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Physiological Characteristics Associated with W′ and W′bal Used During Intermittent Exercise Task to Failure

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Background

Physiological determinants of W′ are not well understood.

W′ correlates with muscle volume in elite track cyclists (Kordi et al., 2021). Yet there are no correlations with muscle fibre composition (Vanhatalo et al., 2016; Mitchell et al., 2018).

It has, however, been suggested that muscle typology influences W'_{rec} following high intensity exercise (Lievens et al., 2020).

Having a greater understanding, could allow us to have strengthen our insight into what physiological components underpin W′ and thus tolerance to severe intensity exercise, which can be integrated into the W_{BAL} model and develop further training analytics

Aims of this study

Assess the relationship between **physiological performance characteristics and W′.**

To determine which characteristics were **associated** with the **total amount of work done above CP (W'_{total})** during an intermittent exercise task to failure, as repeated efforts are key to cycling performance (Mensapá et al., 2017)

W'_{rec} parameters were modelled, using different TAU calculations to assess which would predict a W'_{bal} of 0 kJ at exhaustion.

Methods

Visit 1

Lactate profile

VO_{2max} & MAP assessment

Visits 2 - 4

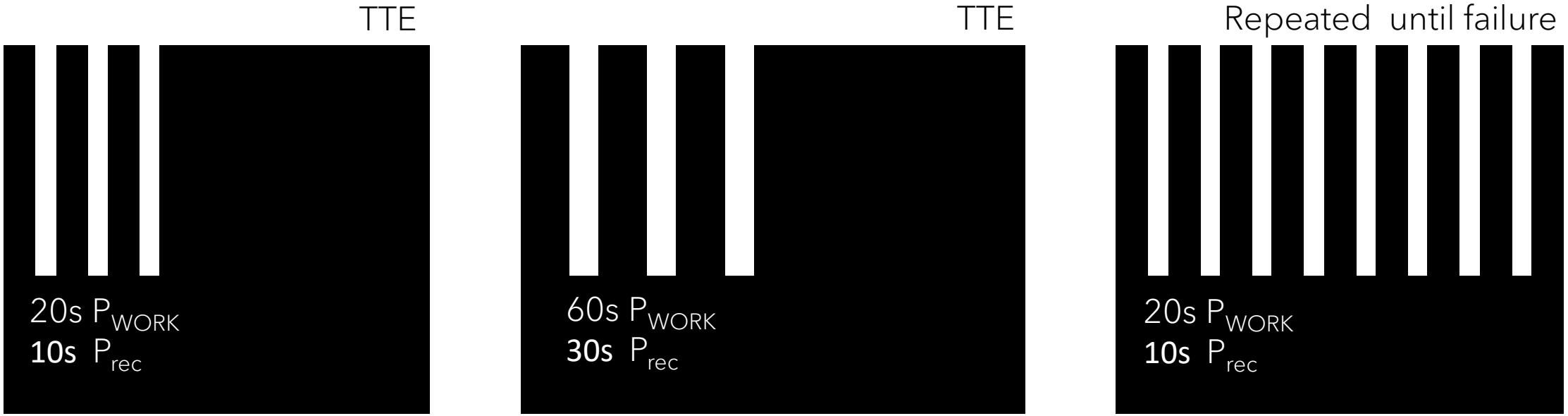
CP 3 min + P_{MAX}

CP 12 min + P_{MAX}

CP 3 + 12 min

Methods

Visits 5 – 7 – Intermittent trials



P_{WORK}
P_4 + (50% ΔCP P_4)

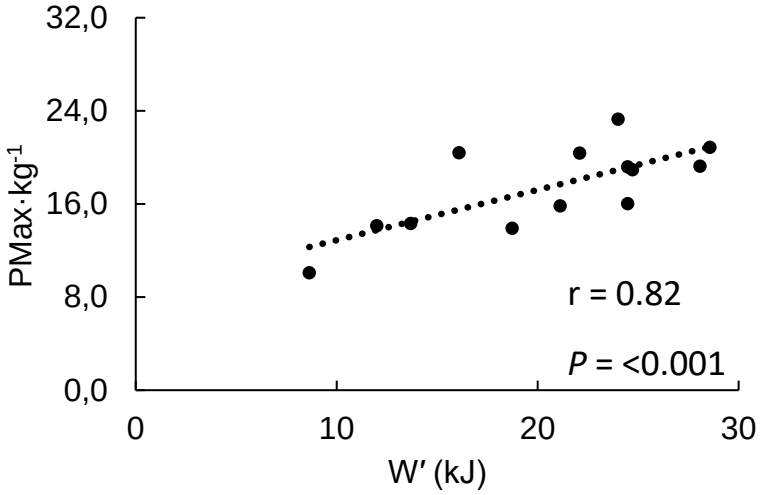
P_{rec}
50% of LT_1
Baseline + 0.4 mMol·L^{-1}

