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The effect of time-trial duration on aerodynamic drag

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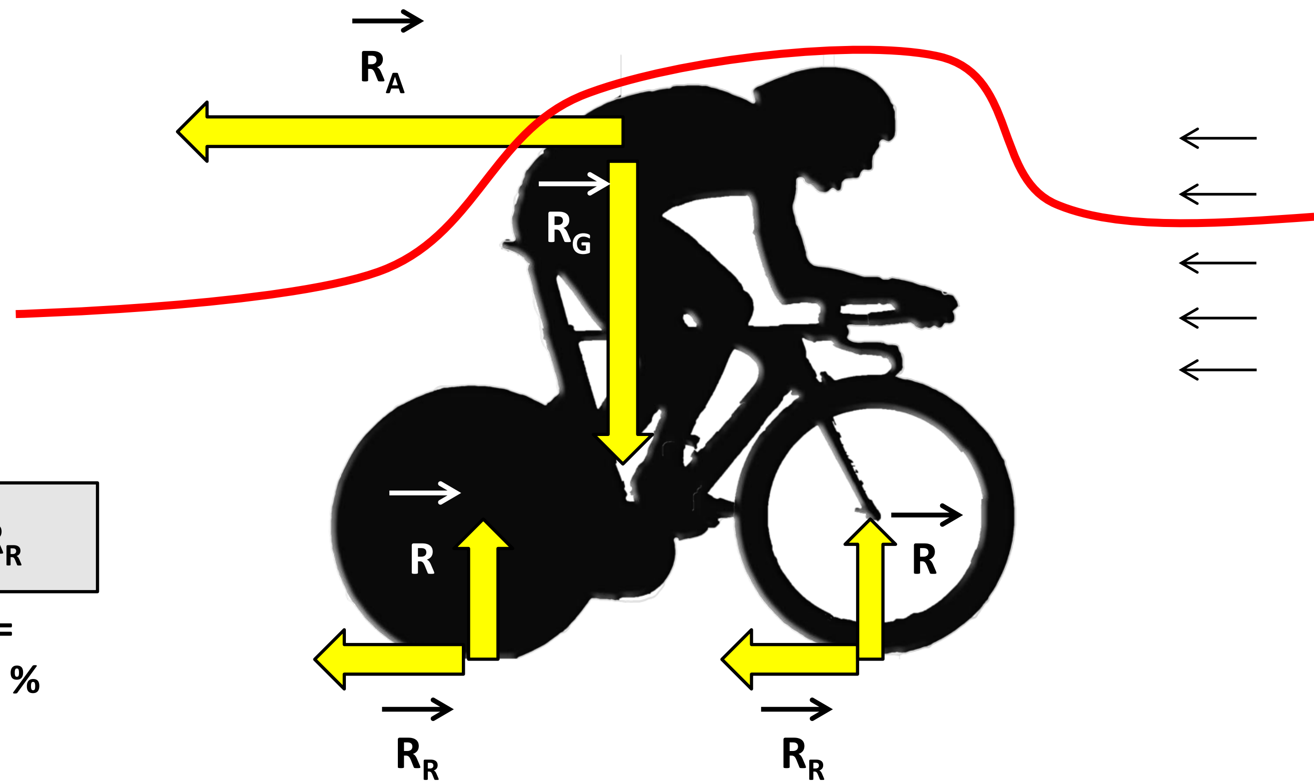
Total resistive forces opposing motion



