The higher fraction of maximal oxygen uptake during interval training, the greater gains in performance

Ingvill Odden, Lars Nymoen, Tomas Urianstad,
Daniel Hammarström, Knut Sindre Mølmen and Bent R. Rønnestad

Ingvill Odden, Ph.D. candidate

The Trainome Research Group
Section for Health and Exercise Physiology
Inland Norway University of Applied Sciences Lillehammer

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Background

"The magnitude of change in VO_{2max} increases as exercise intensity increases from 50 to 100% of VO_{2max}"

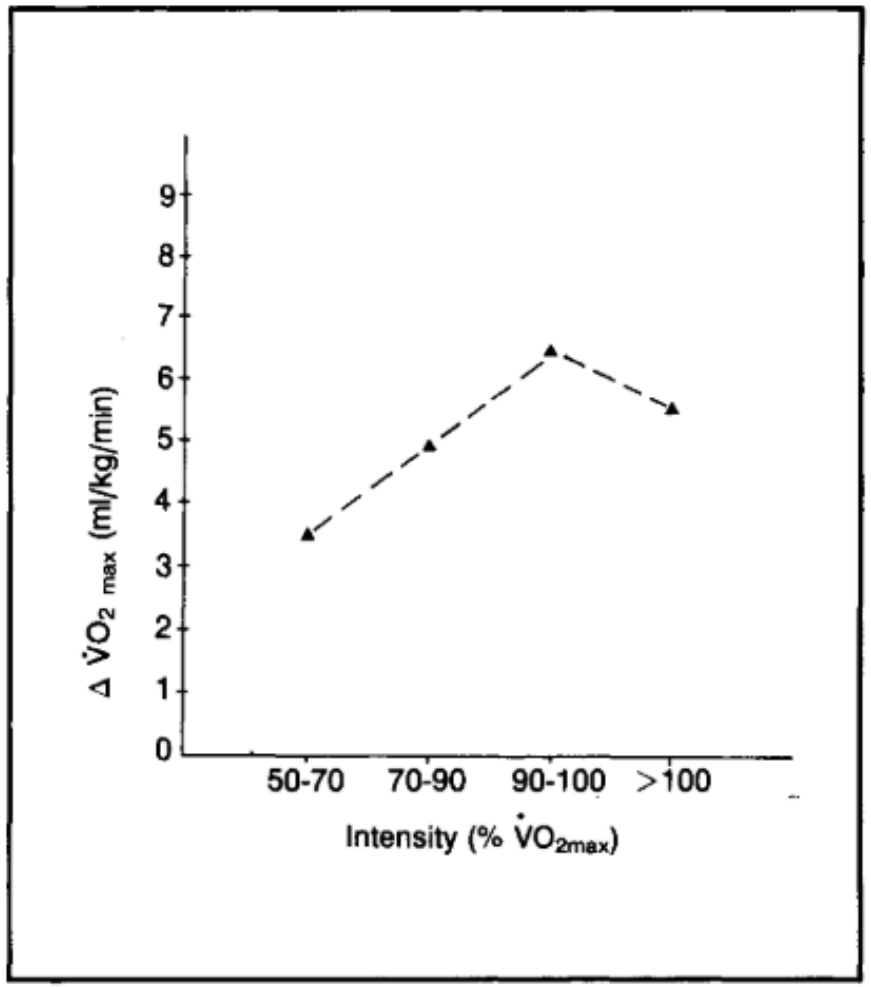
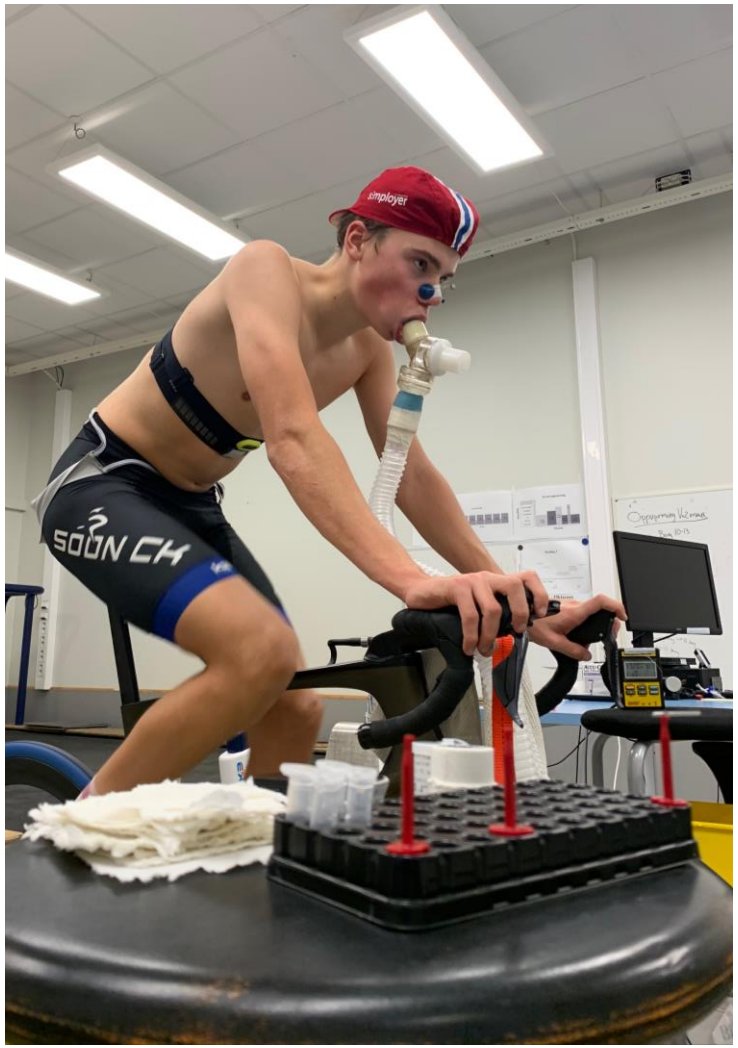


Fig. 1. The effects of intensity of training on improvements in $\dot{V}O_{2\,max}$. These data are grouped into 4 intensity levels independent of the frequency, duration, programme length and initial fitness levels.

Wenger, H. A., & Bell, G. J. (1986). The Interactions of Intensity, Frequency and Duration of Exercise Training in Altering Cardiorespiratory Fitness. Sports Medicine, 3(5), 346-356. https://doi.org/10.2165/00007256-198603050-00004

Background



High % of VO_{2max} during work intervals
→ superior training adaptations?

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Purpose

Investigate the relationship between % of VO_{2max} achieved during a 9-week interval training intervention and changes in endurance performance and physiological determinants of endurance performance in well-trained cyclists

Experimental design

	Period 1 3 weeks	**Period 2** 3 weeks	**Period 3** 3 weeks
Training intervention	●	●	●
5x8-min work intervals	↑ ↑ ↑ ↑ ↑ ↑ ↑	↑ ↑ ↑ ↑ ↑ ↑ ↑	↑ ↑ ↑ ↑ ↑ ↑ ↑
Testing			
40-min cycling trial	↑		
Blood lactate profile	↑		↑
VO_{2max} test	↑	↑	↑ ↑
15-min cycling trial	↑		↑

Experimental design

Period 1
3 weeks

Period 2
3 weeks

Period 3
3 weeks

Training intervention

5x8-min work intervals

Testing

40-min cycling trial

Blood lactate profile

VO_{2max} test

15-min cycling trial

40-min maximal PO = PO during 8-min work intervals

Interval sessions

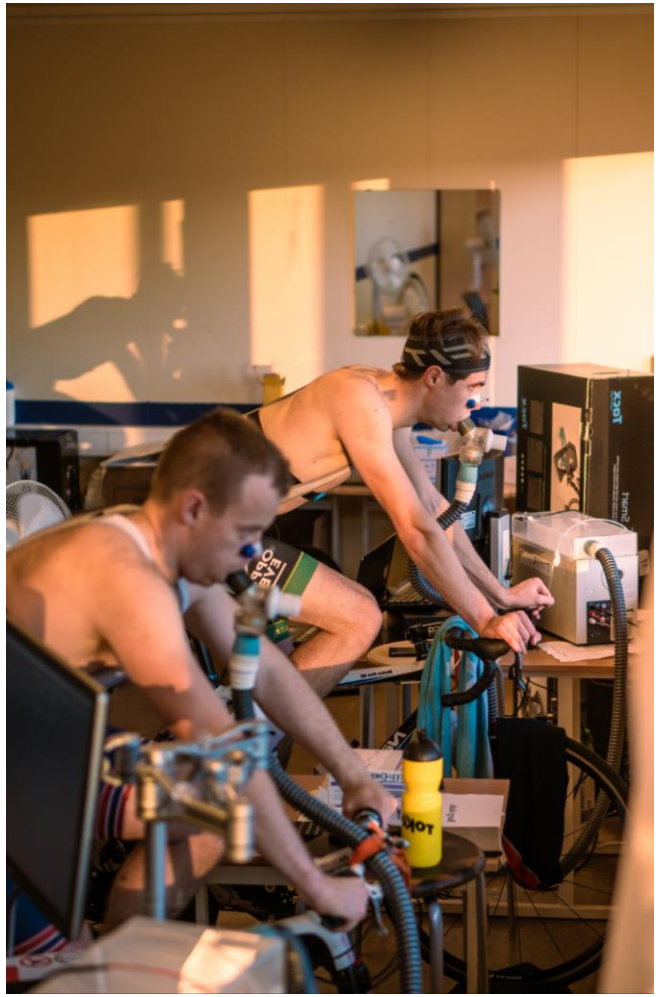
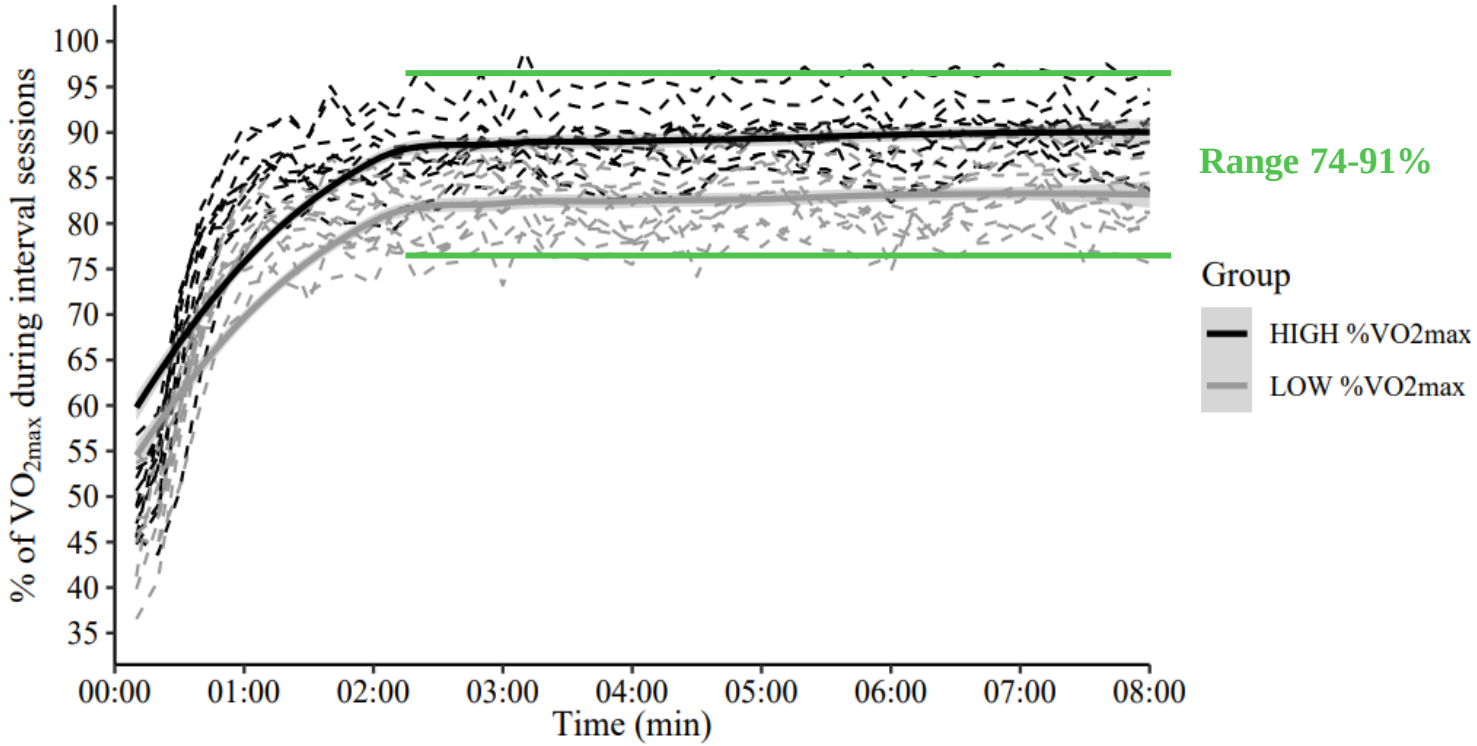


