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Functional threshold power (FTP) in cyclists: validity of the concept and physiological responses

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Background

- Powermeters.
- Functional threshold power (FTP) is the highest power that a cyclist can maintain in a quasi-steady state for approximately one hour without fatiguing (Allen; Coggan, 2010).
- 60-min time-trial (FTP_{60}): FTP corresponds to the mean power output (Allen; Coggan, 2010).
- 20-min time-trial (FTP_{20}): FTP corresponds to 95% of the mean power output (Allen; Coggan, 2010).
- 8-min time-trial (FTP_{8}): FTP corresponds to 90% of the mean power output (Carmichael; Rutberg, 2009).

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Background

Validity of using functional threshold power and intermittent power to predict cross-country mountain bike race outcome

Matthew C Miller [1,2]✉, Gavin L Moir [1] and Stephen R Stannard[2]

Miller et al. (2014) suggest a linear regression model for predicting mountain biking performance time by using the relative to body mass **FTP_{20}**.

COMPARISON OF A FIELD-BASED TEST TO ESTIMATE FUNCTIONAL THRESHOLD POWER AND POWER OUTPUT AT LACTATE THRESHOLD

TIMOTHY P. GAVIN,[1,2,3,4] JESSICA B. VAN METER,[1,4] PATRICIA M. BROPHY,[1,4] GABRIEL S. DUBIS,[1,4] KATLIN N. POTTS,[1,4] AND ROBERT C. HICKNER[1,2,4]

Gavin et al. (2012) suggested that **FTP_{8}** (301 ± 13 W) was not significant different than 4 mmol.L^{-1} (293 ± 9 W, $p < 0.05$).

Title: A field-based cycling test to assess predictors of endurance performance and establishing training zones.

Sanders et al. (2017) found that the **FTP_{8}** overestimates several LT methods in well-trained cyclists ranging from 21 to 62 W.

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Background: objective

- This study had the following aims:

(1) Verify the validity of the FTP_{20} with FTP_{60} and individual anaerobic threshold (IAT).

(2) Analyse the physiological and perceptual responses during the TT used for FTP_{20} and FTP_{60} determination and during time to exhaustion (TTE) at FTP_{20}.

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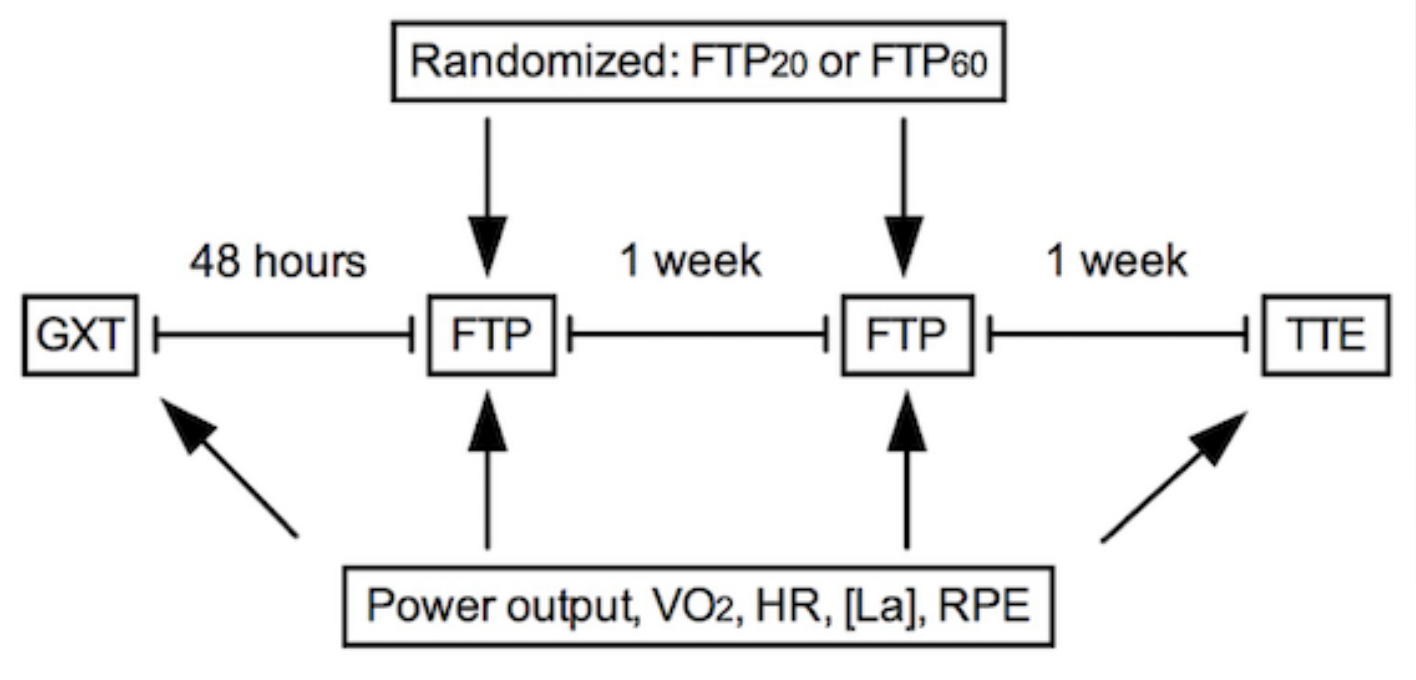
Methods: Experimental design



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Methods: Subjects

- 23 trained cyclists (De Pauw et al. 2013).
- Indoor tests (Velotron Dynafit Pro, USA).
- GXT: 100W + 40W every 4-min until exhaustion.
- VO_2: (Quark PFTergo, Cosmed, Italy).
- RPE: 6-20 Borg scale.
- [La]: 20 µL (Biosen , Germany):

IAT: 1.5 $mmol.L^{-1}$ above the minimum lactate equivalent ($[La].W^{-1}$).

Table 1. Characteristics of the cyclists.

Variables	Mean ± SD
Descriptive data	
Age (years)	32.7 ± 6.5
Body mass (kg)	76.4 ± 8.3
Height (cm)	179 ± 5
Graded exercise test	
PPO (W)	327 ± 34
PPO ($W.kg^{-1}$)	4.3 ± 0.3
VO_{2max} ($L.min^{-1}$)	4.5 ± 0.7
VO_{2max} ($ml.min^{-1}.kg^{-1}$)	59.4 ± 5.9
HR_{max} (bpm)	185 ± 8

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Methods: FTP_{20}, FTP_{60} and TTE

General recommendations:

- Cyclists were able to view their progress over the course, distance and gear selection; all other information was blinded to remove any potential pacing effect.
- No verbal encouragement was provided (Currell and Jeukendrup, 2008).
- Cyclists were able to drink water *ad libitum* during FTP_{60} and TTE.
- Self-selected pacing as fast as possible (FTP) with no restriction on gear selection, cadence or cycling posture.
- TTE: The Velotron was set up with a pacer at a fixed FTP_{20}. The test was interrupted when the cyclist could not follow the pacer for more than 10-s.

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Methods: FTP_{20}, FTP_{60} and TTE

TEST Functional Threshold Power

	Time	Description	% of FTP	% of FTHR
Warm-up	20 min.	Endurance pace	65	70
	3 × 1 min. (1 min. RI)	Fast pedaling, 100 rpm	N/A	N/A
	5 min.	Easy riding	65	<70
Main set	5 min.	All-out effort	max	>106
	10 min.	Easy riding	65	<70
	20 min.	Time trial	100	99–105
Cooldown	10–15 min.	Easy riding	65	<70

Note: FTP = Functional Threshold Power. FTHR = Functional Threshold Heart Rate. N/A = Not Applicable

- FTP_{60}: Warm-up (10-min self-selected) + 60-min TT
- TTE-FTP_{20}: Warm-up (10-min self-selected) + TTE

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Methods: Statistics

- Anova one-way with repeated measures.
- Anova two-way with repeated measures.
- Limits of agreements (Bland and Altman, 1990).
- Pearson´s coefficient of correlation.
- $P < 0.05$.