$$R_T = R_A + R_G + R_R$$

R_A	R_G	R_R
= 90 %	= 0 %	= 10 %

$$R_A = AC_d \times 0.5 \times \rho \times V^2$$

Debraux et al., 2011

ATHLETE = 70 % R_A

R_A

BICYCLE = 30 % R_A

Importance of cycling position

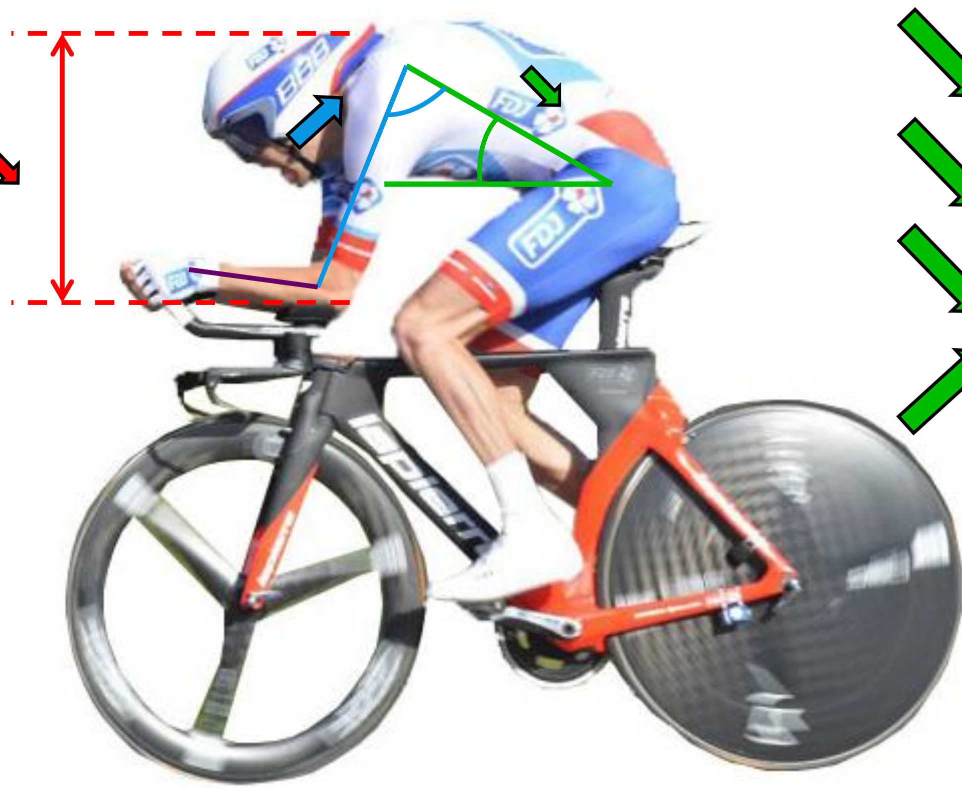
Oggiano et al., 2008

Relationship between body position and AC_d

Underwood et al., 2011

AC_d

PO



Fintelman et al., 2015

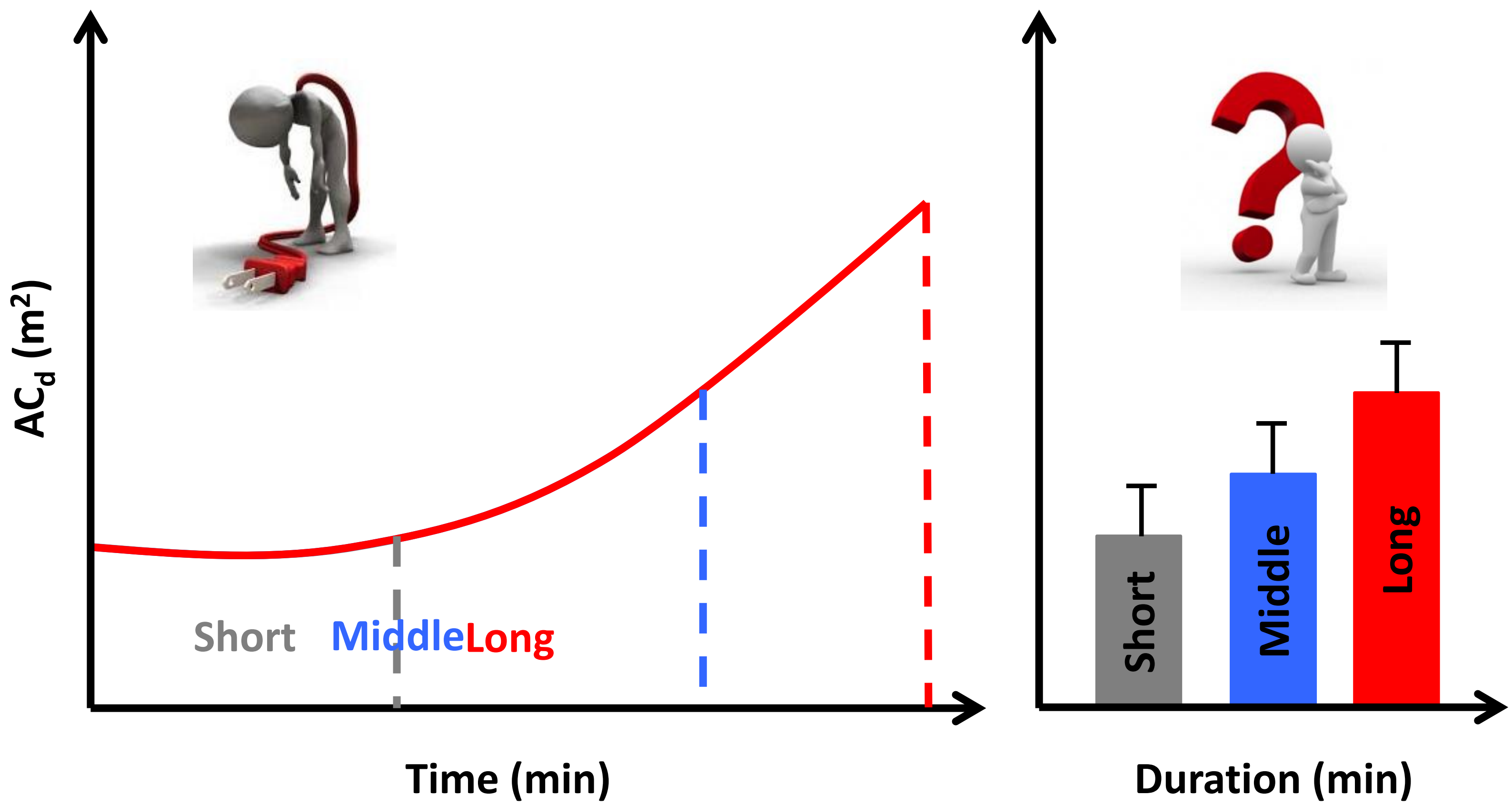
AC_d

PO

Gross efficiency

Physiological variables

Effect of time-trial duration on AC_d

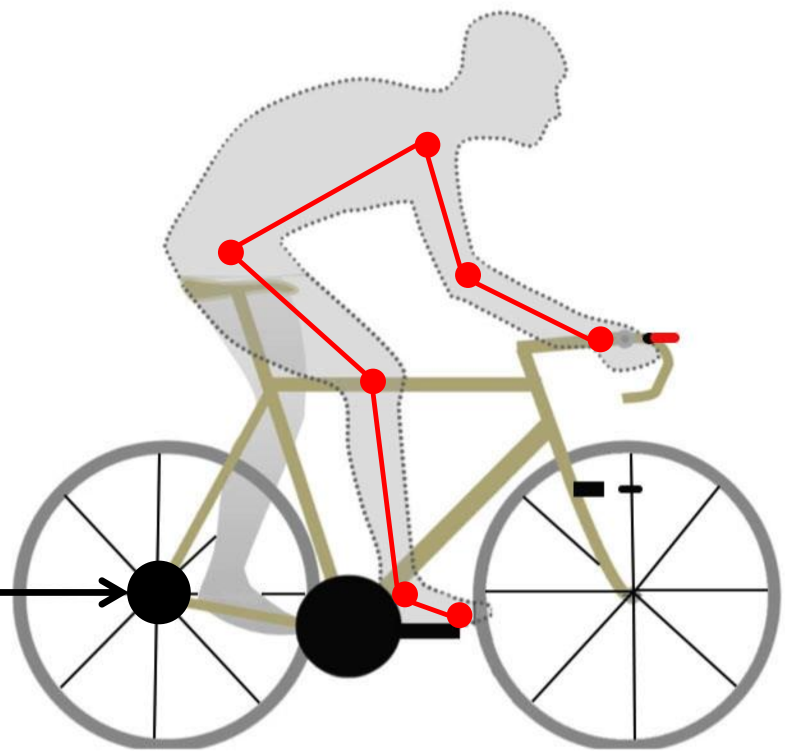


Participants & materials

9 elite road cyclists

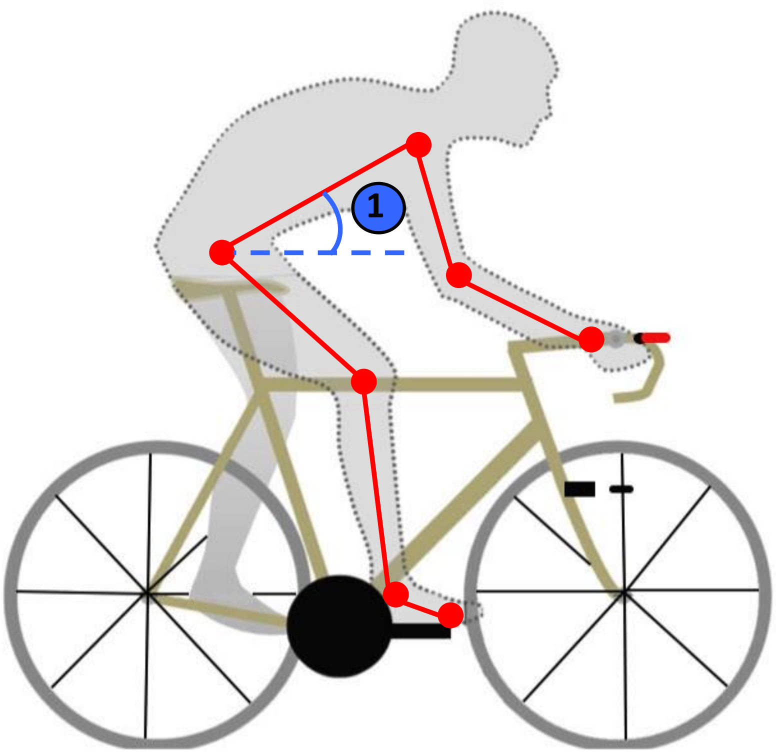
Kestrel

Powertap



Bikefitting

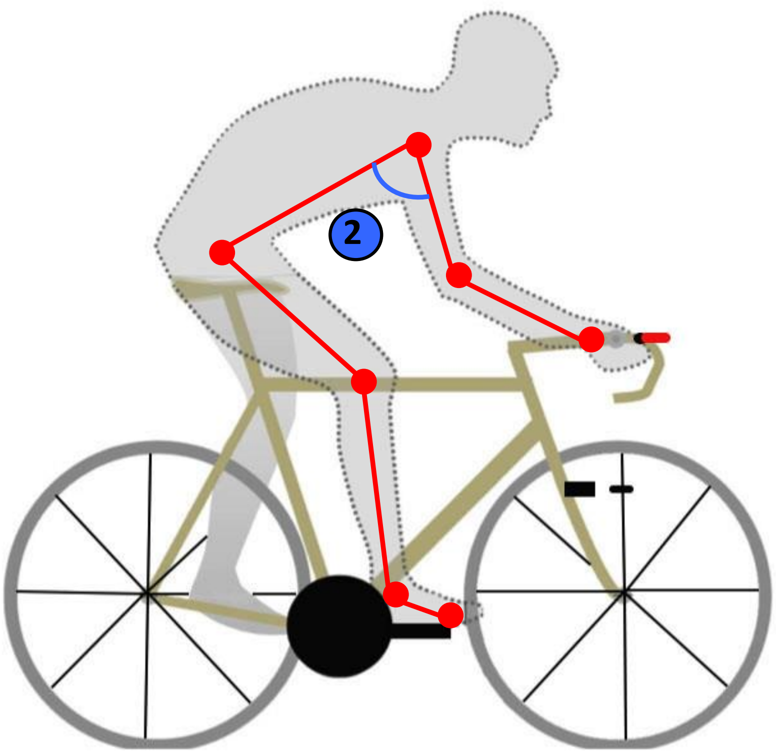
Kinematic analysis



Kinematic variables (n = 9) assessed in the participants' preferred time trial position. Values are reported as mean ± SD

Variable	Value
Torso angle (°)	**15.7 ± 2.3**
Shoulder angle (°)	79.3 ± 7.1
Elbow angle (°)	87.8 ± 10.0
Forearm angle (°)	13.4 ± 4.0
Hip angle extension (°)	84.0 ± 3.2
Hip angle flexion (°)	38.8 ± 3.6
Knee angle extension (°)	42.1 ± 4.5
Knee angle flexion (°)	113.4 ± 3.8
Ankle angle minimum (°)	74.4 ± 4.9
Ankle angle maximum (°)	100.7 ± 5.3

Kinematic analysis



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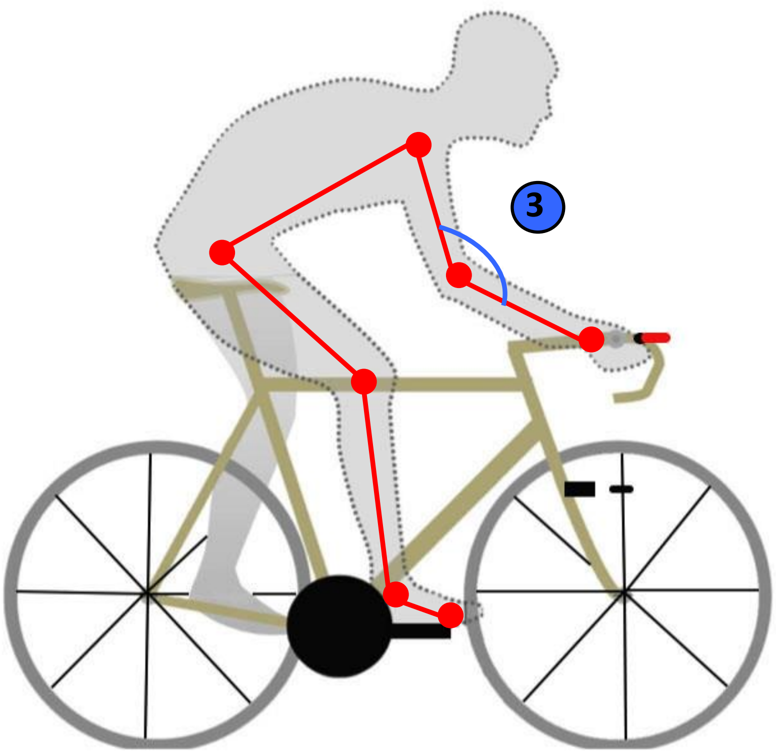