Photo: Andreas Øhrn



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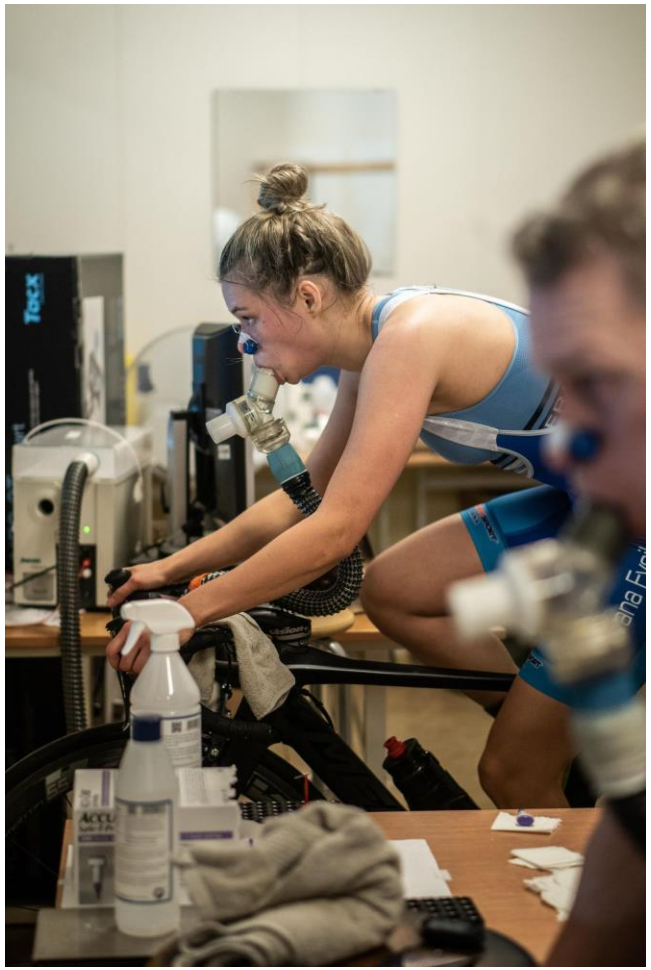
Baseline characteristics

	All participants (n = 22)	**HIGH$_{\%VO2max}$** (♀ = 2, ♂ = 9)	**LOW$_{\%VO2max}$** (♀ = 1, ♂ = 10)
Age (years)	22.6 (6.0)	21.4 (6.7)	22.6 (5.5)
Body mass (kg)	71.9 (9.3)	69.2 (9.8)	74.7 (8.2)
Body height (cm)	180.1 (7.8)	178.3 (8.9)	181.9 (6.3)
HR_{max} (bpm)	192 (8)	197 (8) *	188 (5)
$[La^-]_{max}$ (mmol·L^{-1})	11.56 (1.99)	11.14 (1.29)	11.99 (2.50)
W_{max} (W·kg^{-1})	5.8 (0.6)	5.7 (0.6)	5.8 (0.7)
PO_{4mmol} (W·kg^{-1})	4.0 (0.5)	4.0 (0.6)	4.0 (0.5)
PO_{15min} (W·kg^{-1})	4.2 (0.5)	4.3 (0.6)	4.2 (0.5)
PO_{40min} (W·kg^{-1})	3.8 (0.4)	3.8 (0.5)	3.7 (0.4)
Performance index (arbitrary value, 0-1)	0.749 (0.086)	0.751 (0.092)	0.748 (0.085)
VO_{2max} (ml·min^{-1}·kg^{-1})	67.1 (6.4)	65.1 (5.3)	69.1 (7.1)
% of $VO_{2max@4mmol}$ (%)	82.4 (5.3)	84.1 (5.2)	80.8 (5.2)
GE_{175w} (%)	18.9 (0.8)	19.2 (0.7) #	18.6 (0.9)



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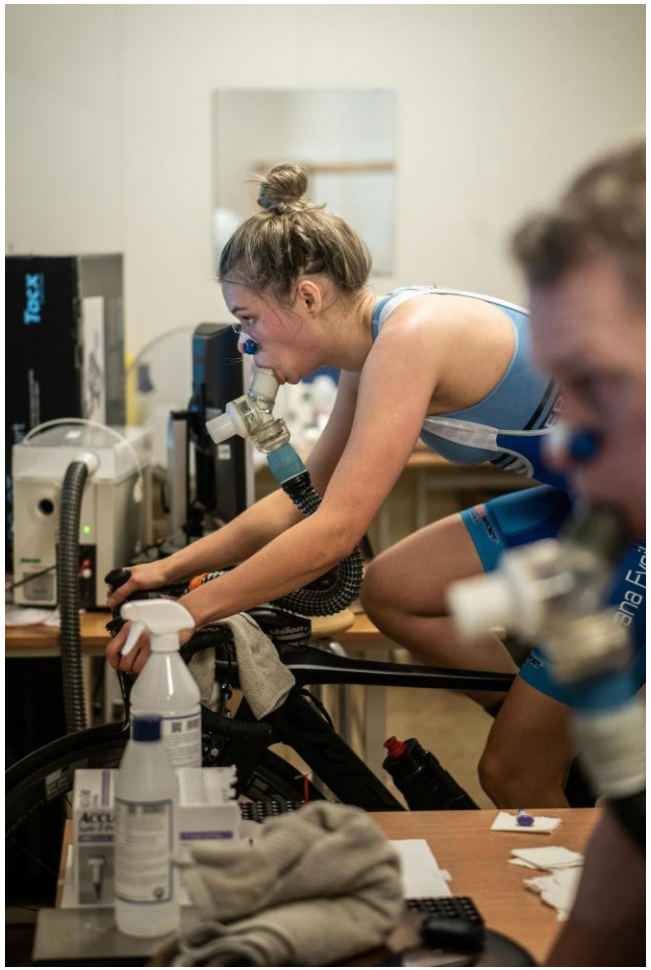

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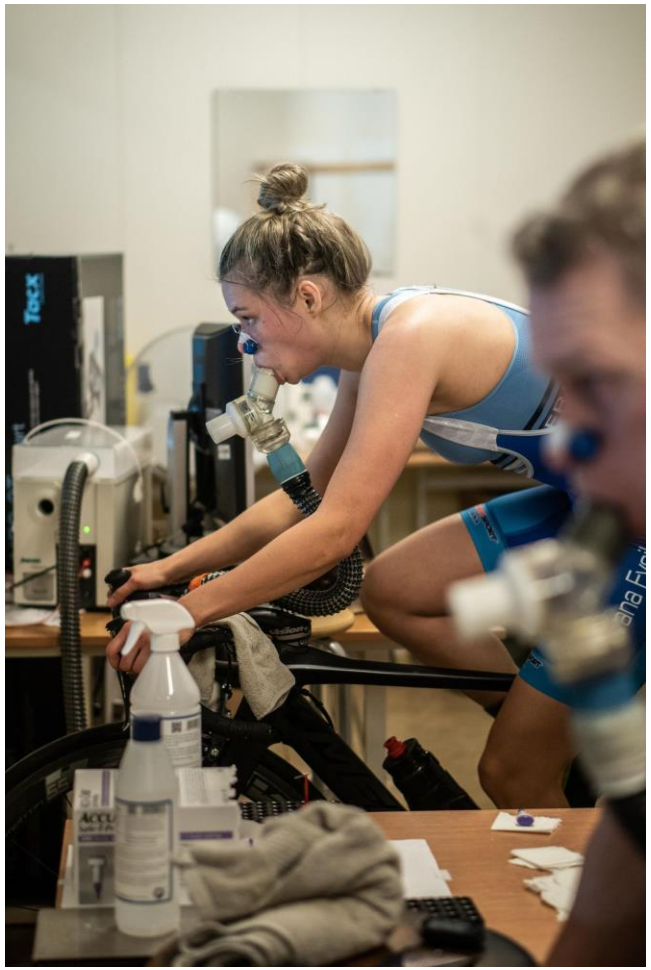

Photo: Andreas Øhrn

Interval session data

	All participants (n = 22)			**HIGH$_{\%VO2max}$** (n = 11)			**LOW$_{\%VO2max}$** (n = 11)		
	Period 1	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**
Time ≥ 90% of VO_{2max} (m:s)									
% of VO_{2max}									
Time ≥ 90% of HR_{max} (m:s)									
% of HR_{max}									
% of W_{max}									
% of PO_{40min} measured at baseline									
% of $[La^-]_{max}$									
% of RPE_{20}									