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Results: FTP, TTE and IAT mean values

Table 1 – Power output (PO), heart rate (HR), oxygen uptake (VO_2), blood lactate concentration [La] and ratings of perceived exertion (RPE) relative to individual anaerobic threshold (IAT), FTP_{20}, FTP_{60} and time-to-exhaustion at FTP_{20} (TTE). Values expressed as mean ± SD.

Variables	IAT	FTP_{20}	FTP_{60}	TTE
PO (W)	237 ± 29	236 ± 38	231 ± 33	51 ± 15.7 min
HR ($b.min^{-1}$)	161 ± 7	159 ± 9	164 ± 11	165 ± 9
VO_2 ($L.min^{-1}$)	3.649 ± 0.6	3.505 ± 0.6	3.520 ± 0.5	3.685 ± 0.7
[La] ($mmol.L^{-1}$)	2.7 ± 0.5[a]	-	4.2 ± 1.9	5.1 ± 2.2
RPE	12.5 ± 1.7[a]	-	15.2 ± 1.3	15.0 ± 1.2

a: significantly different from FTP_{60} and TTE.

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Results: Correlations

Table 2. Pearson's coefficient of correlation (90% confidence intervals)

	IAT x FTP_{20}	IAT x FTP_{60}	FTP_{20} x FTP_{60}
Power output (W)	0.61* (0.32 to 0.79)	0.76** (0.55 to 0.88)	0.88** (0.77 to 0.94)
Heart rate (bpm)	0.29 (-0.07 to 0.58)	0.20 (-0.16 to 0.52)	0.65* (0.38 to 0.81)
Oxygen uptake (l/min)	0.72** (0.49 to 0.85)	0.79** (0.61 to 0.89)	0.81** (0.64 to 0.90)

*P < 0.001; **P < 0.0001.

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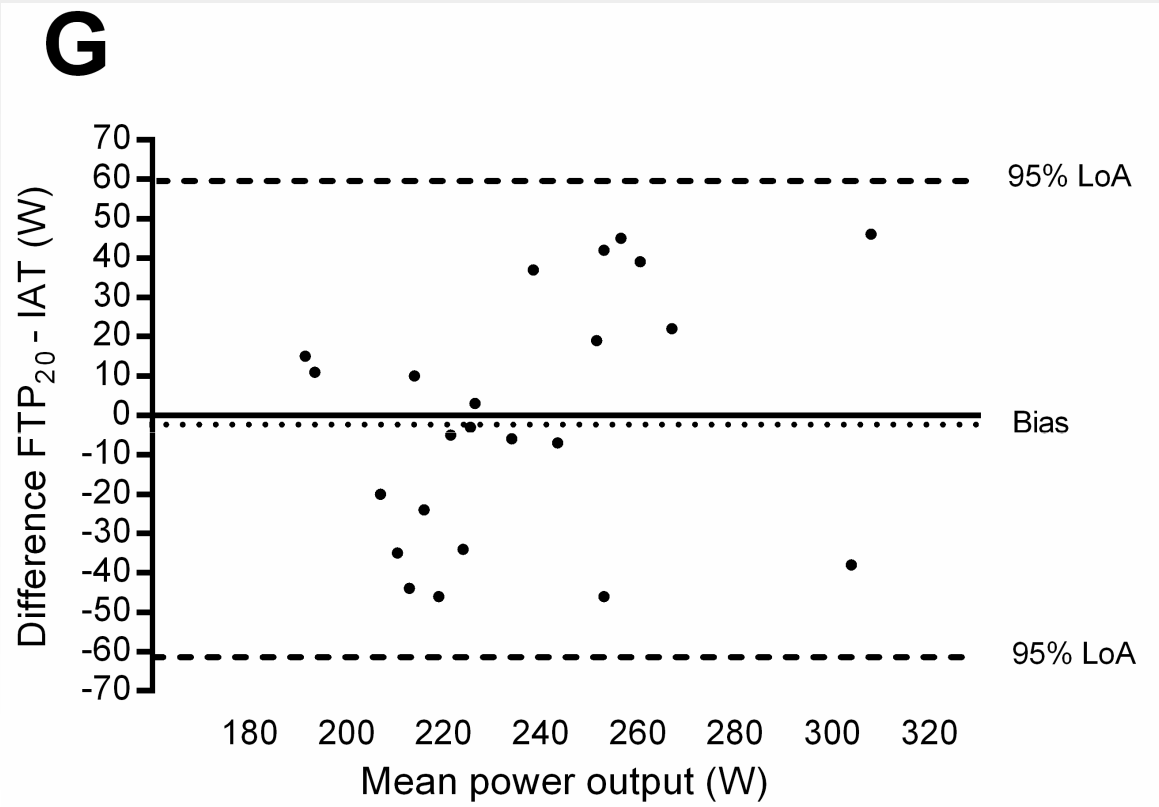
Results: Bland-Altman plots FTP_{20}-IAT Power output



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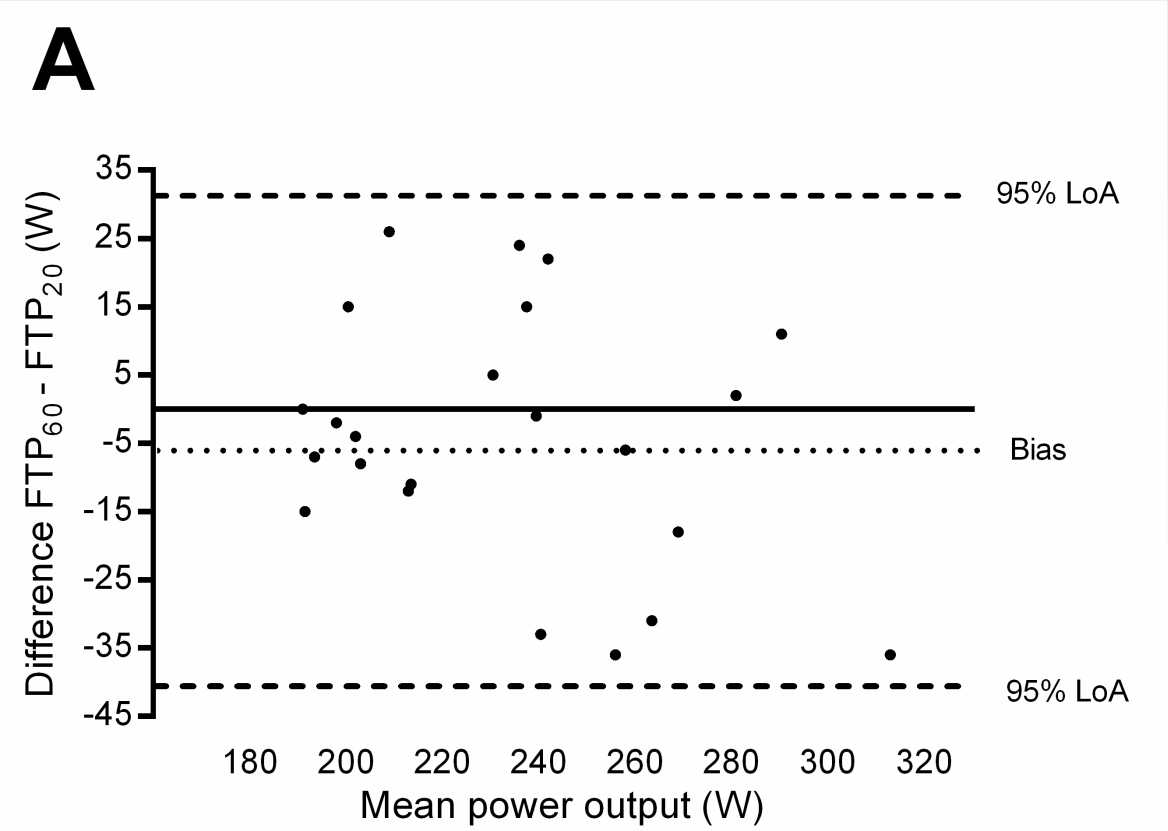
Results: Bland-Altman plots FTP_{60}-FTP_{20} Power output