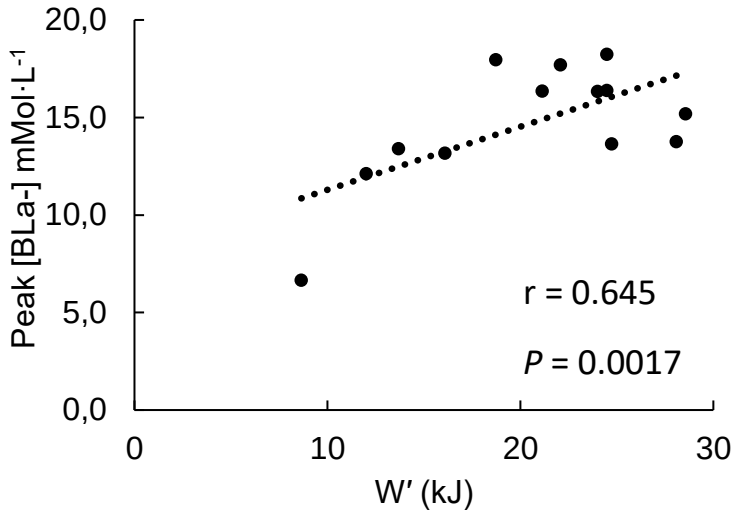
Results

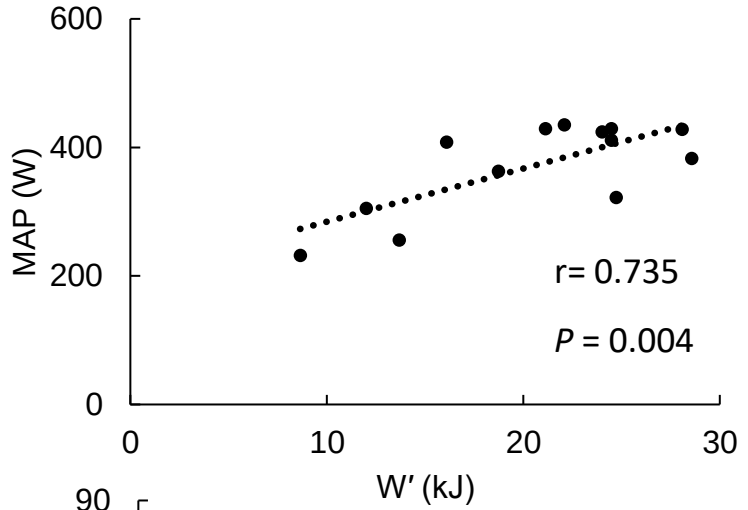
	Mean ± SD	Range
Participant Characteristics		
Age (y)	24 ± 8	19 -50
Height (m)	1.8 ± 0.1	1.64 - 1.86
Mass (kg)	69 ± 7	57 - 81
Performance Parameters		
$VO_{2\ Max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	58 ± 9	39 - 71
MAP (W)	371 ± 70	232 - 435
CP (W)	274 ± 46	187 - 325
W' (kJ)	20.6 ± 6.5	8.6 - 28.6
$LT_{1\ BL+0.4}$ $mmol \cdot L^{-1}$	193 ± 37	130 - 240
$LT_{2\ FBC4}$ $mmol \cdot L^{-1}$	256 ± 42	185 - 305
P_{MAX} (W)	1215 ± 307	627 - 1723
$[Bla^-]_{Peak}$ $mmol \cdot L^{-1}$	14.7 ± 3.1	6.7 - 18.3

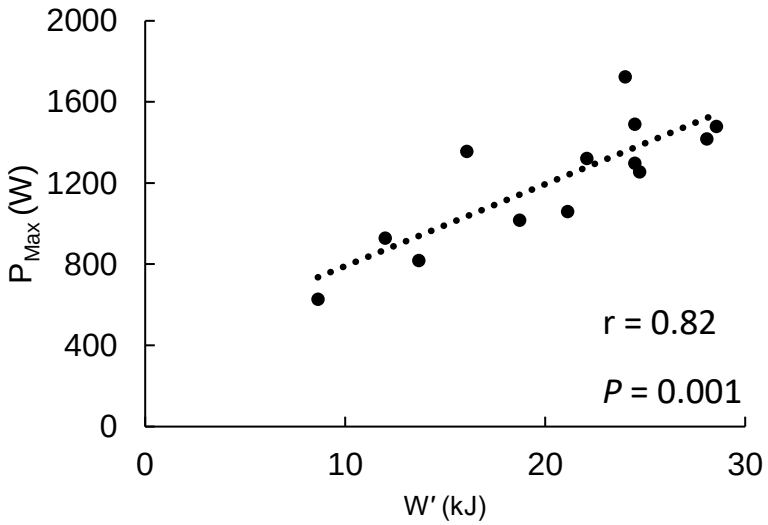
Abbreviations: CP, critical power, W', curvature constant, P_{MAX}, Peak 1s maximal power. BLa, blood lactate

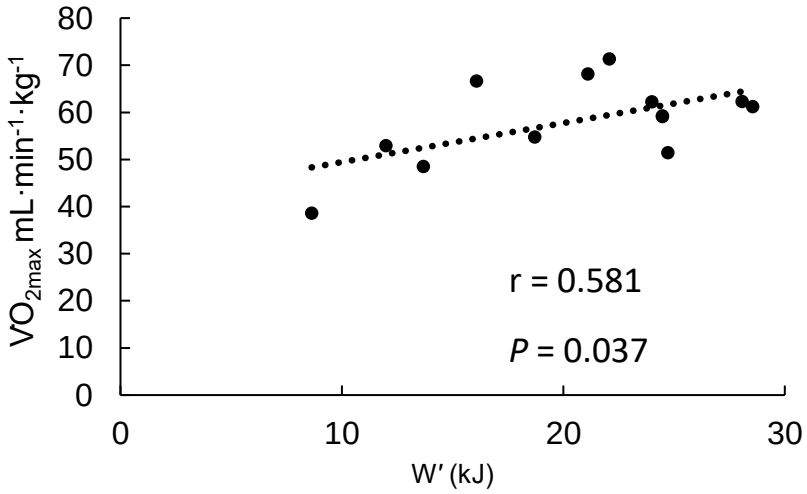
Performance characteristics associated with W′

