High-intensity Interval Training (HIT): Performance and Iron Status in Athletes

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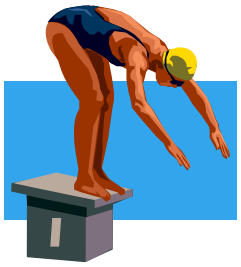


Presentation Purpose

- We have completed five different research studies on the effects of High-Intensity Training on Iron status in competitive athletes.

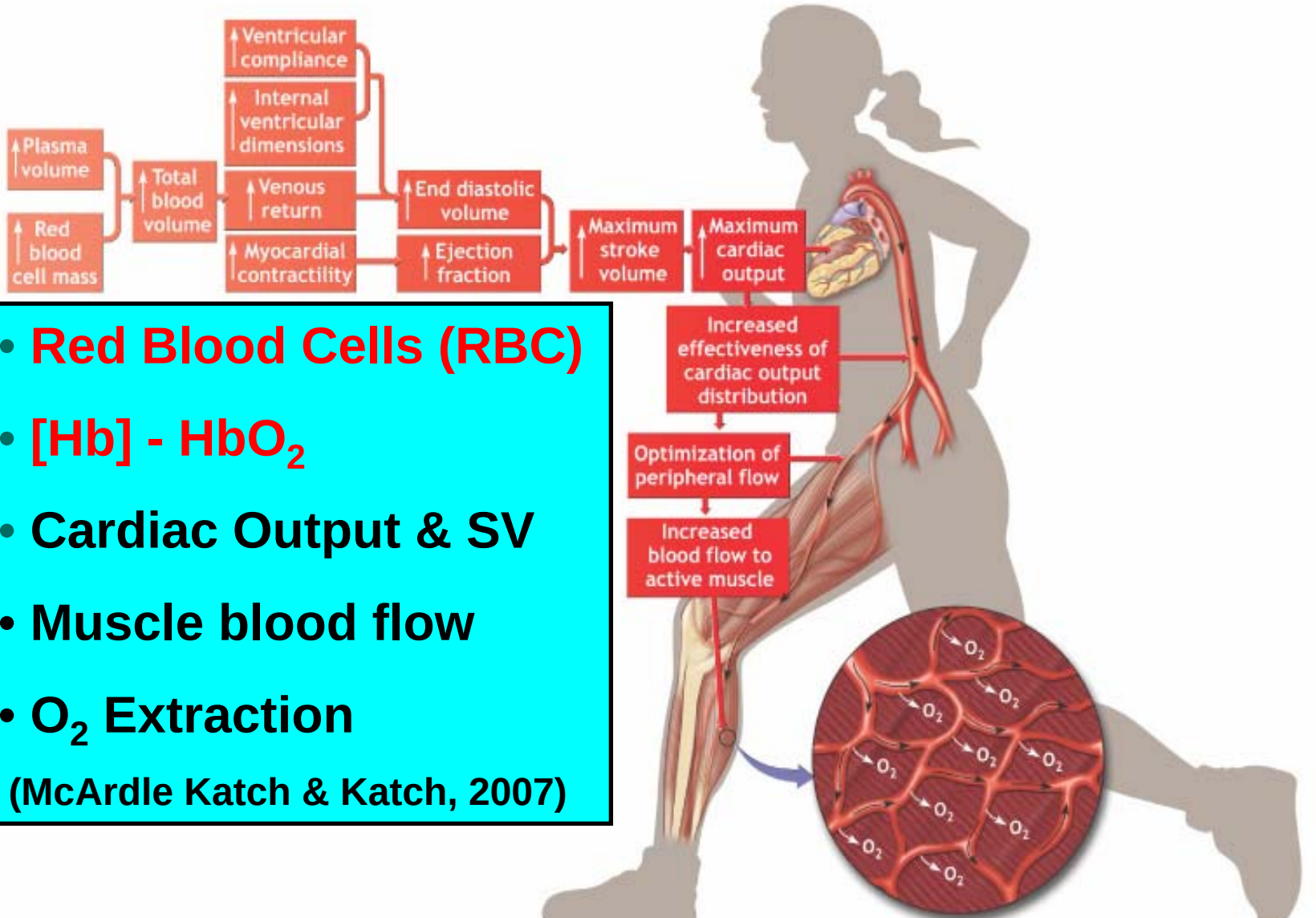
- In this presentation I will briefly report results of three studies; two studies on cyclists and one on swimmers.