Interval session data

	All participants (n = 22)			**HIGH$_{\%VO2max}$** (n = 11)			**LOW$_{\%VO2max}$** (n = 11)		
	Period 1	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**
Time ≥ 90% of VO_{2max} (m:s)	08:50 (10:03)	09:03 (10:08)	10:23 (09:55)	**15:32 (10:03)***	**15:05 (10:47)***	**14:52 (09:43)***	**02:14 (03:38)**	**03:06 (04:18)**	**05:52 (07:53)$^{\&}$**
% of VO_{2max}	82.6 (5.1)	83.0 (5.1)	83.5 (4.8)	**86.3 (3.6)***	**86.2 (4.2)***	**85.9 (3.8)***	**79.0 (3.6)**	**79.7 (3.6)**	**81.0 (4.5)$^{\&}$**
Time ≥ 90% of HR_{max} (m:s)	12:19 (10:23)	15:01 (10:44)$^{\&}$	18:36 (10:16)$^{\&\,\$}$	12:57 (10:03)	18:53 (09:46)$^{\&}$	21:17 (10:12)$^{\&}$	11:41 (10:44)	11:11 (10:19)	15:53 (09:40)$^{\$}$
% of HR_{max}	87.2 (2.2)	87.6 (2.4)	88.3 (2.2)$^{\&\,\$}$	87.6 (2.0)	88.4 (2.4)	88.9 (2.4)$^{\&}$	86.8 (2.3)	86.9 (2.3)	87.7 (1.7)
% of W_{max}	64.6 (3.2)	63.3 (3.6)$^{\&}$	63.0 (3.6)$^{\&}$	64.9 (3.6)	63.4 (4.0)$^{\&}$	62.7 (3.6)$^{\&}$	64.3 (2.6)	63.1 (3.2)$^{\&}$	63.3 (3.5)$^{\&}$
% of PO_{40min} measured at baseline	98.7 (3.2)	102.2 (4.1)$^{\&}$	103.3 (4.8)$^{\&\,\$}$	97.6 (3.4)	101.0 (4.5)$^{\&}$	102.4 (4.4)$^{\&\$}$	99.9 (2.6)	103.5 (3.3)$^{\&}$	104.2 (5.0)$^{\&}$
% of $[La^-]_{max}$	45.1 (12.4)	47.5 (13.4)	52.3 (19.4)$^{\&}$	46.0 (14.3)	50.8 (14.3)	53.7 (23.1)	44.3 (10.8)	44.3 (11.9)	50.9 (15.1)
% of RPE_{20}	80.1 (4.8)	80.6 (5.7)	81.6 (5.8)$^{\&\,\$}$	80.9 (4.8)	82.0 (5.8)	83.0 (5.4)$^{\&}$	79.2 (4.8)	79.3 (5.4)	80.1 (5.9)

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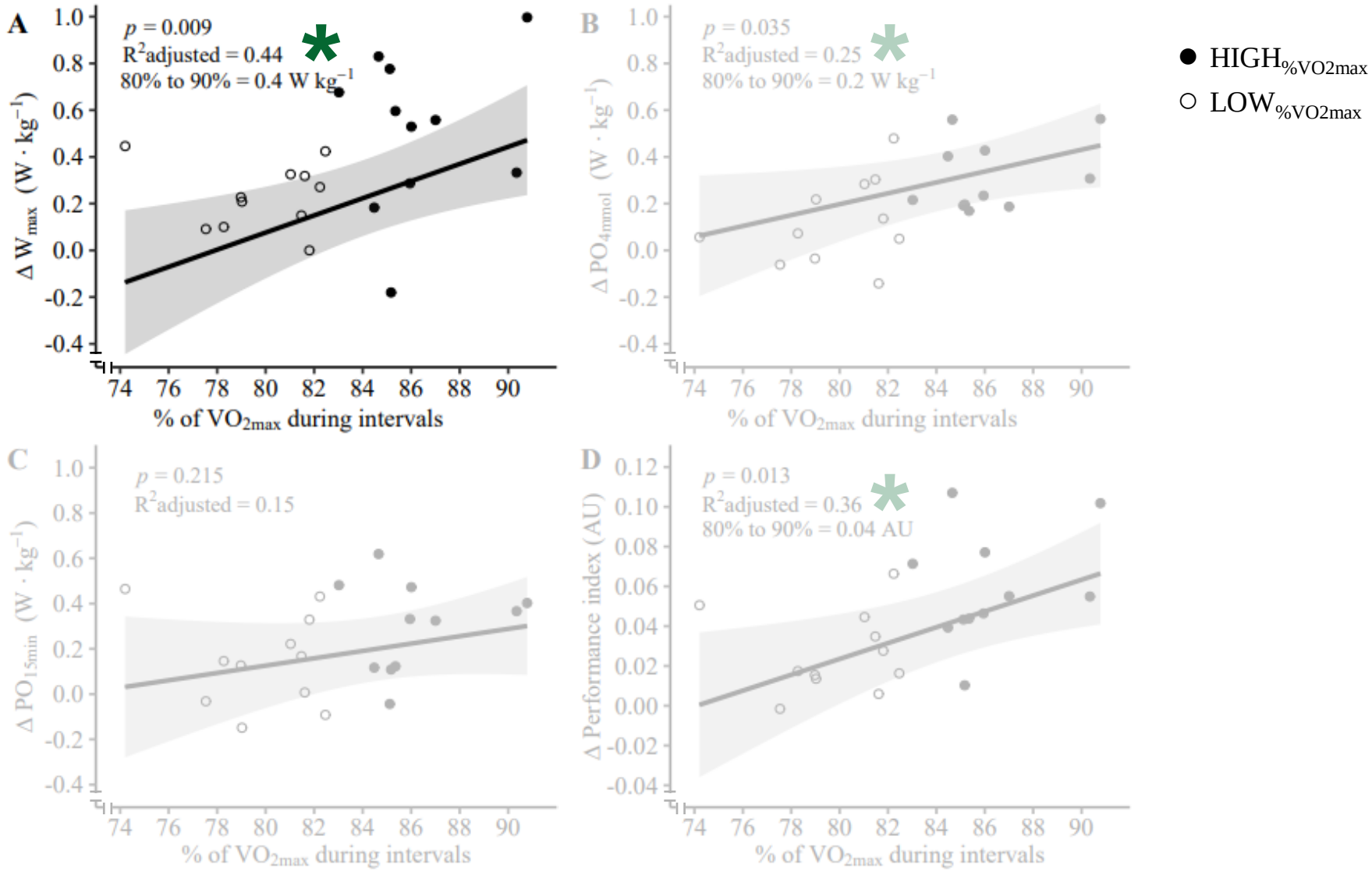
Interval session data

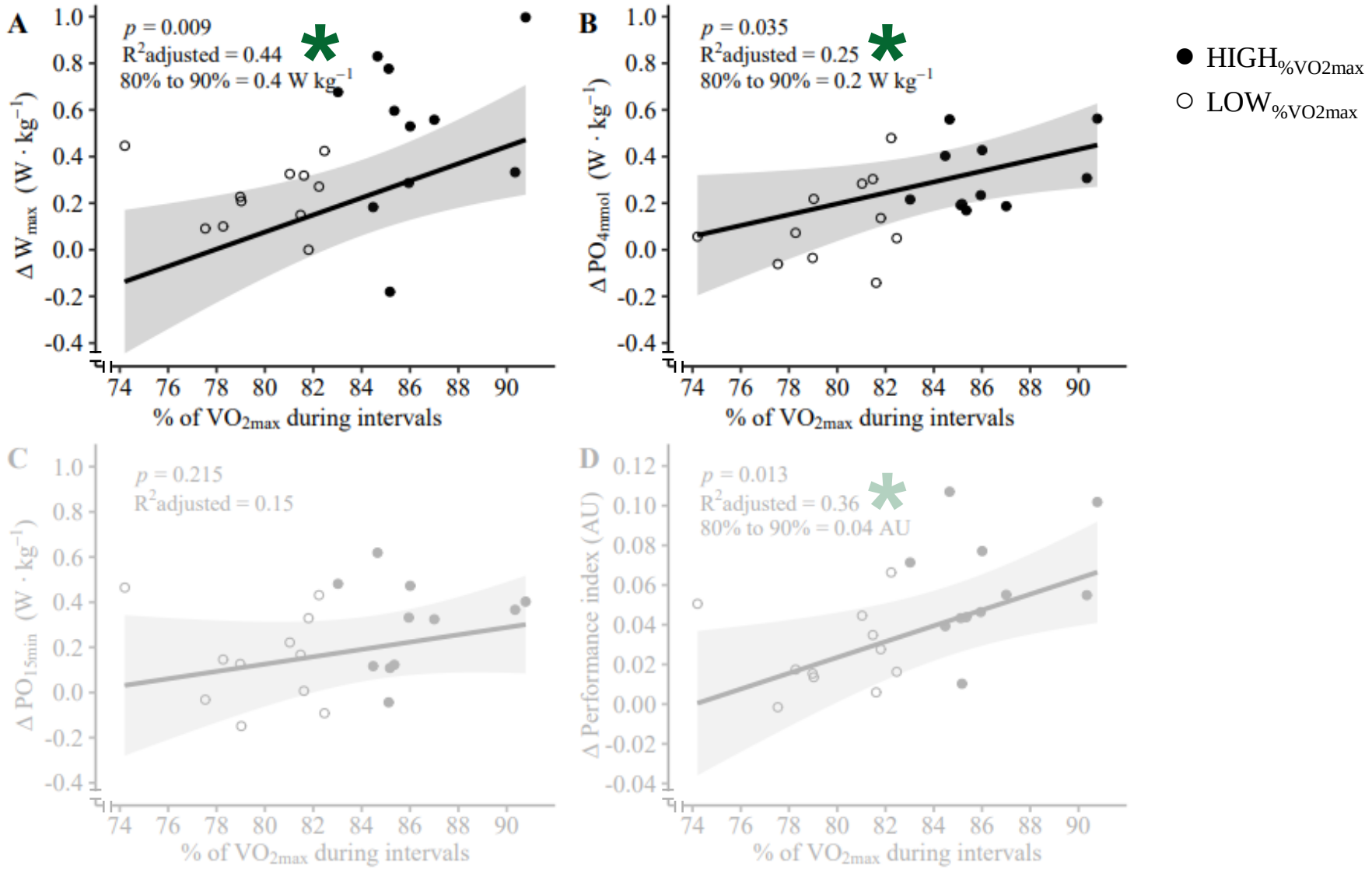
	All participants (n = 22)			$HIGH_{\% VO2max}$ (n = 11)			$LOW_{\% VO2max}$ (n = 11)		
	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3
Time ≥ 90% of VO_{2max} (m:s)	08:50 (10:03)	09:03 (10:08)	10:23 (09:55)	15:32 (10:03)*	15:05 (10:47)*	14:52 (09:43)*	02:14 (03:38)	03:06 (04:18)	05:52 (07:53)&
% of VO_{2max}	[illegible]	[illegible]	83.5 (4.8)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.0 (4.5)&
Time ≥ 90% of HR_{max} (m:s)	12:19 (10:23)	15:01 (10:44)&	[illegible]	12:57 (10:03)	18:53 (09:46)&	21:17 (10:12)&	11:41 (10:44)	[illegible]	[illegible] (09:40)$
% of HR_{max}	87.2 (2.2)	[illegible]	88.3 (2.2)& $	[illegible]	88.4 (2.4)	[illegible]	86.8 (2.3)	86.9 (2.3)	87.7 (1.7)
% of W_{max}	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% of PO_{40min} measured at baseline	98.7 (3.2)	102.2 (4.1)&	103.3 (4.8)& $	97.6 (3.4)	101.0 (4.5)&	102.4 (4.4)&$	99.9 (2.6)	103.5 (3.3)&	104.2 (5.0)&
% of $[La^-]_{max}$	45.1 (12.4)	47.5 (13.4)	52.3 (19.4)&	46.0 (14.3)	50.8 (14.3)	53.7 (23.1)	44.3 (10.8)	44.3 (11.9)	50.9 (15.1)
% of RPE_{20}	80.1 (4.8)	80.6 (5.7)	81.6 (5.8)& $	80.9 (4.8)	82.0 (5.8)	83.0 (5.4)&	79.2 (4.8)	79.3 (5.4)	80.1 (5.9)