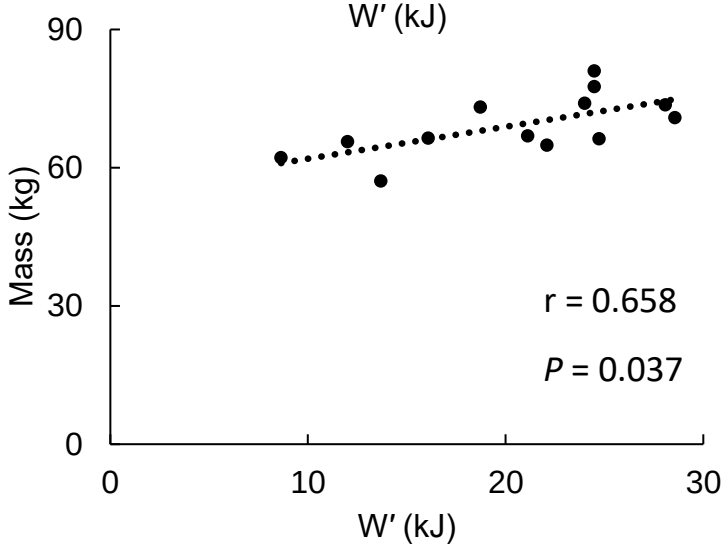




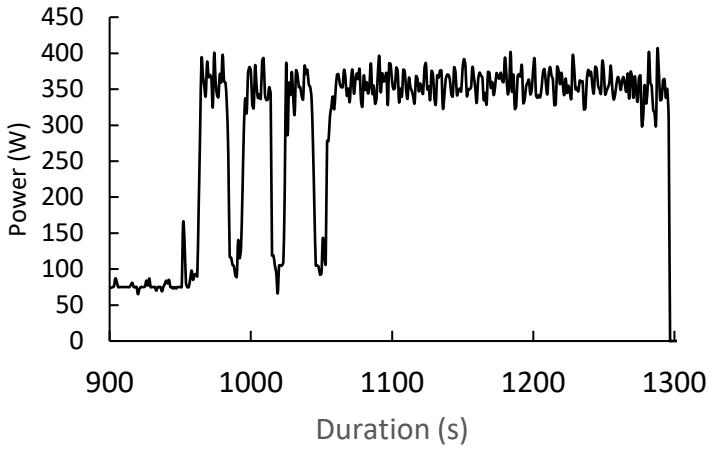


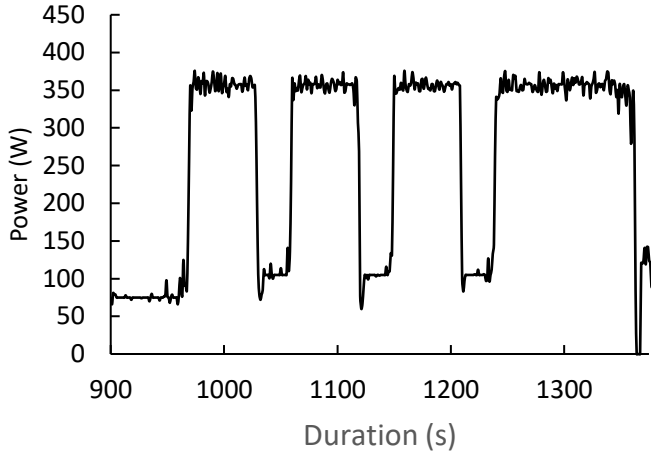


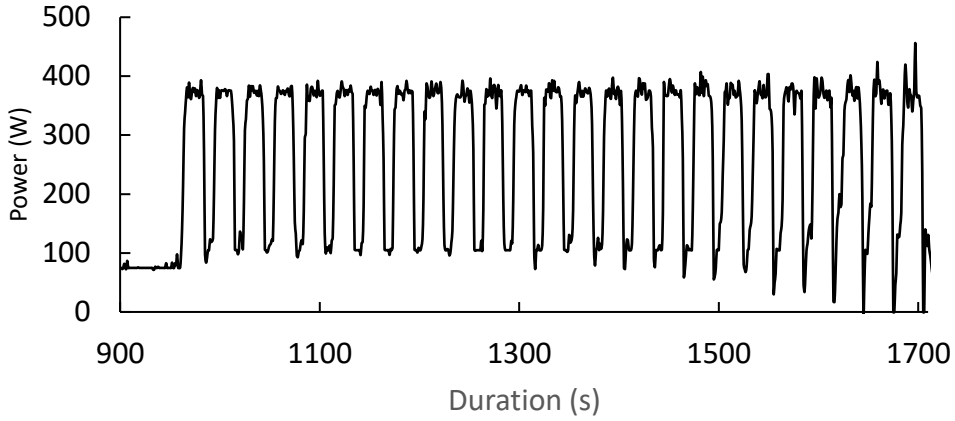


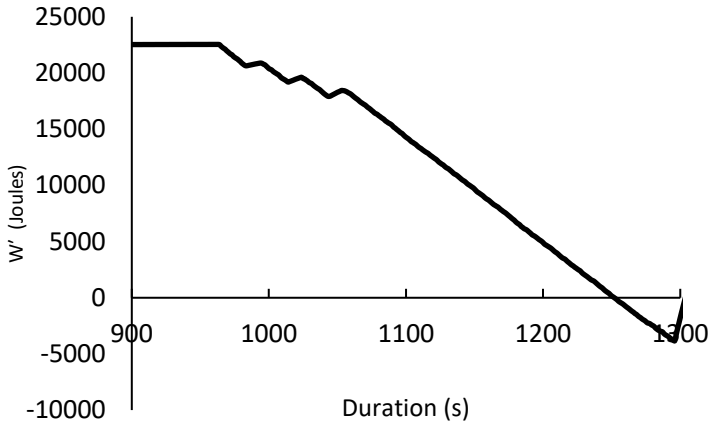


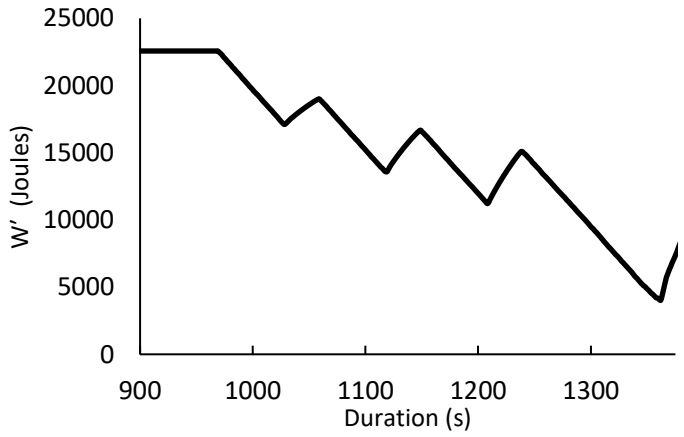
Example of participant data – Intermittent trials

