Muscle deoxygenation kinetics in cycling time trials

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Science & Cycling Conference 2018 Nantes,
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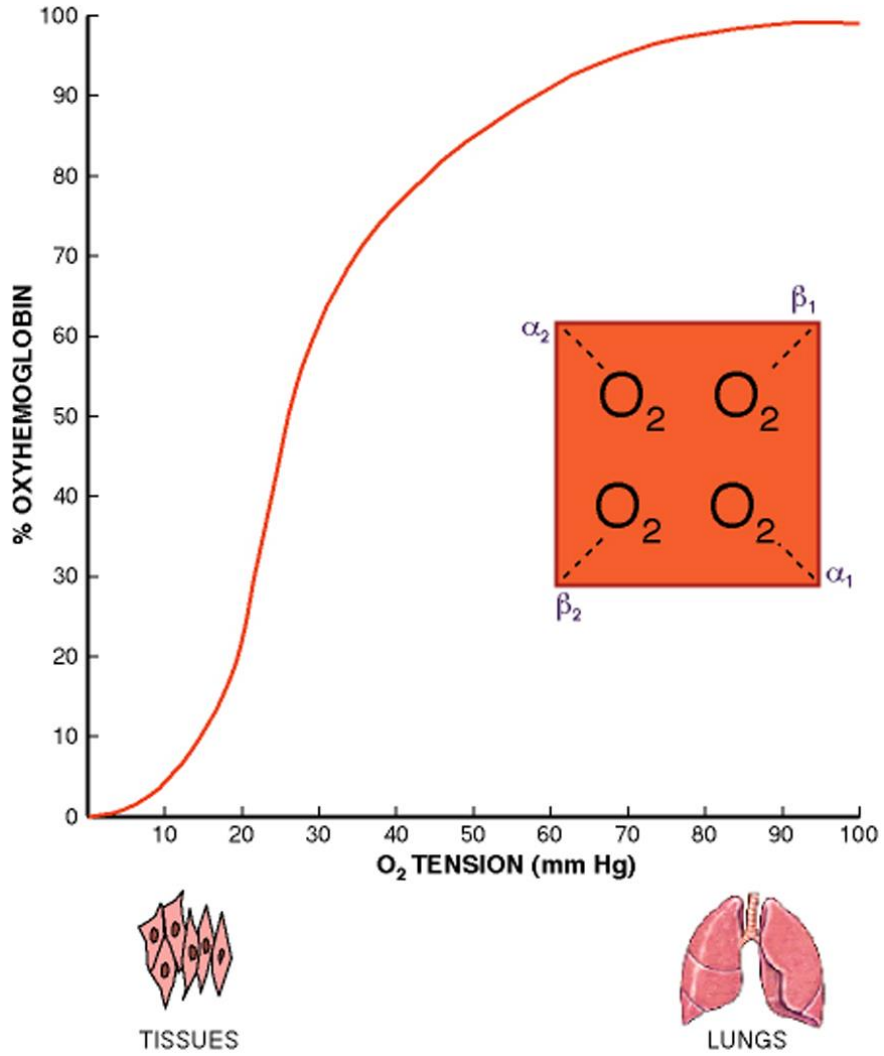
Background

- Muscle deoxygenation kinetics ($\dot{V}O_{2m}$) of deoxygenated hemoglobin
- Measured by near infrared spectroscopy (NIRS)
- Information about the oxygen extraction rate at the muscular level
- No studies have yet shown the effects of $\dot{V}O_{2m}$ during cycling time trials in field conditions
- The aim of this study is to investigate changes in $\dot{V}O_{2m}$ derived from deoxygenated hemoglobin in endurance trained athletes

Chance, B., & Williams, G. (1955), Grassi, B., & Quaresima, V. (2016)

