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Muscle deoxygenation during moderate- and severe-intensity cycling in youth elite-cyclists

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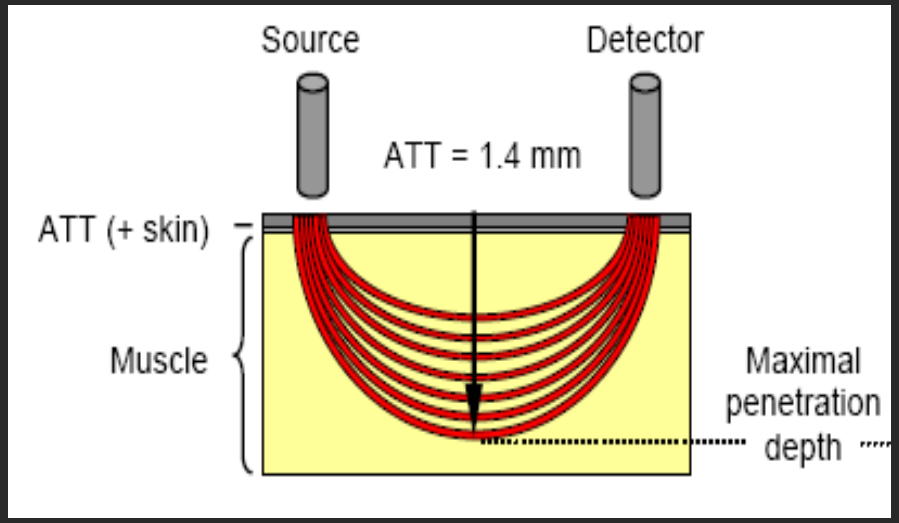
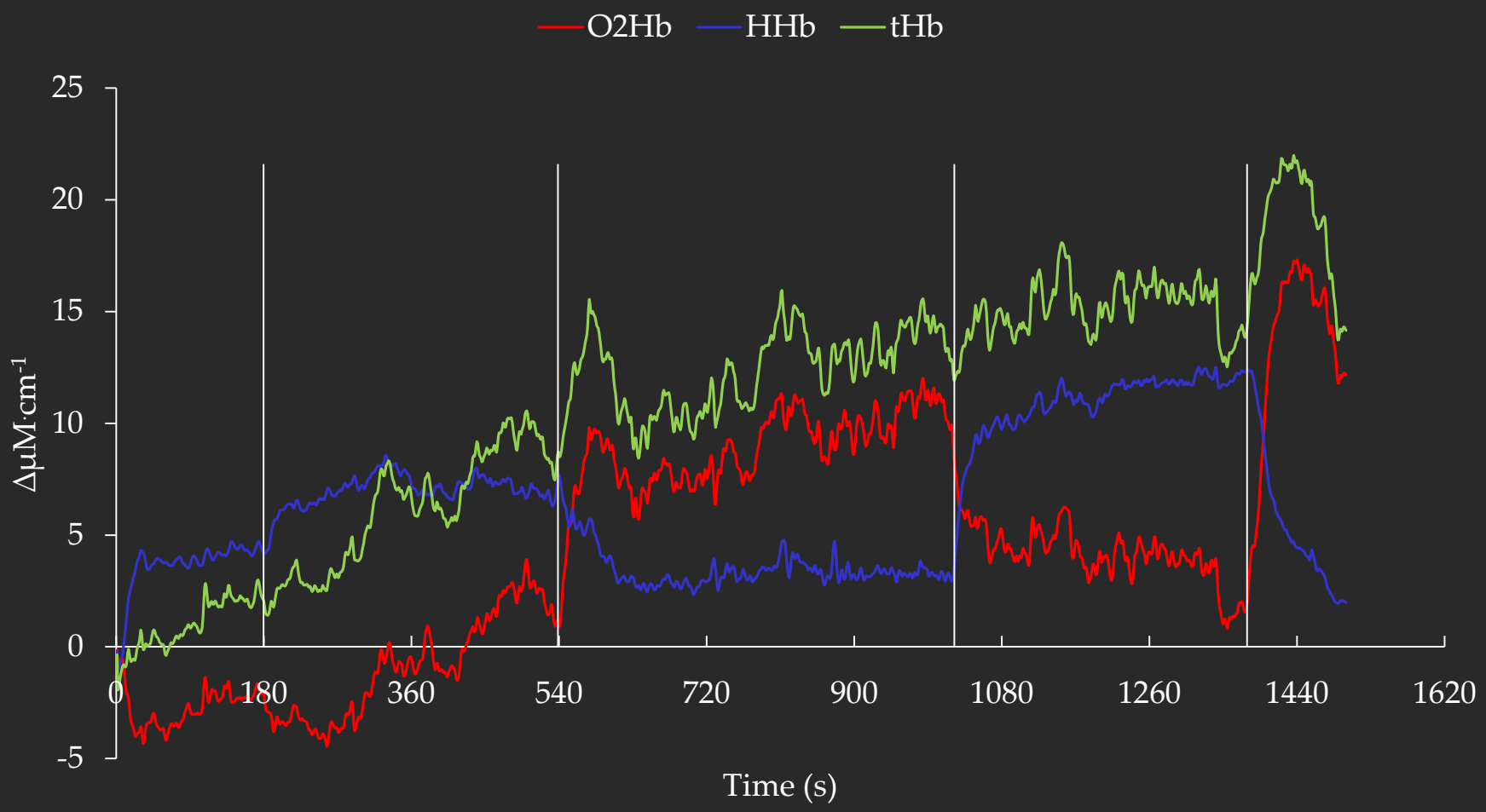
NIRS principles



NIRS principles

- NIR-light is absorbed by haemoglobin (Hb) and myoglobin (Mb)
- Oxygenated (O_2Hb) and deoxygenated (HHb) Hb is discriminated by absorbing different wavelengths
- Non-invasive measurement of oxygenation in skeletal muscle

