



St Mary's
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British Blood
Transfusion Society

Iron Deficiency and the Endurance Athlete

Richard Burden
St Mary's University

BBTS Annual Conference 2014



Doping



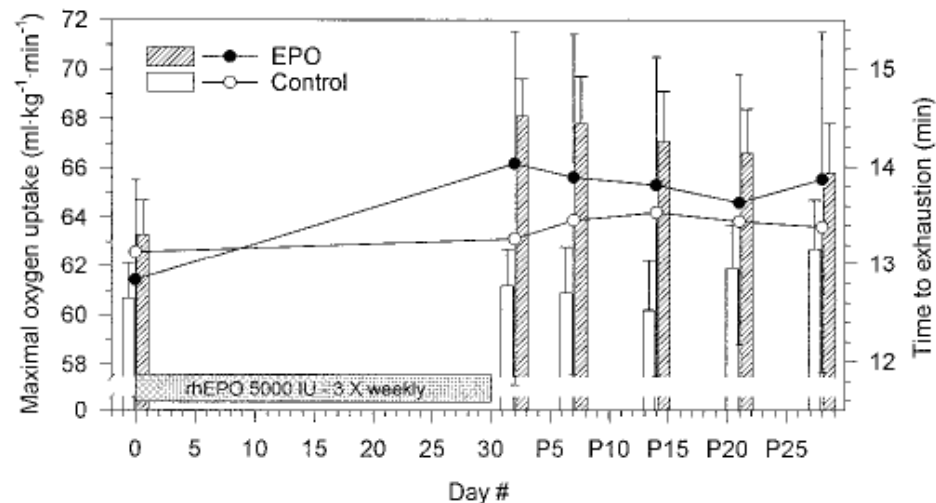


EPO

Effect of rhEPO administration on serum levels of sTfR and cycling performance

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Eur J Appl Physiol (2002) 86: 442-449
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ORIGINAL ARTICLE

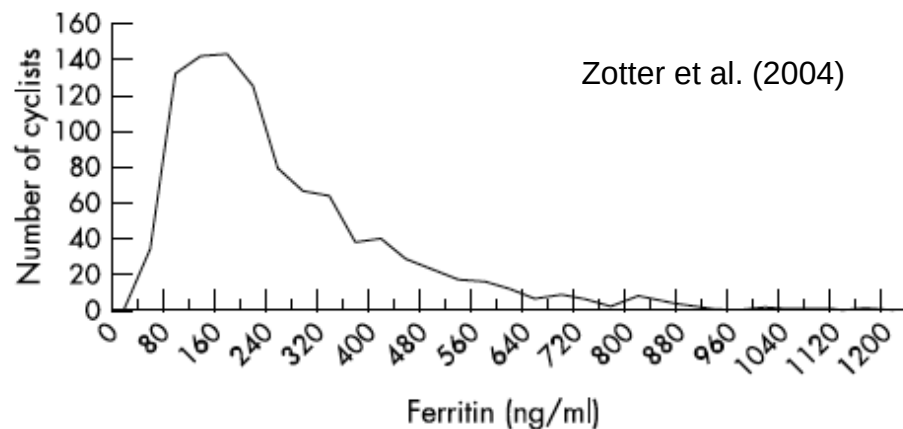
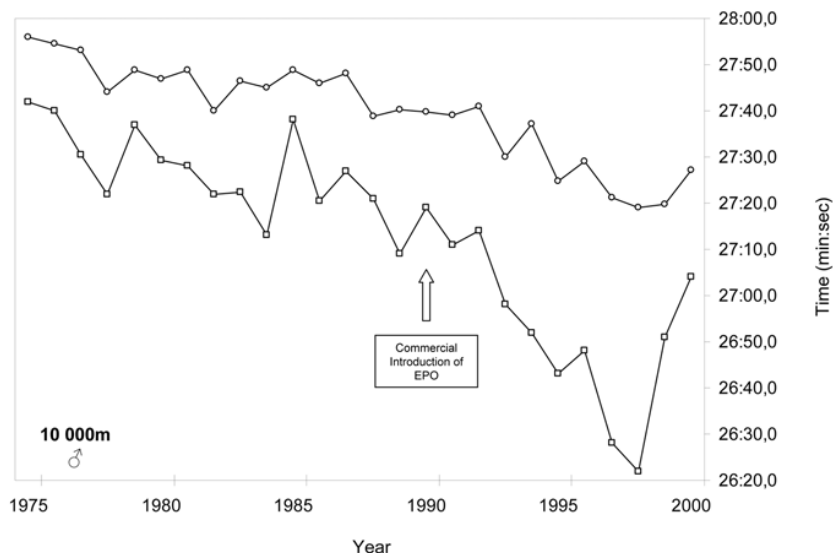
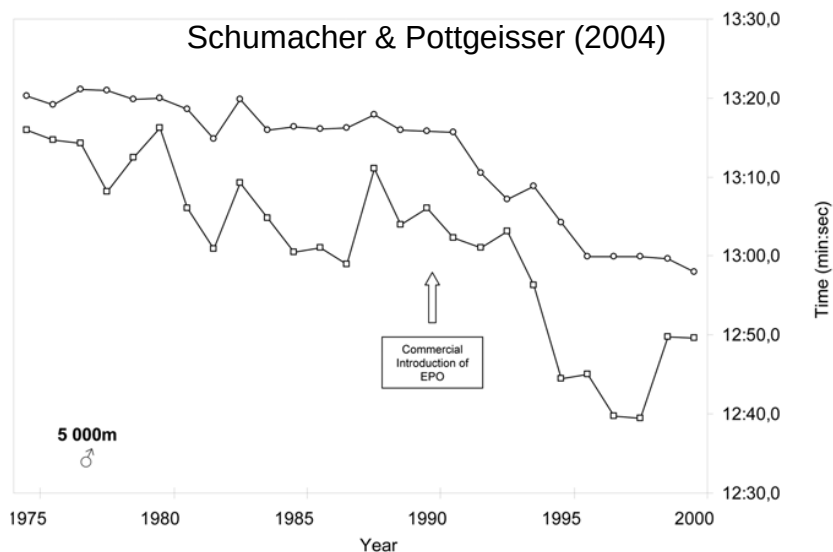
Gabrielle Russell · Christopher J. Gore
Michael J. Ashenden · Robin Parisotto · Allan G. Hahn

Effects of prolonged low doses of recombinant human erythropoietin during submaximal and maximal exercise

- IV and oral iron increase the effect of EPO
- IV more effective than oral

EPO Abuse?

- Current elite athletes intentionally used doping?
– 14-39% (de Hon et al., 2014)

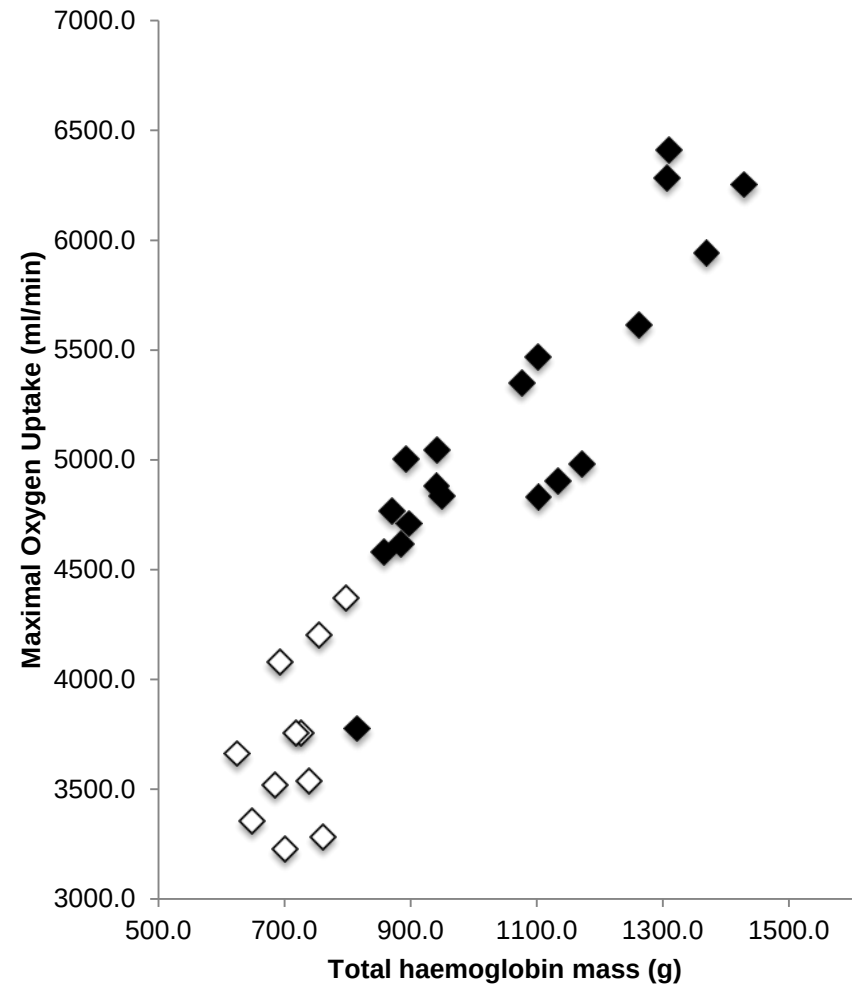




Maximal Aerobic Capacity ($\text{VO}_{2\text{max}}$)



- A key determinant of successful endurance performance
- Highly correlated with Hb-mass



Iron Deficiency and Endurance Athletes

- Endurance athletes more susceptible to greater iron losses
- Iron deficient anaemia (IDA) vs. iron deficient non-anaemia (IDNA)
 - IDA reduces aerobic capacity (Garvican et al., 2011)
 - IDNA is less clear
- Does IDNA exist?