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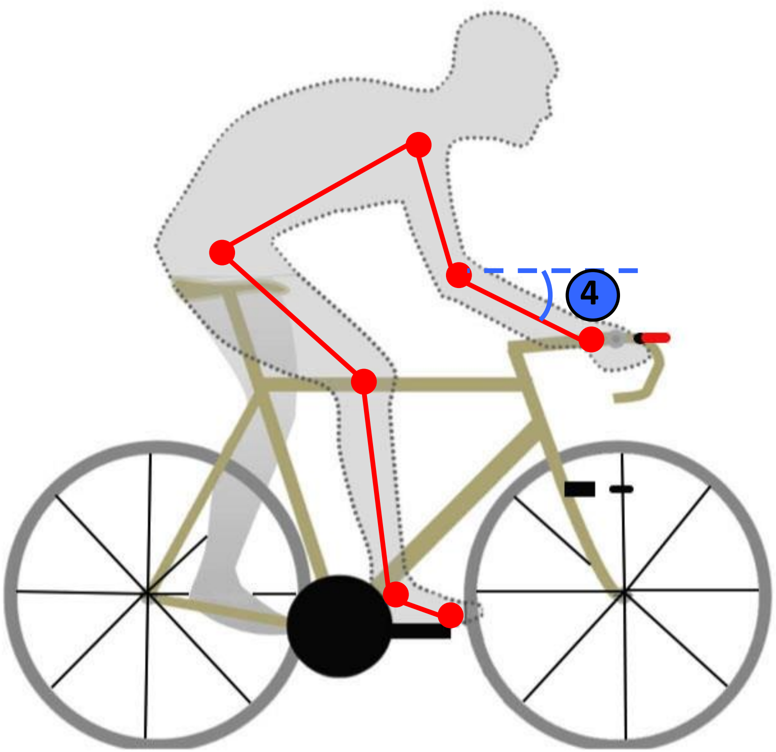

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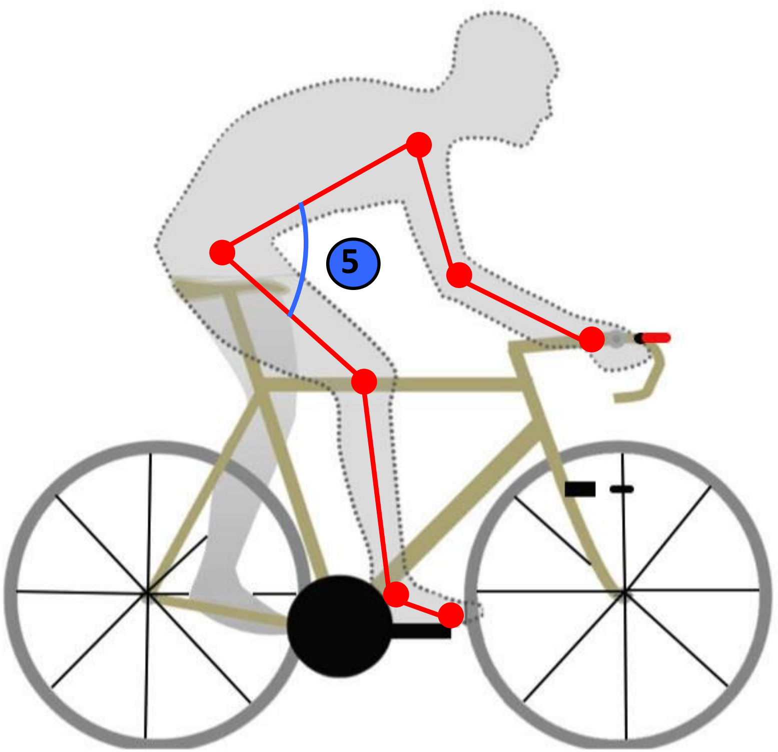

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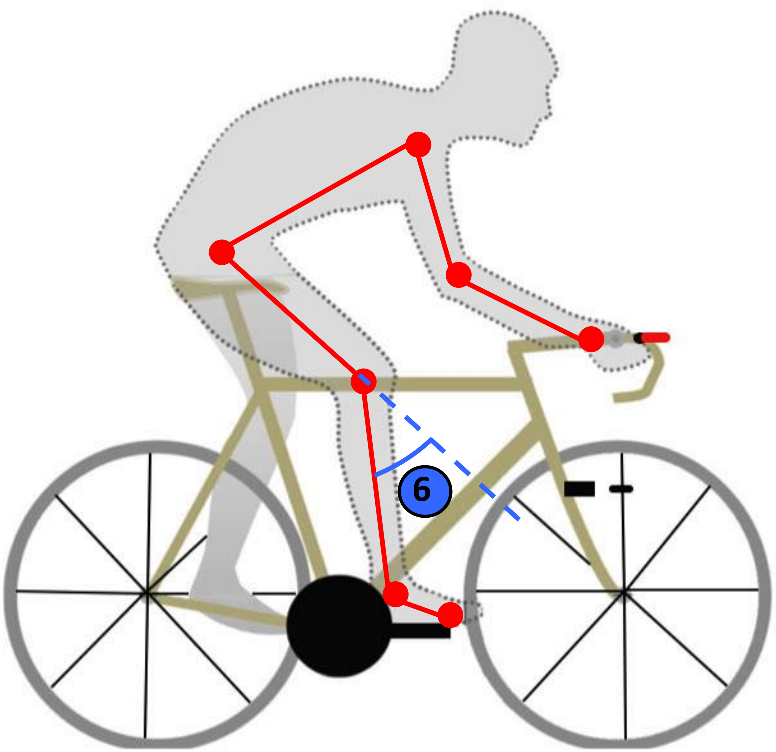

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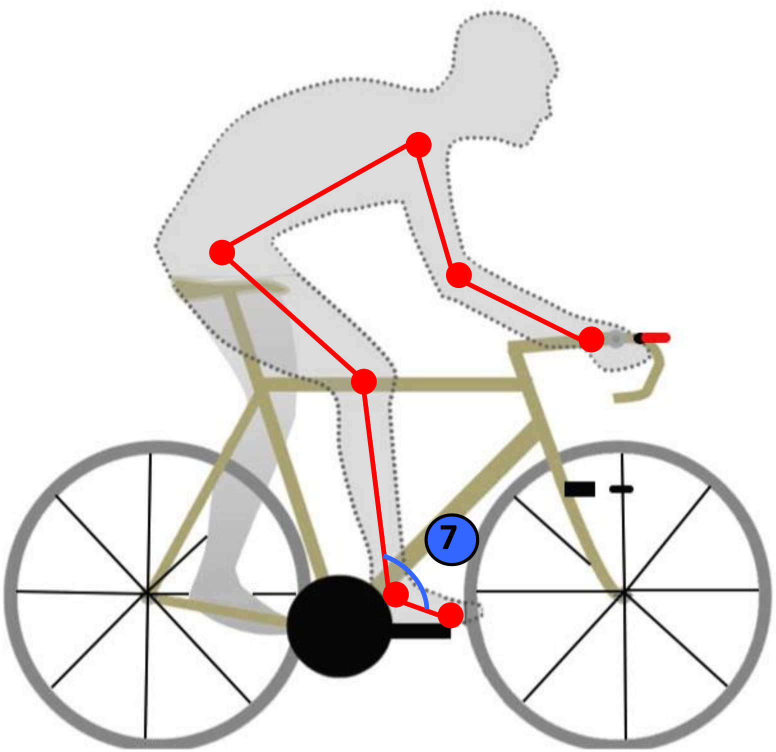

