Field Application of an Omni Power-Duration Model in Swimming

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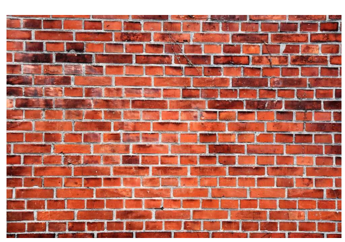
Overview

1. Background

2. Methods

3. Insights



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Background

- **Mathematical modelling in human performance**
  - Emerging technological innovation (e.g., power meters)
- Improvements in training prescription, testing and athlete profiling (Clarke & Skiba, 2013; Leo et al., 2021)

Anaerobic Power Reserve Model

Short Durations <2 mins

Critical Power (CP)/ W'

2-15 mins

Perronet & Thibault Model

Long Durations >15 mins

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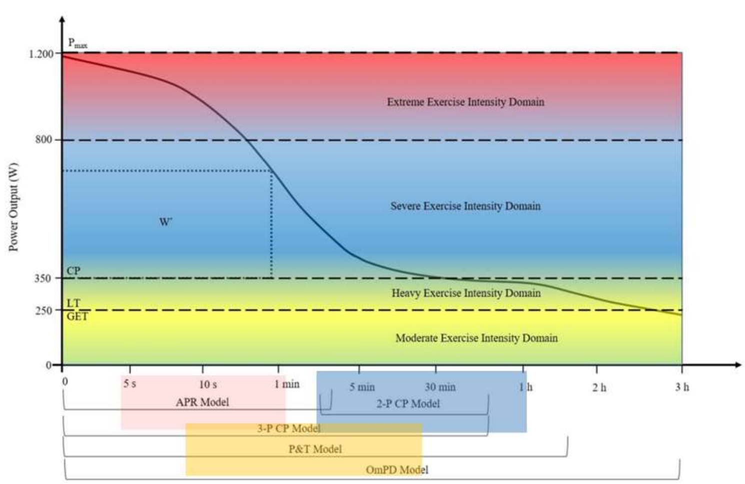
The Omni-Domain Power Duration Model



Leo et al., 2021

- Developed using mean maximal power (MMP) data from trained cyclists (Puchowicz et al., 2020)

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Project Aims

Aim

To determine whether the Omni-PD is an effective method to estimate the critical power (CP) and W' to characterise a swimmer's physiological capacity and quantify performance.

Objectives

1. Internal validation of model to compare goodness of fit for different equations of CS/D'.
2. Determine level of agreement between Omni-PD and pre-existing methods of calculating CS/D'.
3. External Validation of CS/D' calculated using the Omni-PD against race performances within a 1-month window.

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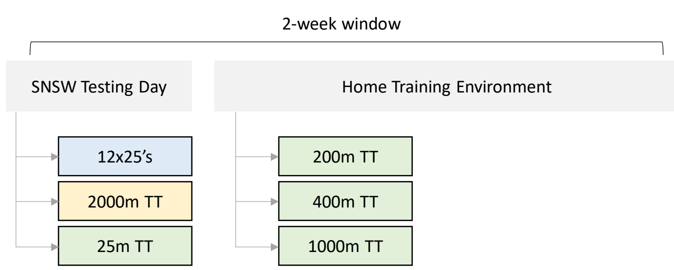
Data Collection

- **Participants**
  - 15 athletes, male and female, age 16-24 years old.
  - Members of the Swimming NSW Performance Pathway – Flippers Squad
    - Highly trained / National Level (McKay et al., 2022)

1. TT Data and 12x25's Test



Modified 3-min all-out *(Mitchell & Pyne et al., 2018)*
Maximal sustainable aerobic speed *(Swimming Australia)*
2-parameter critical speed/D' *(Monod & Scherrer, 1965)*

2. Race Results

- Race results for each subject collected from **NSW State Championships** (- 1 month from test date)
  - Freestyle events only
- Obtained using publicly assessable databases from Swimming Australia (Results Central and Live Results)

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Pragmatic Data Analysis

1

How do the different CS equations/inputs differ?

2

Does a 2-parameter CS/D’ agree with 12x25’s test and 2000m velocity?

3

Can critical power/ omni-PD be used to predict race performance?

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Initial Findings

How do the different CS equations/inputs differ?