A Case Study of an Iron-Deficient Female Olympic 1500-m Runner

Charles R. Pedlar, Gregory P. Whyte, Richard Burden, Brian Moore,
Gill Horgan, and Noel Pollock

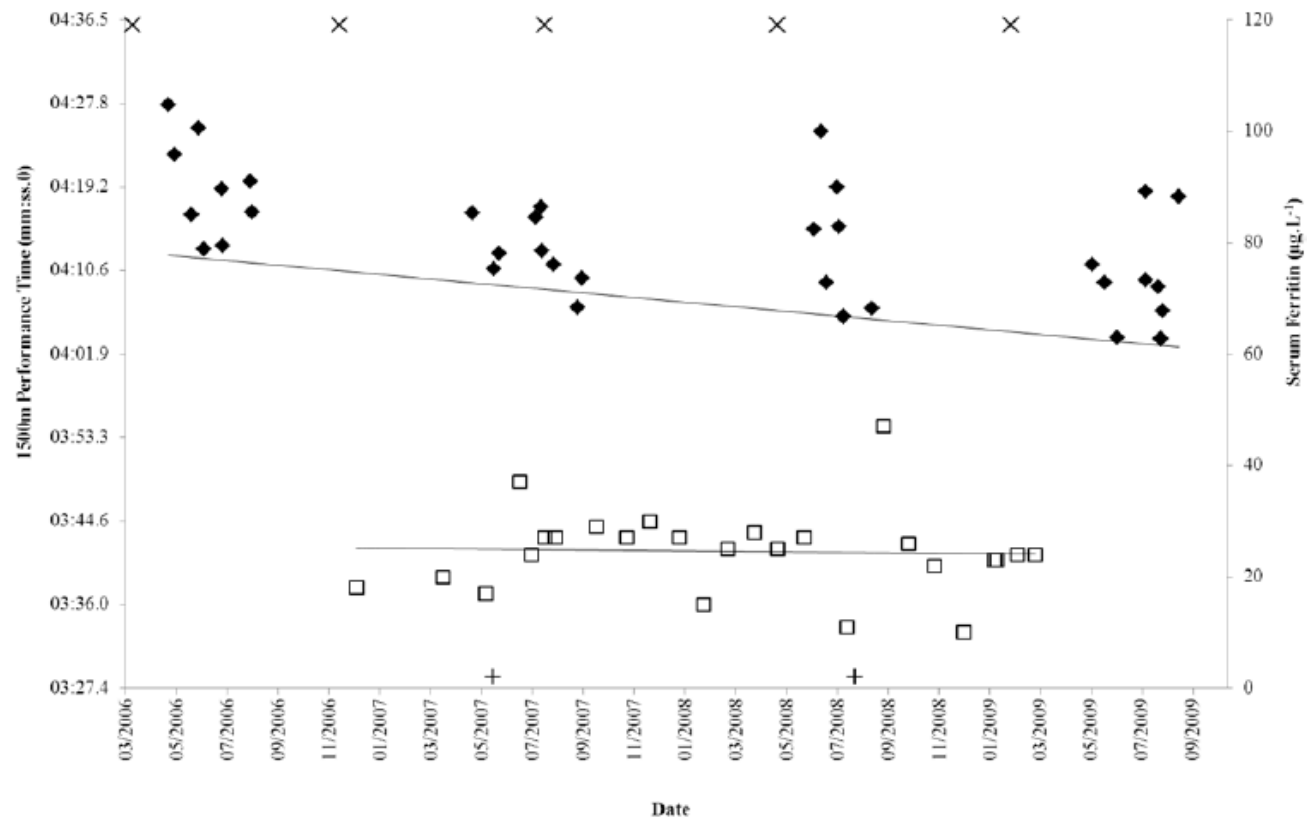
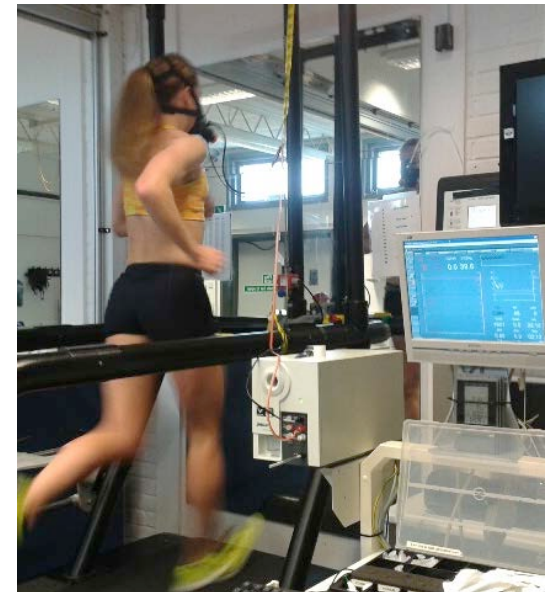


Figure 1 — Ferritin values (open squares) and 1500-m-running time (min:ss; closed diamonds) during the period studied. The 2 highest serum ferritin values (>35 g/dL) occurred after iron injections, and the lowest values (<20 g/dL) corresponded with peak training volumes, often preceding major championships. Linear trend lines of best fit are shown (upper line: $r^2 = .92$ for annual personal best; lower line: $r^2 = .02$ for sFe). 'X's denote the treadmill tests (data are presented in Figure 2) and +'s represent iron injections.



Impact of intravenous iron on aerobic capacity and iron metabolism in elite athletes

- 15 IDNA ($< 30.0 \mu\text{g/L}$, $\text{Hb} > 12.0 \text{ g/dL}$)
 - female $n = 9$, Male $n = 6$
- Randomised control trial
 - IG - 500 mg intravenous iron injection (ferric carboxymaltose)
 - PG - 0.9% sterile saline solution
- 3 x discontinuous exercise tests to exhaustion
 - Pre-treatment
 - 24 h post-treatment
 - 4 wks post-post treatment
- Iron studies
 - Pre-test
 - Immediately post-test
 - 3 h post-test
 - sFer, sFe, Tsat, sTfR, sTf, IL-6, Hepcidin
- Total haemoglobin mass

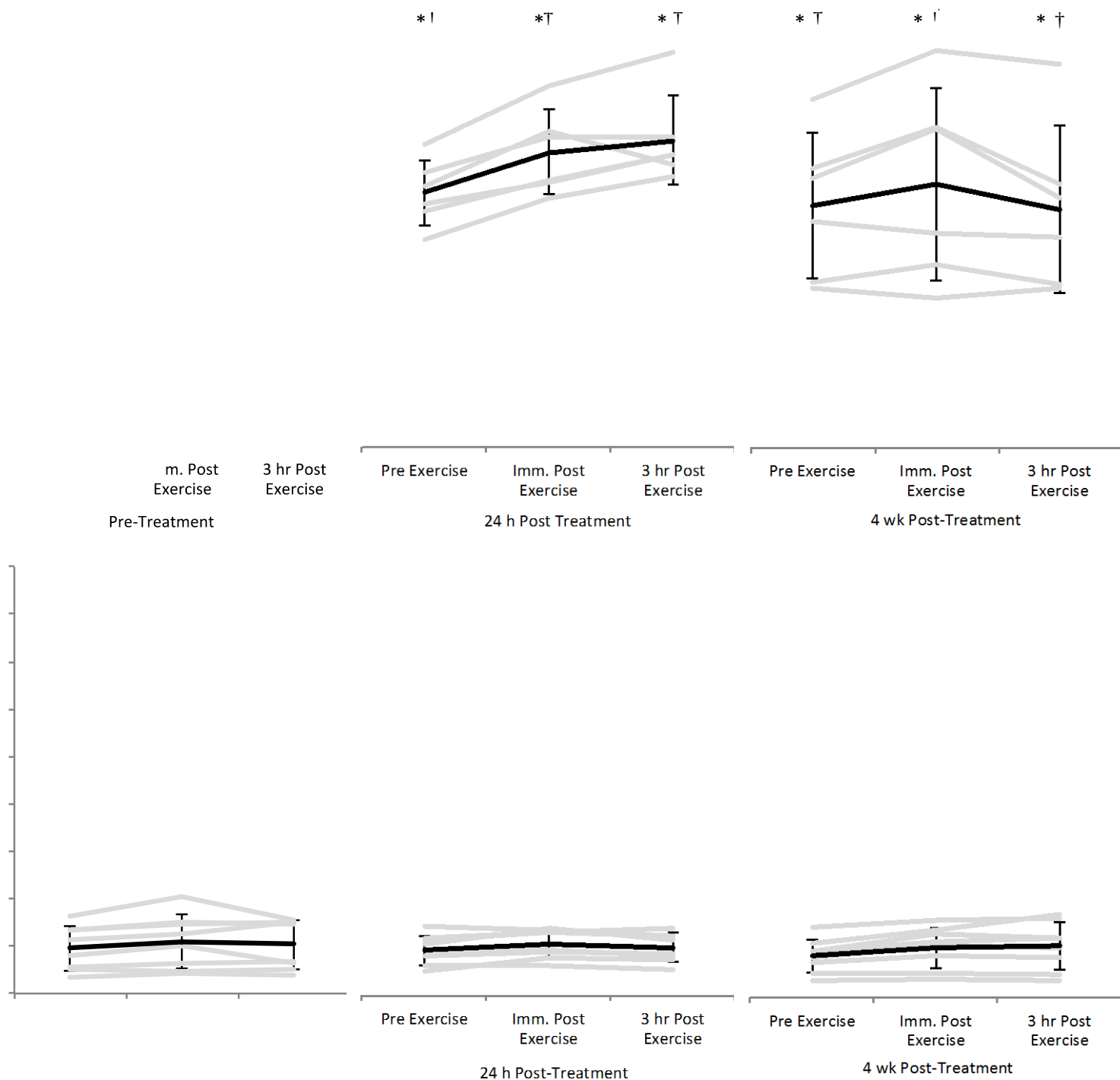




Ferritin ($\mu\text{g}\cdot\text{L}^{-1}$)