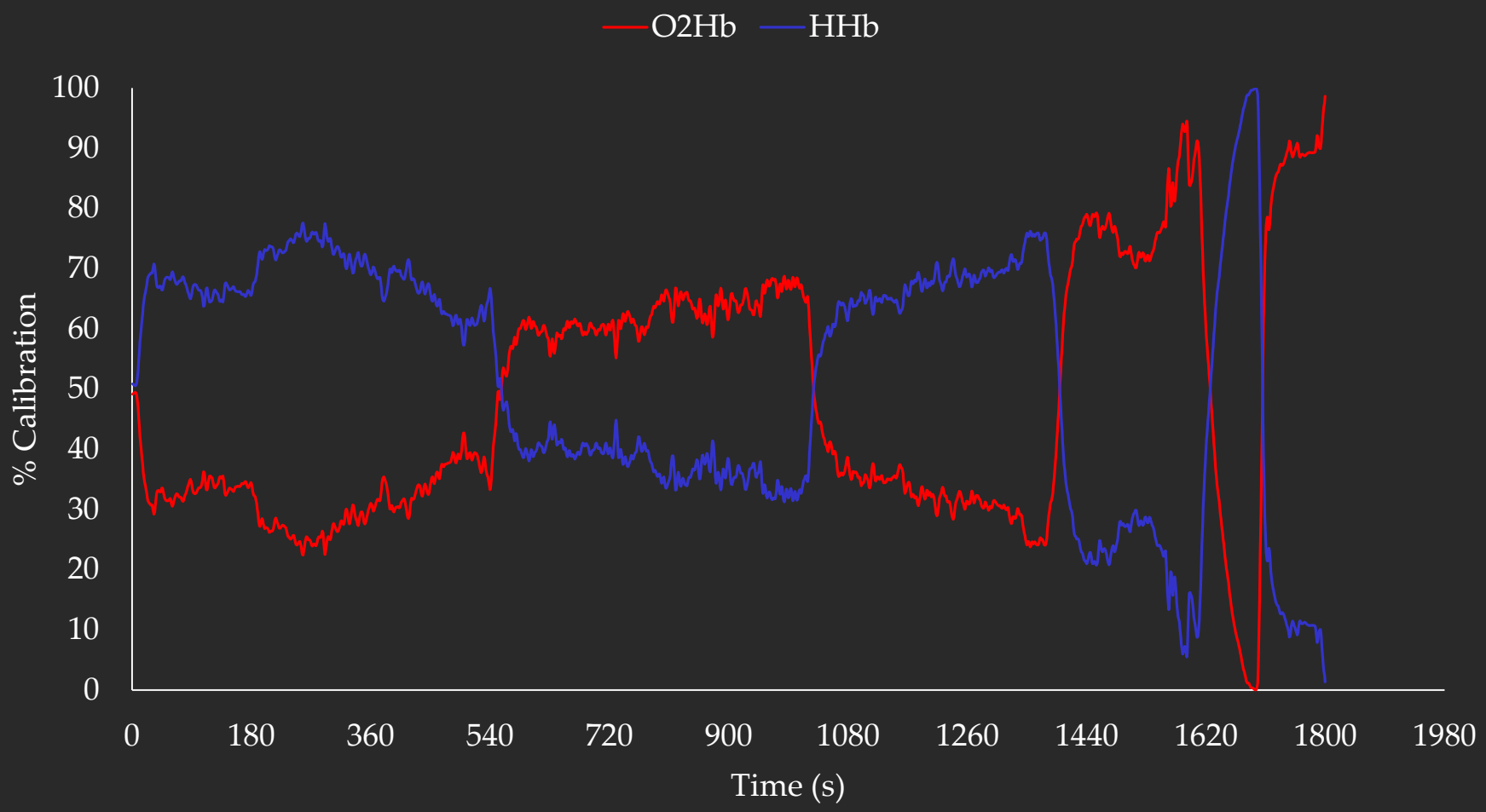

O2Hb
HHb
tHb
25
20
15
10
5
0
-5
ΔμM·cm-1
0
180
360
540
720
900
1080
1260
1440
1620
Time (s)

J Appl Physiol 113: 175–183, 2012.
First published May 10, 2012; doi:10.1152/japplphysiol.00319.2012.

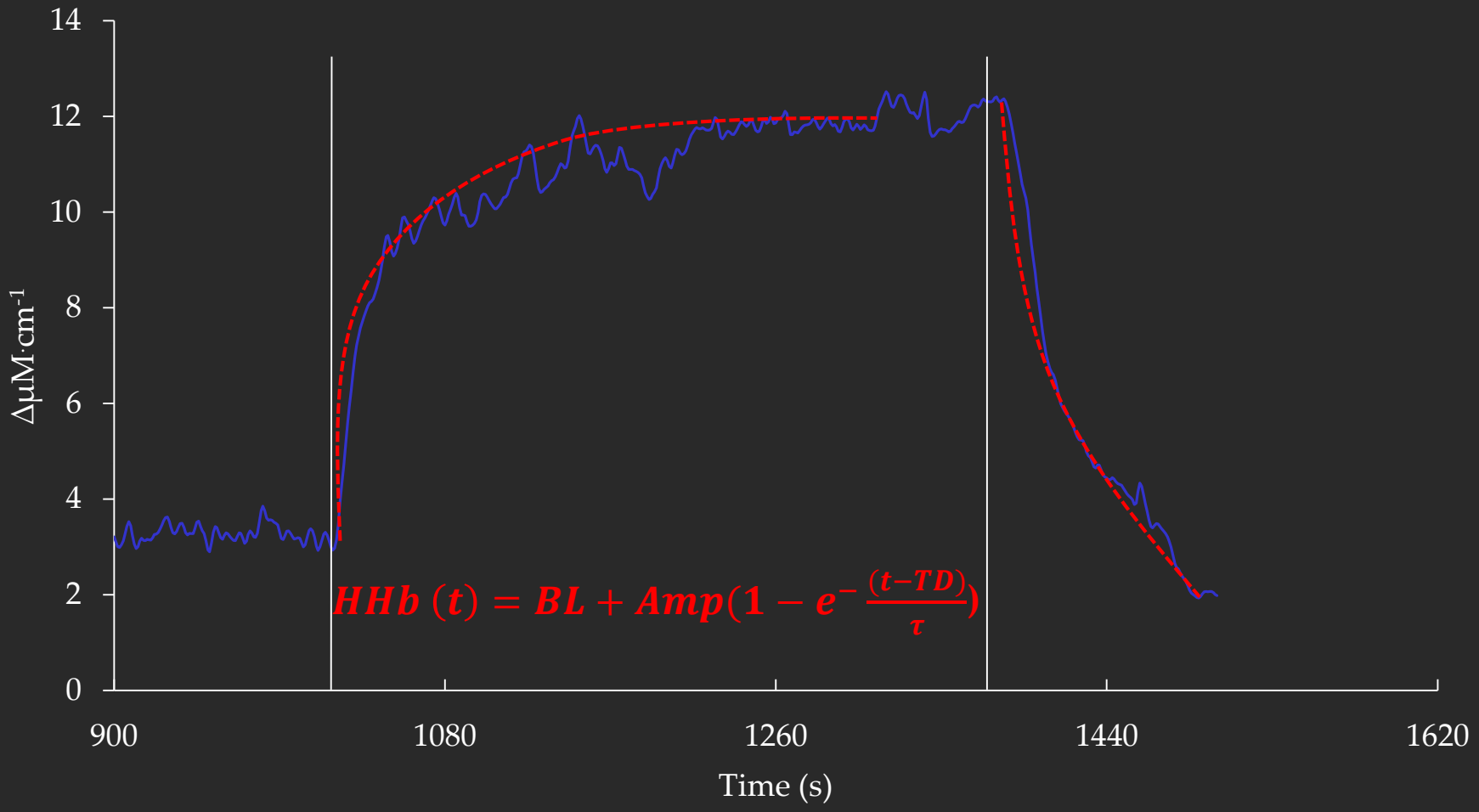
Noninvasive evaluation of skeletal muscle mitochondrial capacity with near-infrared spectroscopy: correcting for blood volume changes

Terence E. Ryan, Melissa L. Erickson, Jared T. Brizendine, Hui-Ju Young, and Kevin K. McCully
Department of Kinesiology, University of Georgia, Athens, Georgia

Submitted 12 March 2012; accepted in final form 3 May 2012


O2Hb
HHb
100
90
80
70
60
50
40
30
20
10
0
% Calibration
0
180
360
540
720
900
1080
1260
1440
1620
1800
1980
Time (s)