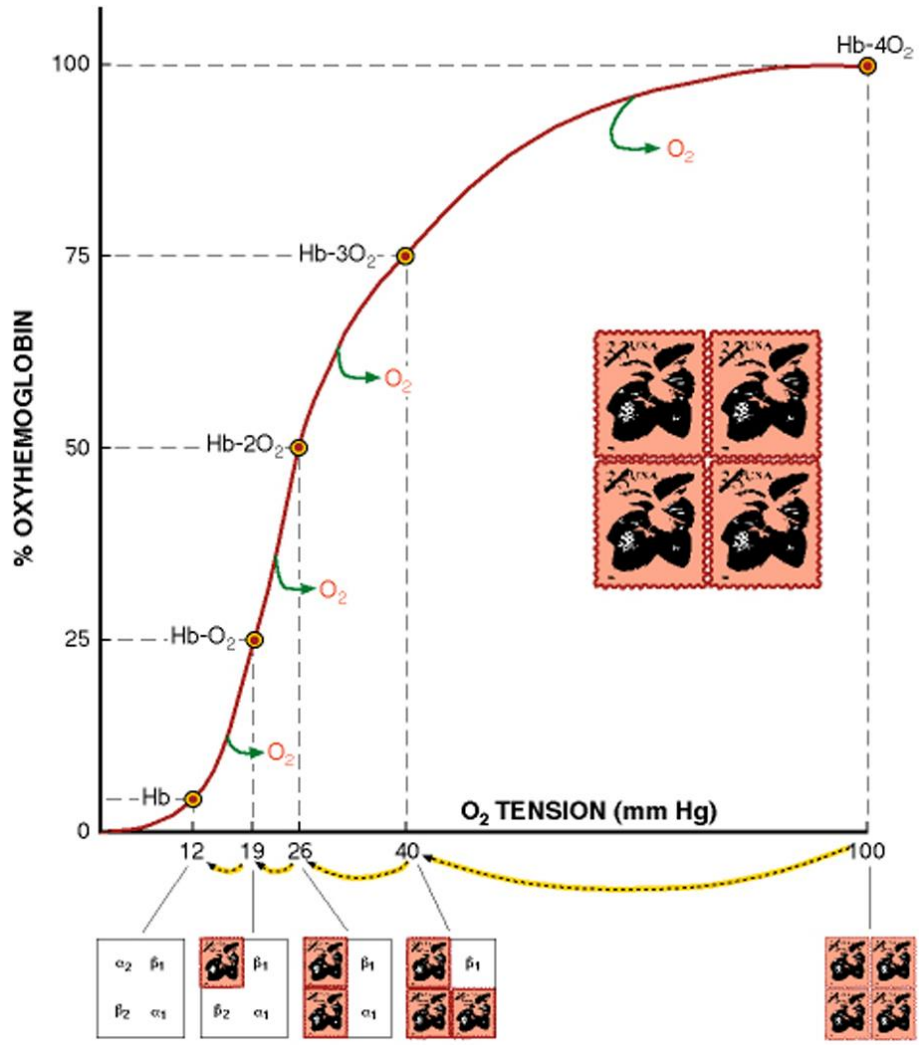
Oxygen Dissociation Curve



- O_2 binding capacity of hemoglobin (Hb) via iron proteins
- High levels of PO_2 in the lungs (100 mmHg)
- Low levels of PO_2 in the muscles (40 mmHg)
- Alterations in the affinity of binding O_2 from lungs to muscle (Bohr effect)

Gomez-Cambronero, J. (2001)