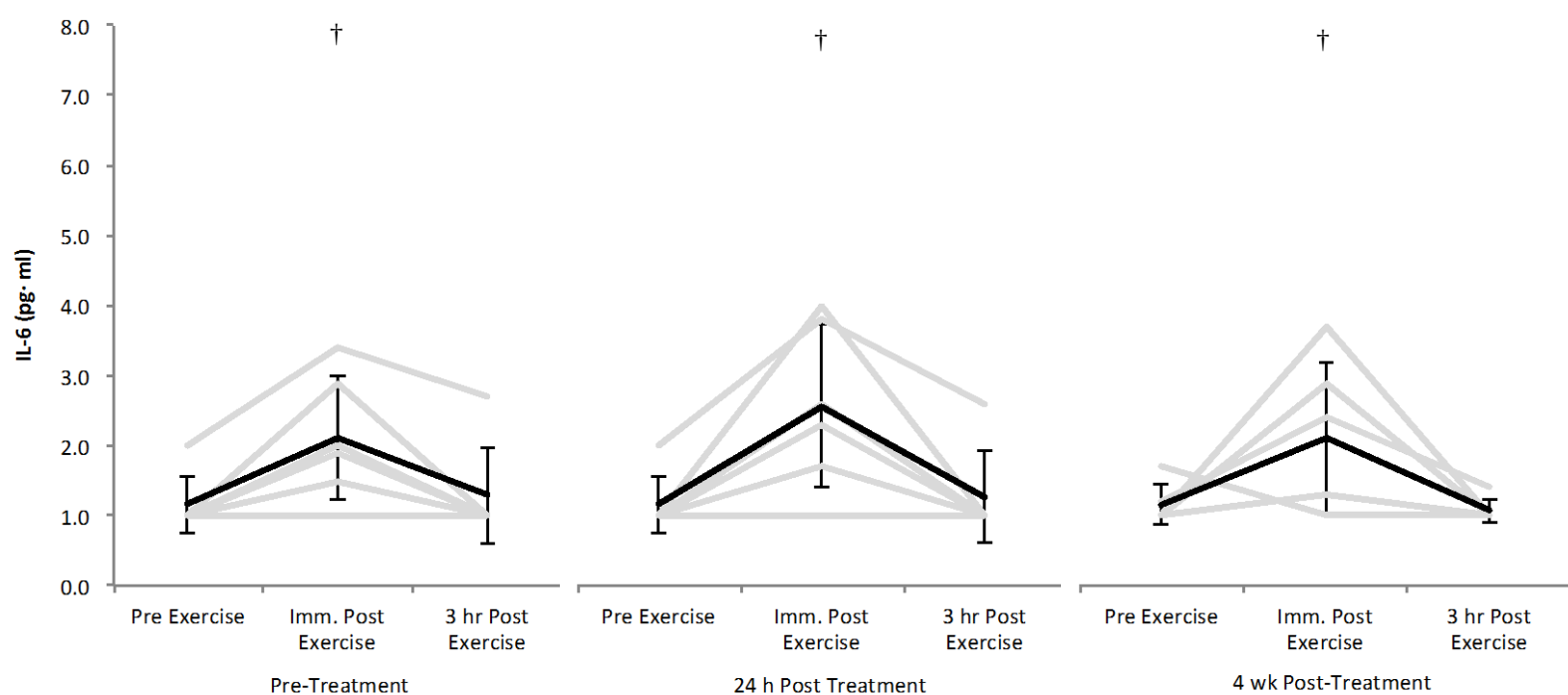
Iron

Placebo

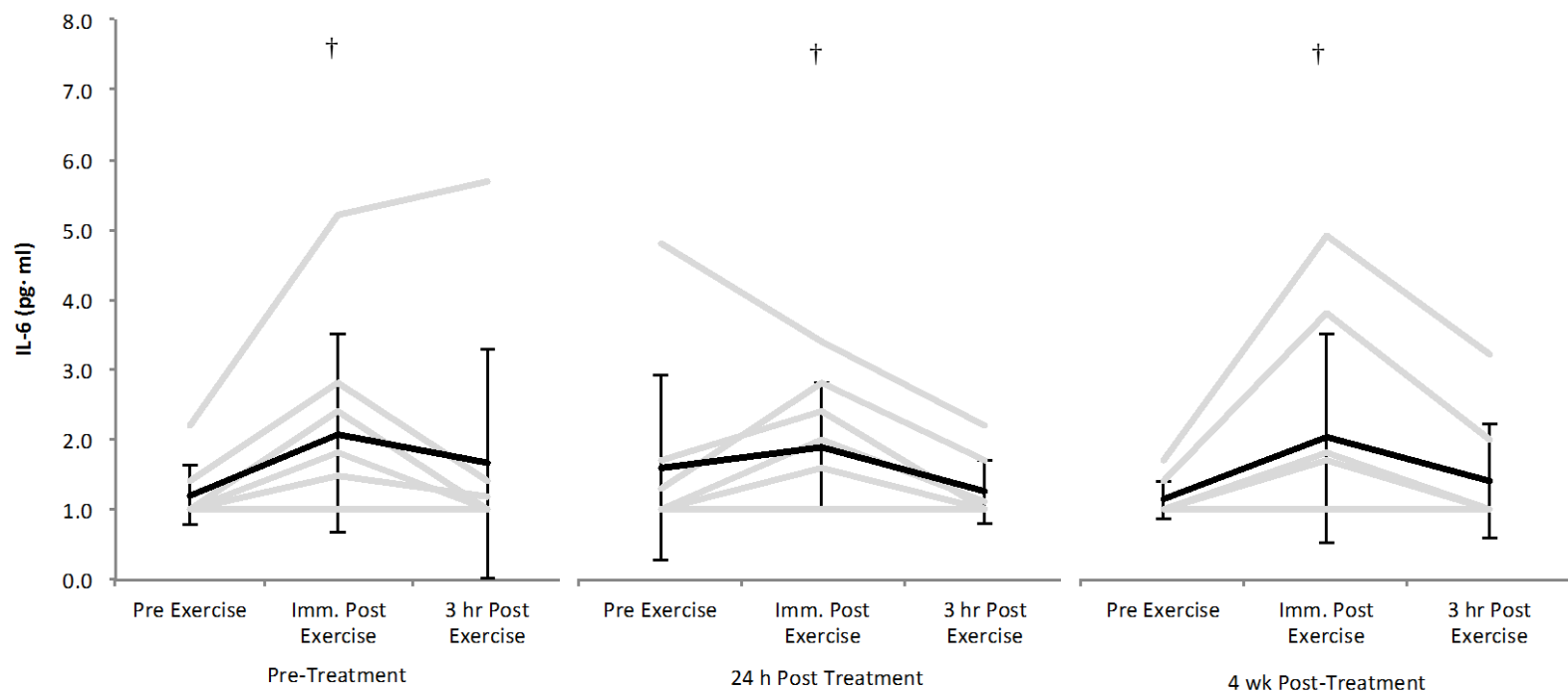




Iron

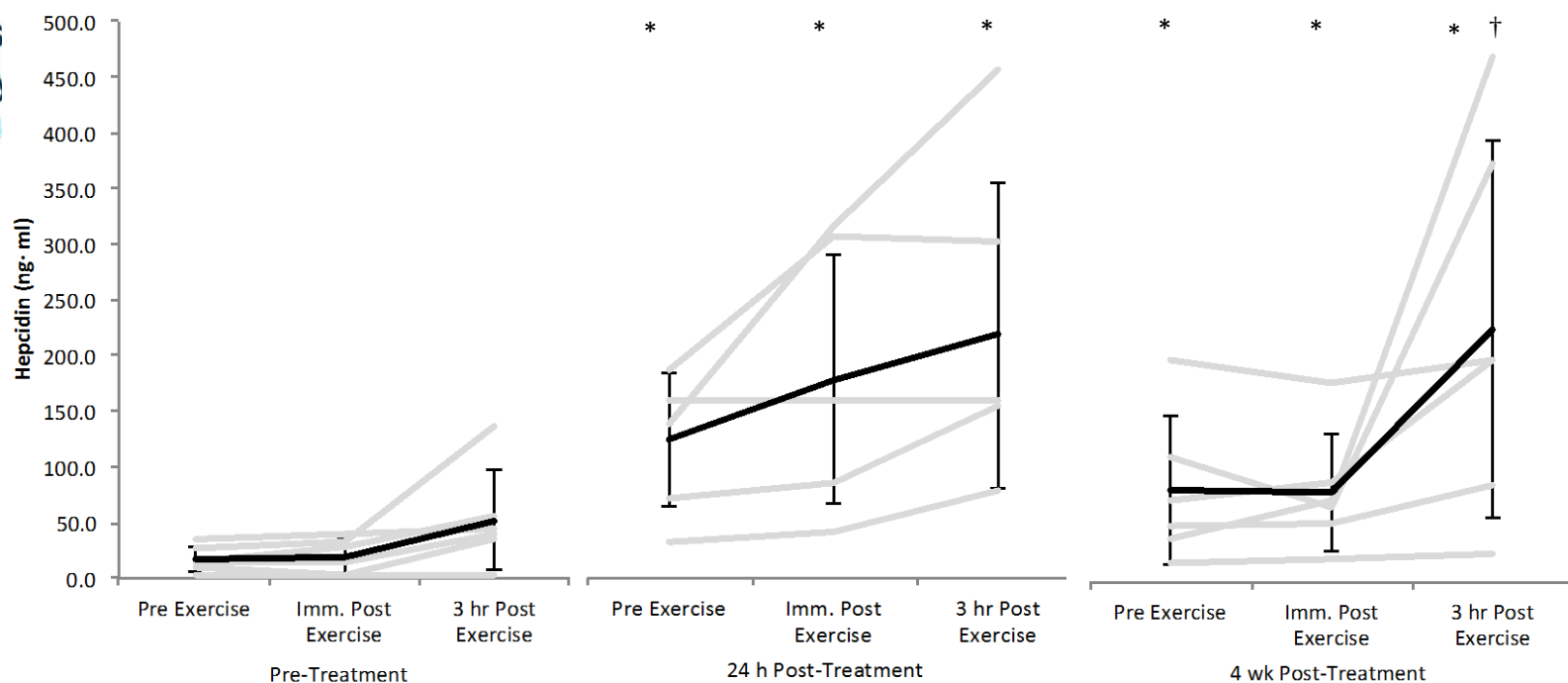


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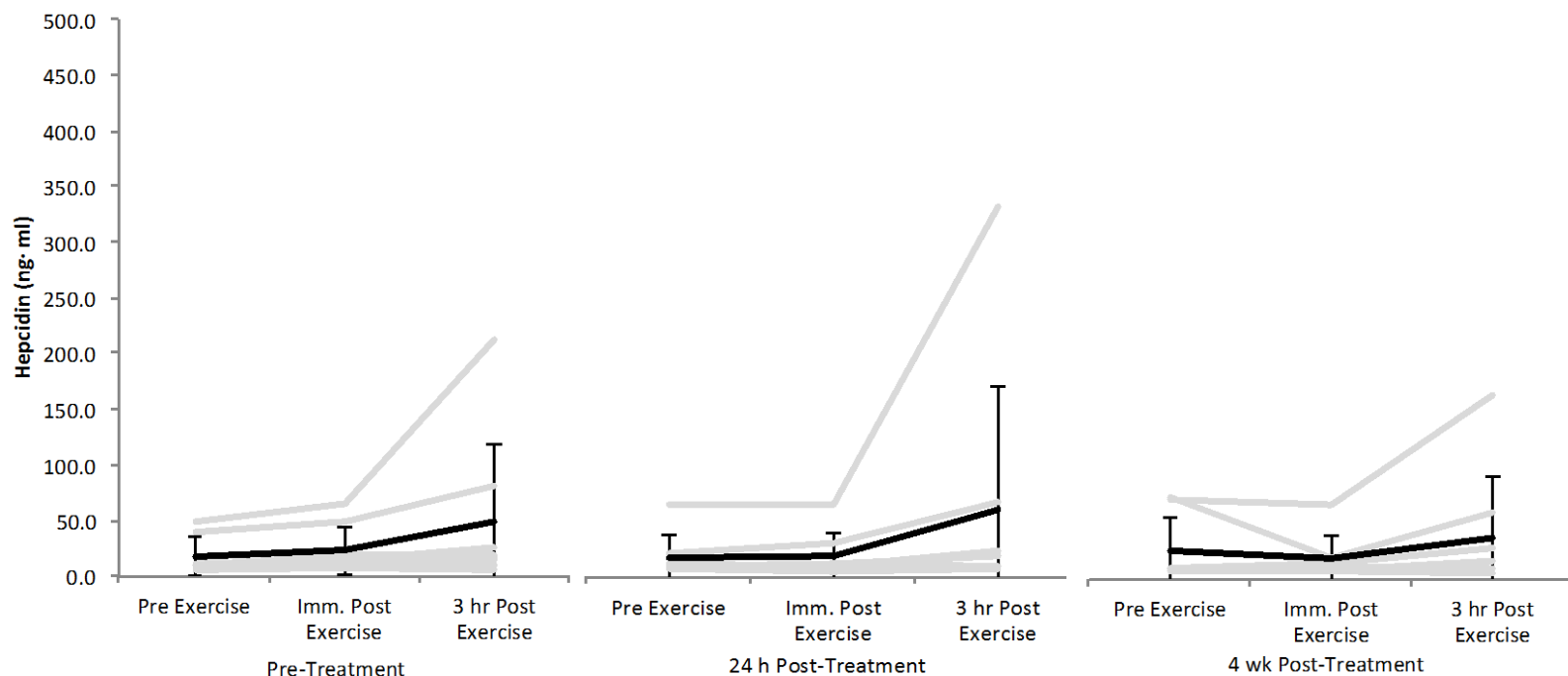




Iron



Placebo





Impact of intravenous iron on aerobic capacity and iron metabolism in elite athletes

- IV iron injections increase ferritin
 - No change
 - aerobic capacity
 - Hb mass
 - Red cell indices
 - Iron availability, not inflammation mediates the hepcidin response following iron treatment
-
- So where they iron deficient?