Only % of VO_{2max} and time ≥ 90% of VO_{2max} during work intervals differed between groups

The effect of % of VO_{2max} on changes in endurance performance



The effect of % of VO_{2max} on changes in endurance performance



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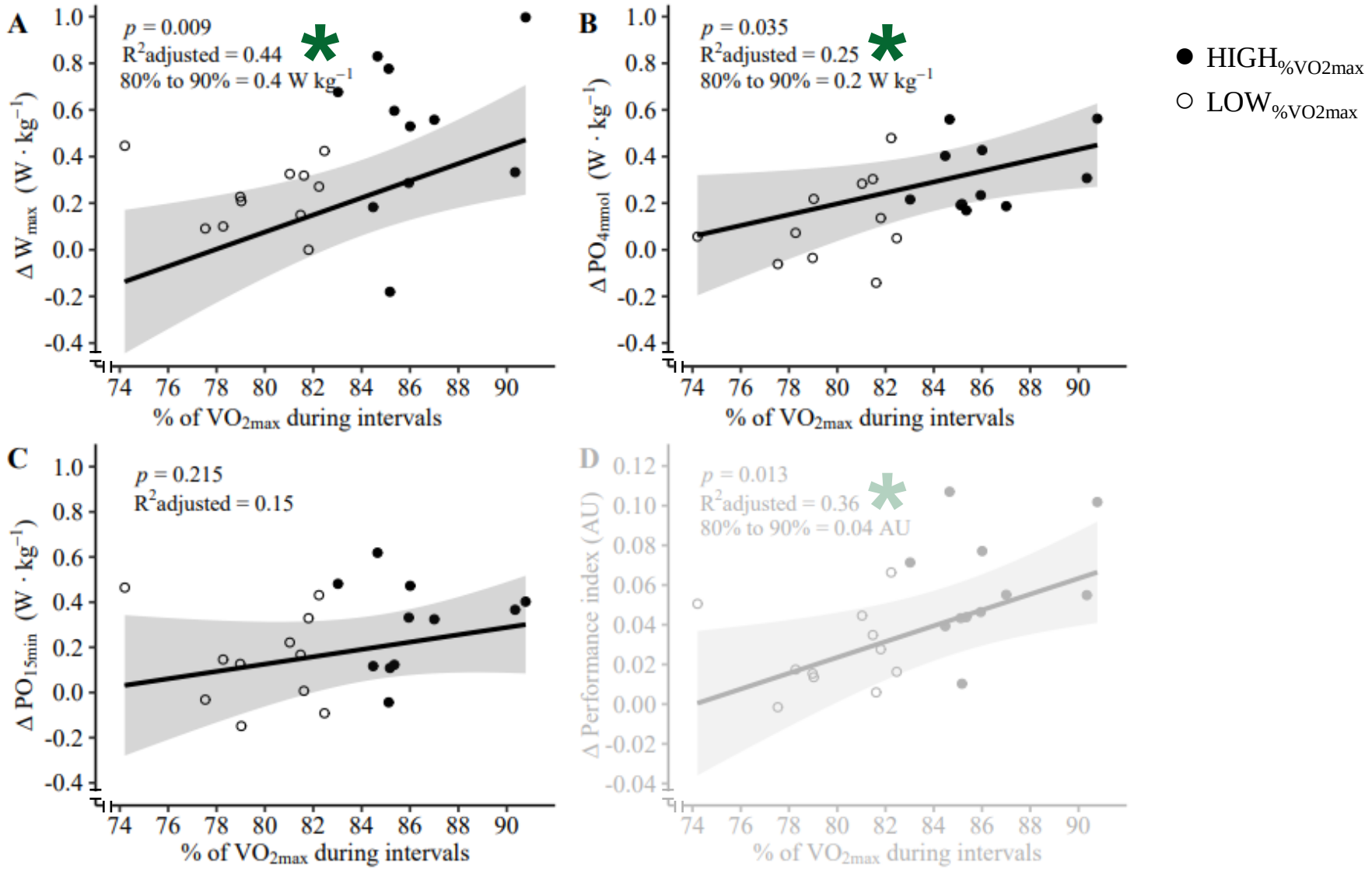

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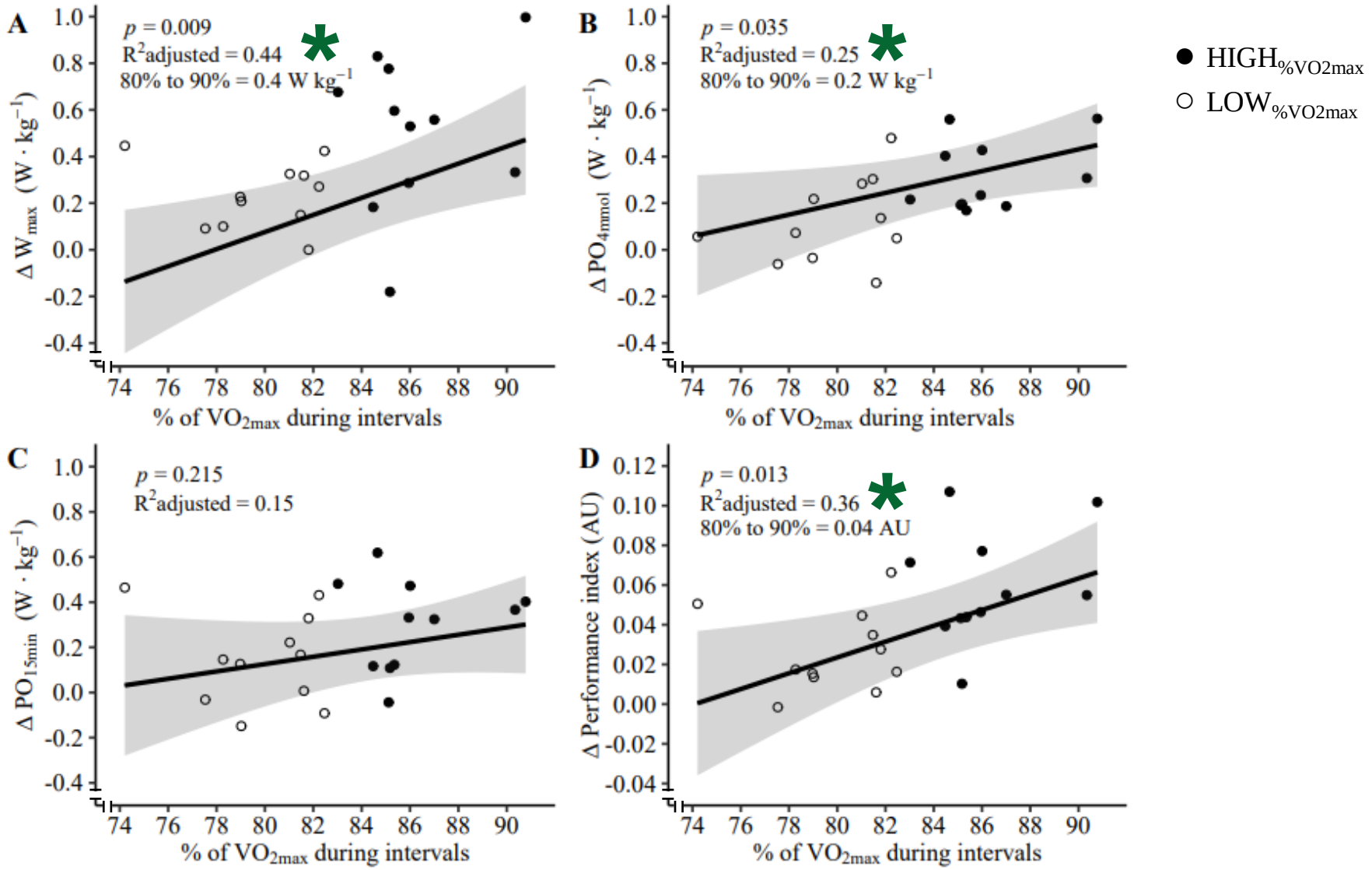
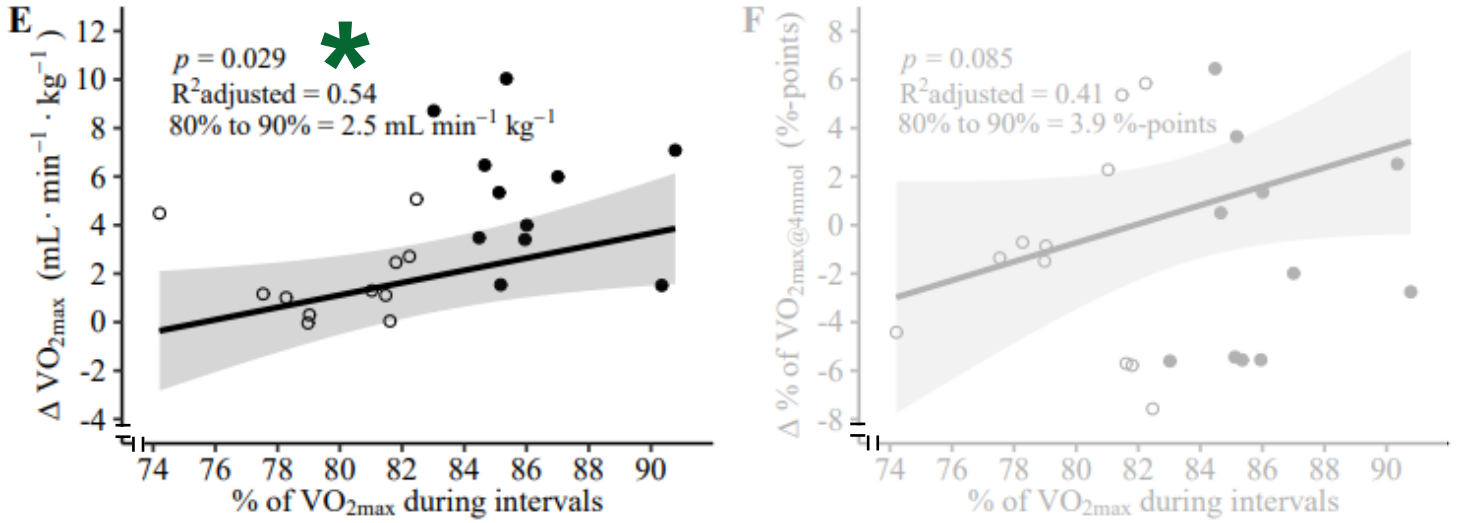