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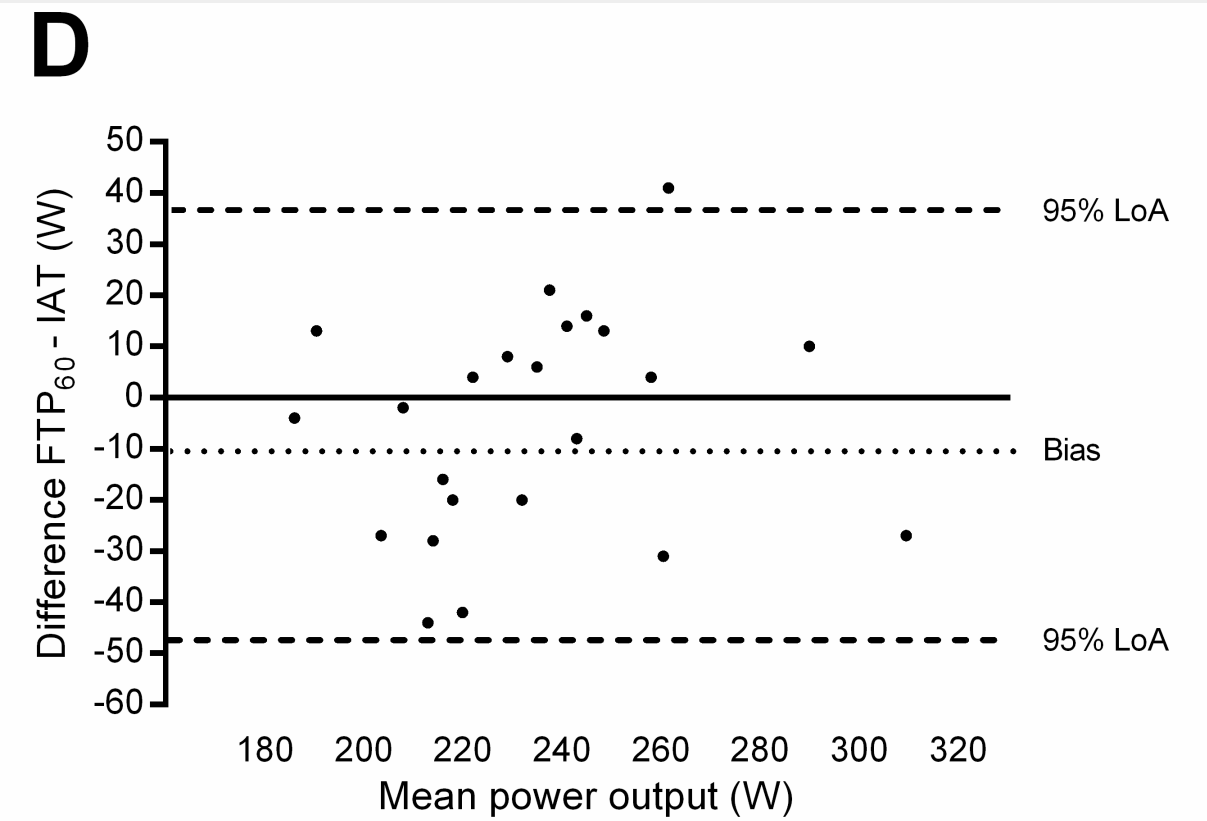
Results: Bland-Altman plots FTP_{60}-IAT Power output



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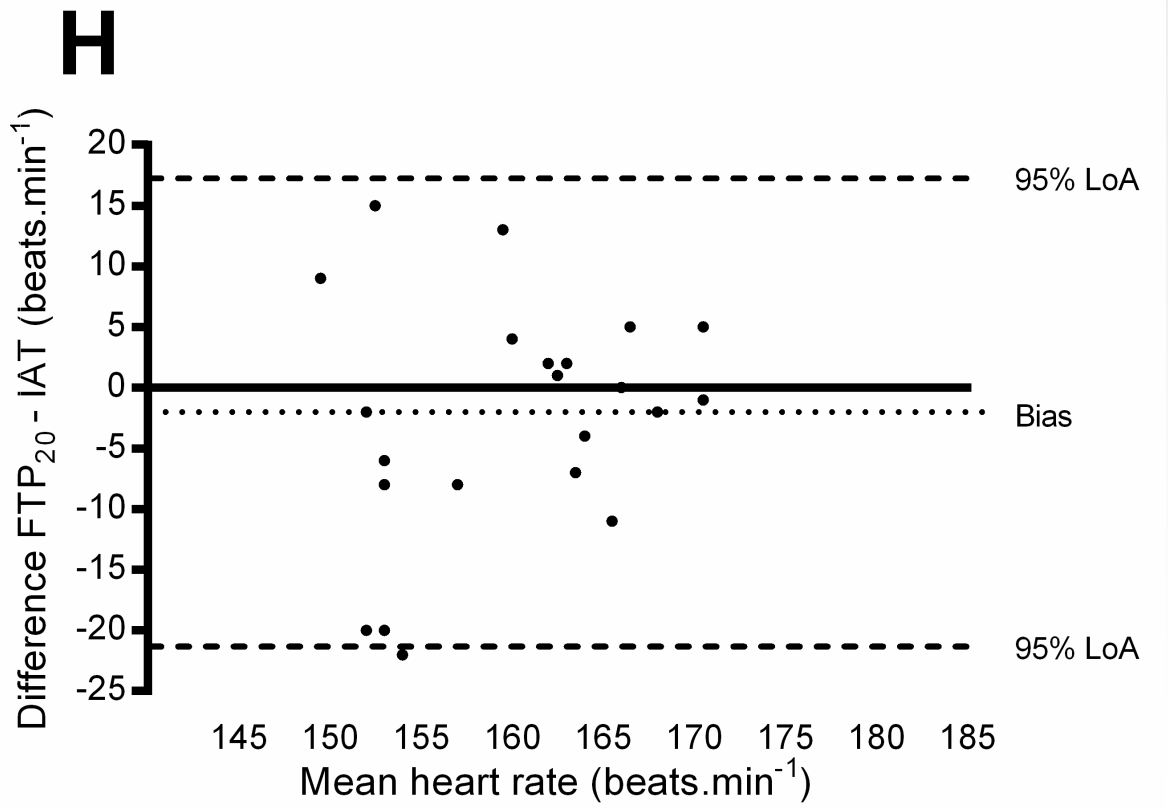
Results: Bland-Altman plots FTP_{20}-IAT Heart rate