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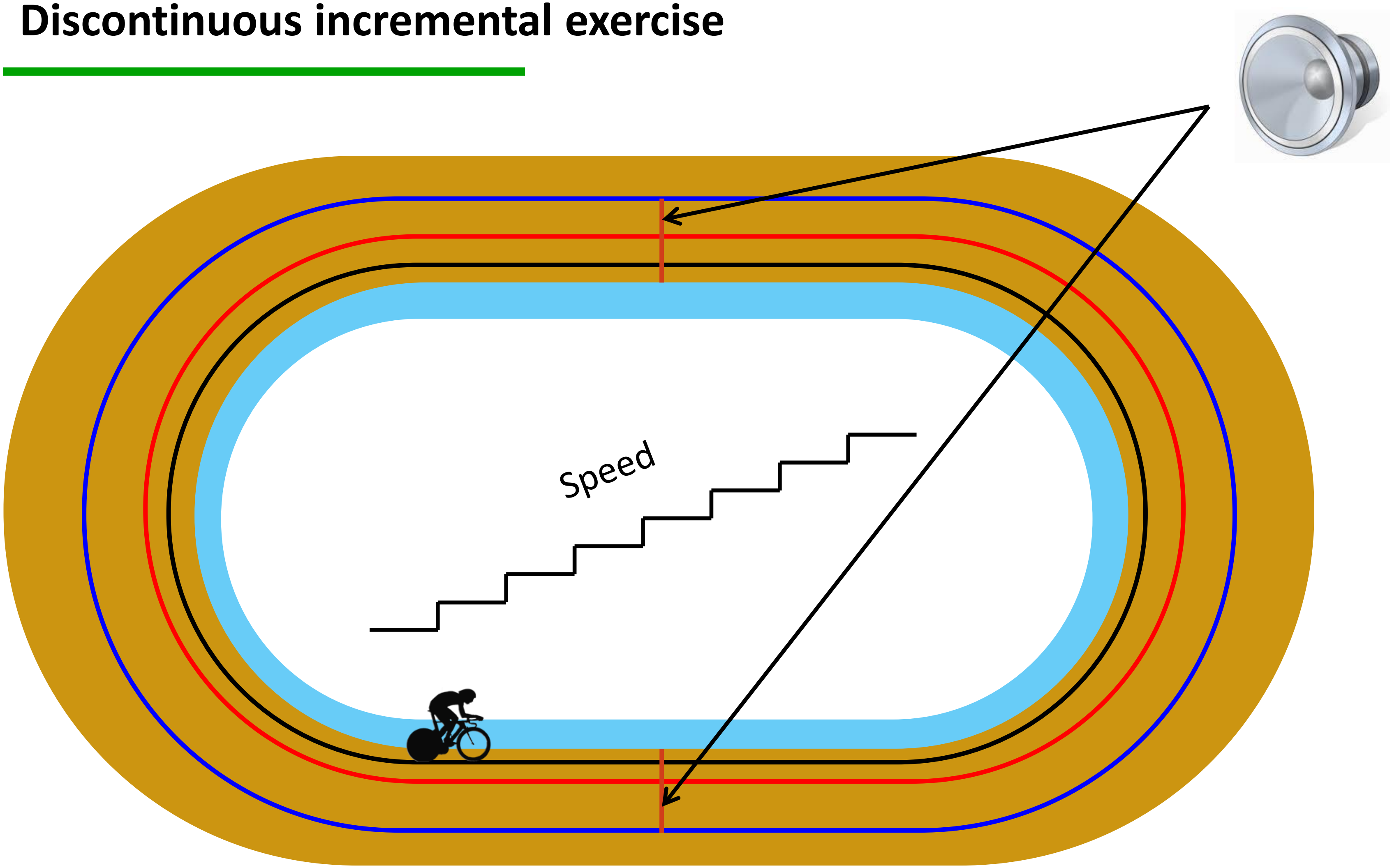
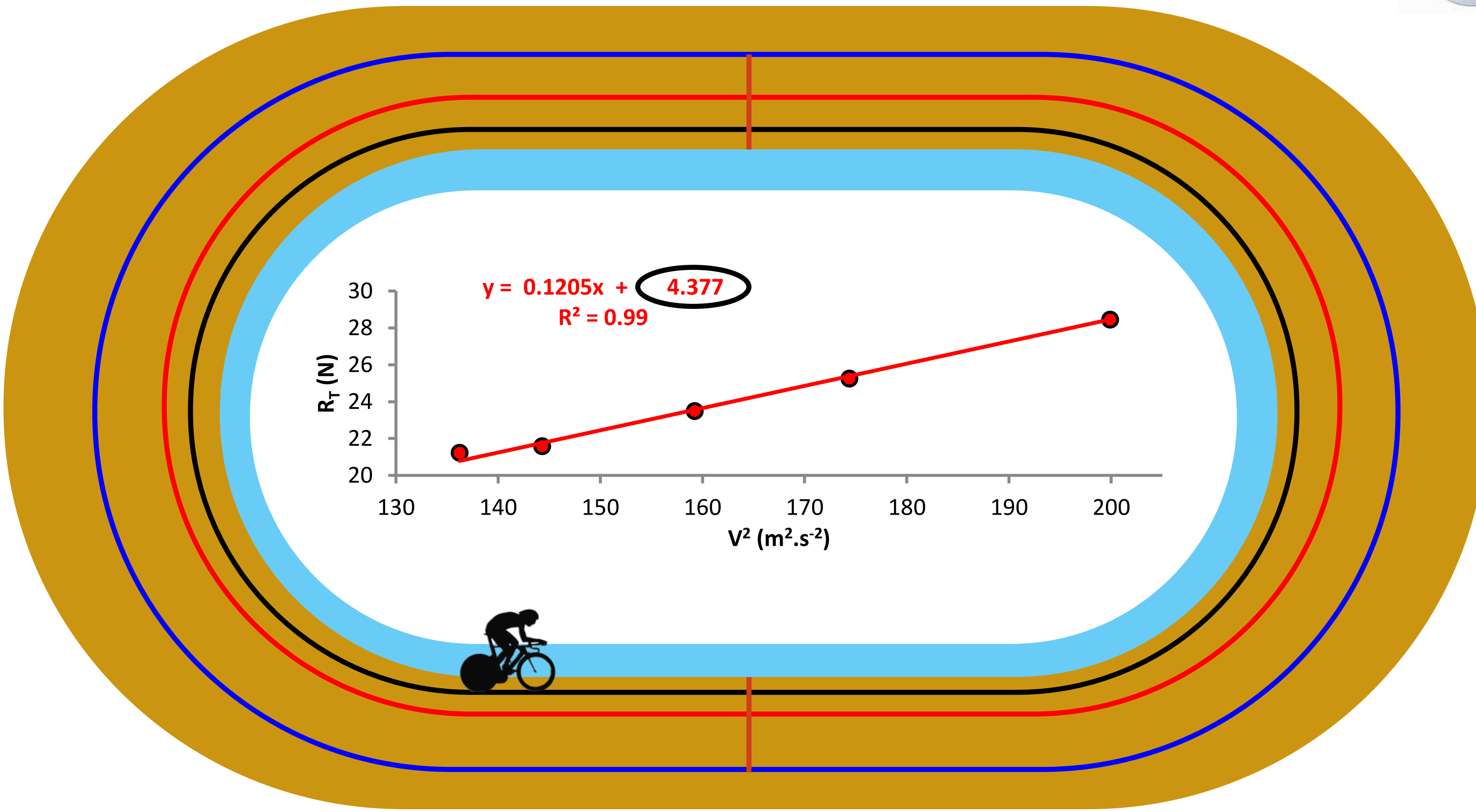
Discontinuous incremental exercise



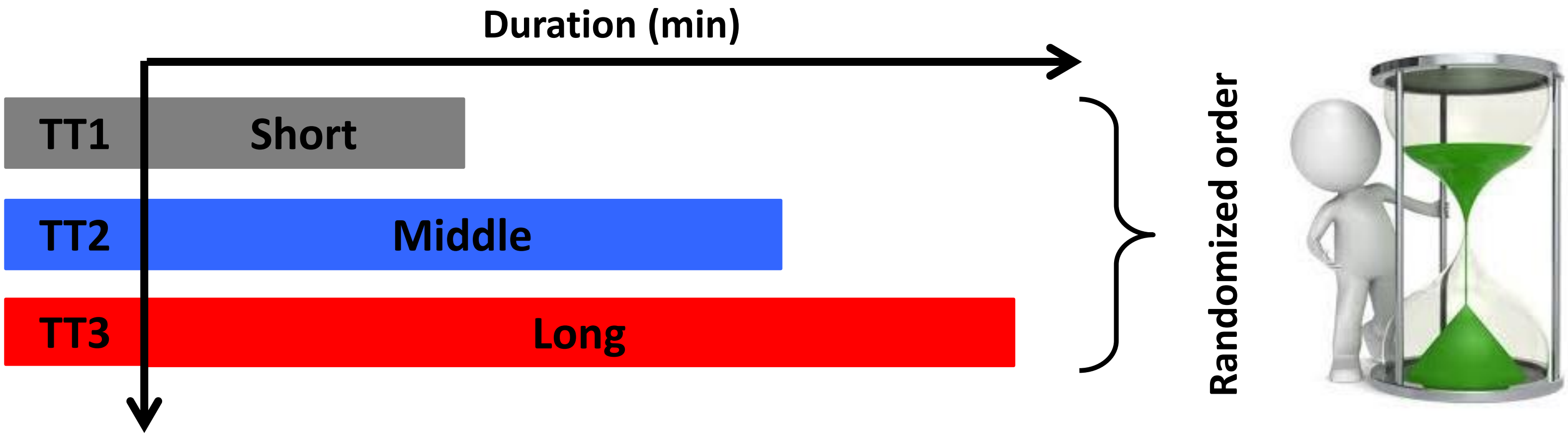
Grappe et al., 1997

Discontinuous incremental exercise



$b = R_R$

TT tests



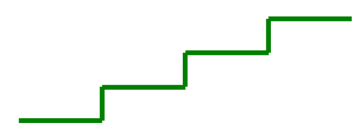
Categories	TT1	TT2	TT3
U17 Men / U19 Women	3	8	15
U19 Men / U23 Women	4	10	20
U23 + Elite Men / Elite Women	5	15	30