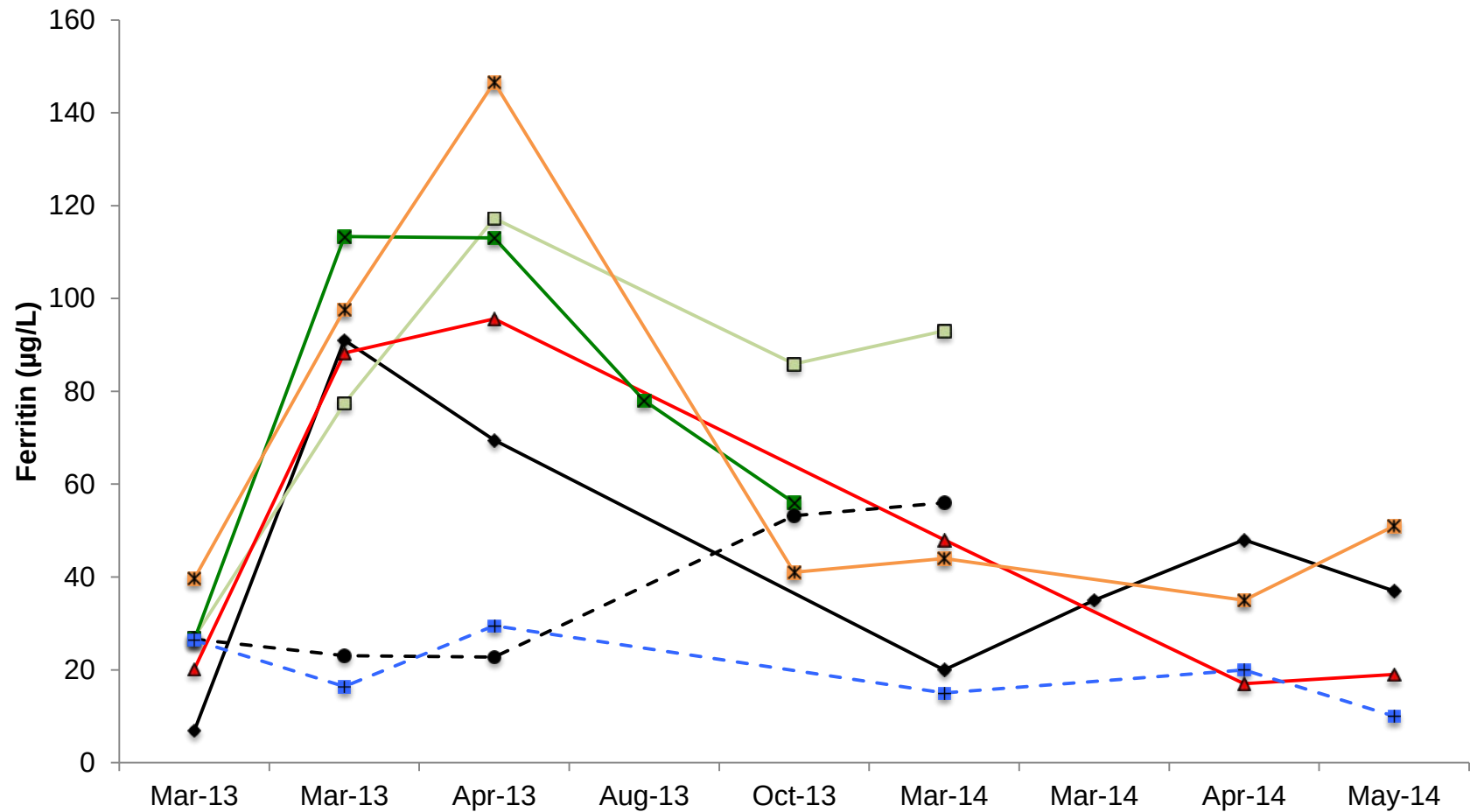


Questions Raised

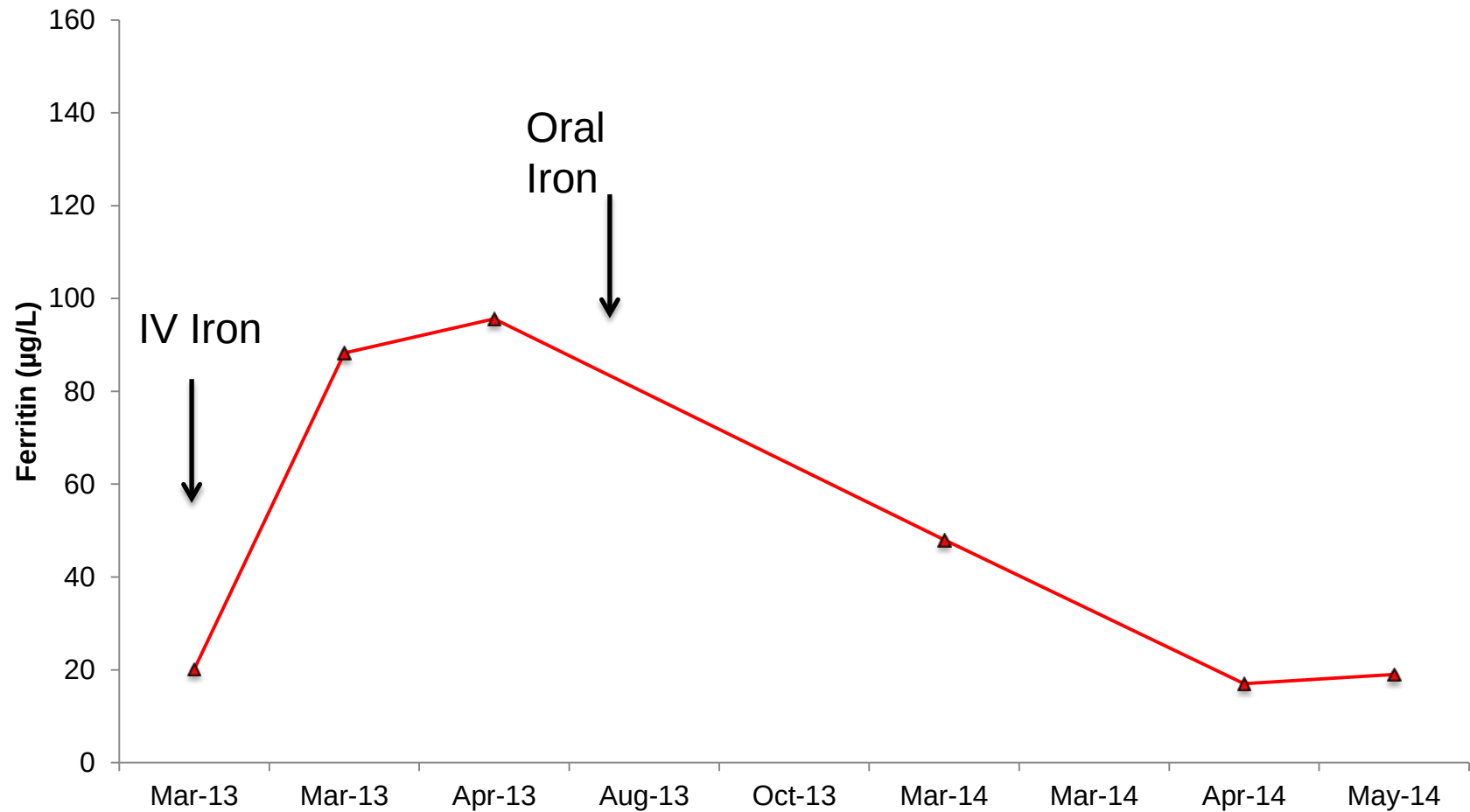
- Target indicators
 - Ferritin



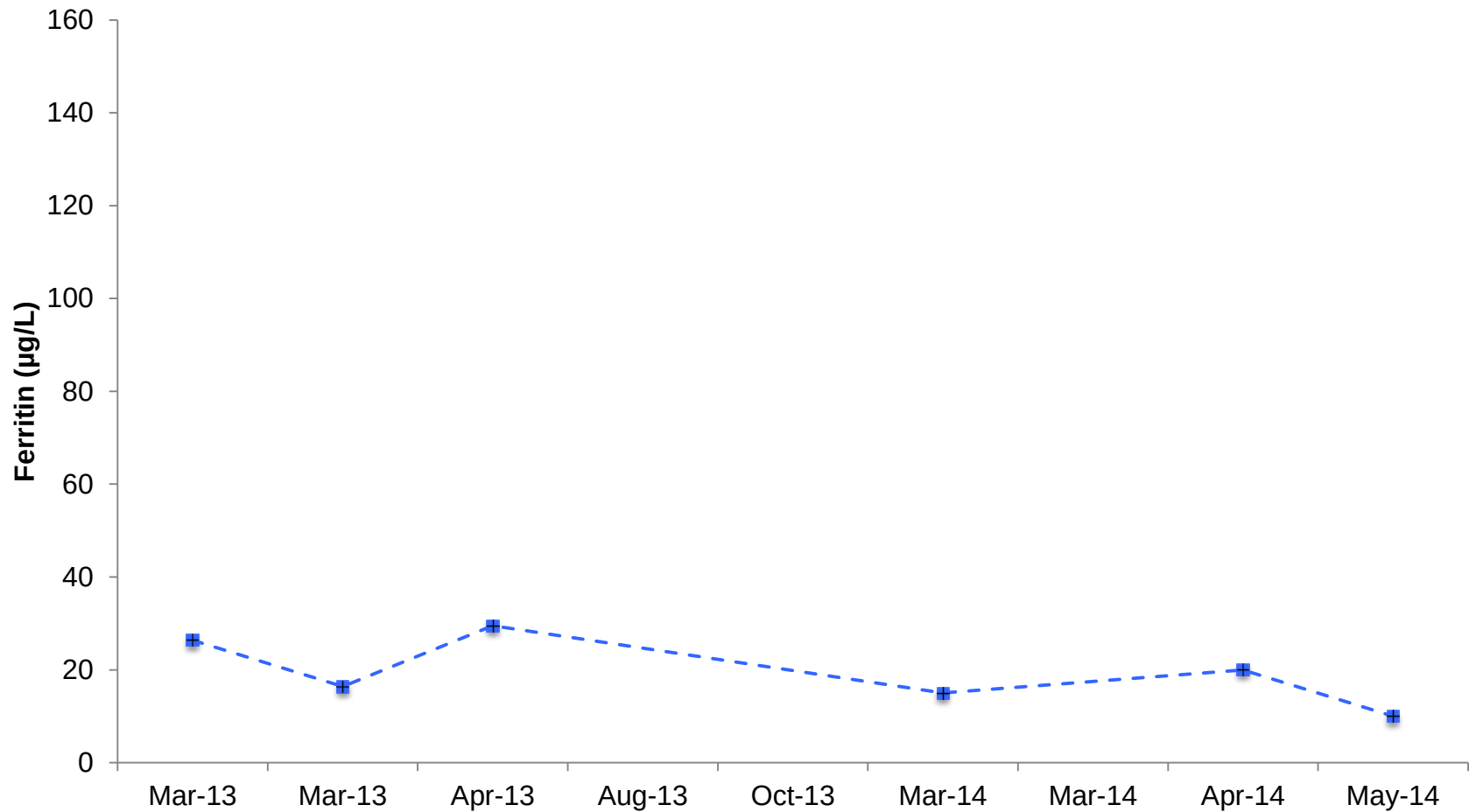
Ferritin



Ferritin



Ferritin





Questions Raised

- Are current indicators appropriate?
 - Ferritin
 - Hepcidin?
- Sensitivity of assessment tools
- Long-term effects of low iron
- IDNA does not exist but...



THANK YOU

References

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Zotter H, Robinson N, Zorzoli M, Schattenberg L, Saugy MP & Mangin P (2004). Abnormally high serum ferritin levels among professional road cyclists. *British Journal of Sports Medicine*, 38, 704-708

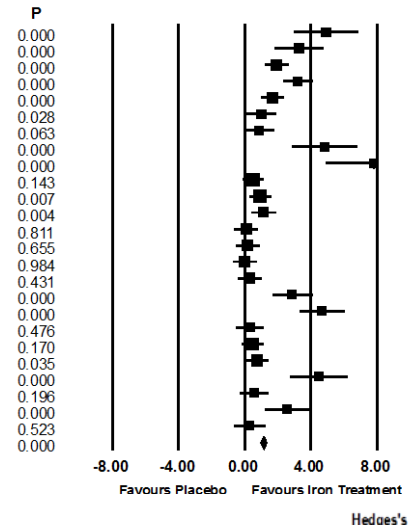
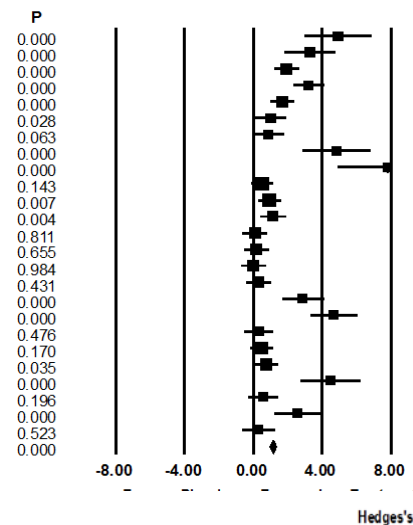
Schimacher YO & Pottgiesser T (2009). Performance profiling: A role for sport science in the fight against doping. *International Journal of Sports Physiology and Performance*, 4, 129-133.



The efficacy of iron treatment for endurance athletes: A meta-analysis

Ferritin

Hedges' $g = 1.068$ (large effect)



Study	Treatment	Hedges' g
Peeling et al. 2007 ⁽²⁰⁾	Injection	0.519
Hinton et al. 2000 ⁽²¹⁾	Oral	2.094
Friedman et al. 2001 ⁽⁸⁴⁾	Oral	0.148
Hinton & Sinclair, 2007 ⁽⁴²⁾	Oral	0.026
Klingshirn et al. 1992 ⁽⁸⁶⁾	Oral	0.141
Blec et al. 1999 ⁽¹⁰⁾	Injection	0.064
Zhu & Haas, 1998 ⁽²⁸⁾	Oral	0.098
Magazanik et al. 1991 ⁽²¹⁾	Oral	2.073
Magazanik et al. 1991 ⁽⁴²⁾	Oral	0.572
LaManca et al. 1993 ⁽⁸⁶⁾	Oral	1.993
Fogelholm et al. 1992 ⁽⁸⁶⁾	Oral	0.261
Radjen et al. 2011 ⁽³⁰⁾	Oral	0.318
Walsh & McNaughton, 1989 ⁽⁸⁴⁾	Oral	1.493
Schoene et al. 1983 ⁽¹⁴⁾	Oral	0.197
DellaValle & Haas 2013 ⁽⁴²⁾	Oral	0.196
Total		0.610