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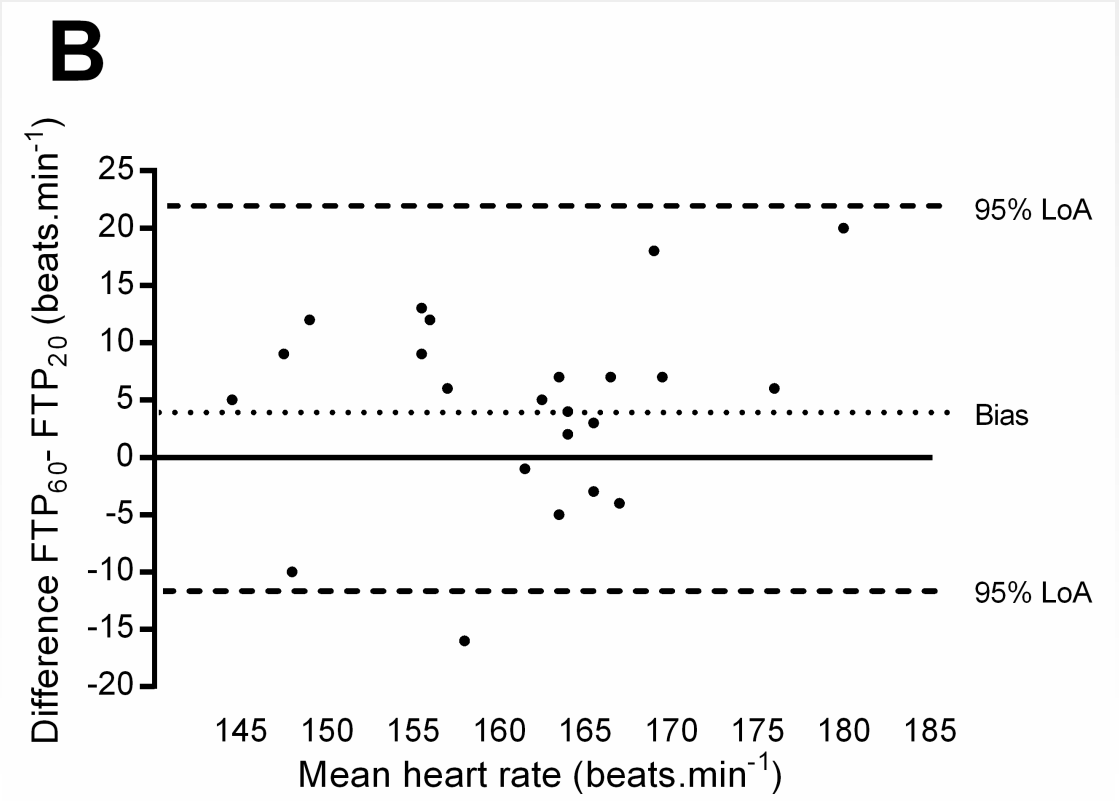
Results: Bland-Altman plots FTP_{60}-FTP_{20} Heart rate



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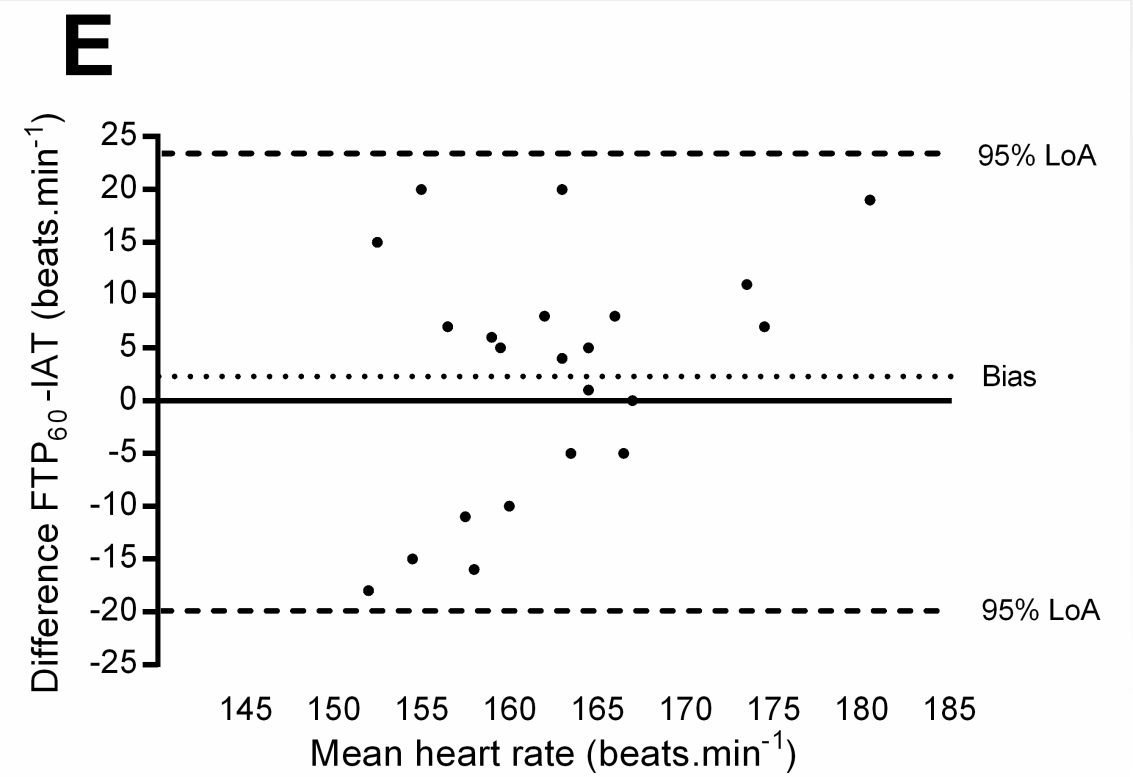
Results: Bland-Altman plots FTP_{60}-IAT Heart rate



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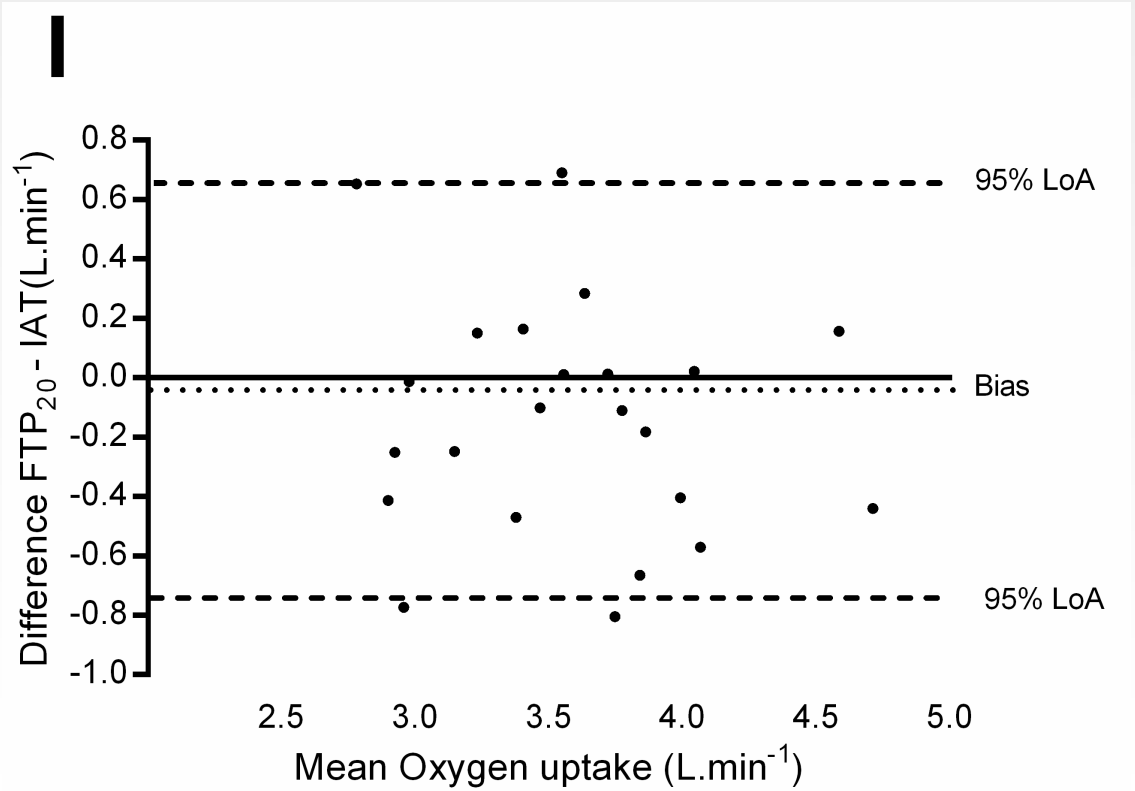
Results: Bland-Altman plots FTP_{20}-IAT Oxygen uptake