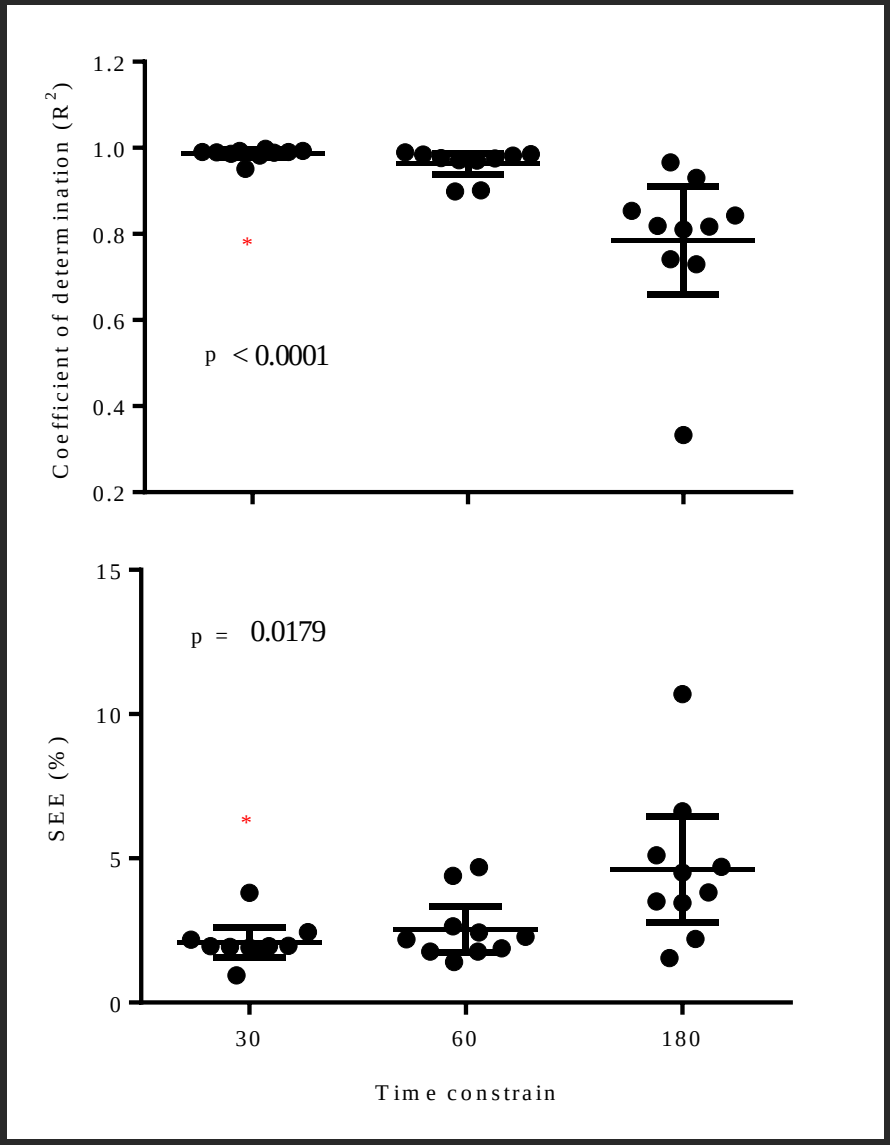
On-and off-kinetics of muscle deoxygenation

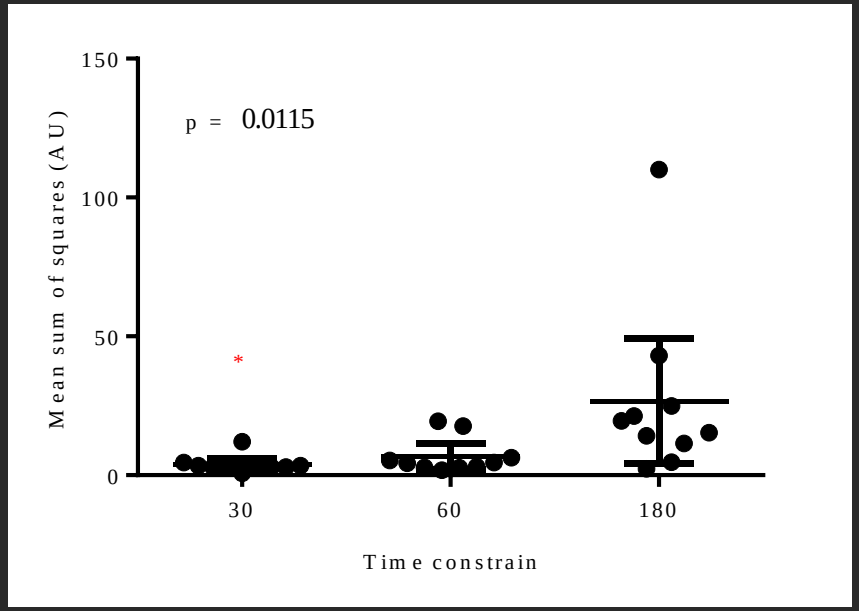


On-and off-kinetics of muscle deoxygenation

- Poor exponential fit in some (Buchheit et al, 2011; Jones et al, 2018) but not all studies (DeLorey et al, 2003, 2004; Nimmerichter et al, 2017)

On-kinetics of muscle deoxygenation





*** Significantly different from 180 s**

On-and off-kinetics of muscle deoxygenation

- **Poor exponential fit in some (Buchheit et al, 2011; Jones et al, 2018) but not all studies (DeLorey et al, 2003, 2004; Nimmerichter et al, 2017)**
- **Alternatively**
  - Changes (Δ) from baseline
  - Linear model to the initial part of recovery to assess reoxygenation rate