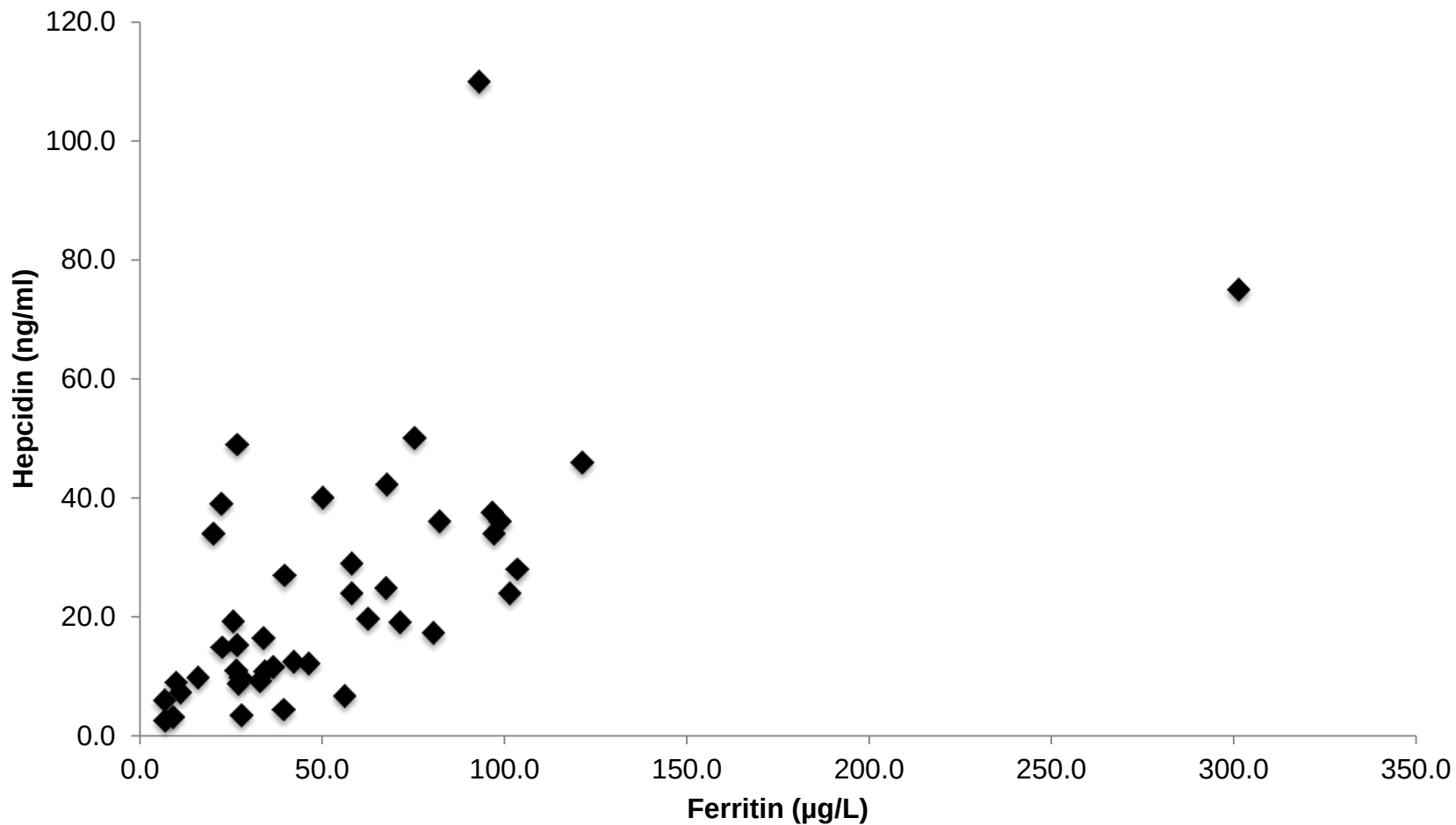
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Total		0.610

VO_{2max}

Hedges' $g = 0.610$ (moderate effect)