- 25m TT, 200m TT, 400m TT and 1000m TT used to fit CS/D’ model
- **Observations**

  1/time model using a combination of 200, 400 and 1000m TT appears to give lowest RMSE

  Combinations of only 2 TT’s appear to give a similar CS value to the 1/time model (+/-0.1ms^{-1})

Critical Speed							
Inputs				Model	CS	D'	RMSE
25	200	400	1000	3-hyp	1.31	25.58	3.51
25	200	400	1000	2-hyp	1.32	20.93	18.75
25	200	400	1000	Lin	1.33	13.75	6.72
25	200	400	1000	1/time	1.38	6.58	0.04
25	200	400		2-hyp	1.33	17.31	20.98
25	200	400		Lin	1.37	9.08	5.49
25	200	400		1/time	1.4	6.26	0.04
25	200		1000	2-hyp	1.32	19.05	22.91
25	200		1000	Lin	1.33	12.35	8.25
25	200		1000	1/time	1.38	6.54	0.06
25		400	1000	2-hyp	1.32	21.2	26.19
25		400	1000	Lin	1.34	10.78	7.36
25		400	1000	1/time	1.35	6.82	0.02
	200	400	1000	2-hyp	1.32	21.39	7.12
	200	400	1000	Lin	1.32	20.81	0.76
	200	400	1000	1/time	1.32	20.19	0.01
25	200			Lin	1.43	5.85	
25	200			1/time	1.43	5.85	
25		400		Lin	1.37	6.59	
25		400		1/time	1.37	6.59	
25			1000	Lin	1.34	7.03	
25			1000	1/time	1.34	7.03	
	200	400		Lin	1.33	19.42	
	200	400		1/time	1.33	19.42	
	200		1000	Lin	1.32	20.29	
	200		1000	1/time	1.32	20.29	
		400	1000	Lin	1.32	21.87	
		400	1000	1/time	1.32	21.87	

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Initial Findings

Level of Agreement with Pre-existing Methods

Does a 2-parameter CS/D' agree with 12x25's test and 2000m velocity?

	CS Comparison		
	TT CS	1225 CS	2000m Vel.
Athlete 1	1.32		1.31
Athlete 2	1.35		1.33
Athlete 3	1.48		1.38
Athlete 4	1.22		1.21
Athlete 5	1.36	1.71	1.44
Athlete 6	1.29		
Athlete 7	1.29	1.74	
Athlete 8	1.43		
Athlete 9	1.37	1.72	
Athlete 10	1.33	1.64	1.38
Athlete 11	1.35	1.85	1.43
Athlete 12	1.33		1.32
Athlete 13	1.41		1.45
Athlete 14	1.34	1.63	
Athlete 15	1.34	1.70	

	D' Comparison	
	TT D'	1225 D'
Athlete 1	20.19	
Athlete 2	26.6	
Athlete 3	23.61	
Athlete 4	27.71	
Athlete 5	37.56	21.21
Athlete 6	28.16	
Athlete 7	28.16	12.03
Athlete 8	9.25	
Athlete 9	36.46	27.27
Athlete 10	27.2	12.19
Athlete 11	39.24	21.63
Athlete 12	19.39	
Athlete 13	26.22	
Athlete 14	34.52	24.69
Athlete 15	36.45	22.51

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Initial Findings

Can Critical Power / Omni-PD be used to predict race performance?

- Best race performance from NSW Senior State Champs
  - Determined by World Record Ratio (WRR)

- Transformed all data into metabolic power (Capelli et al., 1998)
  - N.B. Including TT Results

- Used CP/W' values to predict metabolic power for best event

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Initial Findings

Can Critical Power / Omni-PD be used to predict race performance?

Case Study A: Middle Distance Athlete

Best Event:	200m FS
Time(s):	127.82
Power (w):	414

Model Inputs	**CP** *watts*	**W'** *kJ*	**200m FS Pred.** *watts*	**Δ Actual vs pred.** *%*
Time Trial Data	246	16.3	374	-10%
Race Result Data	301	15.3	420	1%

Case Study B: Sprint Athlete

Best Event:	100m FS
Time(s):	50.58
Power (w):	831

Model Inputs	**CP** *watts*	**W'** *kJ*	**100m FS Pred.** *watts*	**Δ Actual vs pred.** *%*
Time Trial Data	269	28.1	826	-1%
Race Result Data	455	14.5	741	-11%

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Initial Findings

Can Critical Power / Omni-PD be used to predict race performance?

Case Study B: Sprint Athlete

Best Event:	100m FS
Time(s):	50.58
Power (w):	831

Model Inputs	Pmax *watts*	CP *watts*	W' *kJ*	100m FS Pred. *watts*	Δ Actual vs pred. *%*
Time Trial Data		269	28.1	826	-1%
Race Result Data		455	14.5	741	-11%
Race Result Data + Omni PD Model	**2600**	**455**	**14.5**	**828**	**-0.4%**

The omni-PD model:

$$P(t) = \frac{W'}{t}\left(1 - e^{-t\frac{Pmax-CP}{W'}}\right) + CP; t \leq TCPmax$$

Puchowicz et al., 2020

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Limitations

Population Size

Capelli Equations

Finding a suitable determination of Pmax

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