Kestrel

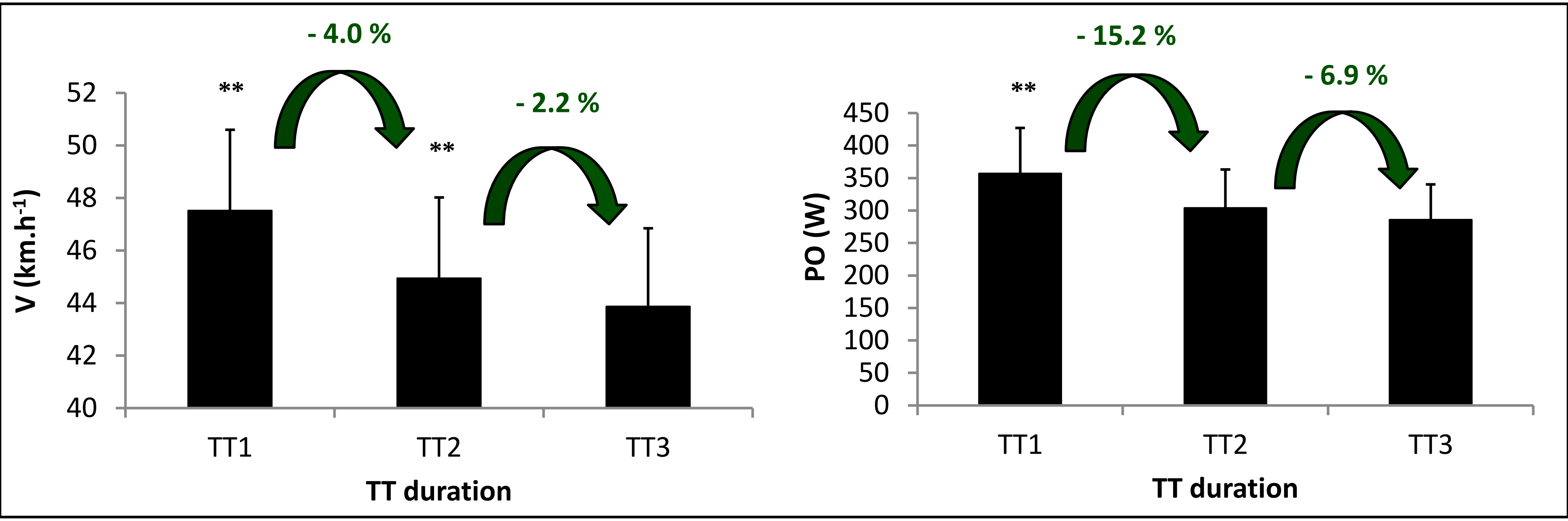
Powertap

$$AC_d = \frac{PO - V \times Rr}{0.5 \times \rho \times V^3}$$

DIE

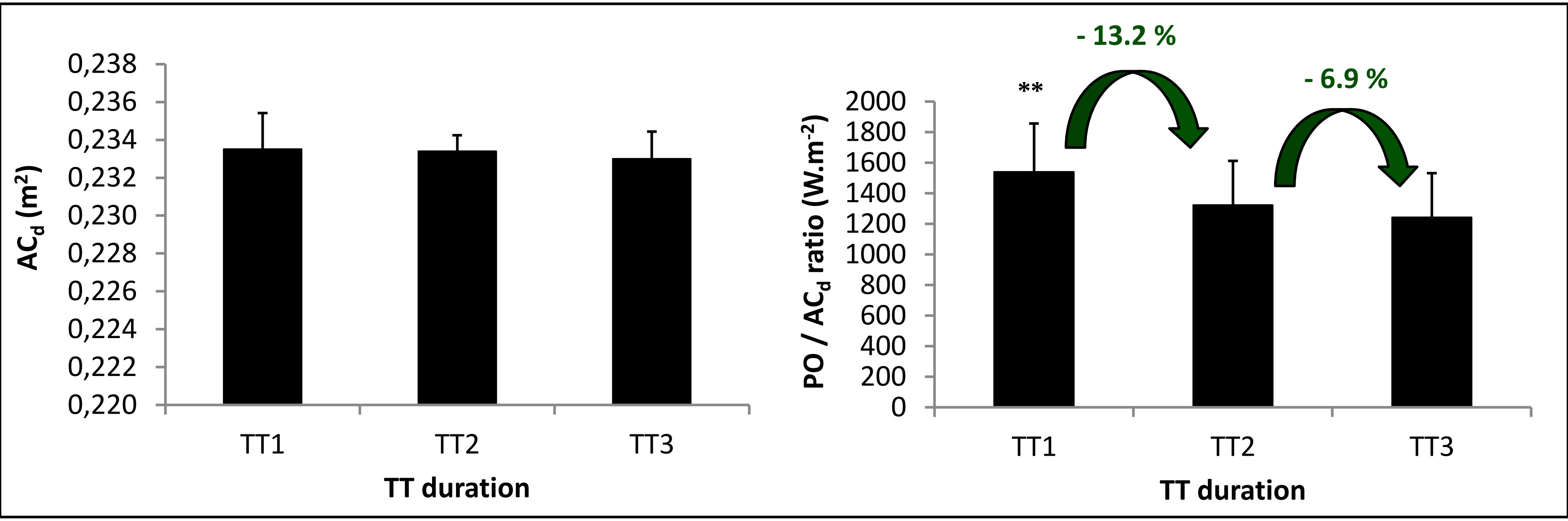


Effect of duration



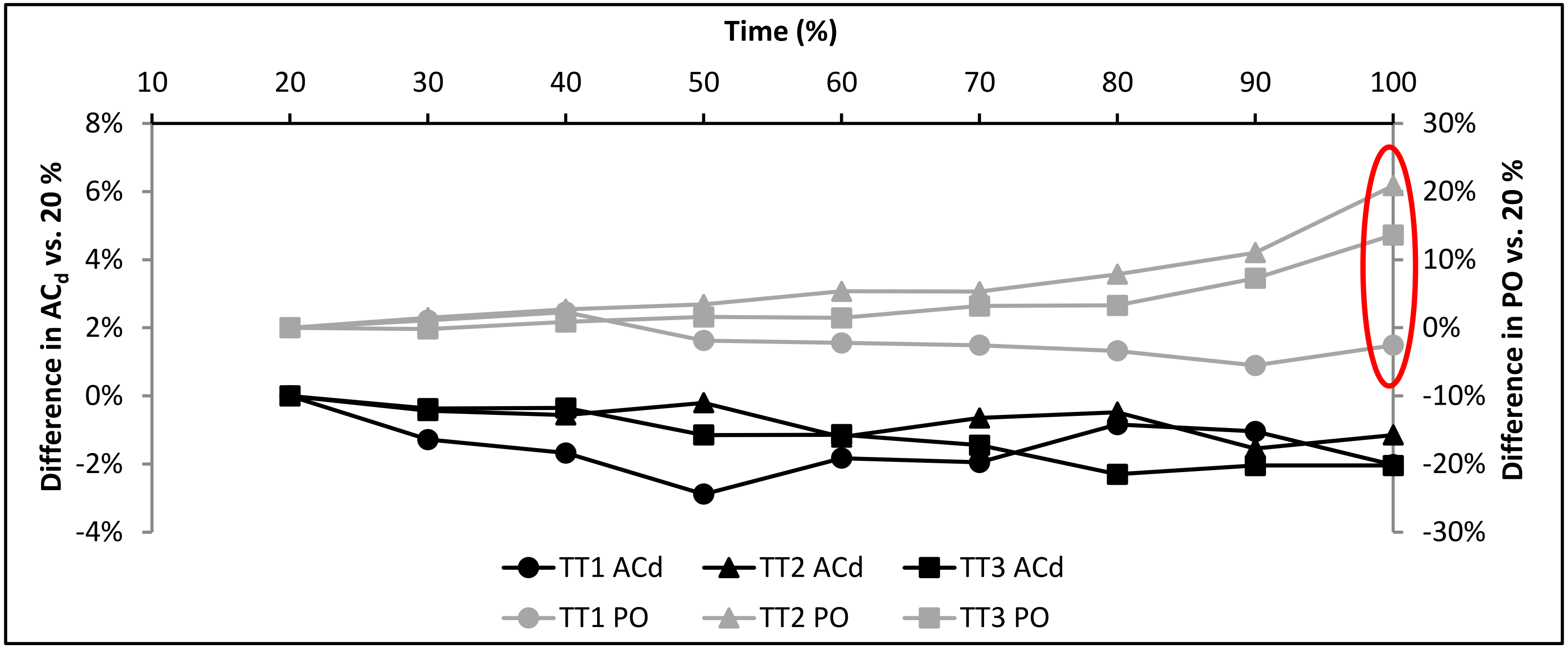
➘ in V and PO according to the TT duration