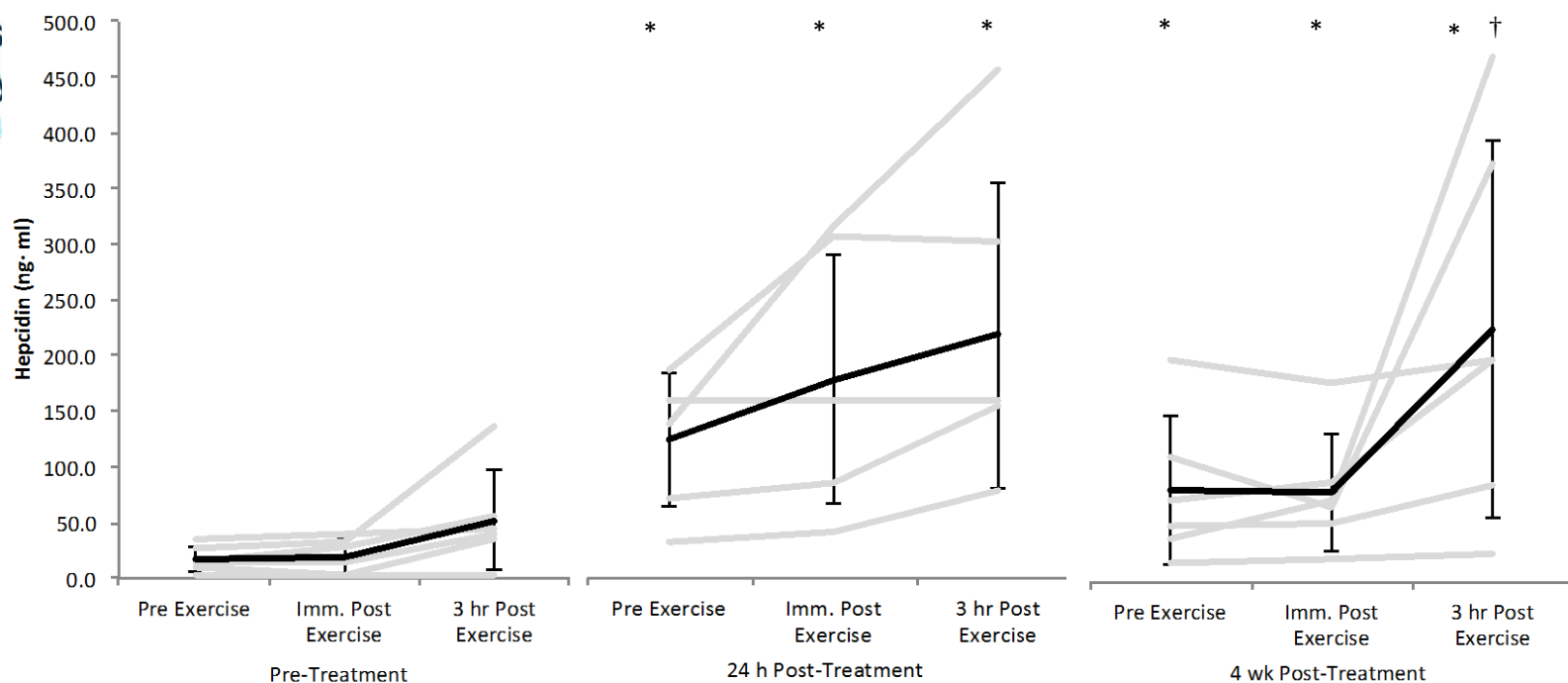


Hepcidin

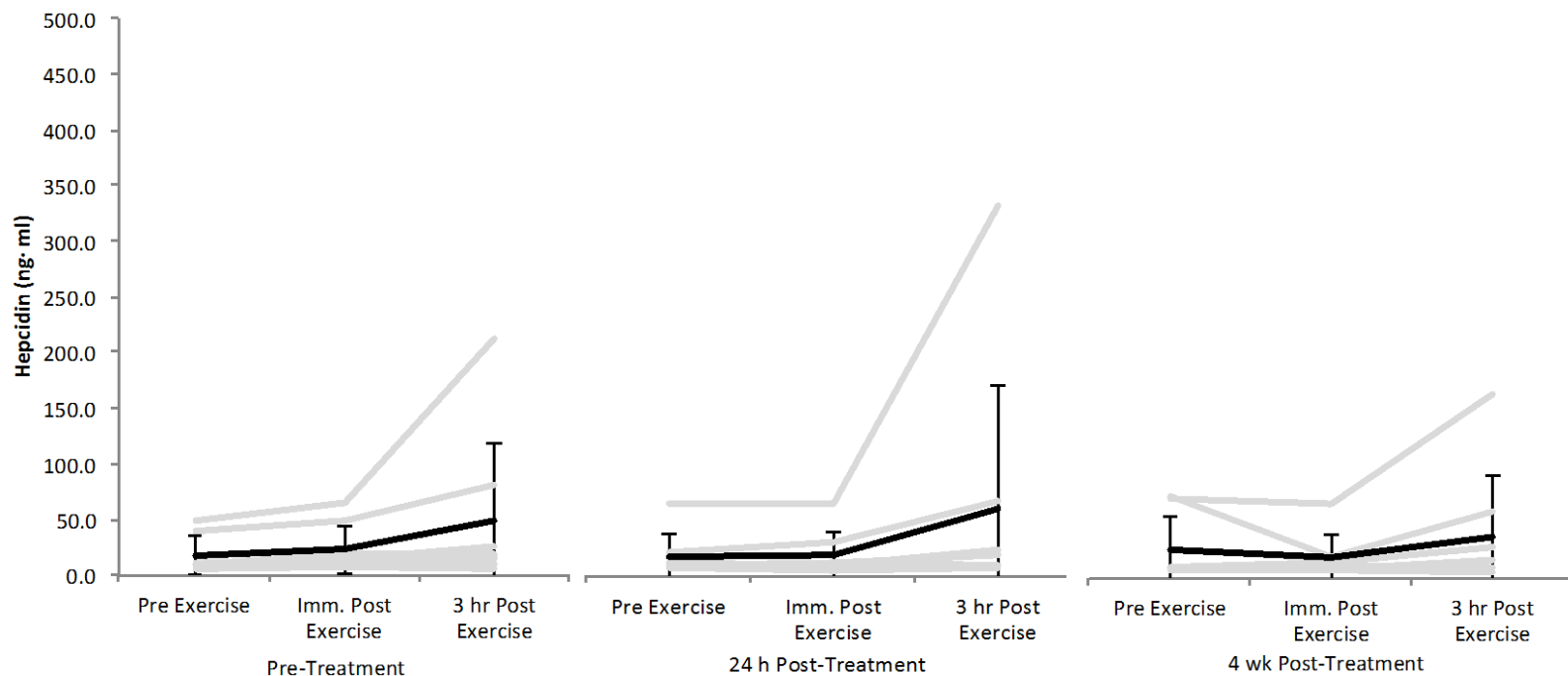




Iron

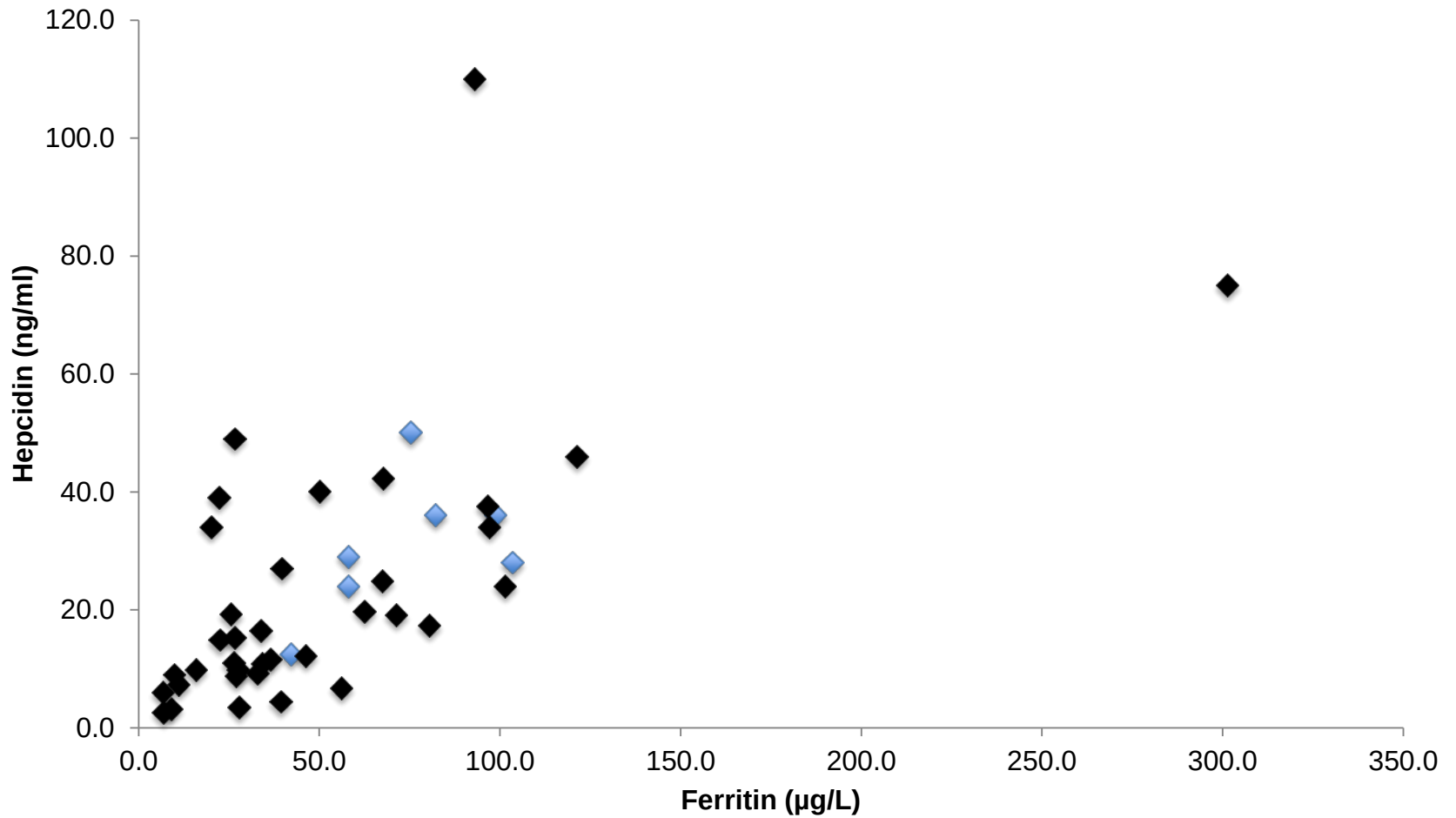


Placebo



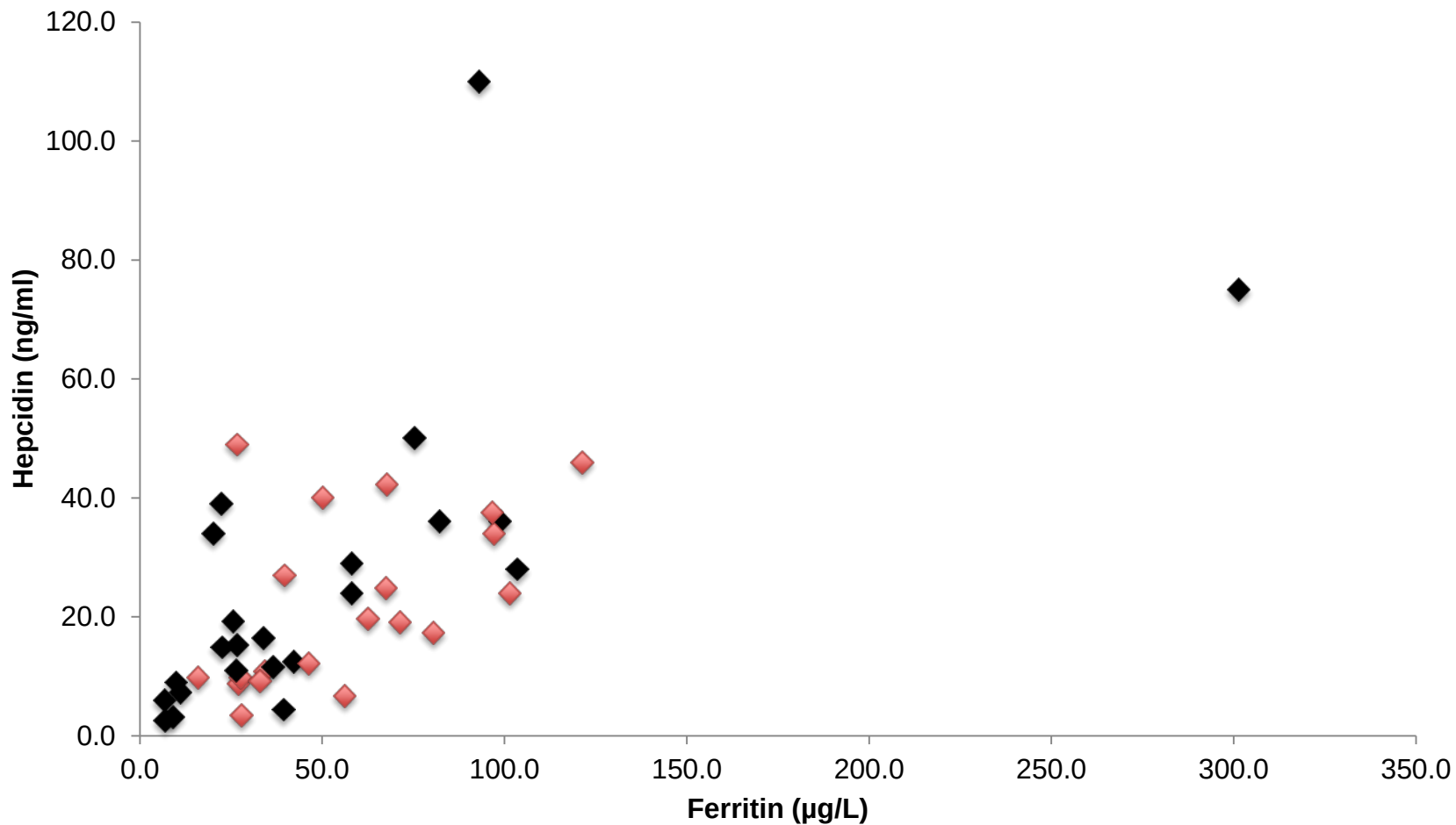


Hepcidin



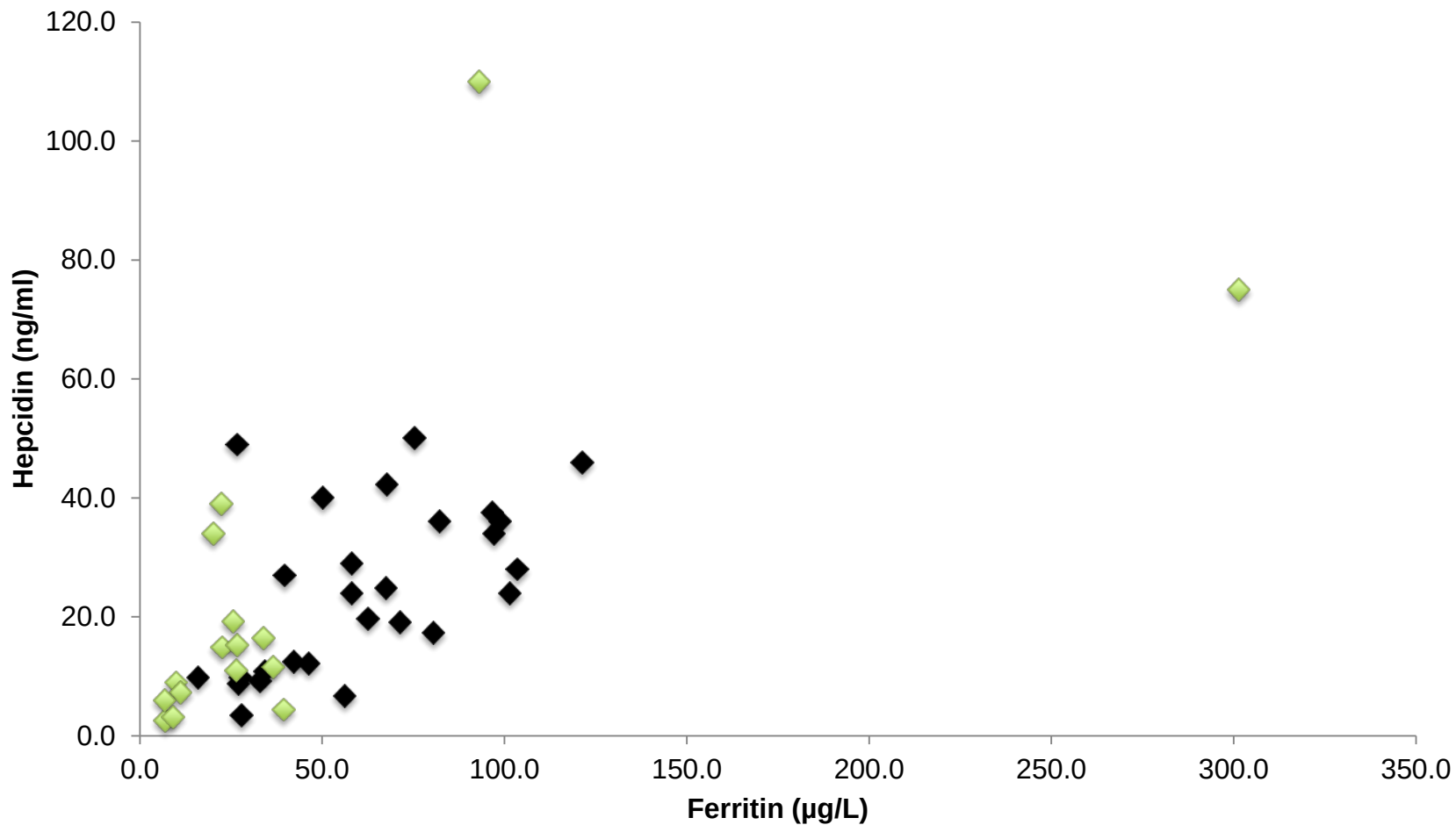


Hepcidin



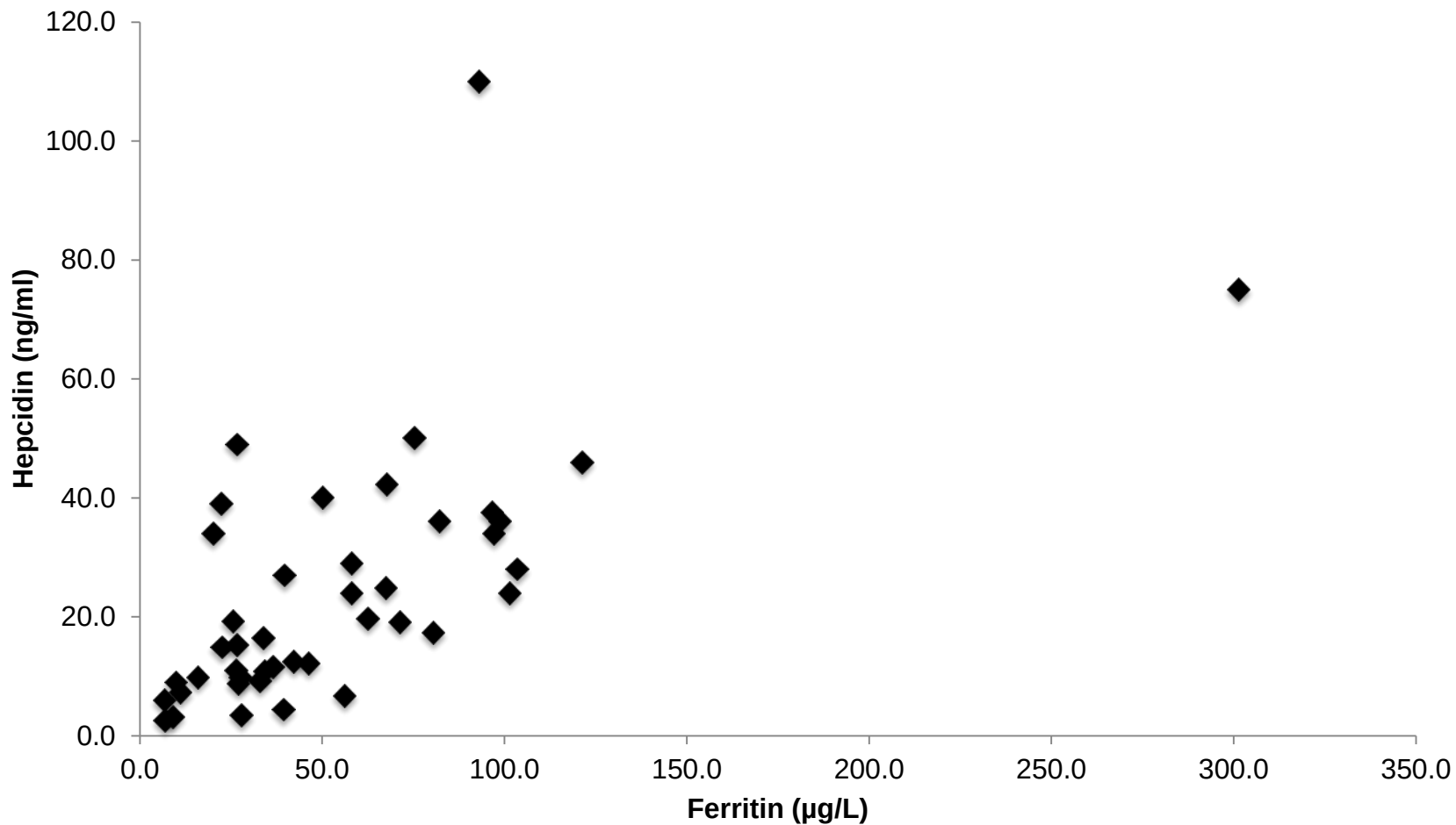


Hepcidin





Hepcidin



Measure	Group	Pre-Treatment			24 Hours Post-Treatment			4 Weeks Post-Treatment		
		Pre	24 h Post	4 wks Post	Pre	24 h Post	4 wks Post	Pre	24 h Post	4 wks Post
Serum Iron, $\mu\text{mol}\cdot\text{L}$	IG	20.3	23.2	20.6	70.7*†	72.8*†	64.0*†	23.4	25.7	21.2
		(7.2)	(8.2)	(9.5)	(10.0)	(8.5)	(11.9)	(4.0)	(3.3)	(4.9)
	PG	19.3	22.5	21.8	20.6	23.4	21.3	15.1	17.9	17.3
		(6.9)	(7.3)	(8.0)	(14.3)	(15.5)	(11.9)	(6.2)	(9.0)	(6.9)
Tsat, %	IG	33.1	34.3	32.4	113.2*†	110.6*†	104.7*†	43.2	45.1	39.2
		(12.0)	(13.9)	(15.0)	(8.4)	(6.9)	(5.9)	(6.3)	(6.0)	(8.4)
	PG	29.1	31.2	31.4	30.3	31.5	30.9	20.9	24.8	24.8
		(11.3)	(11.8)	(12.6)	(19.7)	(19.6)	(17.4)	(11.2)	(12.0)	(10.5)
sTf, $\text{g}\cdot\text{L}$	IG	2.5	2.7	2.6	2.5	2.6	2.4	2.2	2.3	2.2