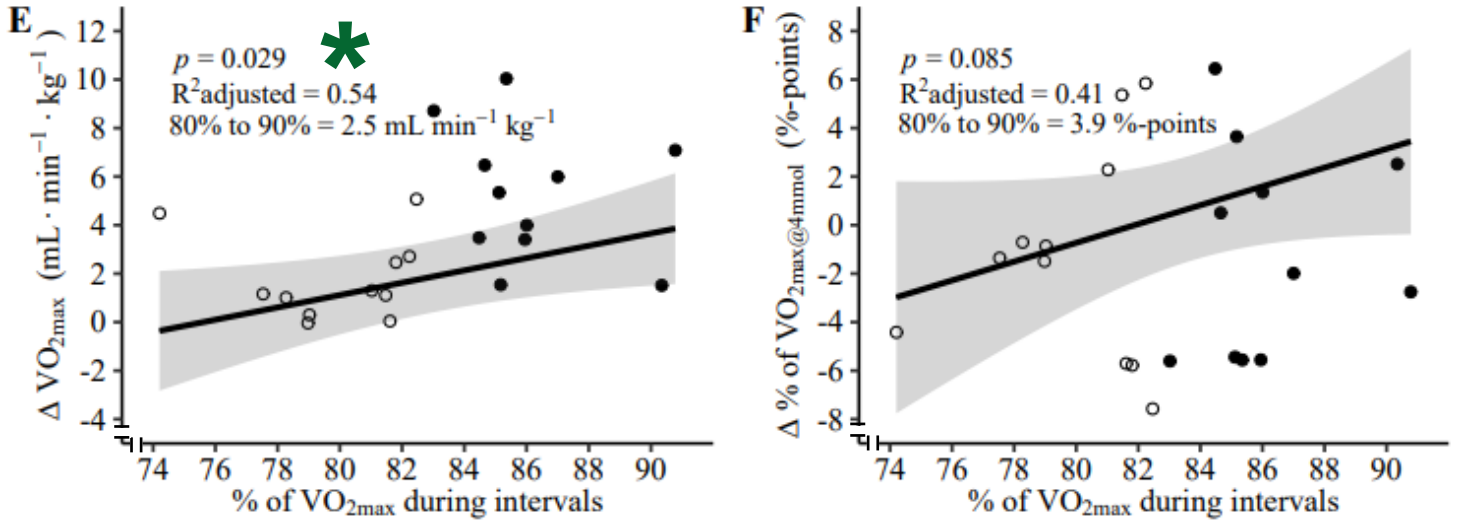
The effect of % of VO_{2max} on changes in determinants of endurance performance

- ● $HIGH_{\%VO2max}$
- ○ $LOW_{\%VO2max}$



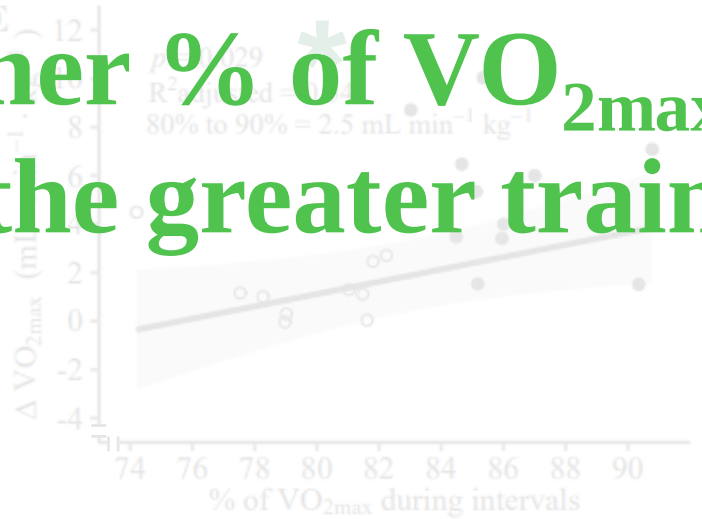
The effect of % of VO_{2max} on changes in determinants of endurance performance

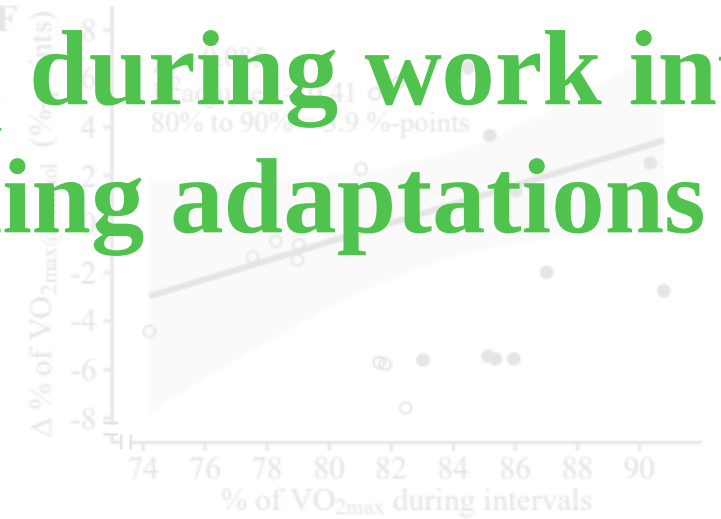
- ● $HIGH_{\%VO2max}$
- ○ $LOW_{\%VO2max}$



The effect of % of VO_{2max} on changes in determinants of endurance performance

HIGH$_{\%VO2max}$
LOW$_{\%VO2max}$





The higher % of VO_{2max} during work intervals, the greater training adaptations

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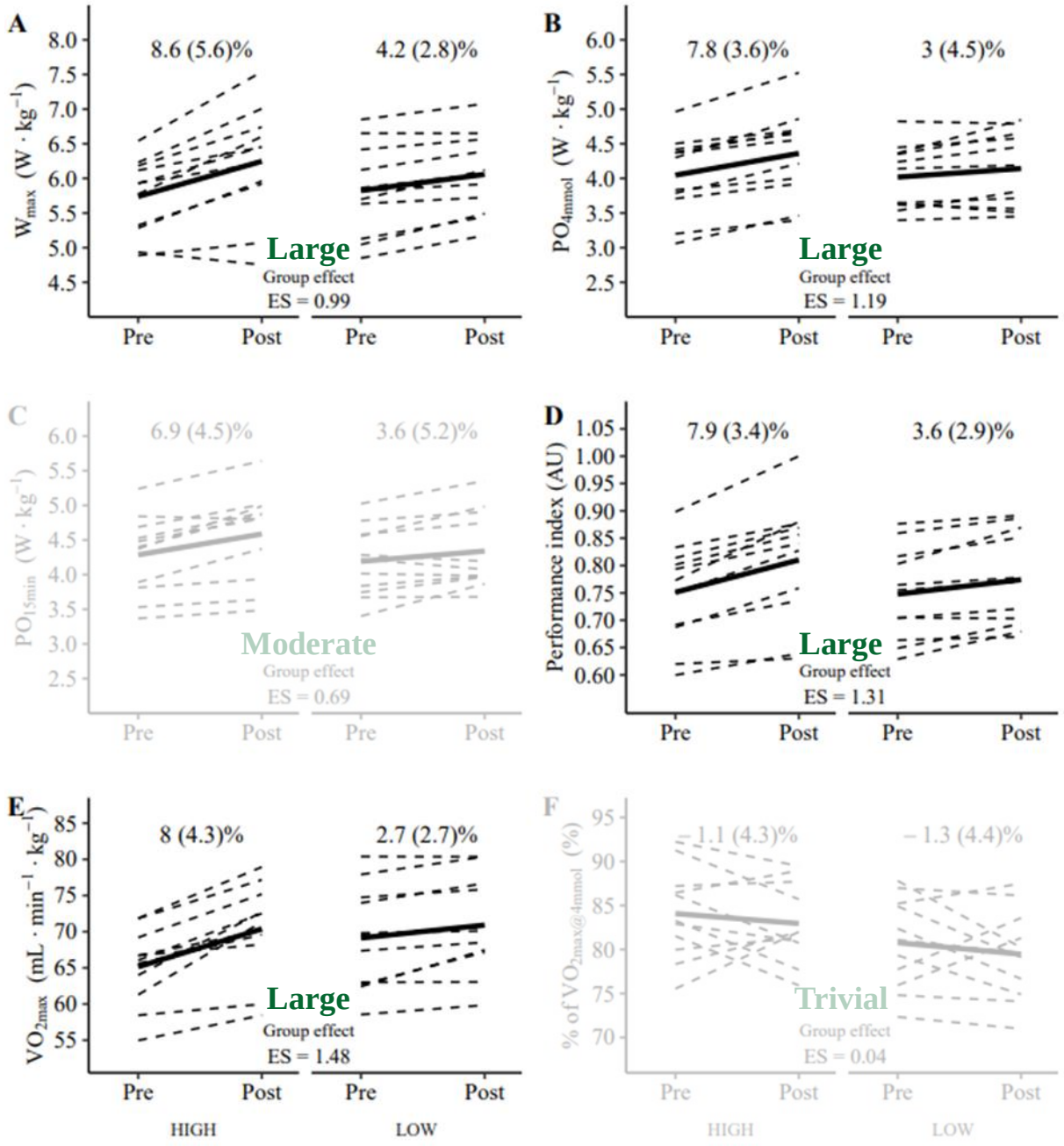
Group comparisons