Purpose

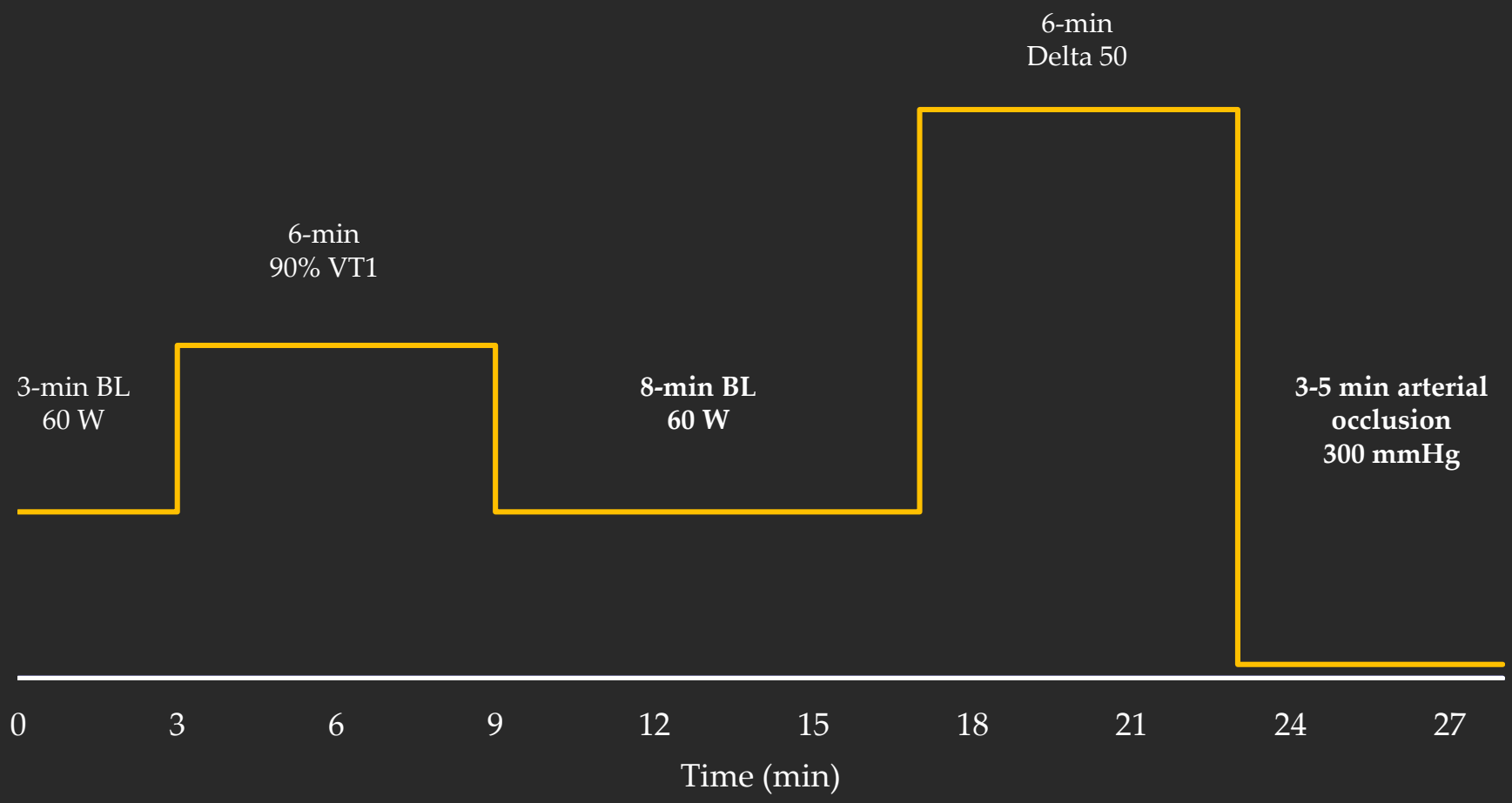
- **Test-retest reliability of**
  - HHb-changes during moderate- and severe-intensity cycling
  - Reoxygenation rate after an arterial occlusion

in youth elite-cyclists

Methods

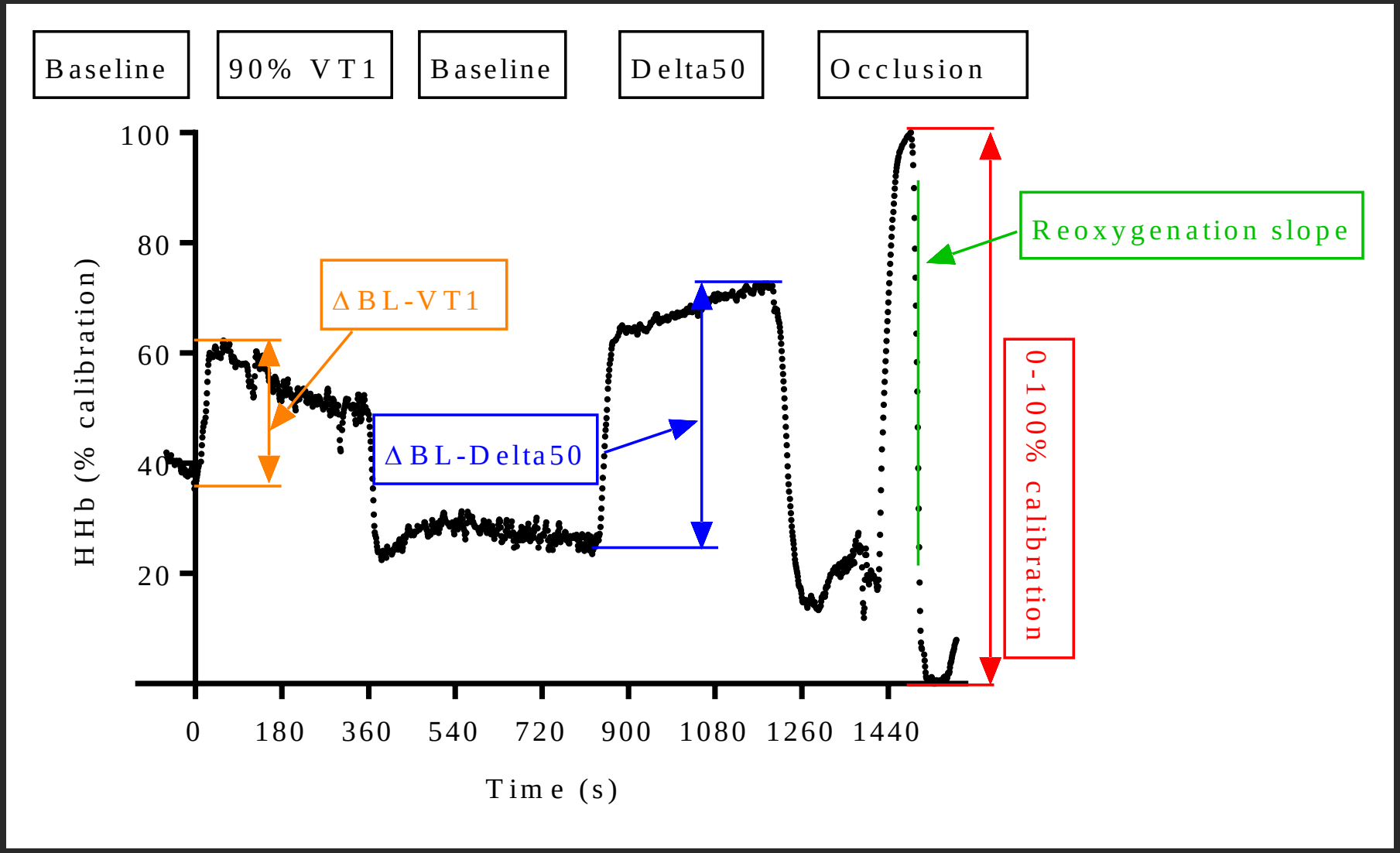
- **15 youth cyclists (2 F)**
  - 13.5 ± 1.8 y
  - 163.2 ± 12.2 cm
  - 51.3 ± 12.4 kg
  - 62.1 ± 4.2 $mL \cdot min^{-1} \cdot kg^{-1}$
- **6-min rest-to-work transition @ 90% VT1 and Delta 50%**
- **Arterial occlusion @ 300 mmHg**
- **NIRS from M. Vastus lateralis**