Effect of duration



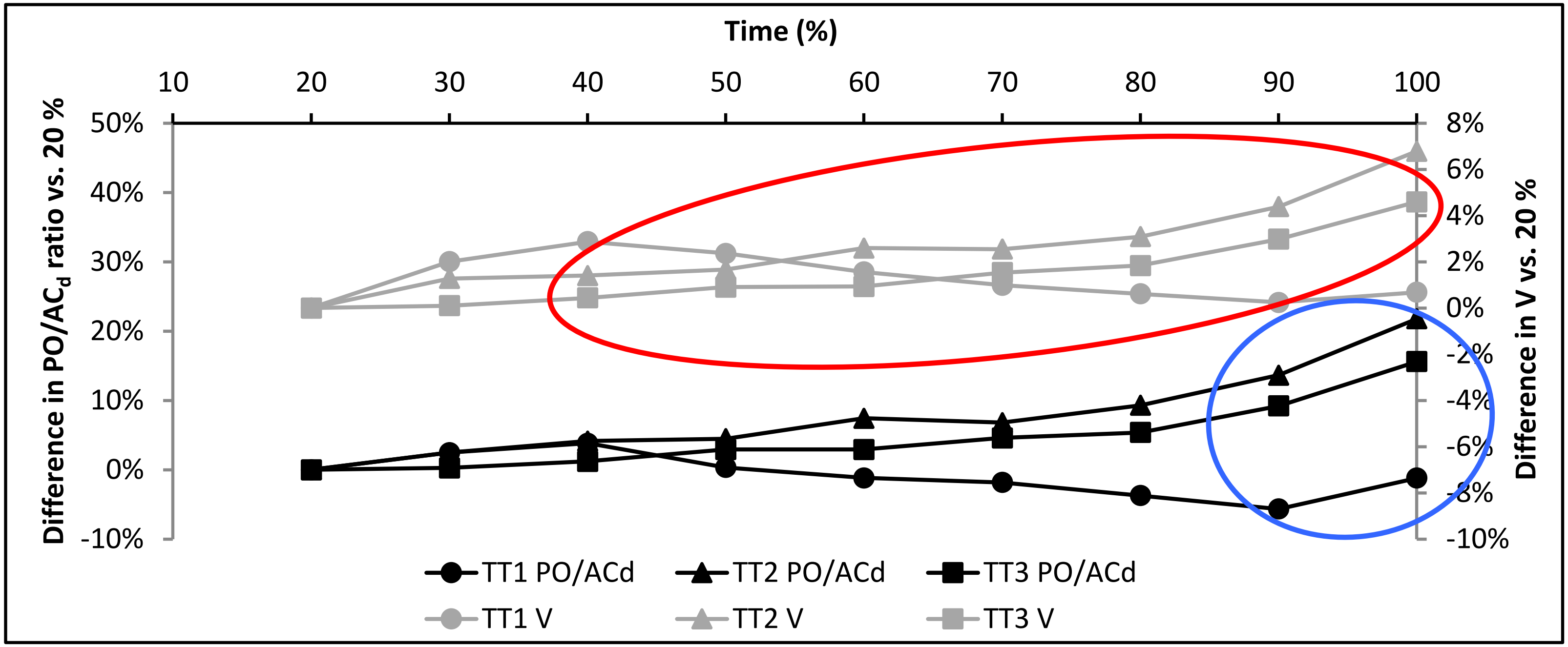
➔ in AC_d	➘ in PO/AC_d ratio

Effect of time



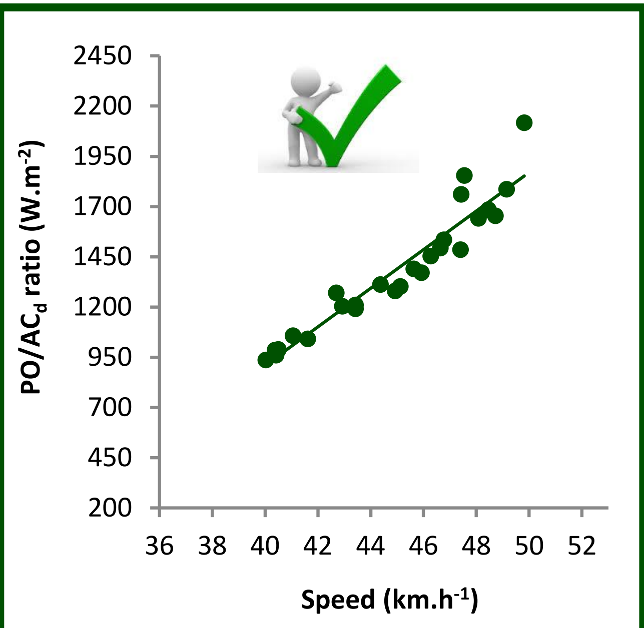
Variable	20%	30%	40%	50%	60%	70%	80%	90%	100%
PO (W)	310.5 ± 61.1	312.3 ± 61.6	314.9 ± 60.6	311.2 ± 61.7	312.2 ± 60.0	312.3 ± 56.5	314.2 ± 59.6	318.5 ± 65.4	336.3 ± 60.2
ES		*-0.031*	*-0.076*	*-0.013*	*-0.031*	*-0.033*	*-0.065*	*-0.134*	*-0.452*
Interpretation		***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Small***
AC_d (m^2)	0.235 ± 0.023	0.233 ± 0.022	0.233 ± 0.021	0.232 ± 0.021	0.232 ± 0.021	0.232 ± 0.020	0.232 ± 0.021	0.231 ± 0.021	0.231 ± 0.021
ES		*0.092*	*0.118*	*0.176*	*0.177*	*0.173*	*0.153*	*0.183*	*0.190*
Interpretation		***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***

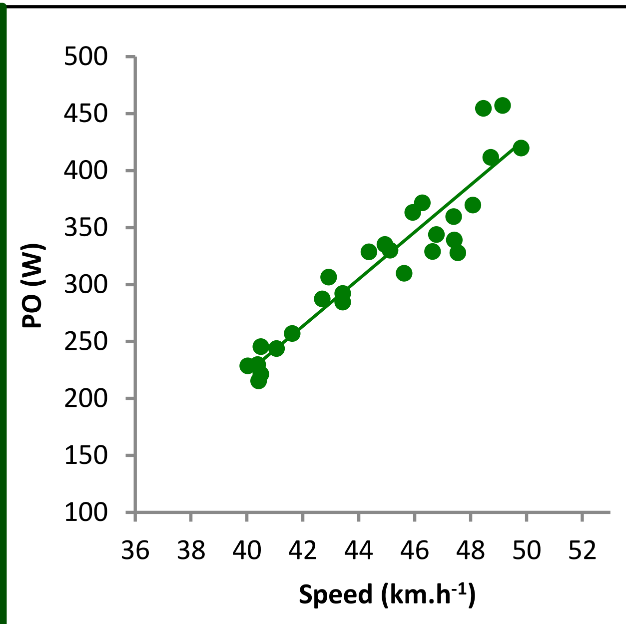
Effect of time

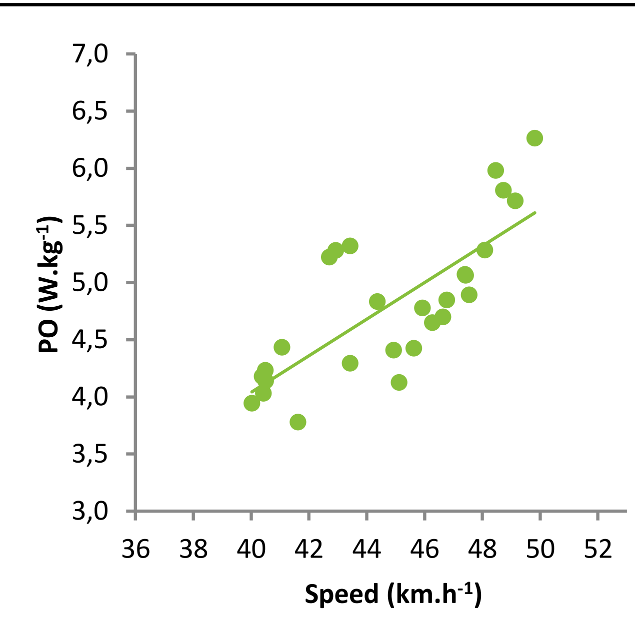


Variable	20%	30%	40%	50%	60%	70%	80%	90%	100%
V ($km.h^{-1}$)	44.7 ± 2.9	45.2 ± 3.0	45.4 ± 3.1	45.4 ± 3.2	45.4 ± 3.1	45.4 ± 3.0	45.5 ± 3.0	45.8 ± 3.2	46.4 ± 2.9
ES		*-0.186*	*-0.255*	*-0.262*	*-0.270*	*-0.269*	*-0.291*	*-0.386*	*-0.648*
Interpretation		***Trivial***	***Small***	***Small***	***Small***	***Small***	***Small***	***Small***	***Moderate***
PO/AC_d ratio ($W.m^{-2}$)	1322.9 ± 259.4	1347.0 ± 290.7	1364.4 ± 302.3	1354.7 ± 302.5	1358.8 ± 300.6	1359.5 ± 294.2	1363.0 ± 295.7	1385.9 ± 314.7	1467.6 ± 304.3
ES		*-0.092*	*-0.156*	*-0.119*	*-0.136*	*-0.140*	*-0.153*	*-0.231*	*-0.543*
Interpretation		***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Trivial***	***Small***	***Moderate***

Relationship between speed and PO/AC_d ratio, PO (W) and PO ($W.kg^{-1}$)