		(0.3)	(0.2)	(0.2)	(0.3)	(0.3)	(0.4)	(0.4)	(0.3)	(0.3)
	PG	2.7	2.9	2.8	2.8	3.0	2.8	2.7	2.9	2.8
		(0.4)	(0.4)	(0.6)	(0.5)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)
sTfR, $\text{nm}\cdot\text{L}$	IG	19.4	21.2	19.6	20.4	21.3	20.3	19.4	19.9	19.0
		(2.9)	(2.1)	(2.8)	(3.1)	(2.2)	(3.1)	(2.6)	(2.4)	(2.4)
	PG	23.2	23.4	21.8	21.4	23.1	21.3	22.1	23.4	22.1
		(3.0)	(2.1)	(2.5)	(2.7)	(3.1)	(3.1)	(2.1)	(2.8)	(2.0)

	Placebo Group		Iron group	
	Pre	4 wks Post	Pre	4 wks Post
Haemoglobin, g·L ⁻¹	143.6 (9.0)	138.7 (11.7)	140.2 (15.4)	137.2 (13.8)
Haematocrit, L·L	0.426 (0.021)	0.406 (0.024)	0.415 (0.032)	0.414 (0.025)
Mean Cell Volume, fL ⁻¹	89.13 (3.72)	88.29 (2.75)	90.27 (4.46)	92.98 (5.95)
Mean Cell Hb, pg	30.01 (1.37)	30.06 (1.28)	30.38 (1.59)	30.70 (1.51)
Mean Cell Hb Conc, g·L ⁻¹	337.25 (8.38)	341.29 (11.59)	337.17 (13.93)	330.83 (15.14)
RDW, %	13.08 (0.78)	13.04 (0.68)	12.70 (0.68)	12.92 (0.58)
Red Cell Count, 10 ¹² ·L ⁻¹	4.7938 (0.3046)	4.6171 (0.3541)	4.6083 (0.4271)	4.4750 (0.4428)
Red Cell Folate, µg·L ⁻¹	269.63 (133.51)	245.19 (118.18)	265.70 (110.41)	238.42 (67.22)