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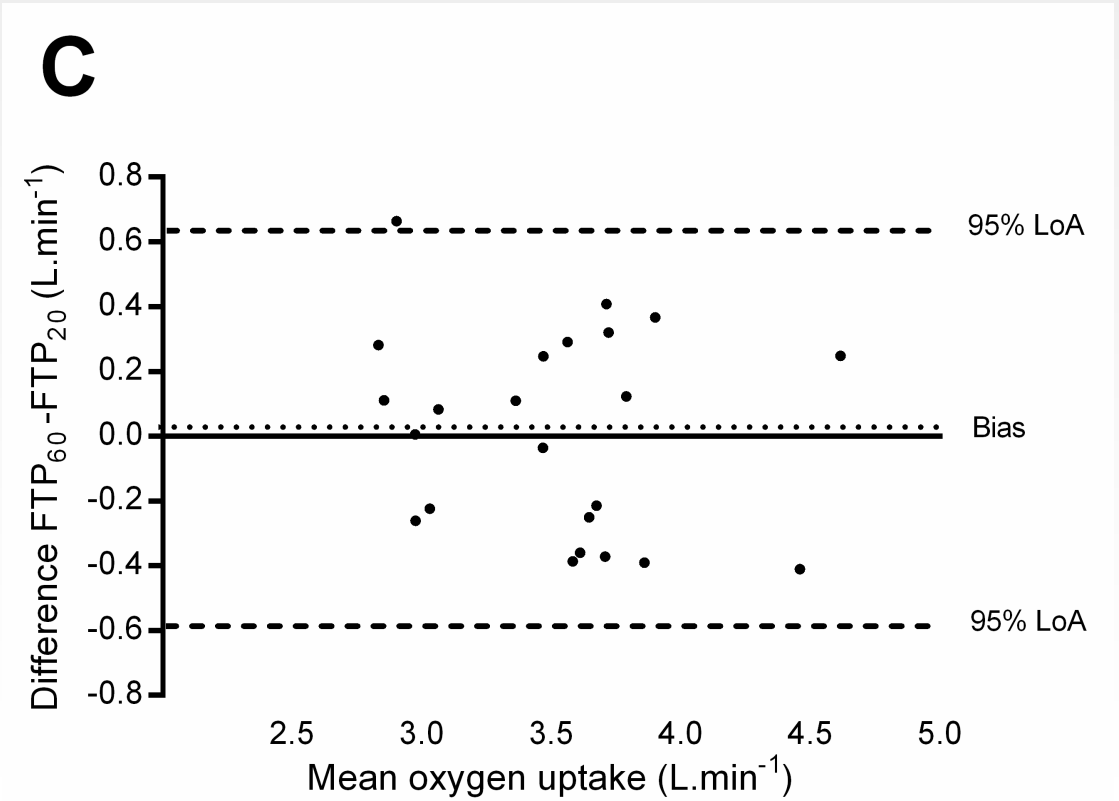
Results: Bland-Altman plots FTP_{60}-FTP_{20} Oxygen uptake



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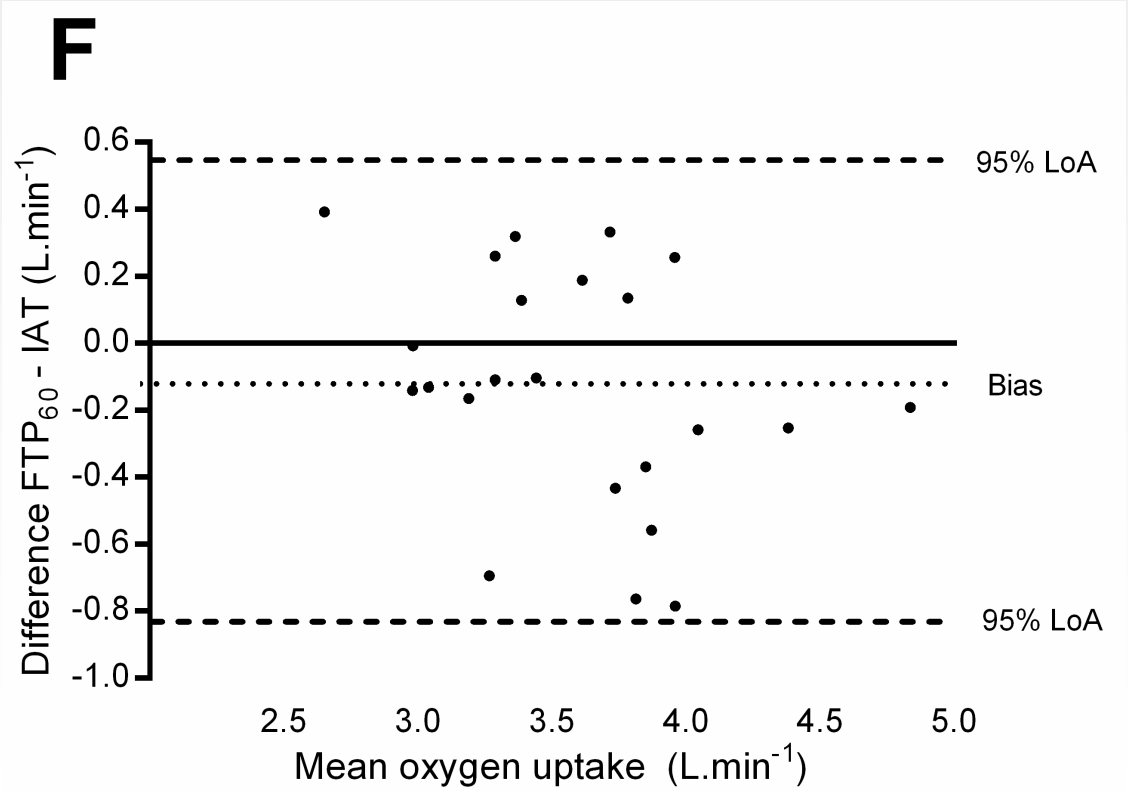
Results: Bland-Altman plots FTP_{60}-IAT Oxygen uptake