Protocol

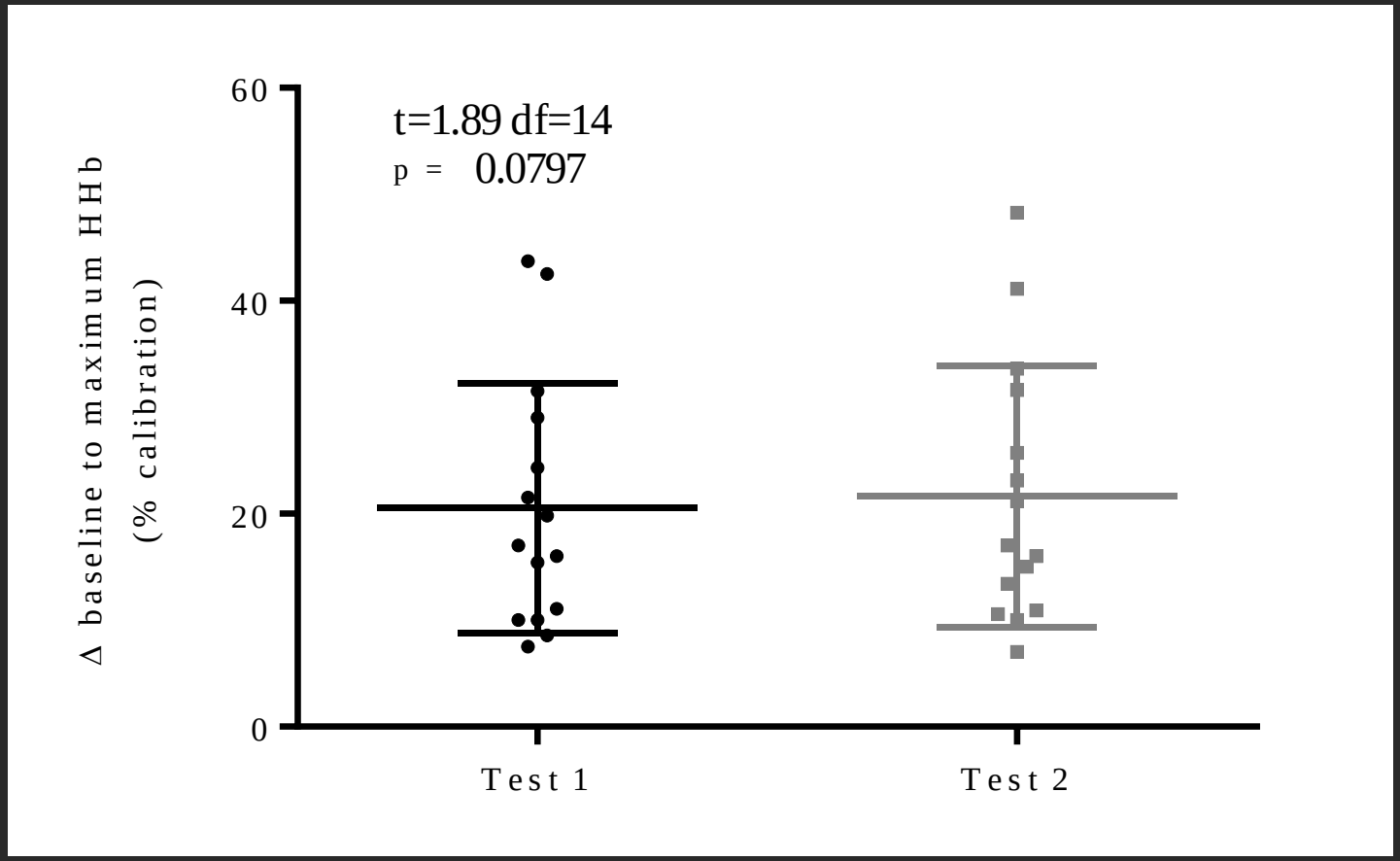

6-min
Delta 50
6-min
90% VT1
3-min BL
60 W
8-min BL
60 W
3-5 min arterial
occlusion
300 mmHg
0
3
6
9
12
15
18
21
24
27
Time (min)

Analysis

- **Second-per-second HHb-data corrected for blood volume changes (Ryan et al, 2012)**
- **Normalised to full range of arterial occlusion**
- **Changes in HHb from**
  - BL to maximum of VT1 (ΔBL-VT1)
  - BL to maximum of Delta50 (ΔBL-Delta50)
- **Reoxygenation after occlusion (linear regression slope)**
- **T-test, ICC, CV and 95% LoA for reliability**


Baseline
90% VT1
Baseline
Delta50
Occlusion
100
80
60
40
20
HHb (% calibration)
ΔBL-VT1
ΔBL-Delta50
Reoxygenation slope
0-100% calibration
0
180
360
540
720
900
1080
1260
1440
Time (s)

