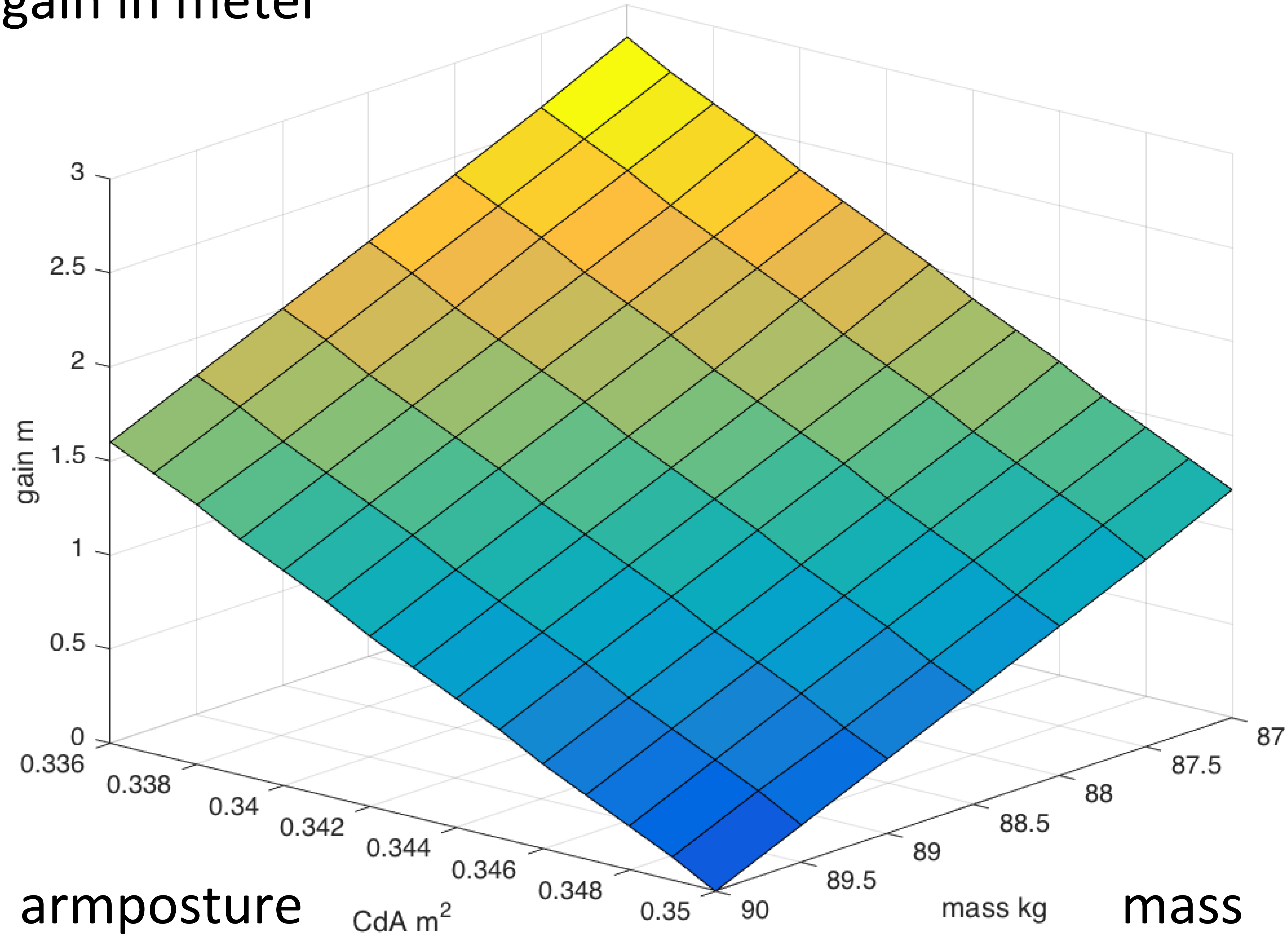
Fa 310 N

1.80 m
88 kg

Ergofet, max 1300 N


elbow angle: 120°
Force (N)
Arm Posture
500
450
400
350
300
250
200
150
100
50
0
0.5
1
1.5
2
2.5

gain in meter



armposture

mass


TeamNL

Simulating track cycling in an Olympic event

Bert Otten

Human Movement Sciences, UMCG, RuG

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