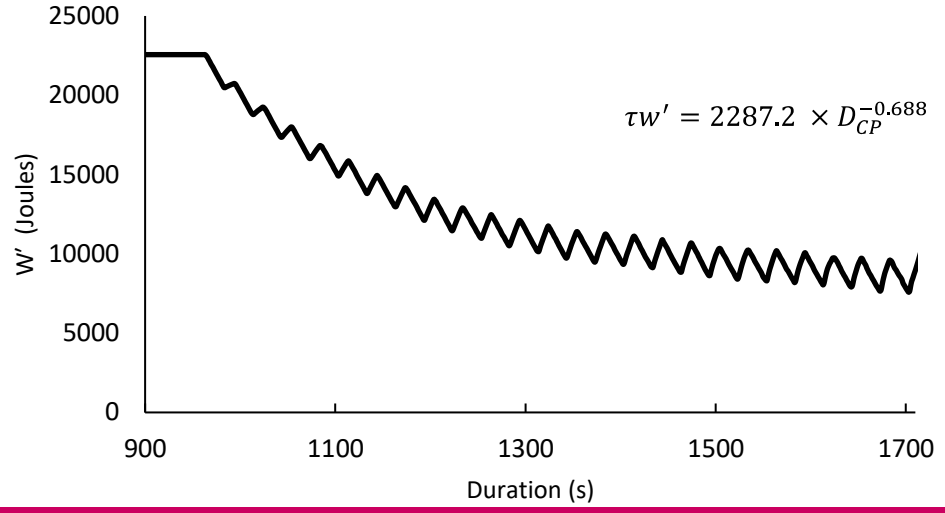




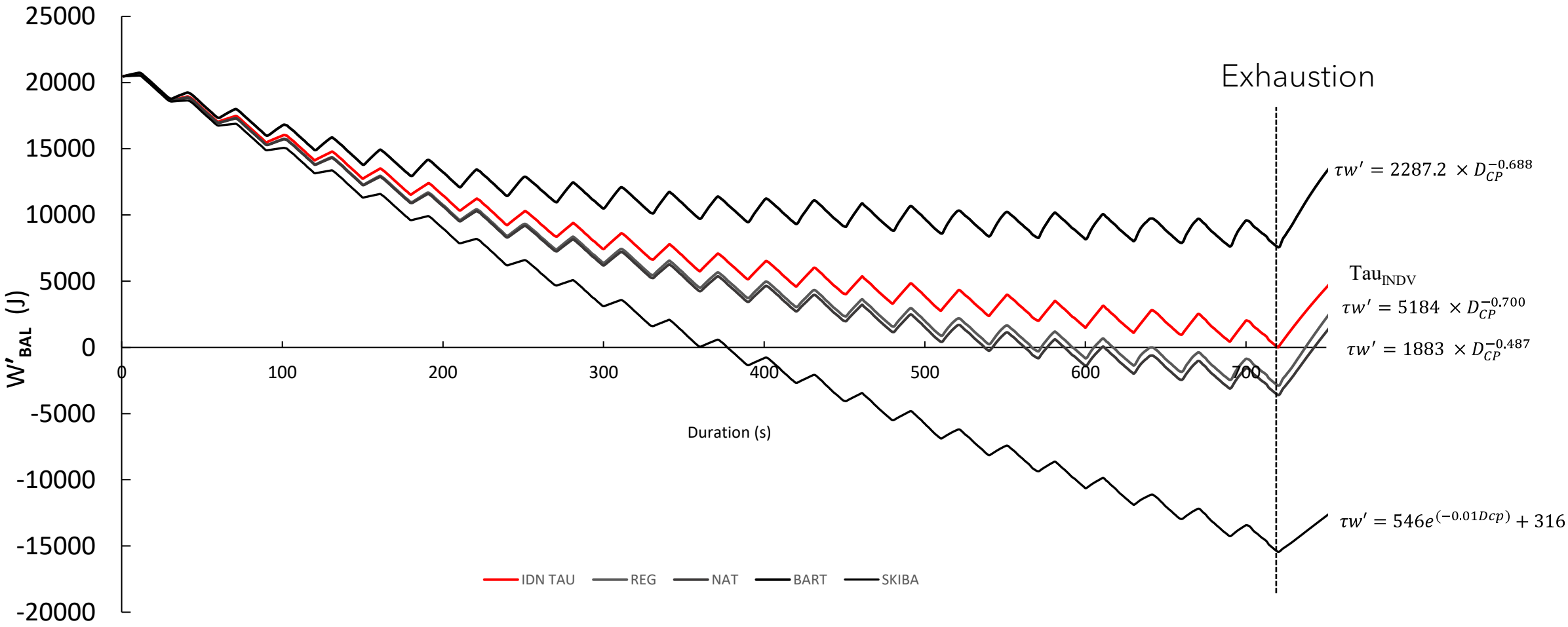




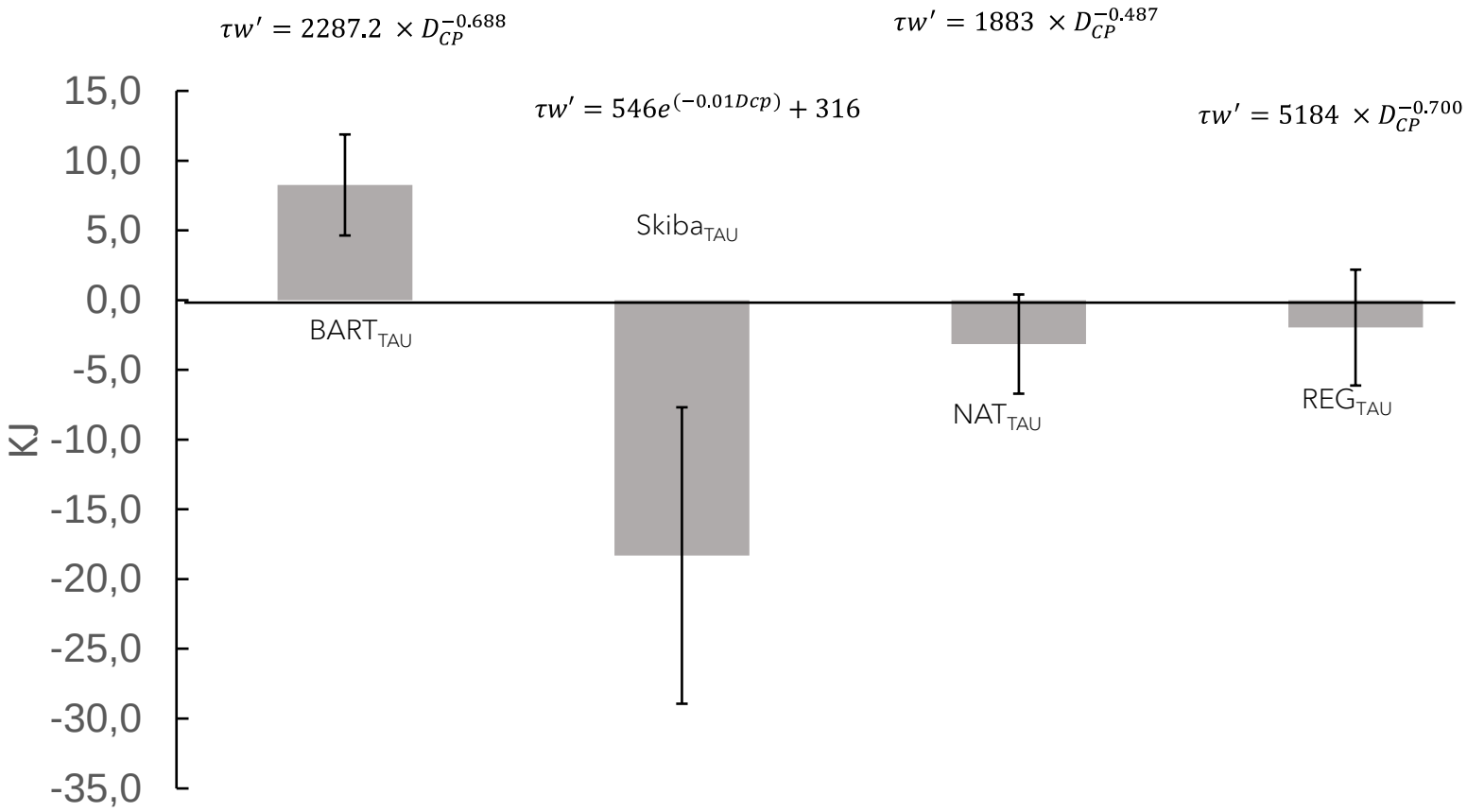




W'_{BAL} at task failure during 20:10

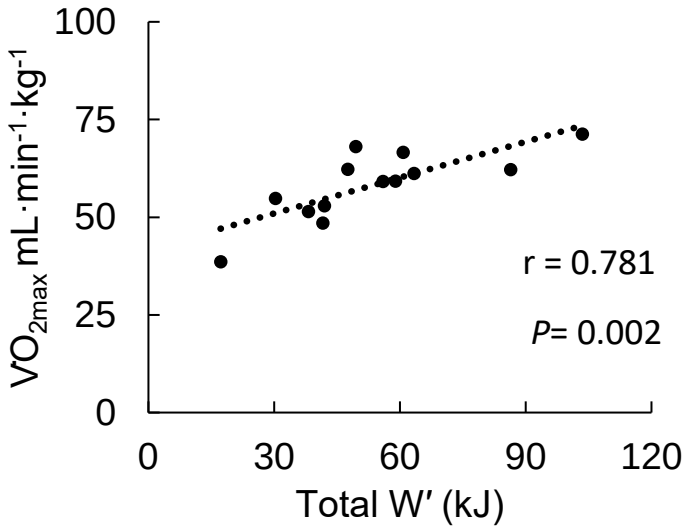


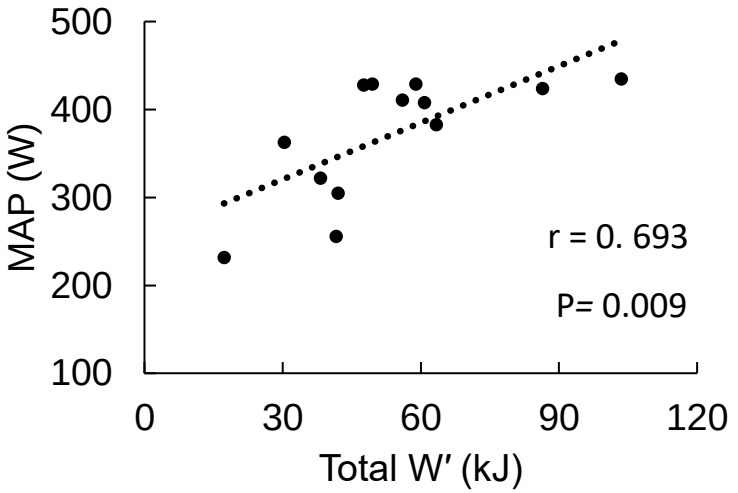
W'_{BAL} at task failure during 20:10

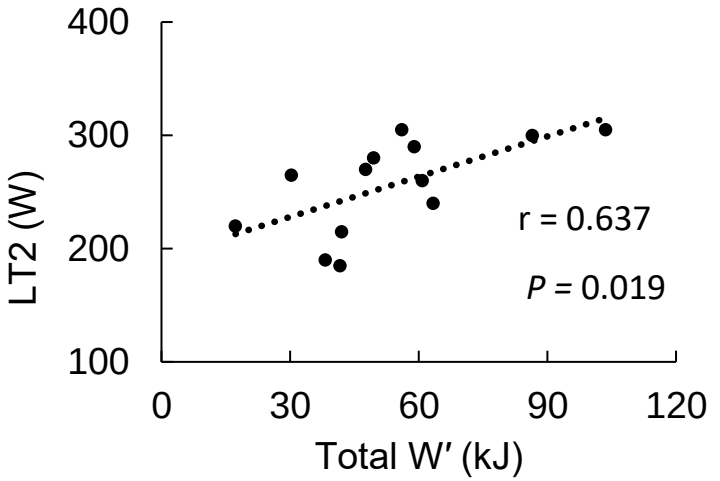