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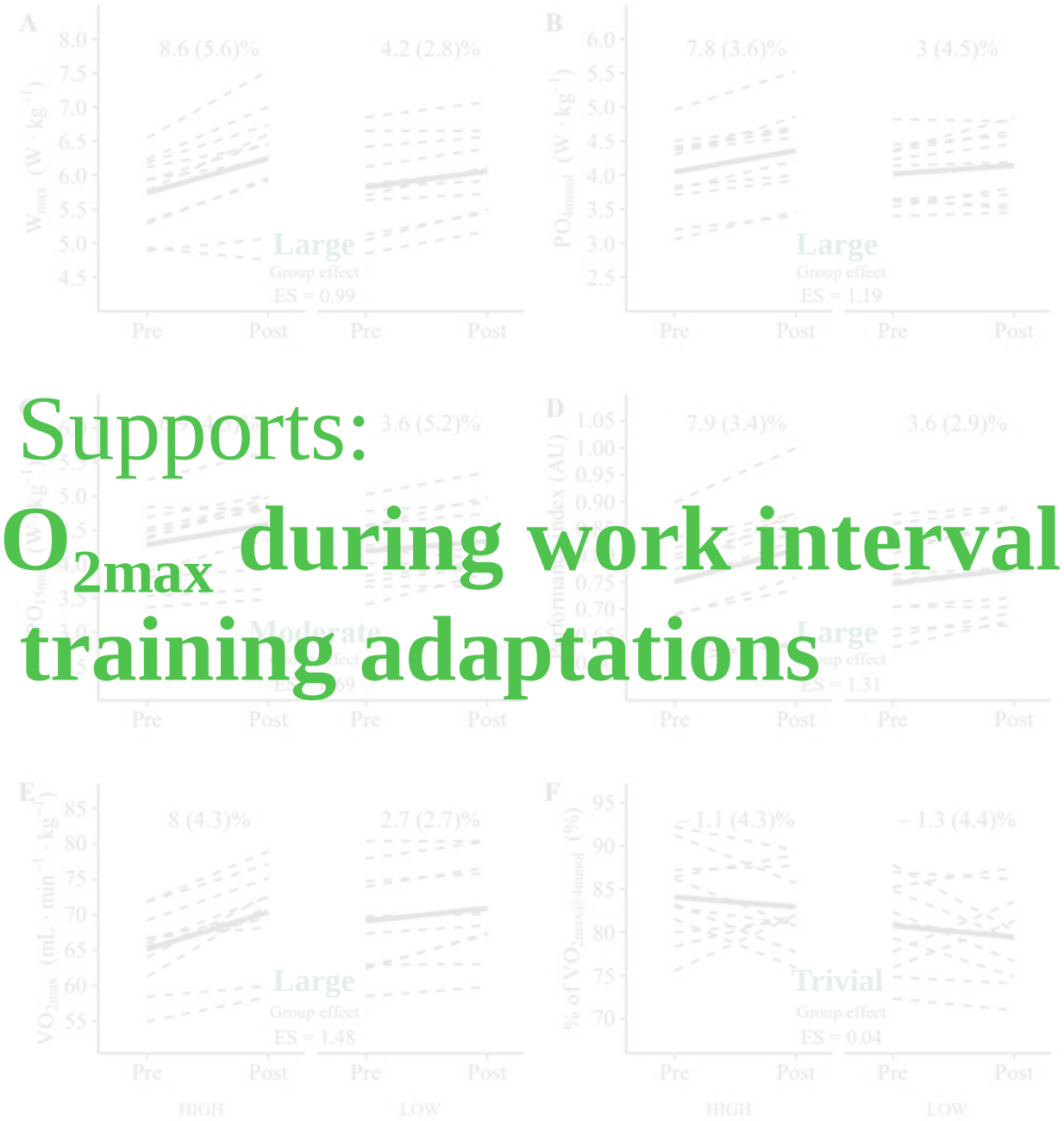

Supports:

The higher % of VO_{2max} during work intervals, the greater training adaptations

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Characteristics of participants with a high % of VO_{2max} during work intervals

	% of VO_{2max} during intervals (dependent variable)
Baseline characteristics (independent variables)	
Baseline W_{max} ($W \cdot kg^{-1}$)	
Baseline PO_{4mmol} ($W \cdot kg^{-1}$)	*
Baseline PO_{15min} ($W \cdot kg^{-1}$)	*
Baseline VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	
Baseline % of $VO_{2max@4mmol}$ (%)	*
Baseline GE_{175W} (%)	

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Baseline % of $VO_{2max@4mmol}$ (%)	*
Baseline GE_{175W} (%)	

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Baseline VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	
Baseline % of $VO_{2max@4mmol}$ (%)	*
Baseline GE_{175W} (%)	

The higher fractional utilization of VO_{2max}, the higher % of VO_{2max} during work intervals

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All exercise intensity measures and their associations with training adaptations

Training adaptations (dependent variables)	**Exercise intensity measures** (independent variables)							
	% of VO_{2max}	Time ≥ 90% of VO_{2max}	% of HR_{max}	Time ≥ 90% of HR_{max}	% of W_{max}	% of PO_{40min}	% of $[La^-]_{max}$	% of RPE_{20}
Δ W_{max} ($W \cdot kg^{-1}$)	*	*						
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	*	*		*				
Δ PO_{15min} ($W \cdot kg^{-1}$)								
Δ Performance index (AU)	*	*	*	*				
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	*							
Δ % of $VO_{2max@4mmol}$ (%-points)					*			
Δ GE_{175W} (%-points)								

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Δ W_{max} ($W \cdot kg^{-1}$)	*	*						
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	*	*		*				
Δ PO_{15min} ($W \cdot kg^{-1}$)								
Δ Performance index (AU)	*	*	*	*				
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	*							
Δ % of $VO_{2max@4mmol}$ (%-points)					*			
Δ GE_{175W} (%-points)								

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Δ W_{max} ($W \cdot kg^{-1}$)	*	*						
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	*	*		*				
Δ PO_{15min} ($W \cdot kg^{-1}$)								
Δ Performance index (AU)	*	*	*	*				
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	*							
Δ % of $VO_{2max@4mmol}$ (%-points)					*			
Δ GE_{175W} (%-points)								

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Δ W_{max} ($W \cdot kg^{-1}$)	*	*						
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	*	*		*				
Δ PO_{15min} ($W \cdot kg^{-1}$)								
Δ Performance index (AU)	*	*	*	*				
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	*							
Δ % of $VO_{2max@4mmol}$ (%-points)					*			
Δ GE_{175W} (%-points)								

% of VO_{2max} the best exercise intensity measure in reflecting training adaptations

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Reliability of exercise intensity measures between interval sessions

	ICC	Session-to session reliability
% of VO_{2max}	**0.61**	**Moderate**
Time ≥ 90% of VO_{2max}	**0.56**	**Moderate**
% of HR_{max}	0.31	Poor
Time ≥ 90% of HR_{max}	0.24	Poor

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Reliability of exercise intensity measures between interval sessions

	ICC	Session-to session reliability
% of VO_{2max}	0.61	Moderate
Time ≥ 90% of VO_{2max}	0.56	Moderate
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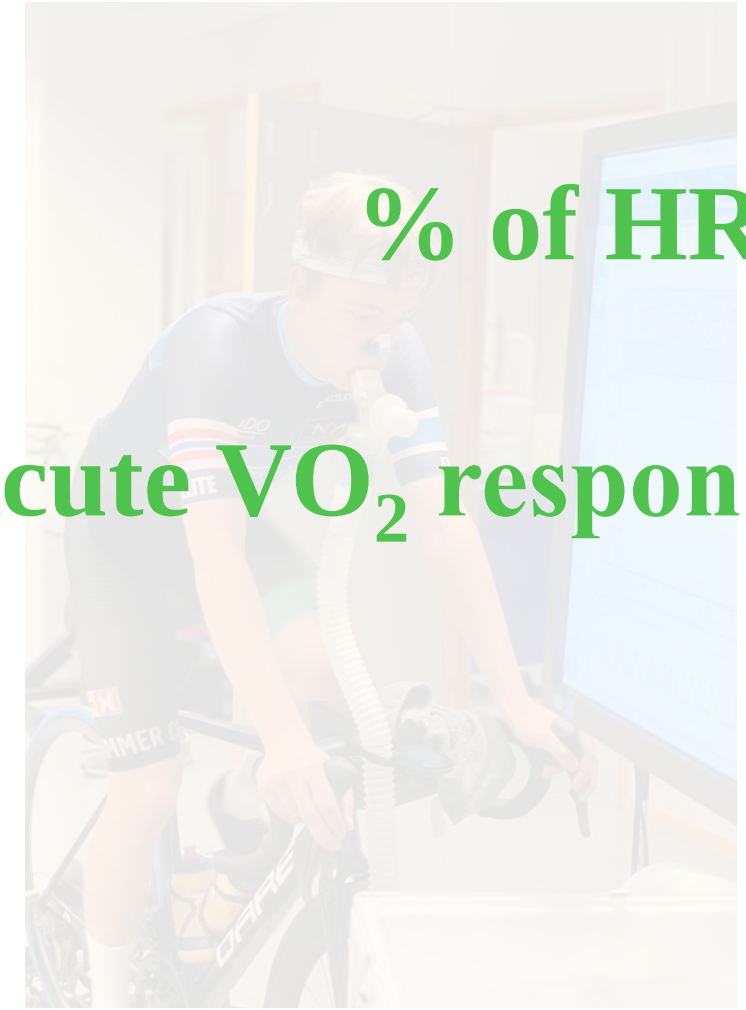
Reliability of exercise intensity measures between interval sessions



% of HR_{max} ≠ % of VO_{2max}

Acute VO_2 response ≠ VO_2 response over time

	ICC	Session-to session reliability
% of VO_{2max}	0.61	Moderate
Time ≥ 90% of VO_{2max}	[illegible]	Moderate
% of HR_{max}	0.31	Poor
Time ≥ 90% of HR_{max}	0.24	Poor

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Main finding

- **The higher % of VO_{2max} during work intervals, the greater training adaptations**

Additional findings

- % of VO_{2max} the best exercise intensity measure in reflecting training adaptations
- % of VO_{2max} better session-to-session reliability compared to % of HR_{max}
- Acute VO_2 response to a single interval session ≠ VO_2 response over time