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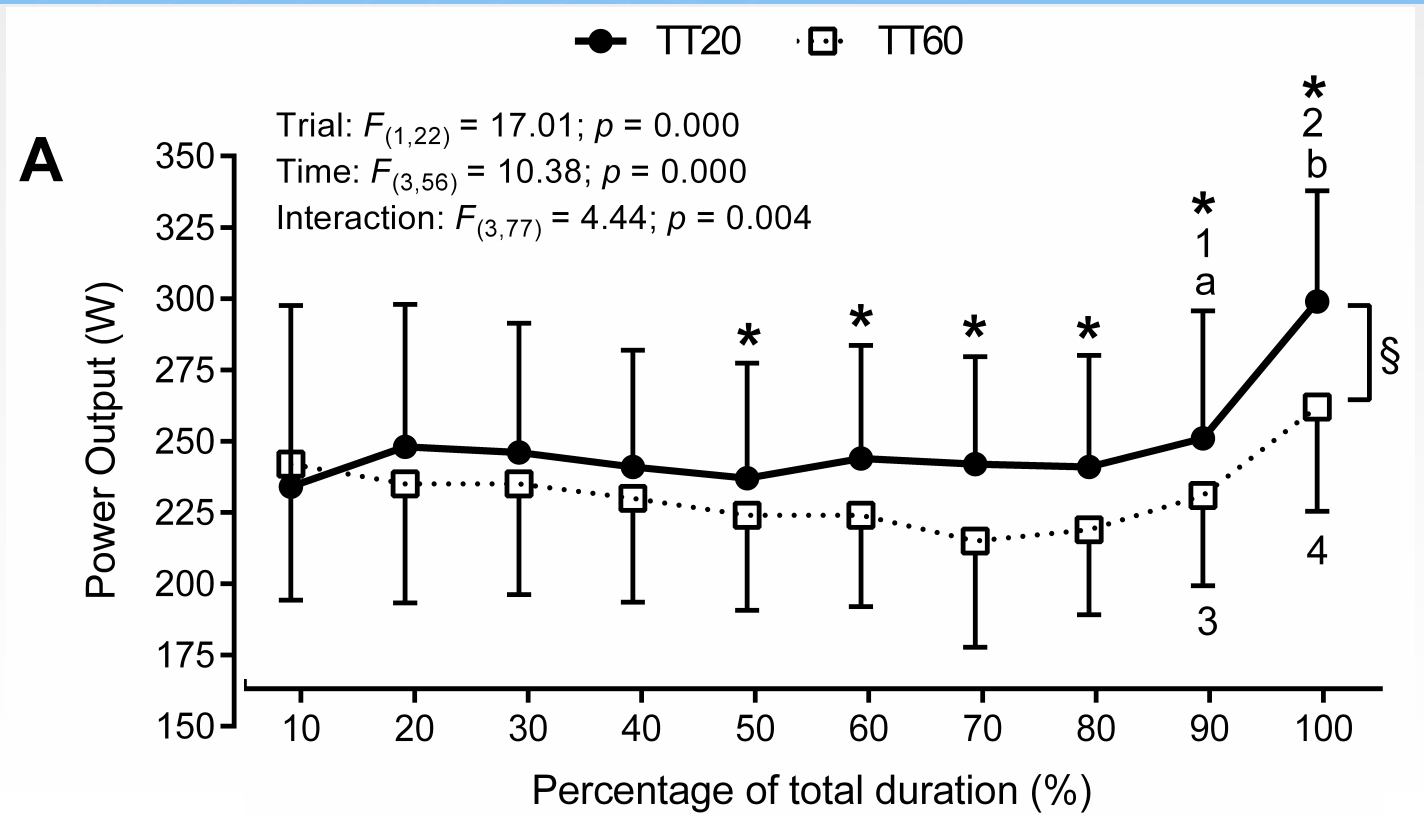
Results: Power output during time-trials



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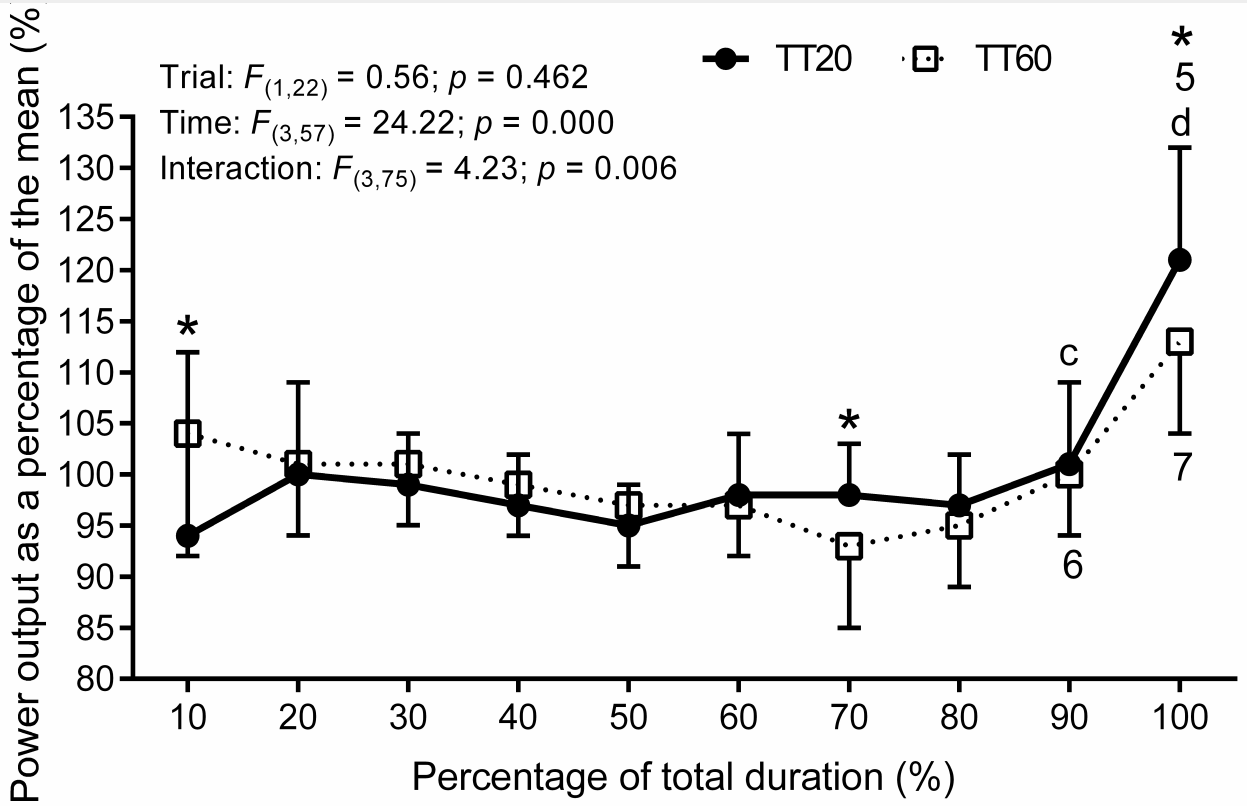
Results: Normalized power output during time-trials



War[illegible]p: ~ [illegible]min

5´: 10 [illegible]mmol.L^{-1}

Post: [illegible].5 ± 2.9 [illegible]mmol.L^{-1}

Recommendations

(McGowan et al. 2015):

~ 15 to 20 minutes [La]

< 3.0 mmol.L^{-1}

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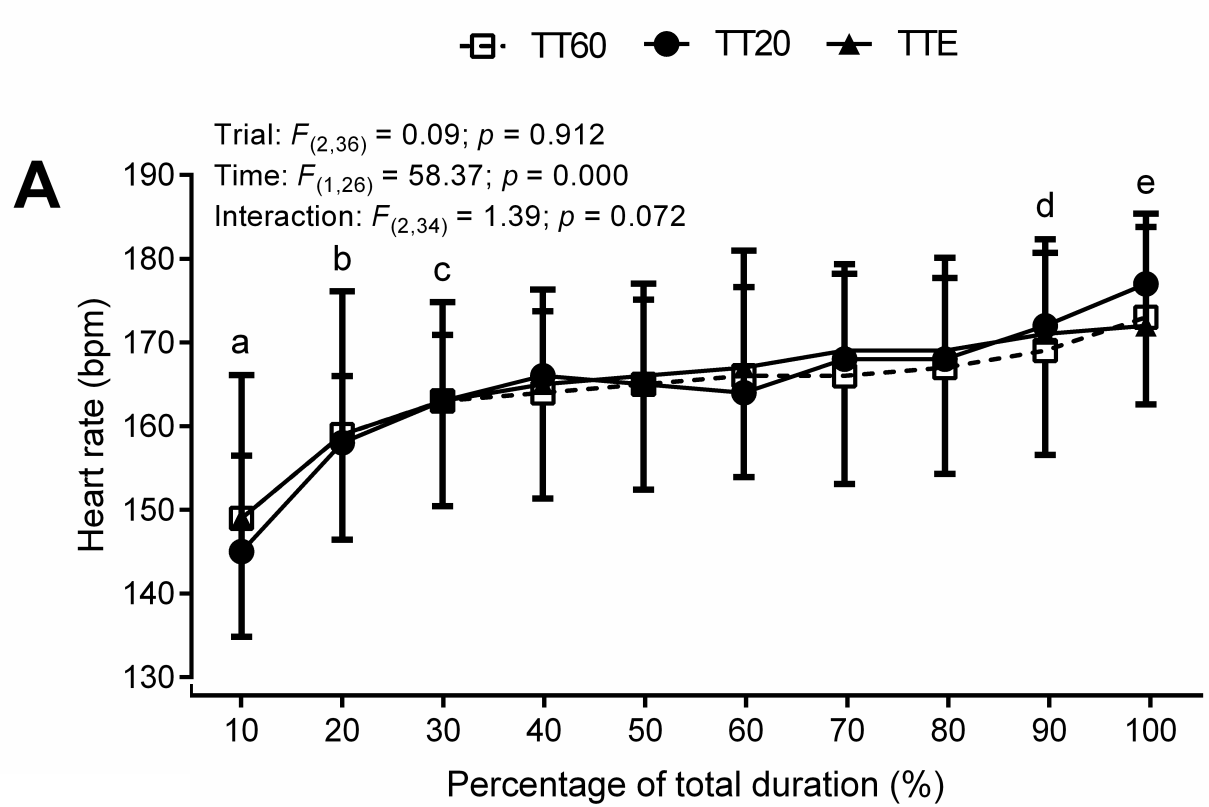
Results: Heart rate during TT and TTE