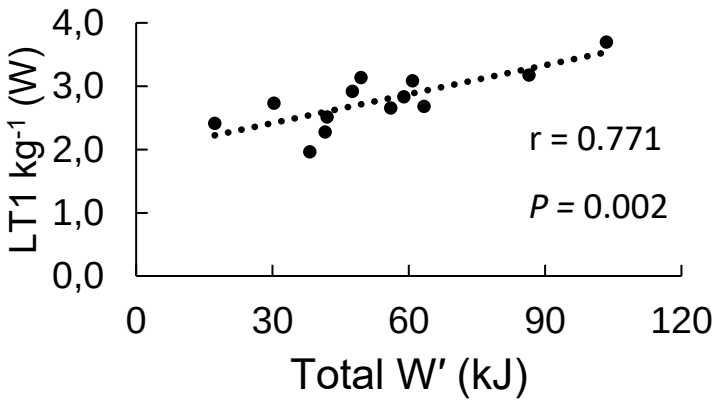
Mean W'_{BAL} noted at failure between the different TAU calculations $SKIBA_{TAU}$ -18.3 [10.6 kJ] ; REG_{TAU} -2 [4.2] kJ; NAT_{TAU} -3.1 [3.6] kJ; $BART_{TAU}$ 8.3 [3.6] kJ. $BART_{TAU}$

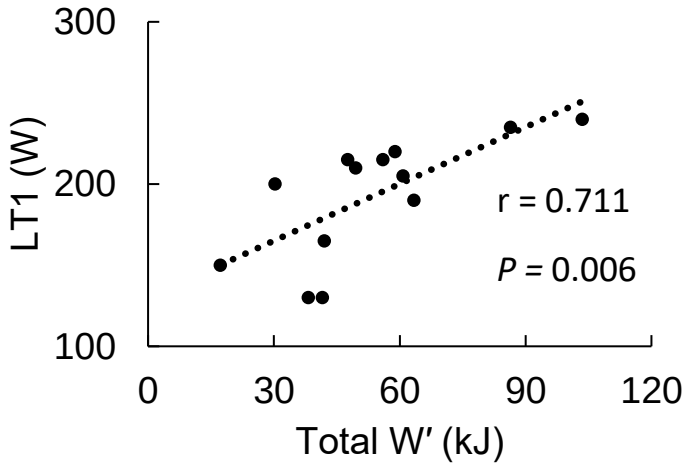
Performance characteristics associated with work done above CP (W'_{total})