Photo: Andreas Øhrn

Practical implications

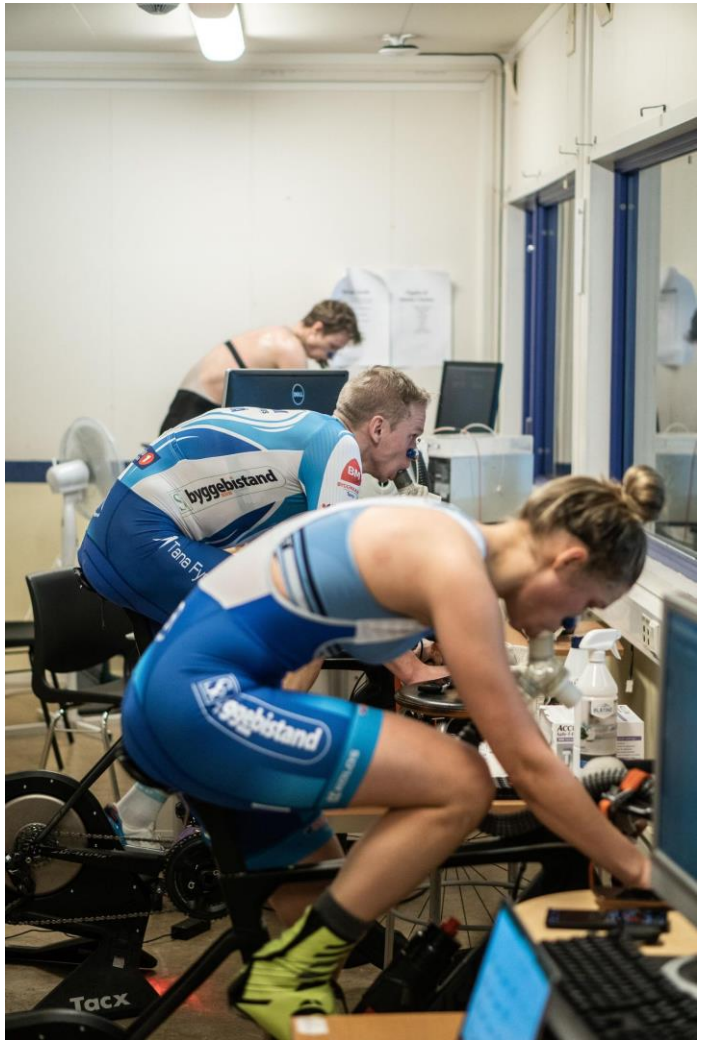

Photo: Andreas Øhrn

- Low fractional utilization of VO_{2max}
  → shorter work intervals at higher power output?

- Regularly verify the PO and HR associated with a high % of VO_{2max}

Thank you for the attention!

Ingvill Odden, Ph.D. candidate

ingvill.odden@inn.no

The Trainome Research Group

Section for Health and Exercise Physiology

Inland Norway University of Applied Sciences Lillehammer

Høgskolen i Innlandet

Supplementary

Høgskolen i Innlandet

Statistics

- Performance index
  - W_{max}, PO_{4mmol}, and PO_{15min}
- Relationships between exercise intensity/baseline characteristics and training adaptations
  - Multiple linear regression models
- Reliability of exercise intensity measures
  - Intraclass correlation coefficient
- Differences between groups at baseline
  - ANOVA
- Differences in interval session measures
  - Linear mixed models
- Differences between groups in training adaptations
  - Chohen´s d effect size

Training data

Table 2: *Average weekly training data during the nine-week training intervention for groups eliciting the highest and lowest average fraction of maximal oxygen consumption during interval sessions (HIGH$_{\%\dot{V}O_{2max}}$ and LOW$_{\%\dot{V}O_{2max}}$, respectively).*

	All participants (n = 22)	**HIGH$_{\%\dot{V}O_{2max}}$** (n = 11)	**LOW$_{\%\dot{V}O_{2max}}$** (n = 11)
Zone 1 (< 55% of PO_{40min}; h:m)	02:32 (01:25)	03:12 (01:29) *	01:48 (00:48)
Zone 2 (56-75% of PO_{40min}; h:m)	02:54 (01:20)	03:19 (01:22)	02:28 (01:13)
Zone 3 (76-90 of PO_{40min}; h:m)	01:09 (00:25)	01:09 (00:26)	01:10 (00:24)
Zone 4 (91-105% of PO_{40min}; h:m)	01:22 (00:20)	01:20 (00:20)	01:25 (00:21)
Zone 5 (> 106% of PO_{40min}; h:m)	00:30 (00:21)	00:25 (00:16)	00:34 (00:25)
Heavy resistance training (h:m)	00:10 (00:23)	00:02 (00:07)	00:17 (00:31)
Core training (h:m)	00:17 (00:19)	00:15 (00:17)	00:18 (00:22)
Total training (h:m)	08:41 (02:36)	09:43 (02:24) #	07:40 (02:28)
Feeling legs (1-9)	5.1 (0.3)	5.1 (0.3)	5.2 (0.3)

*Feeling legs, perceived well-being in the legs where 1 is very very good and 9 is very very bad. Values are mean (SD). * Significantly different from LOW$_{\%\dot{V}O_{2max}}$ ($p \leq 0.05$). # Tendency to different from LOW$_{\%\dot{V}O_{2max}}$ ($p < 0.1$ and > 0.05).*

Interval session data

	All participants (n = 22)			**HIGH$_{\%VO2max}$** (n = 11)			**LOW$_{\%VO2max}$** (n = 11)		
	Period 1	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**	**Period 1**	**Period 2**	**Period 3**
Time ≥ 90% of VO_{2max} (m:s)	08:50 (10:03)	09:03 (10:08)	10:23 (09:55)	15:32 (10:03)*	15:05 (10:47)*	14:52 (09:43)*	02:14 (03:38)	03:06 (04:18)	05:52 (07:53)$^{\&}$
% of VO_{2max}	82.6 (5.1)	83.0 (5.1)	83.5 (4.8)	86.3 (3.6)*	86.2 (4.2)*	85.9 (3.8)*	79.0 (3.6)	79.7 (3.6)	81.0 (4.5)$^{\&}$
VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	55.4 (5.6)	57.3 (5.8)$^{\&}$	58.6 (6.1) $^{\& \$}$	56.3 (5.6)	58.2 (6.0)$^{\&}$	59.2 (6.0)$^{\&\$}$	54.6 (5.4)	56.3 (5.5)$^{\&}$	58.0 (6.2)$^{\&\$}$
Time ≥ 90% of HR_{max} (m:s)	12:19 (10:23)	15:01 (10:44)$^{\&}$	18:36 (10:16)$^{\& \$}$	12:57 (10:03)	18:53 (09:46)$^{\&}$	21:17 (10:12)$^{\&}$	11:41 (10:44)	11:11 (10:19)	15:53 (09:40)$^{\$}$
% of HR_{max}	87.2 (2.2)	87.6 (2.4)	88.3 (2.2)$^{\& \$}$	87.6 (2.0)	88.4 (2.4)	88.9 (2.4)$^{\&}$	86.8 (2.3)	86.9 (2.3)	87.7 (1.7)
HR (bpm)	168 (8)	168 (9)	169 (8)$^{\&}$	172 (8)*	173 (10)*	174 (7) *	163 (5)	164 (5)	165 (5)
% of W_{max}	64.6 (3.2)	63.3 (3.6)$^{\&}$	63.0 (3.6)$^{\&}$	64.9 (3.6)	63.4 (4.0)$^{\&}$	62.7 (3.6)$^{\&}$	64.3 (2.6)	63.1 (3.2)$^{\&}$	63.3 (3.5)$^{\&}$
% of PO_{40min} measured at baseline	98.7 (3.2)	102.2 (4.1)$^{\&}$	103.3 (4.8)$^{\& \$}$	97.6 (3.4)	101.0 (4.5)$^{\&}$	102.4 (4.4)$^{\&\$}$	99.9 (2.6)	103.5 (3.3)$^{\&}$	104.2 (5.0)$^{\&}$
PO ($W \cdot kg^{-1}$)	3.7 (0.4)	3.9 (0.5)$^{\&}$	3.9 (0.5)$^{\& \$}$	3.7 (0.5)	3.9 (0.5)$^{\&}$	3.9 (0.6)$^{\&\$}$	3.7 (0.4)	3.9 (0.4)$^{\&}$	3.9 (0.5)$^{\&\$}$
% of $[La^-]_{max}$	45.1 (12.4)	47.5 (13.4)	52.3 (19.4)$^{\&}$	46.0 (14.3)	50.8 (14.3)	53.7 (23.1)	44.3 (10.8)	44.3 (11.9)	50.9 (15.1)
$[La^-]$ ($mmol \cdot L^{-1}$)	5.24 (1.76)	5.85 (1.65)$^{\&}$	6.32 (2.34)$^{\&}$	5.15 (1.94)	5.88 (1.39)	6.19 (2.53)	5.31 (1.62)	5.83 (1.90)	6.45 (2.17)$^{\&}$
% of RPE_{20}	80.1 (4.8)	80.6 (5.7)	81.6 (5.8)$^{\& \$}$	80.9 (4.8)	82.0 (5.8)	83.0 (5.4)$^{\&}$	79.2 (4.8)	79.3 (5.4)	80.1 (5.9)
RPE (6-20)	16.0 (1.0)	16.1 (1.1)	16.3 (1.2)$^{\& \$}$	16.2 (1.0)	16.4 (1.2)	16.6 (1.1)$^{\&}$	15.8 (1.0)	15.9 (1.1)	16.0 (1.2)
Feeling legs (1-9)	5.3 (0.9)	5.4 (0.8)	5.4 (0.7)	5.2 (0.9)	5.5 (0.9)	5.4 (0.7)	5.4 (0.9)	5.2 (0.7)	5.4 (0.7)
sRPE (0-10)	6.4 (1.6)	6.5 (1.5)	6.8 (1.5)$^{\&}$	6.9 (1.7)	7.0 (1.6)	7.4 (1.4)	5.9 (1.4)	6.1 (1.3)	6.3 (1.4)
Completed sessions (n)	6.9 (0.3)	7.0 (0.2)	6.8 (0.5)$^{\& \$}$	6.8 (0.4)	6.9 (0.3)	6.8 (0.6)	7.0 (0.0)	7.0 (0.0)$^{\&}$	6.7 (0.6)$^{\&\$}$

W_{max} and $\dot{V}O_{2max}$ during the intervention

Table 4: *Maximal 1-min incremental power output (W_{max}) and maximal oxygen consumption ($\dot{V}O_{2max}$) prior to the intervention (baseline) and following 3, 6, and 9 weeks of training for all participants combined and groups eliciting the highest and lowest average fraction of $\dot{V}O_{2max}$ during interval sessions ($HIGH_{\%\dot{V}O2max}$ and $LOW_{\%\dot{V}O2max}$, respectively).*