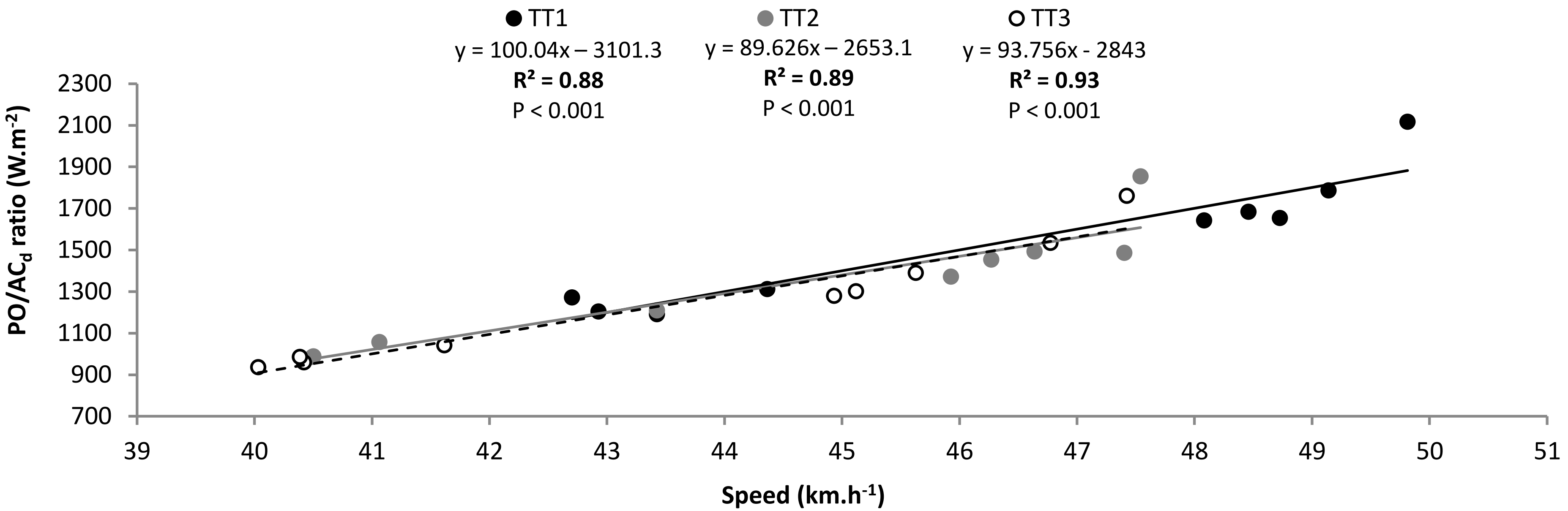






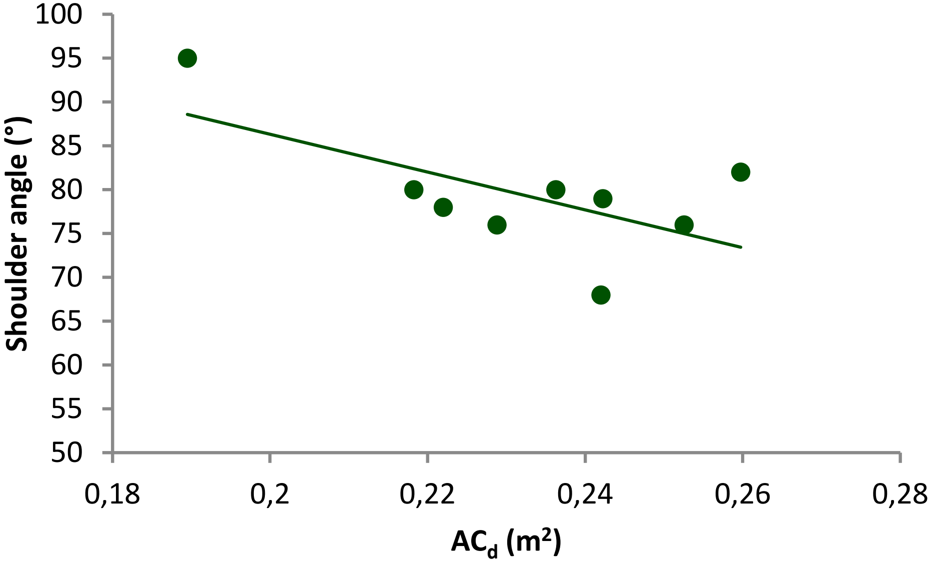
PO/AC_d ratio ($W.m^{-2}$)	PO (W)	PO ($W.kg^{-1}$)
$y = 96.157x – 2937.2$	$y = 20.627x – 602.83$	$y = 0.1603x – 2.3746$
$R^2 = 0.91$ ($p < 0.001$)	**$R^2 = 0.88$ ($p < 0.001$)**	**$R^2 = 0.58$ ($p < 0.001$)**

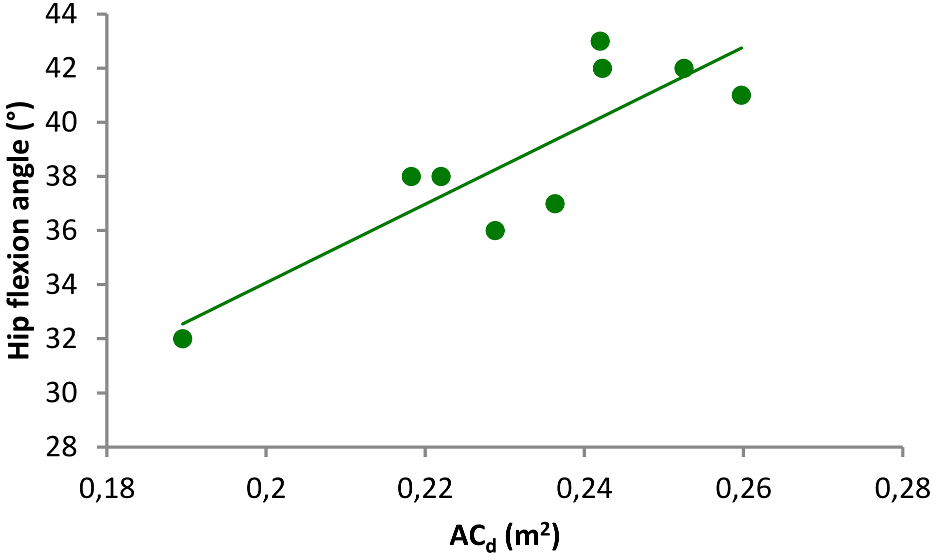
Relationship between speed and PO/AC_d ratio in each TT



The more the duration is high the more the relationship is

Relationship between AC_d and kinematic variables



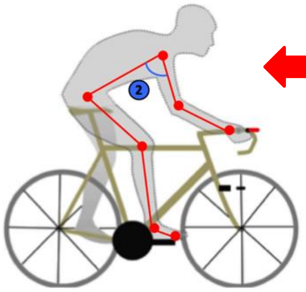


Shoulder angle

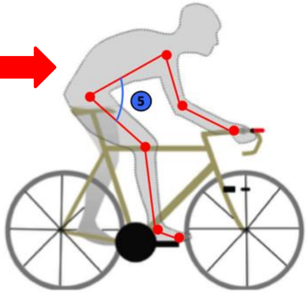
y = -215.82x + 129.49

R^2 = 0.40

P = 0.066



AC_d



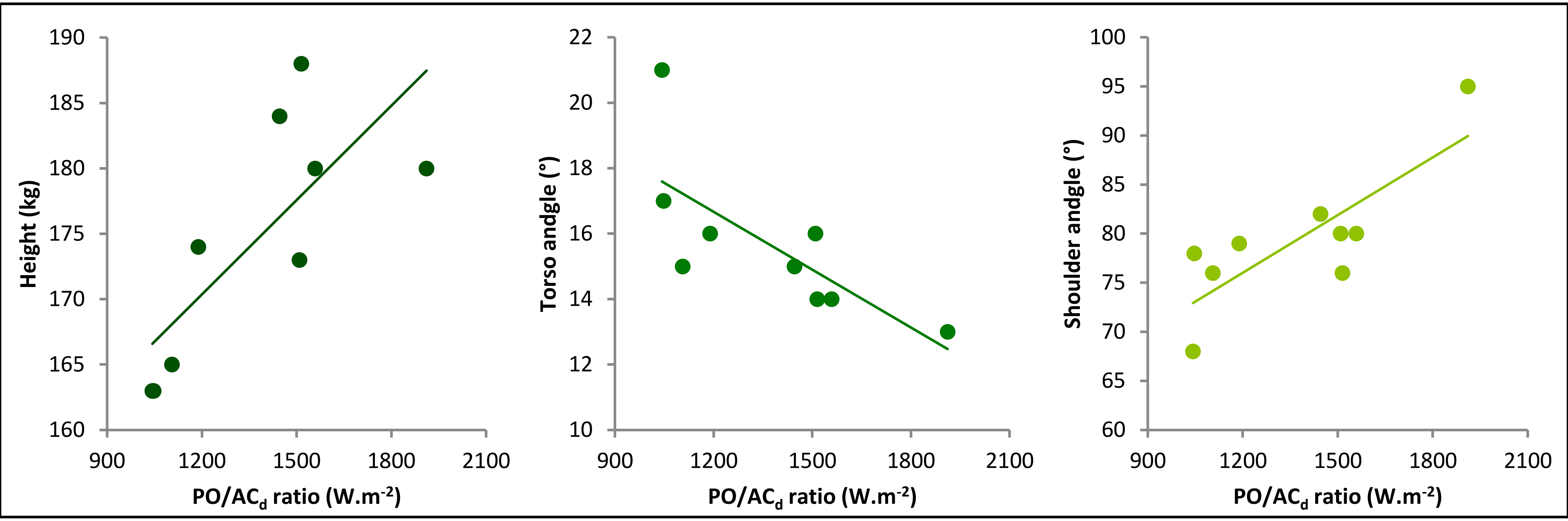
Hip flexion angle

y = 145.19x + 5.0372

R^2 = 0.73

$P < 0.05$

Relationship between PO/AC_d ratio and both morphological and kinematic variables