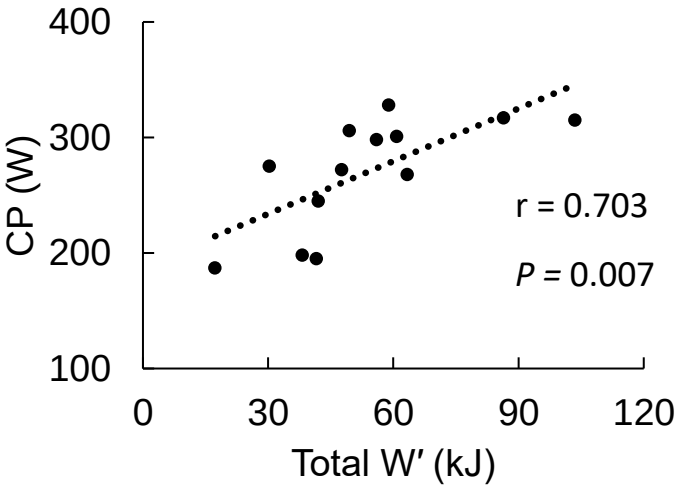




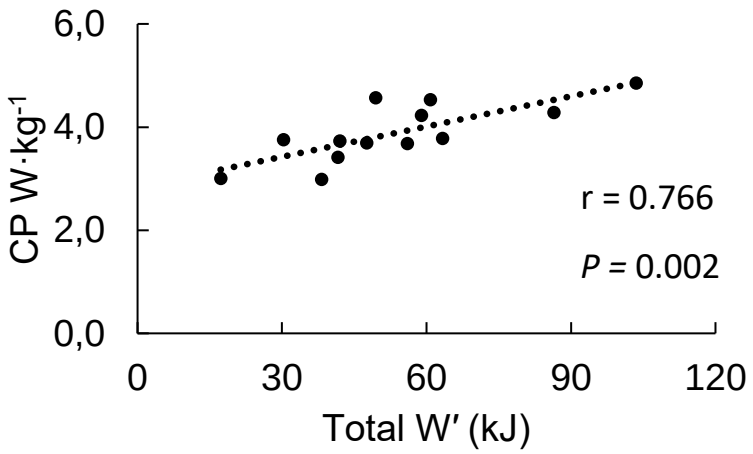


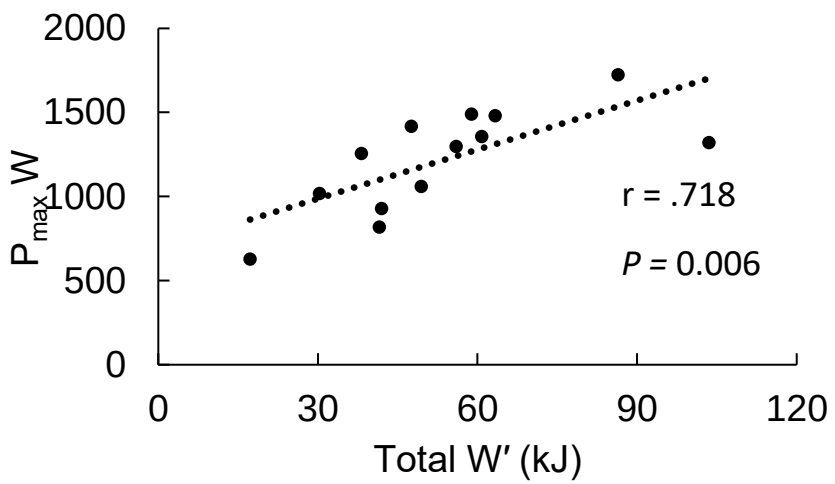


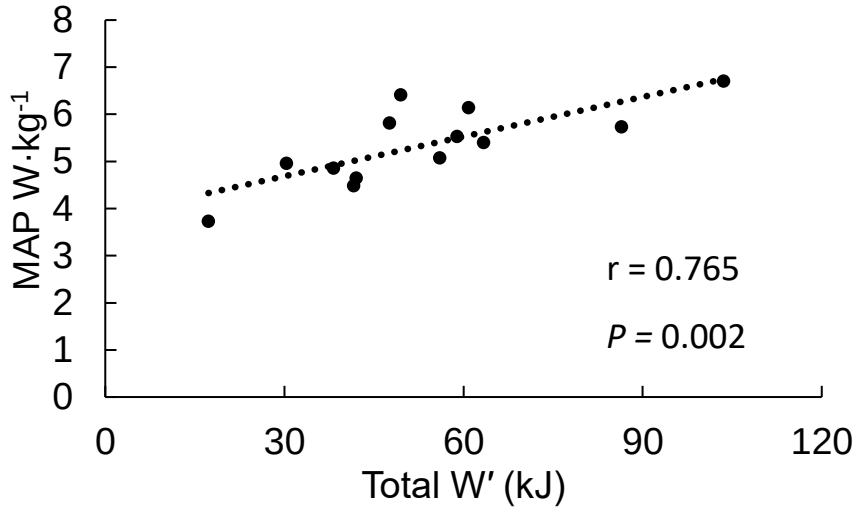


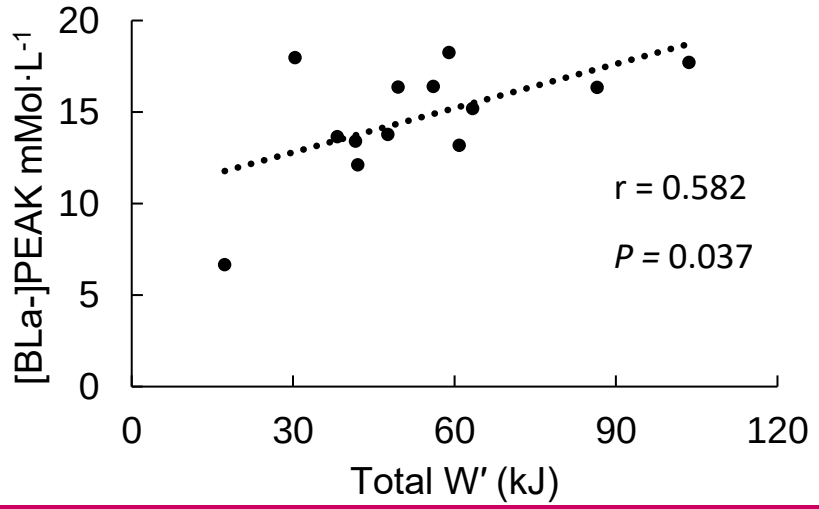


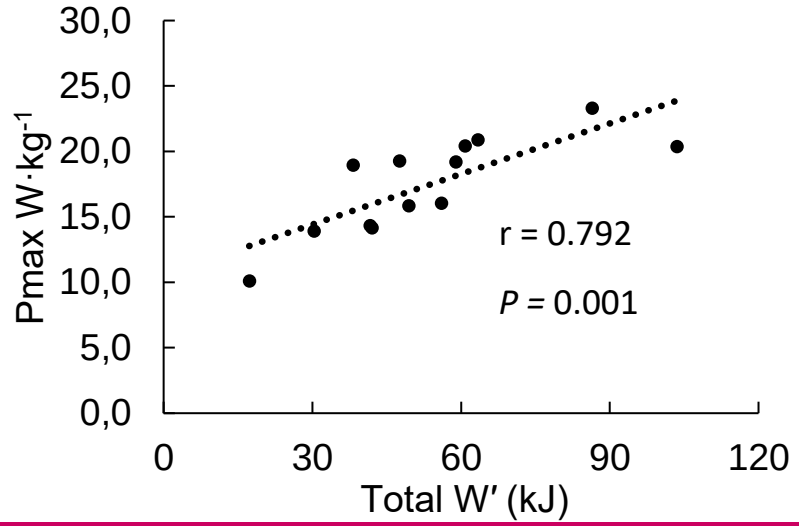
Performance characteristics associated with work done above CP (W'_{total})