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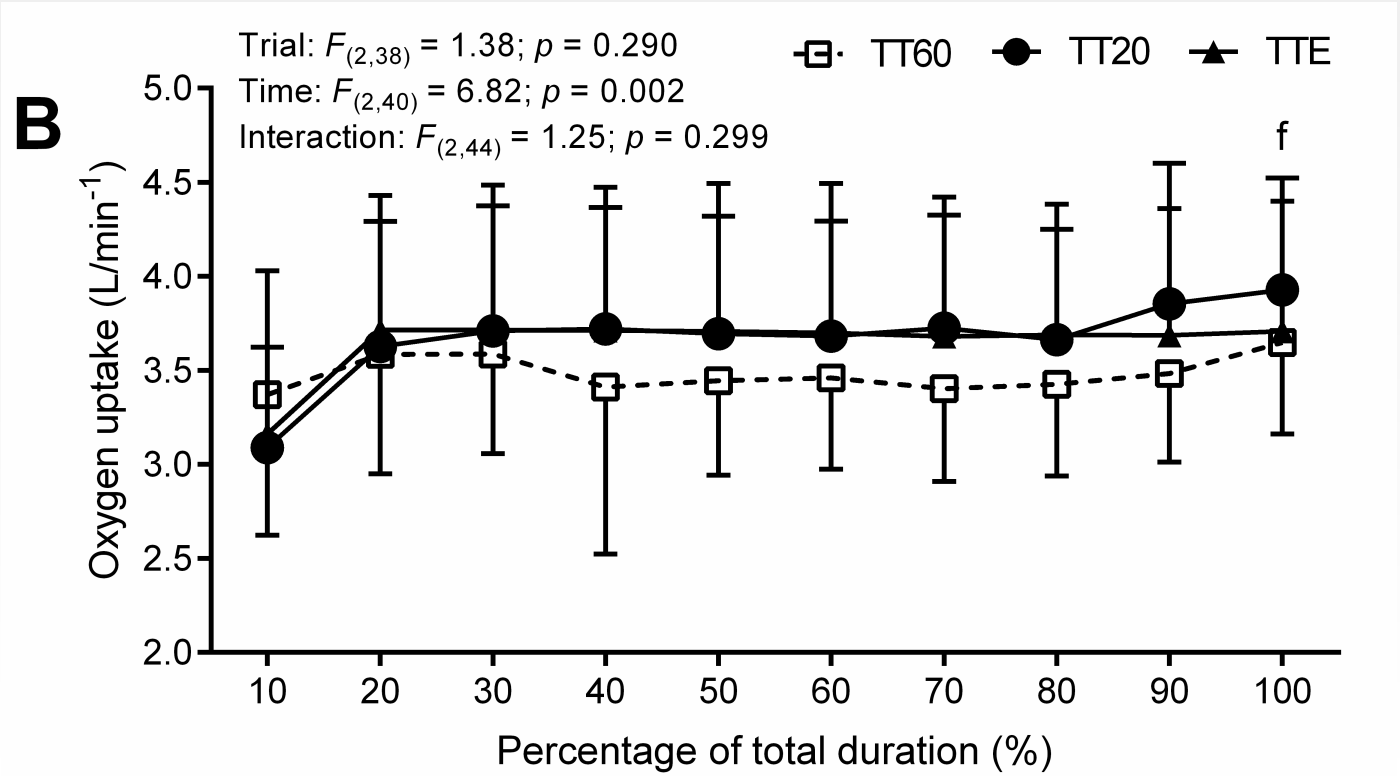
Results: Oxygen uptake during TT and TTE



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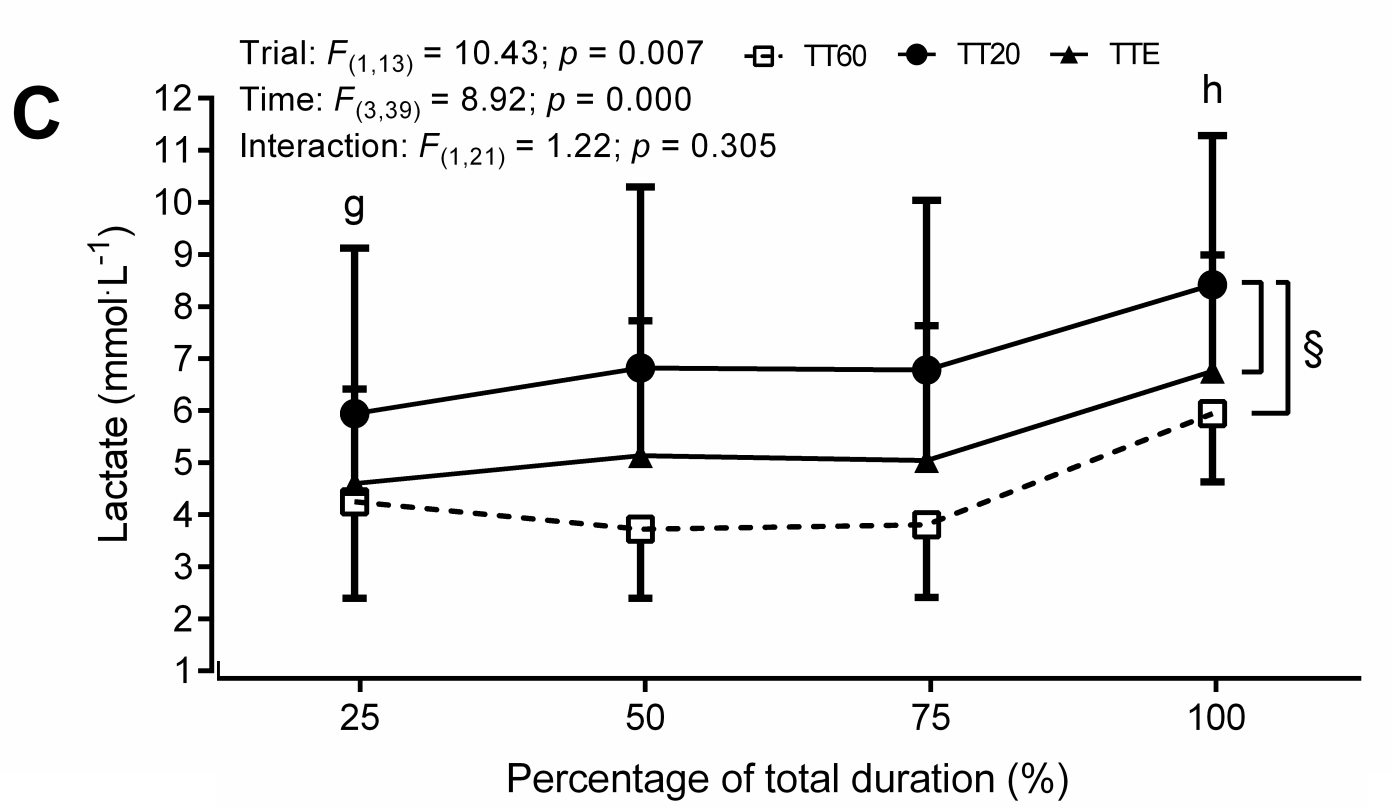
Results: Blood lactate during TT and TTE