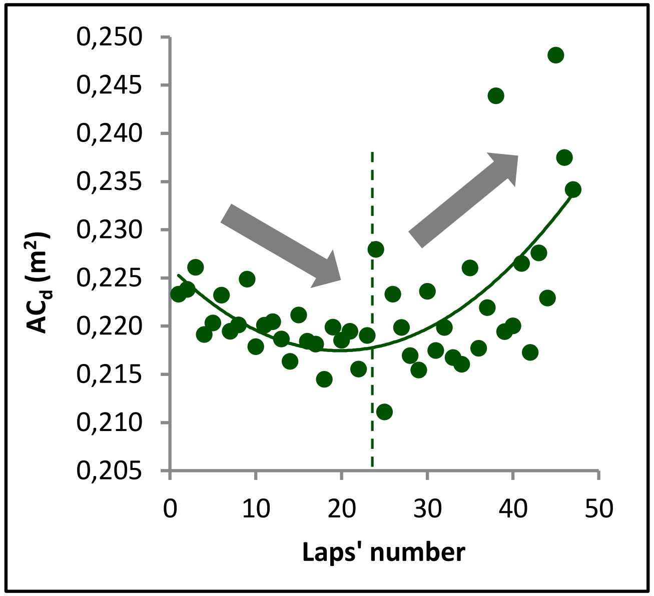
Height : $R^2 = 0.58$ ($p < 0.05$) **Torso angle : $R^2 = 0.55$ ($p < 0.05$)** **Shoulder angle : $R^2 = 0.65$ ($p < 0.05$)**

PO/AC_d ratio = -4071.672 + (17.475 × Height) + (17.036 × Torso angle) + (26.793 × Shoulder angle)

$R^2 = 0.85$ ($p < 0.05$)

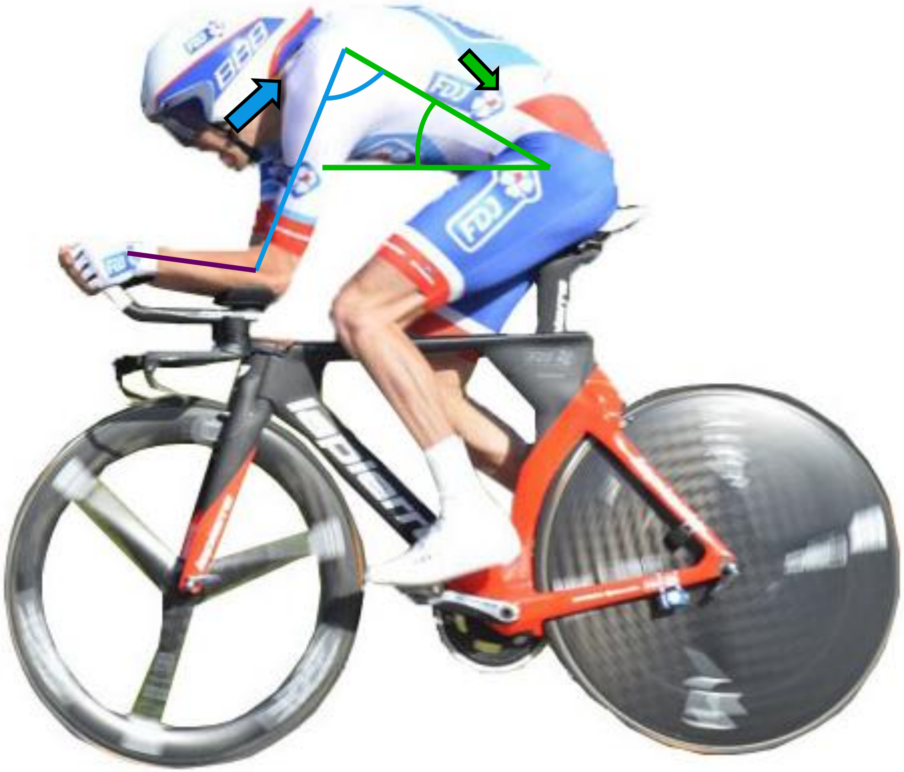
Effects of duration and time

- ➘ in V and PO in accordance with the literature
- Negative pacing strategy
- The AC_d remains relatively ➔ during the efforts
- Individual testing to identify the optimal position
- Strong correlations between V and PO/AC_d ratio
- ➚ PO and ➘ AC_d to ➚ performance
  Peterman et al. 2015



- PO/AC_d ratio depends on the height ($P < 0.05$), the torso angle ($P < 0.001$) and the shoulder angle ($P < 0.05$)
- AC_d depends on the shoulder angle ($P = 0.066$) and hip flexion angle ($P < 0.05$)

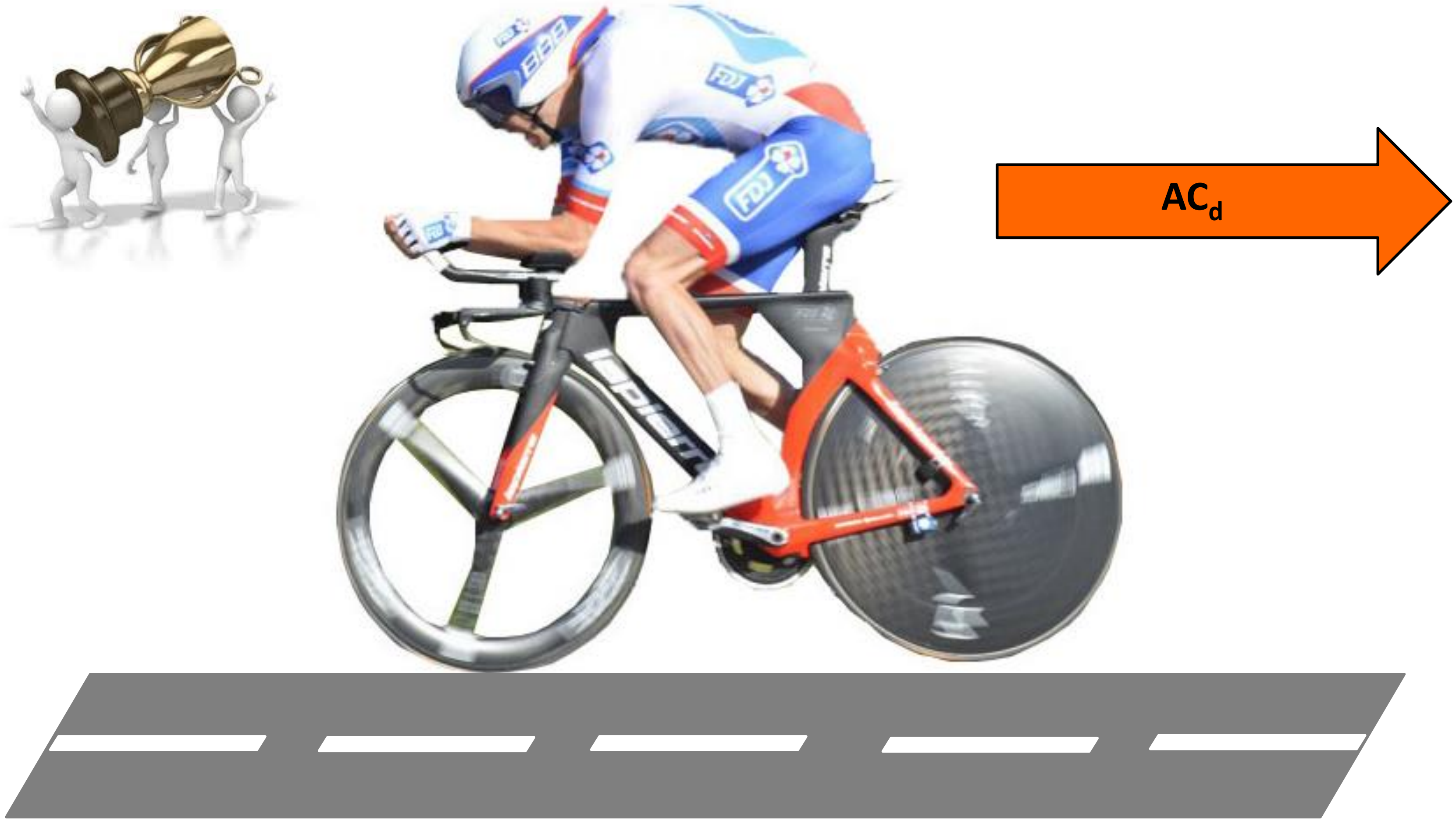
Effect of torso and shoulder angles on AC_d during different TT durations



↘ Torso angle induces an ↗ in AC_d ?

↗ Shoulder angle induces an ↗ in AC_d ?

Measure AC_d in real cycling locomotion on the field



THANKS FOR YOUR ATTENTION

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