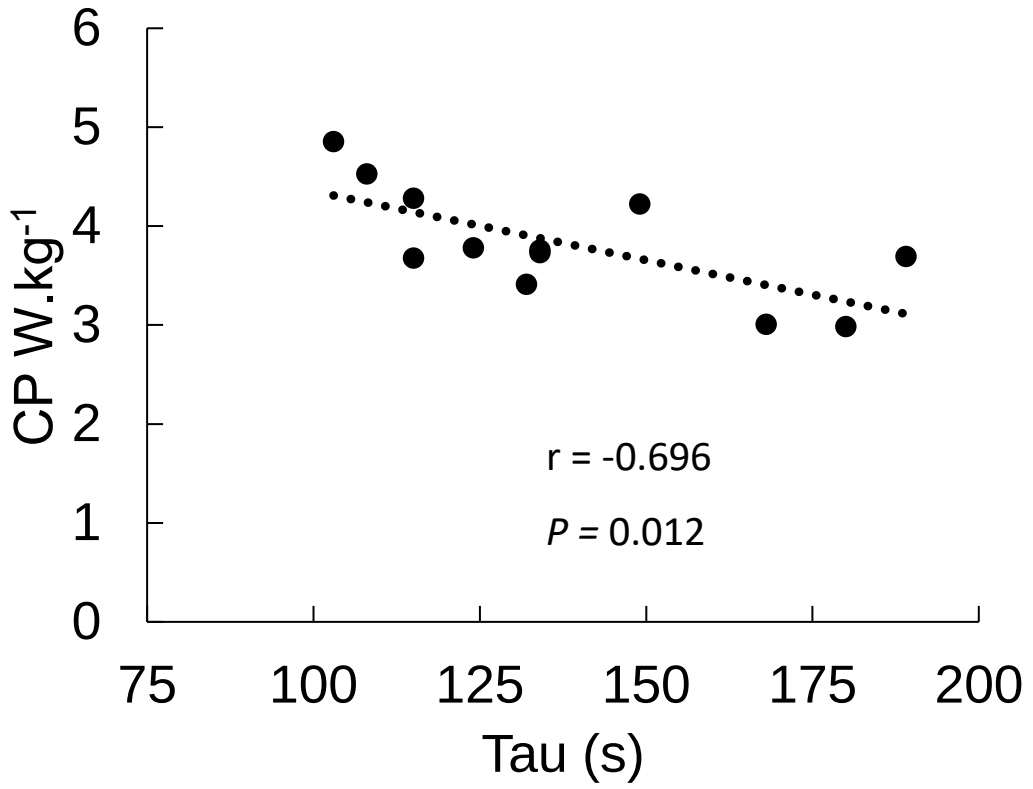


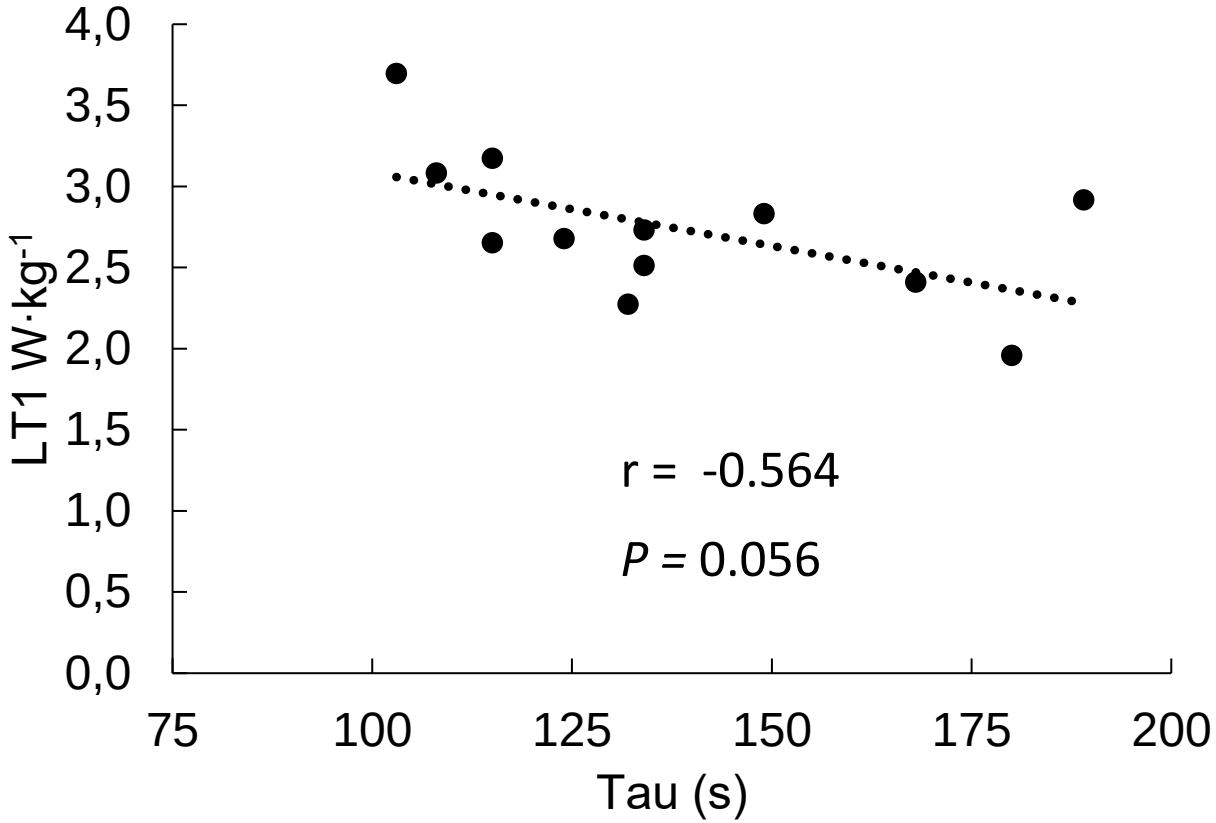






Performance characteristics associated with TAU_{IND}





Take home message and practical implications

We demonstrate the importance of **CP, LT_1 and P_{max}** normalised to body mass with W'_{total} during severe intensity intermittent exercise.

These data suggest that W′ has **many contributing factors**, with P_{max} and MAP being of particular importance, suggesting an interaction between aerobic and anaerobic contributions.