B12, ng·L ⁻¹	482.75 (117.66)	476.29 (172.44)	567.00 (175.03)	573.00 (175.87)



	Placebo Group			Iron Group		
	Pre Treatment	24 h Post Treatment	4 wks Post Treatment	Pre Treatment	24 h Post Treatment	4 wks Post Treatment
tHb, g·kg ⁻¹	12.15 (1.53)	12.16 (1.84)	12.43 (2.10)	14.13 (1.93)	13.88 (1.77)	13.12 (1.72)
VO _{2max} , ml·kg ⁻¹ ·min ⁻¹	64.40 (10.22)	64.83 (9.56)	64.27 (7.35)	73.02 (4.80)	71.60 (6.78)	70.30 (5.29)
Economy, ml·kg ⁻¹ ·km ⁻¹	220.13 (3.14)	216.63 (10.02)	215.29 (10.11)	221.33 (6.12)	217.00 (9.83)	218.00 (22.27)
vVO _{2max} , km·h ⁻¹	17.51 (2.60)	17.93 (2.50)	17.90 (1.95)	19.83 (1.53)	20.33 (1.55)	19.80 (1.61)
Speed @ 2mmol·L, km·h ⁻¹	14.42 (2.58)	14.55 (2.55)	15.10 (1.96)	16.43 (1.63)	16.67 (1.24)	16.54 (1.52)
Speed @ 4mmol·L, km·h ⁻¹	16.20 (2.43)	16.15 (2.47)	16.82 (1.91)	18.23 (1.80)	18.24 (1.26)	18.01 (1.50)
TTE, s	370.25 (29.79)	365.50 (35.66)	352.86 (64.14)	350.86 (26.46)	369.43 (42.16)	373.33 (48.10)
RPE, Borg 6-20	12.88 (0.95)	12.68 (1.12)	12.29 (1.47)	13.89 (2.25)	12.96 (1.86)	12.95 (1.99)



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