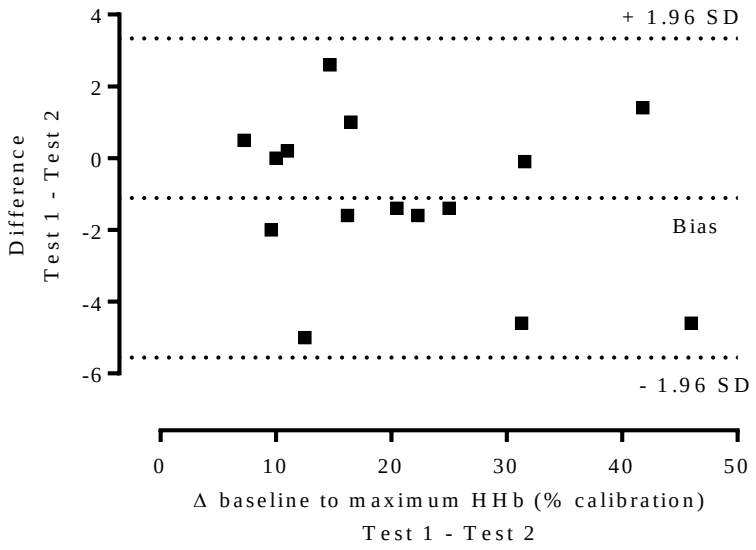
Moderate-intensity cycling

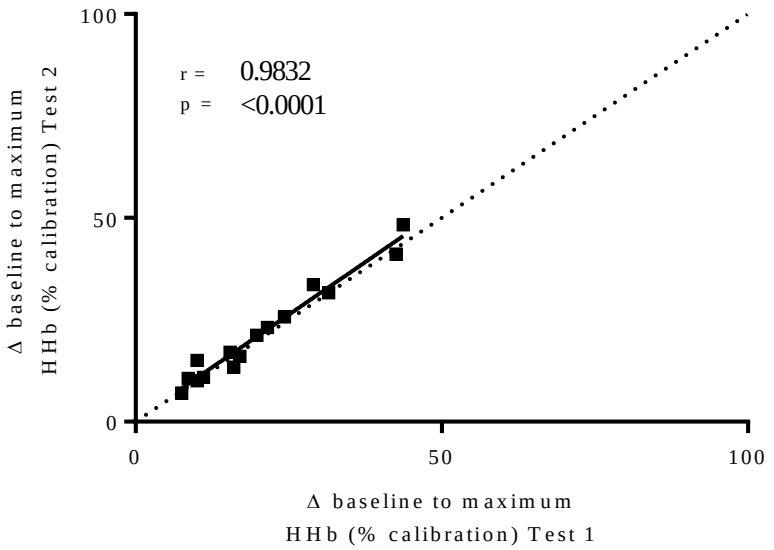


Test 1: 20.5 ± 11.7%

Test 2: 21.6 ± 12.3%

Moderate-intensity cycling





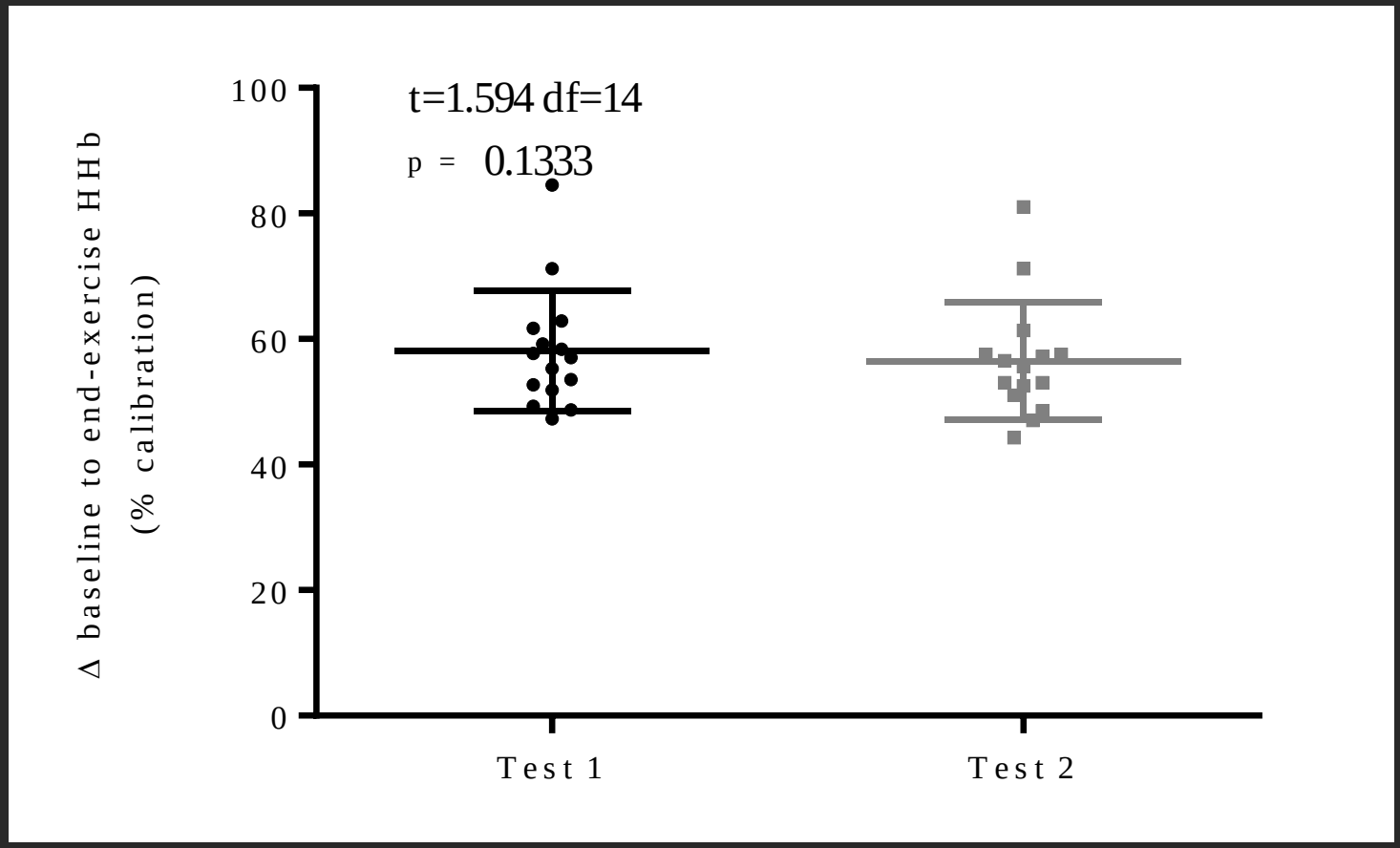
Bias: -1.1 ± 2.3%

95% LoA: -5.6 to 3.3

CV: 10.1% (7.3 to 16.4)

ICC: 0.98 (0.96 to 0.99)