Take home - P_{max} should be part of a CP/W′ assessment

Thank you

Questions

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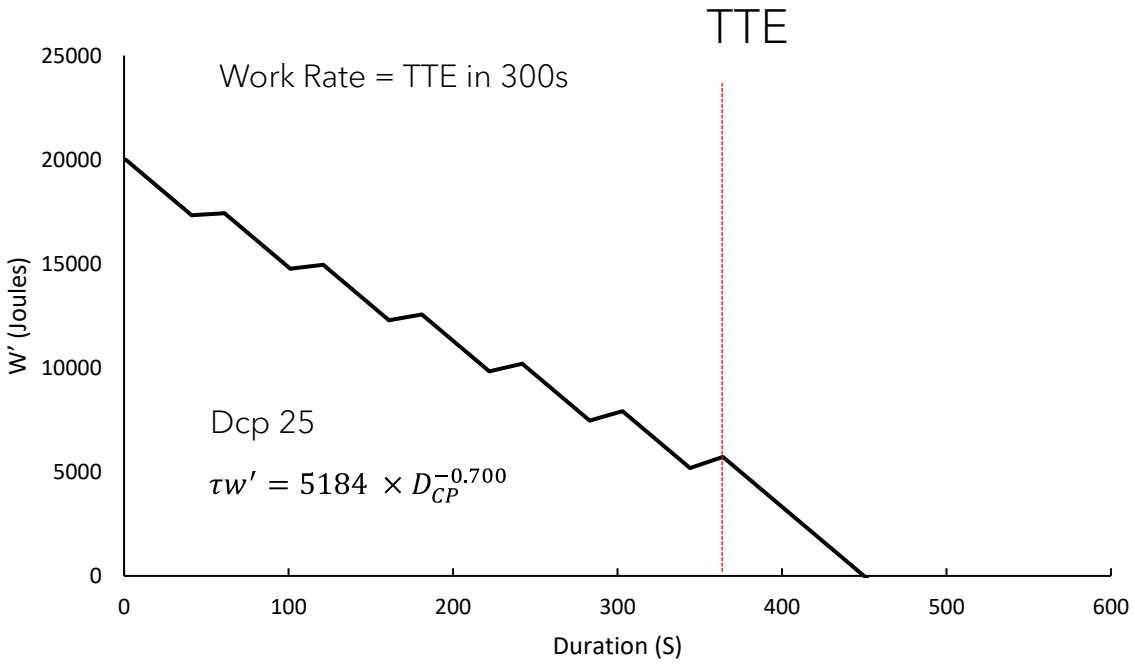
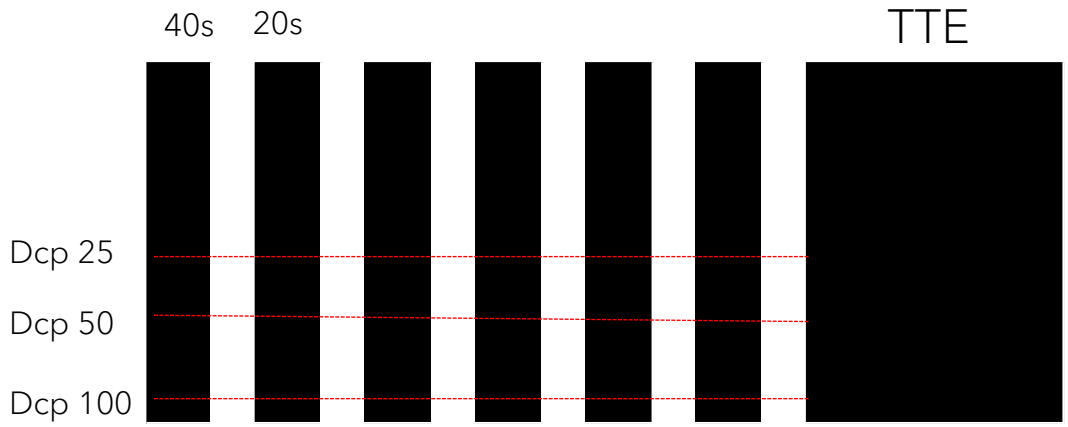
Further practical implications

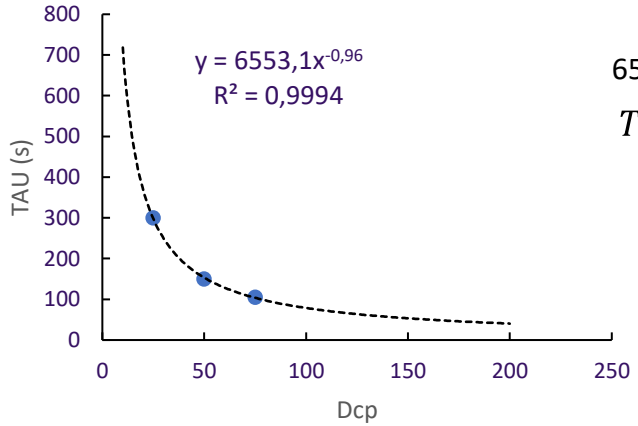
Finally, we propose the use of TAU as a training metric, allowing the assessment of whether an individual is improving their rate of recovery, something not yet considered.(TAU_{REC})

Furthermore, due to the large variances in the W'_{bal} remaining at the point of task failure it suggests that the current models need further improvement, likely developed with a more standardised protocol to establish individualised TAU values.

Suggested Protocol







$6553.1 \cdot Dcp^{-0.96}$

$Tau = A \cdot D_{CP}{}^{B}$

Supplementary information

Power data from the three intermittent exercise trials along with CP and W′ were used to calculate W'_{BAL} using the formula below.

$$W'_{BAL} = \begin{cases} W'_{bal_{,i\_1}} - ([P_{i\_} CP] \cdot \Delta\mu, P_i > CP \\ W'_0 - W'_{expended} \cdot (e^{-\frac{\Delta\mu_i}{tau}}), Pi_{<} CP \end{cases}$$

(1)

Where i=the i^{th} segment of the total time subdivided into n segments at 1 Hz, $(\Delta\mu)_{P_i}$ = mean power output for the segment i. W'_{bal} is calculated sequentially and $W'_{BAL_{i\_1}}$ represents the preceding estimation of W'_{bal}. $W'_{expended}$ is the quantity of the depleted W′ at i_1 and is calculated as:

$$W'_{expended} - W'_0 - W'_{bal_{,i\_1}},$$

(**2**)

The recovery time constant for the W'_{BAL} was calculated with four different version, the first variation used equation 4 below (Skiba et al., 2012)

$$\tau w' = 546e^{(-0.01Dcp)} + 316$$

(3)

The below equations for the reconstitution time constant $\tau w'$ (s) is calculated by the power function of Dcp- $\tau w'$ in which A represent the scaling factor and B represents the rate of decay,

$$Tau = A \cdot D_{CP}{}^{B}$$

(4)

$$\tau w' = 2287.2 \times D_{CP}^{-0.688}$$

(5)

Equation 6 Bartram et al. (2018) and equations 7 and 8 are generalised from national (NAT) and regional level track cyclists respectively from the work of Pugh et al. (2022)

$$\tau w' = 1883 \times D_{CP}^{-0.487}$$

(6)

$$\tau w' = 5184 \times D_{CP}^{-0.700}$$

(7)

Upon completion of the interment trial of 20s on 10s until failure, a single TAU value was given and generalised for each participant using the excel solve function to give a W'_{BAL} of 0 at the point of task failure producing Tau_{INDV},