		Timepoints			
		Baseline	**3 weeks**	**6 weeks**	**9 weeks**
All participants ($n = 22$)	W_{max} ($W \cdot kg^{-1}$)	5.8(0.6)	6.1(0.6)[&]	6.2(0.7)[&]	6.2(0.7)[&]
	$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	67.1(6.4)	69.1(6.4)[&]	69.8(6.0)[&]	70.6(6.4)[&$]
$HIGH_{\%\dot{V}O2max}$ ($n = 11$)	W_{max} ($W \cdot kg^{-1}$)	5.7(0.6)	6.1(0.7)[&]	6.2(0.7)[&]	6.2(0.8)[&]
	$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	65.1(5.3)	67.5(5.9)[&]	69.1(6.1)[&]	70.4(6.4)[&$]
$LOW_{\%\dot{V}O2max}$ ($n = 11$)	W_{max} ($W \cdot kg^{-1}$)	5.8(0.7)	6.1(0.6)[&]	6.1(0.7)[&]	6.1(0.6)
	$\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	69.1(7.1)	70.7(6.8)	70.6(6.1)	70.9(6.7)[#]

[&] *Significantly different from baseline ($p \leq 0.05$).* [#] *Tendency to different from baseline ($p < 0.1$ and > 0.05).*
[$] *Significantly different from 3 weeks.*

Characteristics of participants with a high % of $\dot{V}O_{2max}$ during intervals

Table 5: *Multiple linear regression of baseline measures related to % of $\dot{V}O_{2max}$ during intervals, all when controlling for sex.*

	Dependent variable: % of $\dot{V}O_{2max}$ during intervals			
Independent variables	Estimate [£]	*p*	95% CI	$R^2_{adjusted}$
Baseline W_{max} ($W \cdot kg^{-1}$)	2.66	0.172	[-1.26, 6.57]	0.00
Baseline PO_{4mmol} ($W \cdot kg^{-1}$)	4.70	0.028 *	[0.57, 8.83]	0.15
Baseline PO_{15min} ($W \cdot kg^{-1}$)	4.76	0.013 *	[1.13, 8.38]	0.21
Baseline $\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	-0.06	0.757	[-0.44, 0.33]	-0.10
Baseline % of $\dot{V}O_{2max@4mmol}$ (%-points)	0.42	0.011 *	[0.11, 0.73]	0.22
Baseline GE_{175W} (%-points)	2.36	0.052 #	[-0.02, 4.73]	0.11

*% of $\dot{V}O_{2max}$ during intervals; average fraction of maximal oxygen consumption ($\dot{V}O_{2max}$) elicited during intervals; W_{max}, maximal 1-min incremental power output; PO_{4mmol}, power output at 4 mmol·L^{-1} blood lactate concentration ([La$^-$]); PO_{15min}, maximal power output during the 15-min cycling trial; $\dot{V}O_{2max}$, maximal oxygen consumption; % of $\dot{V}O_{2max@4mmol}$, fractional utilization of $\dot{V}O_{2max}$ at 4 mmol·L^{-1} [La$^-$]; GE_{175W}, gross efficiency at 175 watts. * Significant relationship ($p \leq 0.05$). # Tendency to relationship ($p < 0.1$ and > 0.05). £ For each unit higher baseline value of the independent variable, the estimate indicates how much higher % of $\dot{V}O_{2max}$ (dependent variable) theoretically would be.*

Reliability of exercise intensity measures between interval sessions

	ICC	Explanation	CI
% of $\dot{V}O_{2max}$	0.61	Moderate	[0.47, 0.76]
Time ≥ 90% of $\dot{V}O_{2max}$	0.56	Moderate	[0.42, 0.73]
% of HR_{max}	0.31	Poor	[0.20, 0.49]
Time ≥ 90% of HR_{max}	0.24	Poor	[0.14, 0.42]
% of W_{max}	0.62	Moderate	[0.48, 0.77]
% of RPE_{20}	0.67	Moderate	[0.54, 0.81]
$[La^-]_{max}$	0.44	Poor	[0.30, 0.62]

The effect of time ≥ 90% of $\dot{V}O_{2max}$ on training adaptations

	Independent variable			
	Time ≥ 90% of $\dot{V}O_{2max}$ during intervals (minutes)			
Dependent variables	Estimate [£]	p	95% CI	$R^2_{adjusted}$
Δ W_{max} ($W \cdot kg^{-1}$)	**0.02**	**0.026***	**[0.00, 0.03]**	**0.37**
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	**0.01**	**0.045***	**[0.00, 0.02]**	**0.23**
Δ PO_{15min} ($W \cdot kg^{-1}$)	0.01	0.165	[-0.00, 0.02]	0.17
Δ Performance index (AU)	**0.00**	**0.021***	**[0.00, 0.00]**	**0.33**
Δ $\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	0.11	0.094[#]	[-0.02, 0.23]	0.48
Δ % of $\dot{V}O_{2max@4mmol}$ (%-points)	0.20	0.071[#]	[-0.02, 0.42]	0.42
Δ GE_{175W} (%-points)	-0.02	0.562	[-0.07, 0.04]	0.08

The effect of % of HR_{max} and time ≥ 90% of HR_{max} on training adaptations

	Independent variables							
	% of HR_{max} during intervals				Time ≥ 90% of HR_{max} during intervals (minutes)			
Dependent variables	Estimate £	p	95% CI	$R^2_{adjusted}$	Estimate £	p	95% CI	$R^2_{adjusted}$
Δ W_{max} ($W \cdot kg^{-1}$)	0.07	0.134	[-0.02, 0.16]	0.25	0.01	0.266	[-0.01, 0.04]	0.21
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	0.06	0.060#	[-0.00, 0.13]	0.21	**0.02**	**0.043***	**[0.00, 0.03]**	**0.24**
Δ PO_{15min} ($W \cdot kg^{-1}$)	0.05	0.172	[-0.02, 0.12]	0.16	0.01	0.095#	[-0.00, 0.03]	0.21
Δ Performance index (AU)	**0.01**	**0.036***	**[0.00, 0.02]**	**0.29**	**0.00**	**0.037***	**[0.00, 0.00]**	**0.29**
Δ $\dot{V}O_{2max}$ ($mL \cdot min^{-1} \cdot kg^{-1}$)	0.48	0.226	[-0.32, 1.27]	0.43	0.10	0.292	[-0.09, 0.30]	0.42
Δ % of $\dot{V}O_{2max@4mmol}$ (%-points)	0.86	0.300	[-0.84, 2.57]	0.34	0.27	0.139	[-0.10, 0.64]	0.38
Δ GE_{175W} (%-points)	-0.08	0.574	[-0.40, 0.23]	0.07	0.02	0.515	[-0.10, 0.05]	0.08

Other intensity measures and their associations with training adaptations

Supplementary

Table 1: *Multiple linear regression of % of W_{max}, % of PO_{40min}, % of $[La^-]_{max}$, and % of RPE_{20} during intervals related to training adaptions, all when controlling for baseline values, change in body mass, and sex.*

	Independent variables							
	% of W_{max} during intervals				% of PO_{40min} during intervals			
Dependent variables	Estimate £	*p*	95% CI	$R^2_{adjusted}$	Estimate £	*p*	95% CI	$R^2_{adjusted}$
Δ W_{max} ($W \cdot kg^{-1}$)	0.01	0.759	[-0.04, 0.05]	0.15	0.00	0.875	[-0.04, 0.04]	0.14
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	0.01	0.254	[-0.01, 0.05]	0.10	0.02	0.148	[-0.01, 0.04]	0.14
Δ PO_{15min} ($W \cdot kg^{-1}$)	0.02	0.209	[-0.01, 0.06]	0.15	0.02	0.246	[-0.01, 0.05]	0.14
Δ Performance index (AU)	0.00	0.328	[-0.00, 0.01]	0.13	0.00	0.293	[-0.00, 0.01]	0.14
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	-0.04	0.815	[-0.43, 0.34]	0.38	-0.01	0.943	[-0.35, 0.32]	0.38
Δ $\%VO_{2max@4mmol}$ (%-points)	0.61	0.024 *	[0.09, 1.13]	0.48	0.28	0.254	[-0.22, 0.79]	0.35
Δ GE_{175} (%-points)	0.07	0.325	[-0.07, 0.21]	0.11	-0.00	0.996	[-0.12, 0.12]	0.06
	% of $[La^-]_{max}$ during intervals				% of RPE_{20} during intervals			
Dependent variables	Estimate £	*p*	95% CI	$R^2_{adjusted}$	Estimate £	*p*	95% CI	$R^2_{adjusted}$
Δ W_{max} ($W \cdot kg^{-1}$)	0.00	0.902	[-0.01, 0.01]	0.14	0.01	0.659	[-0.02, 0.03]	0.15
Δ PO_{4mmol} ($W \cdot kg^{-1}$)	0.00	0.360	[-0.00, 0.01]	0.07	0.00	0.977	[-0.02, 0.02]	0.02
Δ PO_{15min} ($W \cdot kg^{-1}$)	0.00	0.457	[-0.01, 0.01]	0.09	-0.01	0.337	[-0.03, 0.01]	0.11
Δ Performance index (AU)	0.00	0.496	[-0.00, 0.00]	0.10	-0.00	0.924	[-0.00, 0.00]	0.08
Δ VO_{2max} ($mL \cdot min^{-1} \cdot kg^{-1}$)	0.01	0.783	[-0.08, 0.11]	0.38	0.13	0.283	[-0.11, 0.36]	0.42
Δ $\%VO_{2max@4mmol}$ (%-points)	0.04	0.611	[-0.12, 0.20]	0.30	-0.15	0.437	[-0.54, 0.24]	0.32
Δ GE_{175} (%-points)	-0.02	0.389	[-0.05, 0.02]	0.10	-0.07	0.126	[-0.15, 0.02]	0.19

*W_{max}, maximal 1-minute power output during the incremental test for determination of maximal oxygen consumption ($\dot{V}O_{2max}$-test); PO_{40min}, maximal power output during the 40-min cycling trial; $[La^-]_{max}$, whole blood lactate concentration measured 1 minute after the $\dot{V}O_{2max}$-test; RPE_{20}, the highest possible rating of perceived exhaustion (20); PO_{4mmol}, power output at 4 $mmol \cdot L^{-1}$ blood lactate concentration ($[La^-]$); PO_{15min}, maximal power output during the 15-min cycling trial; $\%\dot{V}O_{2max@4mmol}$, fractional utilization of $\dot{V}O_{2max}$ at 4 $mmol \cdot L^{-1}$ $[La^-]$; GE_{175W}, gross efficiency at 175W. * Significant relationship ($p \leq 0.05$). # Tendency to relationship ($p < 0.1$ and > 0.05). £ For each %-point increase in the different expressions of exercise intensity during intervals, the dependent variables change according to the estimate.*