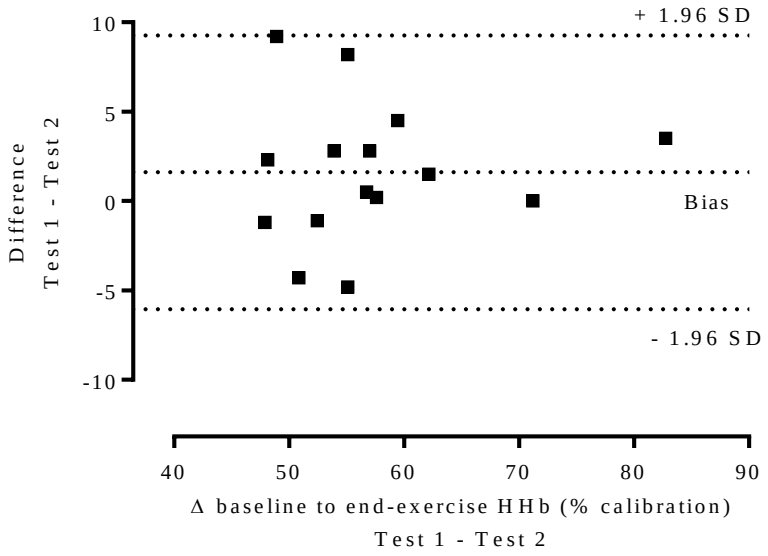
Severe-intensity cycling

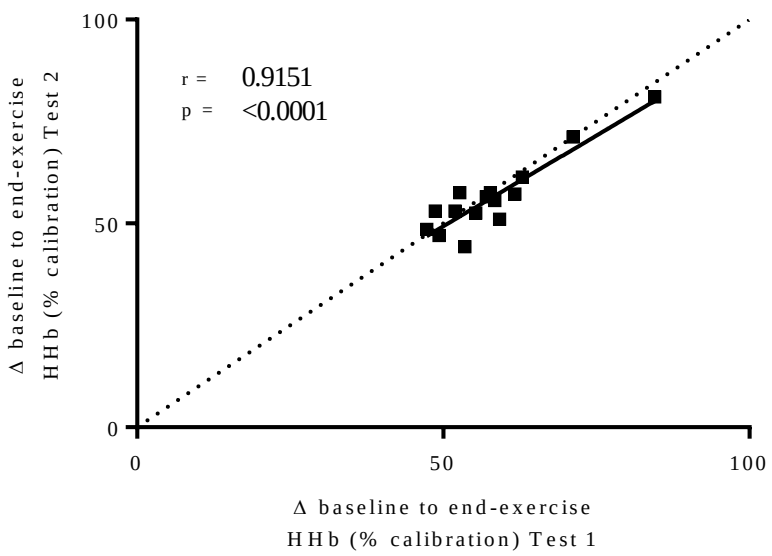


Test 1: 58.1 ± 9.6%

Test 2: 56.5 ± 9.3%

Severe-intensity cycling





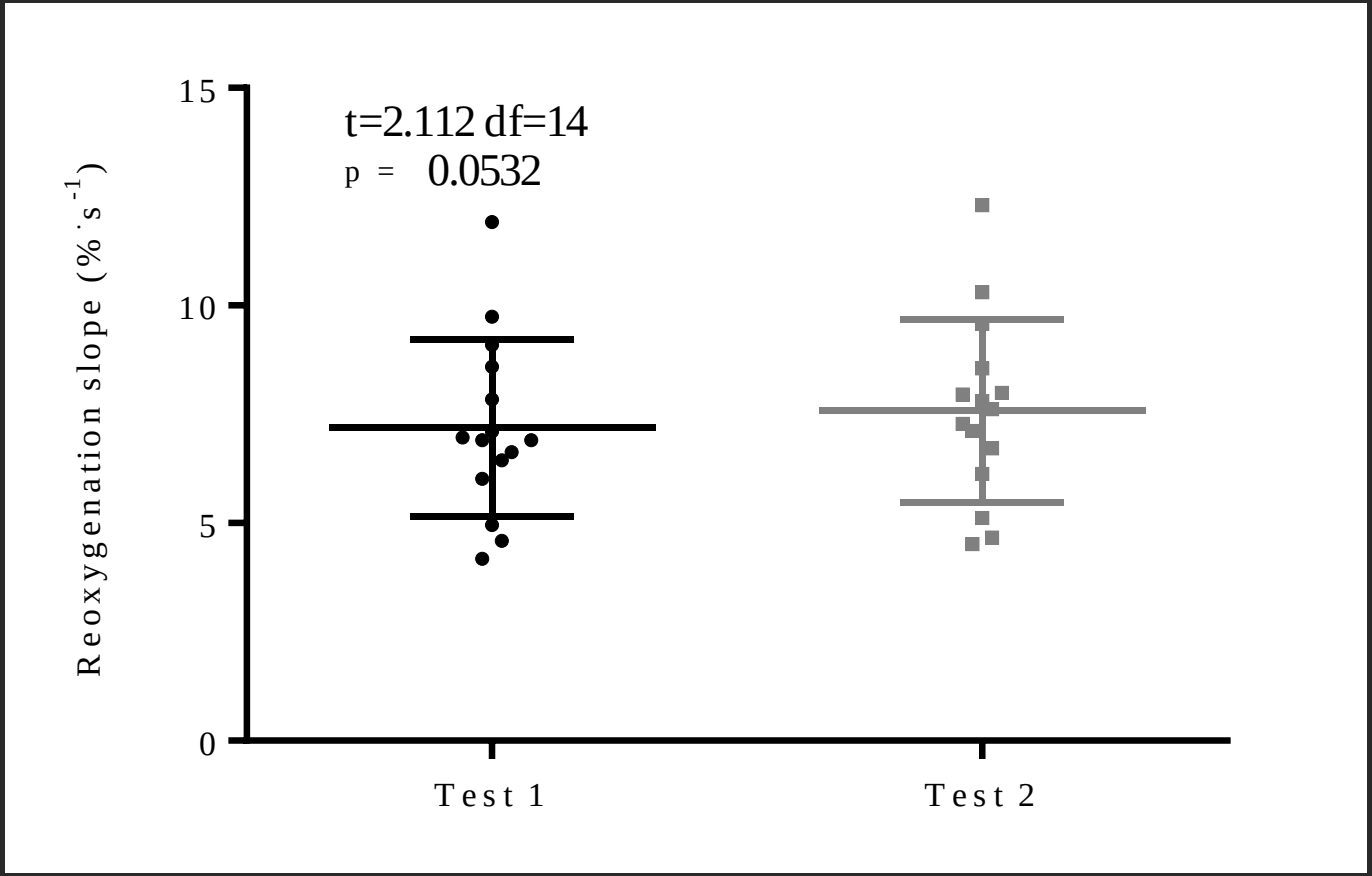
Bias: 1.6 ± 3.9%

95% LoA: -6.0 to 9.3

CV: 5.4% (3.9 to 8.6)

ICC: 0.93 (0.80 to 0.97)

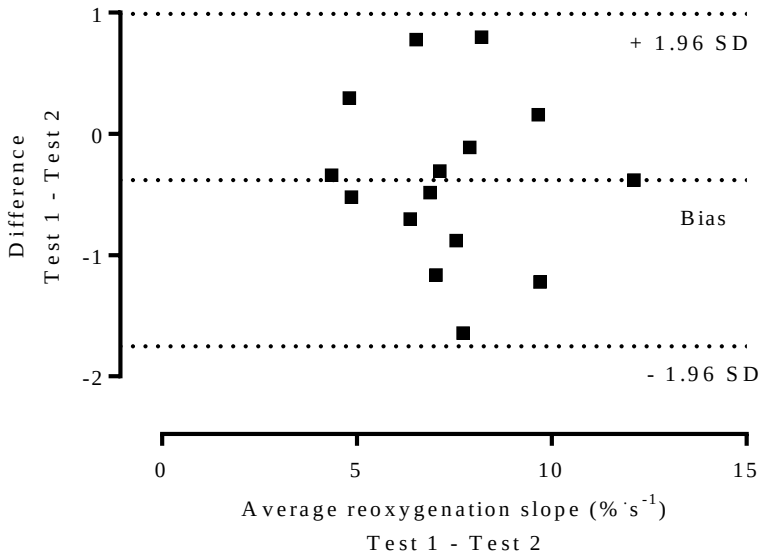
Reoxygenation slope

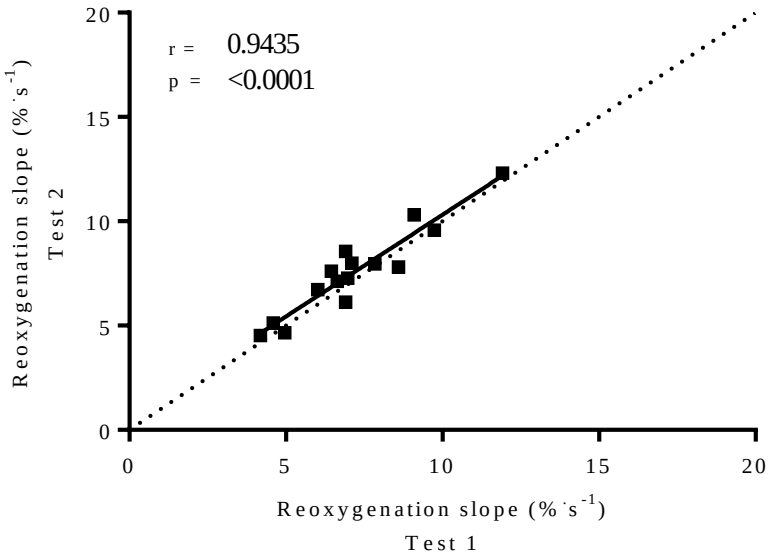


Test 1: 7.2 ± 2.0 %·s^{-1}

Test 2: 7.6 ± 2.1 %·s^{-1}

Reoxygenation slope





Bias: -0.4 ± 0.7 %·s^{-1}

95% LoA: -1.8 to 1.0

CV: 7.0% (5.1 to 11.2)