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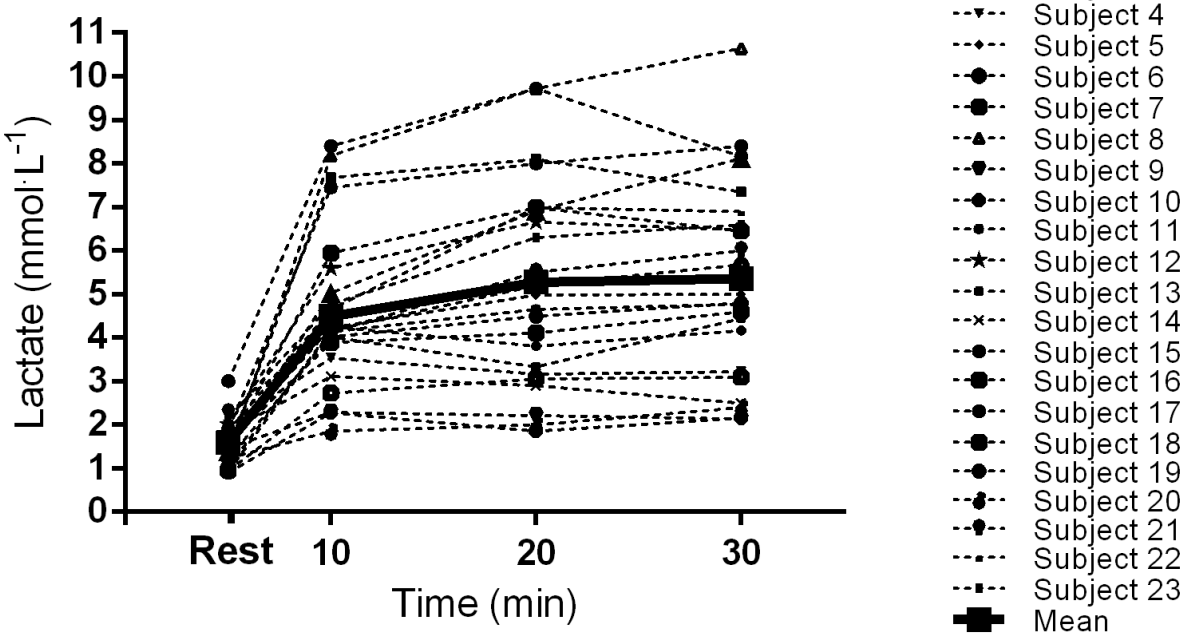
Results: Individual blood lactate response during TTE



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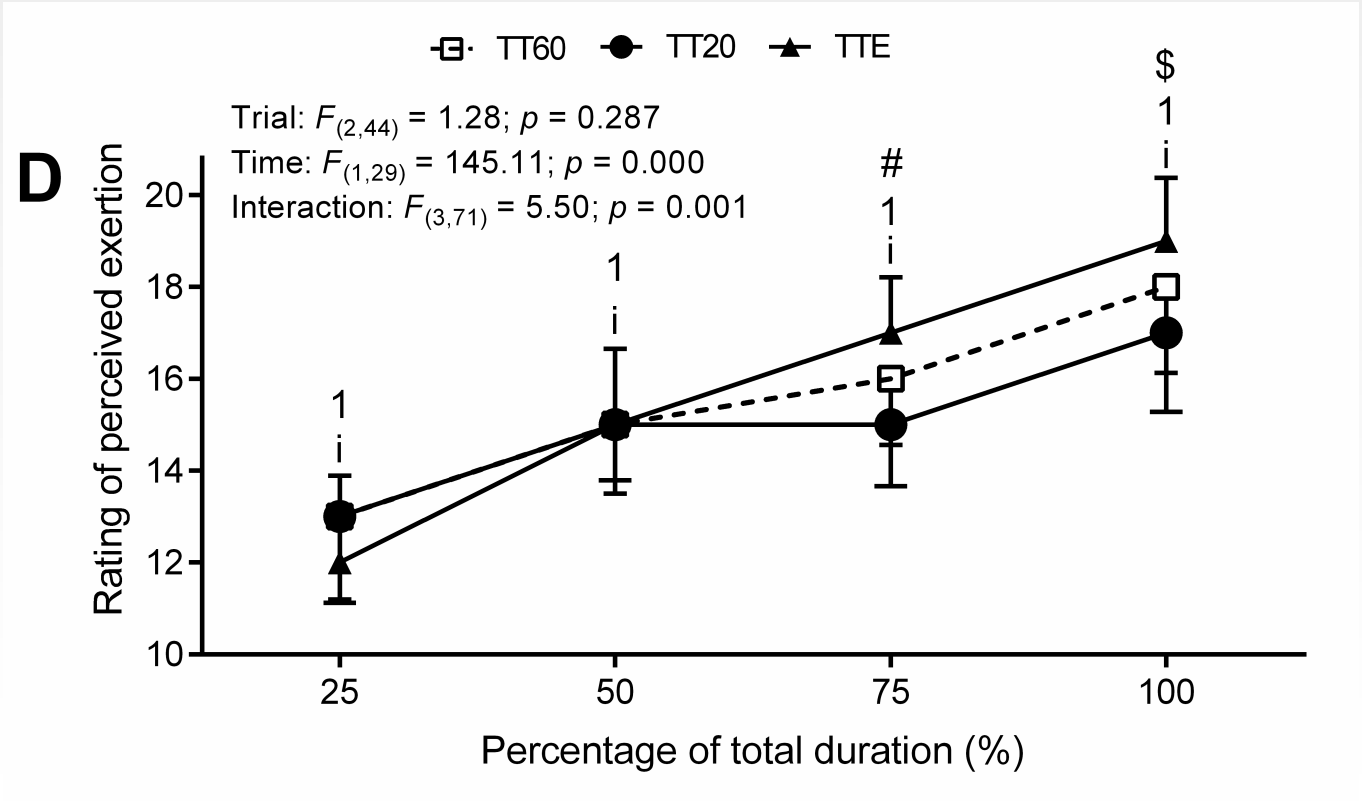
Results: RPE during TT and TTE



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Conclusions

- The mean PO, HR and VO_2 at FTP_{20} were equivalent with IAT and FTP_{60}. High and significant correlations were found between FTP_{20} with IAT and FTP_{60}. Also low bias and high limits of agreements were found between FTP_{20} with IAT and FTP_{60}. In addition, TTE at FTP_{20} (~ 51-min).
- The FTP_{20} warm-up (~45-min) is not in according with previous recommendations (McGowan et al. 2015) consequently cyclists appeared to perform a negative pacing strategy during a 20-min TT.
- This study gives an opportunity for coaches to include FTP_{20} test over a cycling season. However, the use of the FTP_{20} to estimate IAT and FTP_{60} should be analysed with caution due to high limits of agreements found between the variables.

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Thank you very much!

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