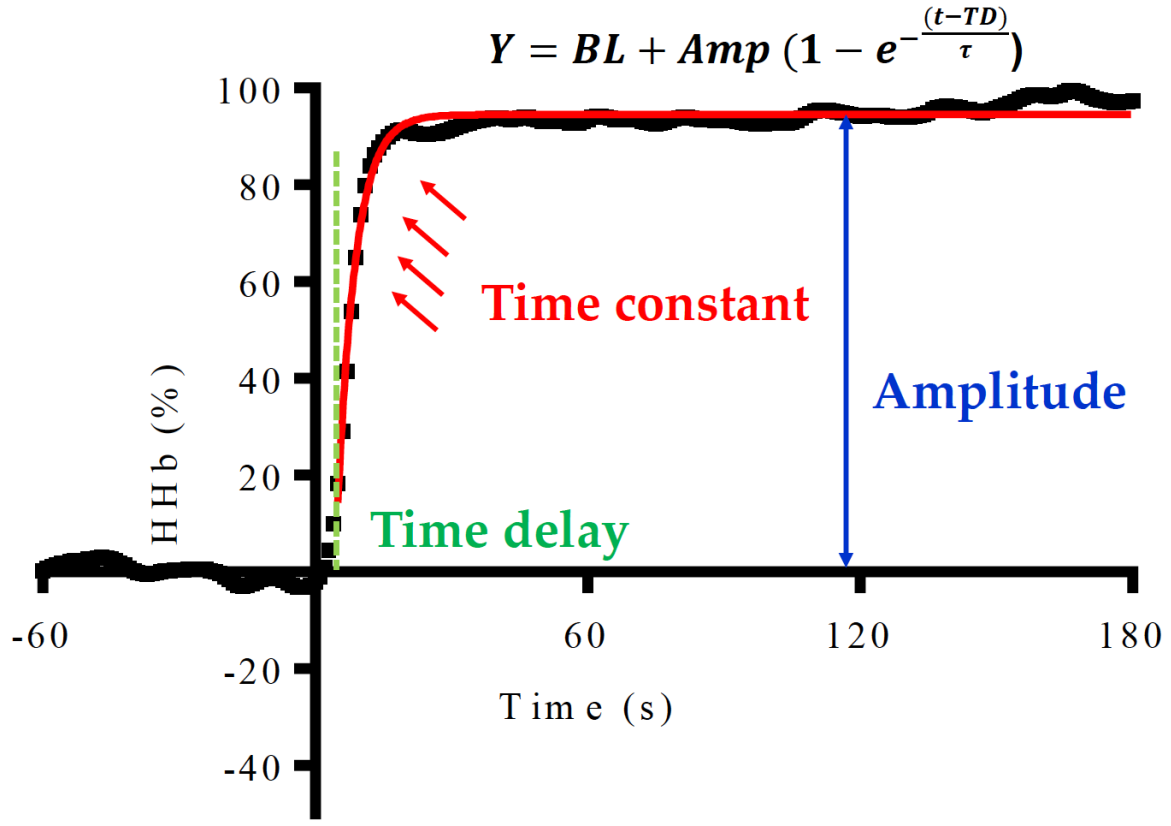
Oxygen Binding



- Step-wise reduction in PO_2 enables faster off-loading of remaining oxygen molecules
- Oxygen saturation decreases
- Ratio of oxy- vs. deoxyhemoglobin shifts
- Triggers: pH, temperature, 2,3-BPG, PCO_2
- Hemoglobin as a buffer (Haldane effect)

Gomez-Cambronero, J. (2001)

Muscle Deoxygenation Kinetics ($\dot{V}O_{2m}$)



- Amplitude - AMP (%)
- Time Delay - TD (s)
- Time constant - τ (s)
- Mean Response Time - MRT (s)
- Resolved by nonlinear regression

Adopted from: Nimmerichter & Wartbichler (2017)

Methodology & Statistics

- Thirteen trained cyclists and triathletes
- Graded incremental Exercise Test in the lab (60-20-1)
- Cycling time trials lasting 10-, 4- and 1-min in flat conditions
- Relative changes in $\dot{V}O_{2m}$ were recorded on the right vastus lateralis muscle with a portable continuous-wave NIRS device
- $\dot{V}O_{2m}$ was characterized by a single exponential model in GraphPad
- A repeated measure one – way ANOVA was used to compare power output and muscle deoxygenation parameters during 10-, 4- and 1-min durations

Results: Subjects (N=13)

Parameter	Mean ± SD
Age	31 ± 7 yrs
Height	181.4 ± 4.7 cm
Pmax	406 ± 39 W
VO_{2max}	67.85 ± 2.99 $ml.min^{-1}.kg^{-1}$

Results: Power Output

Time Trials	Mean ± SD of TT	Results
10min TT	352 ± 45 W*	p=0.001
4min TT	385 ± 49 W*	
1min TT	525 ± 73 W*	

- Significant differences in power output in the 10-, 4- and 1-min time trials (p=0.001)

Results: Cadence (CAD)

Time Trials	Mean ± SD of CAD	Results
10min TT	90 ± 3 rpm	
4min TT	89 ± 4 rpm*	p = 0.05
1min TT	93 ± 5 rpm*	

- Significant differences in CAD between 4- and 1-min time trials (p=0.05)

Results: Amplitude (AMP)

Time Trials	Mean ± SD of AMP	Results
10min TT	78.20 ± 8.42 %*	$p < 0.05$
4min TT	74.99 ± 6.12 %#	
1min TT	89.16 ± 6.82 %*#	

- Significant differences in the AMP between 10- and 1-min ($p=0.022$) as well as 4- and 1-min time trials ($p=0.006$)

Results: Time Delay (TD)

Time Trials	Mean ± SD of TD	Results
10min TT	9.54 ± 2.07 s*	$p < 0.05$
4min TT	6.30 ± 3.02 s	
1min TT	3.65 ± 1.71 s*	

- Significant differences in the TD between 10- and 1-min time trials (p=0.001)

Results: Mean Response Time (MRT)

Time Trials	Mean ± SD of (τ)	Results
10min TT	13.45 ± 2.39 s*	$p < 0.05$
4min TT	10.07 ± 2.86 s	
1min TT	6.85 ± 1.90 s*	

- Significant differences in the MRT between 10- and 1-min time trials (p=0.001)

Discussion

- $\dot{V}O_{2m}$ as a response parameter for exercise tolerance during maximal effort cycling
- Alterations in $\dot{V}O_{2m}$ parameter estimates amplitude, time delay and mean response time between different time trial durations
- Potential influence of cycling cadence as confirmed in previous studies Boone et al. (2015), Zorgati et al. (2015)
- Microvascular response is very sensitive to alterations in exercise intensity especially at the transition from rest to work
- We recommend further ecological validity of NIRS in field conditions to confirm our results

Thank you for your attention