ICC: 0.95 (0.86 to 0.98)

Discussion

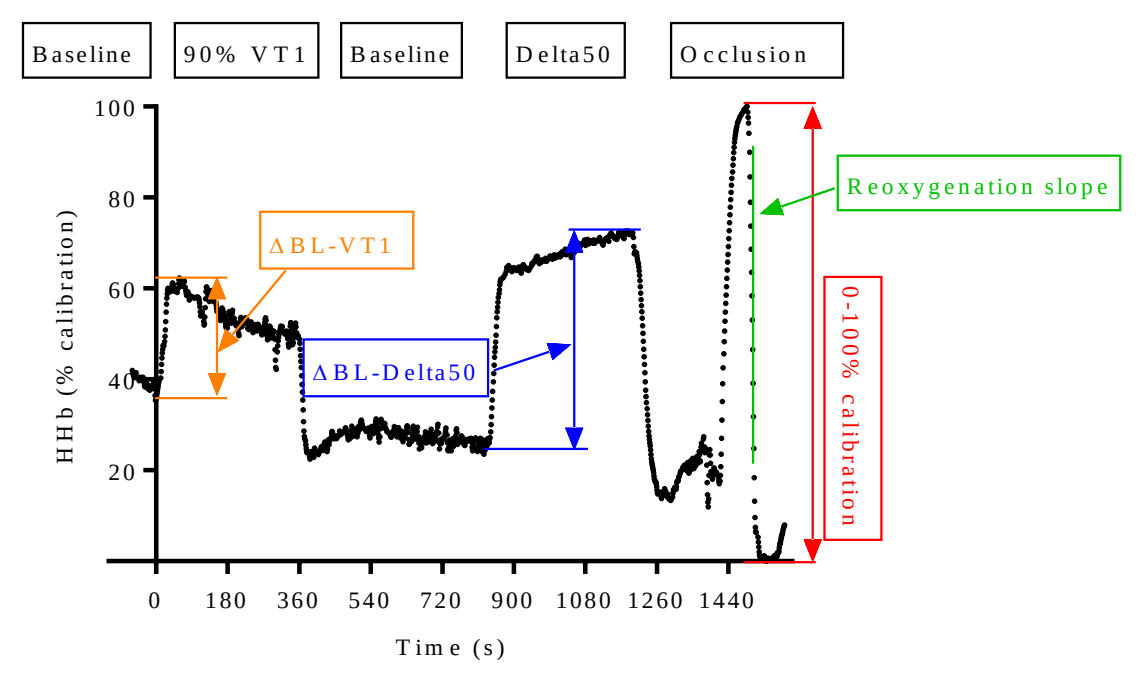
- TSI and tHb during continuous and intermittend running (CV 3.5-35%) (Ihsan et al. 2012)
- TSI on biceps brachii during isometric contraction (CV 7-36%) (Muthalib et al. 2010)
- On-kinetics amplitude (CV 3%), time constant (13.2%) and time delay (10.5%) during running (Nimmerichter et al. 2017)
- Time constant of recovery HbO_2 and HHb (CV ~10.6%) (Ryan et al. 2012)
- Recovery kinetics of HbO_2 and Hb_{diff} after running (CV 17-37%) (Buchheit et al. 2011)

Summary

- Changes in HHb reflect O_2 extraction during moderate- and severe-intensity cycling (20% vs 58%)
- At moderate intensity O_2 supply > O_2 consumption
- At severe intensity O_2 supply < O_2 consumption
- Changes in HHb, as well as the reoxygenation slope, are reliable (CV 5-10%) in youth cyclists

Summary

- Changes in HHb reflect O_2 extraction during moderate- and severe-intensity cycling (20% vs 58%)
- At moderate intensity O_2 supply > O_2 consumption
- At severe intensity O_2 supply < O_2 consumption
- Changes slope, are reliable



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Thank you for your attention

Acknowledgements:
Clemens Rumpl
Manfred Zöger
Bernhard Prinz

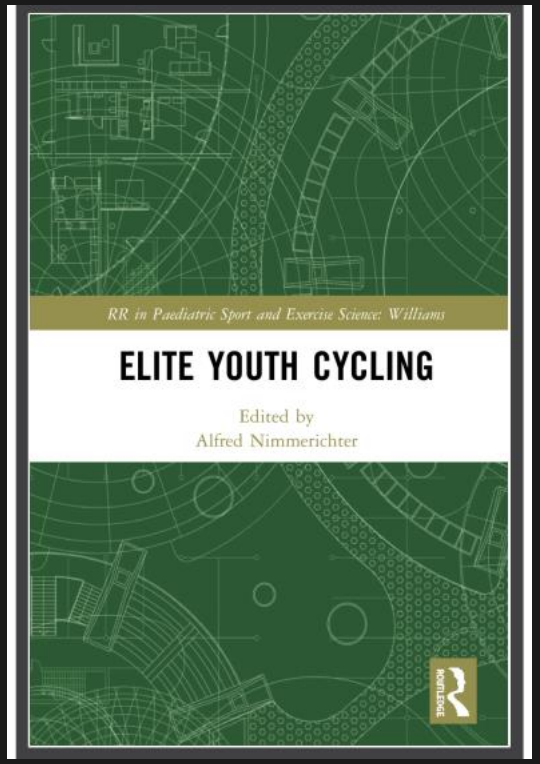

TABLE OF CONTENTS:

Contact: nimmerichter@fhwn.ac.at

Parameter estimates moderate intensity (HHb)

	Mean ± SD	ICC 95% CI	CV (%) 95% CI
Amplitude (%) T 1 T 2	 63.9 ± 10.5 63.1 ± 11.4	 0.87 0.65-0.95	 7.3 5.3-11.8
MRT (s) T 1 T 2	 11.5 ± 3.8 11.3 ± 4.8	 0.85 0.6-0.95	 18.6 13.3-30.8

Parameter estimates severe intensity (HHb)

	Mean ± SD	ICC 95% CI	CV (%) 95% CI
Amplitude (%) T 1 T 2	 72.6 ± 11.0 69.4 ± 13.4	 0.88 0.67-0.96	 8.2 5.9-13.2
MRT (s) T 1 T 2	 13.5 ± 2.4 13.0 ± 2.9	 0.95 0.87-0.98	 5.8 4.2-9.3

Parameter estimates moderate intensity (TSI)

	Mean ± SD	ICC 95% CI	CV (%) 95% CI
Amplitude (%) T 1 T 2	 65.0 ± 5.4 64.5 ± 5.6	 0.87 0.66-0.95	 3.5 2.5-5.5
MRT (s) T 1 T 2	 12.9 ± 9.1 14.3 ± 9.1	 0.46 0.05-0.78	 115.6 75.5-236

Parameter estimates severe intensity (TSI)

	Mean ± SD	ICC 95% CI	CV (%) 95% CI
Amplitude (%) T 1 T 2	 61.2 ± 4.7 60.7 ± 4.9	 0.93 0.81-0.98	 2.3 1.6-3.6
MRT (s) T 1 T 2	 9.9 ± 11.6 9.2 ± 13.2	 0.96 0.89-0.99	 72.3 49-135.9