INTRODUCTION

- **Iron deficiency without anemia has been reported in endurance athletes for many years.** ***(Malczewska et al, Int J Sport Nut, 2001; Fallon, Clin J Sport Med, 2004).***

- **Iron deficiency anemia, (↓ [Hb]), is less common than simple iron deficiency, however, even mild anemia can compromise exercise performance in both male and female endurance athletes.** **(Friedman et al, *Med Sci Sports Exerc*, 2001; *Mayer et al, Int J Sport Med, 2006*).**

Training and Total O_2 Transport

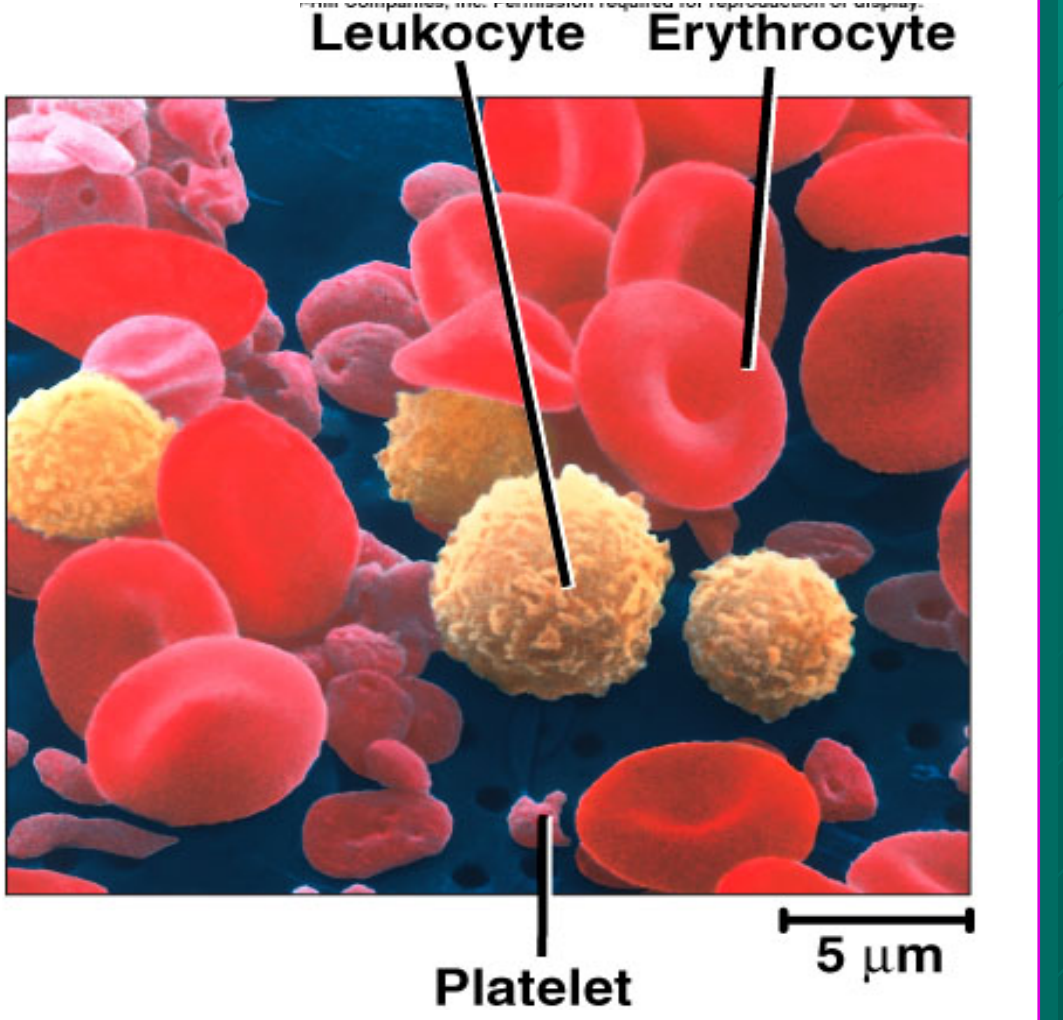


- **Red Blood Cells (RBC)**
- **[Hb] - HbO_2**
- **Cardiac Output & SV**
- **Muscle blood flow**
- **O_2 Extraction**

(McArdle Katch & Katch, 2007)

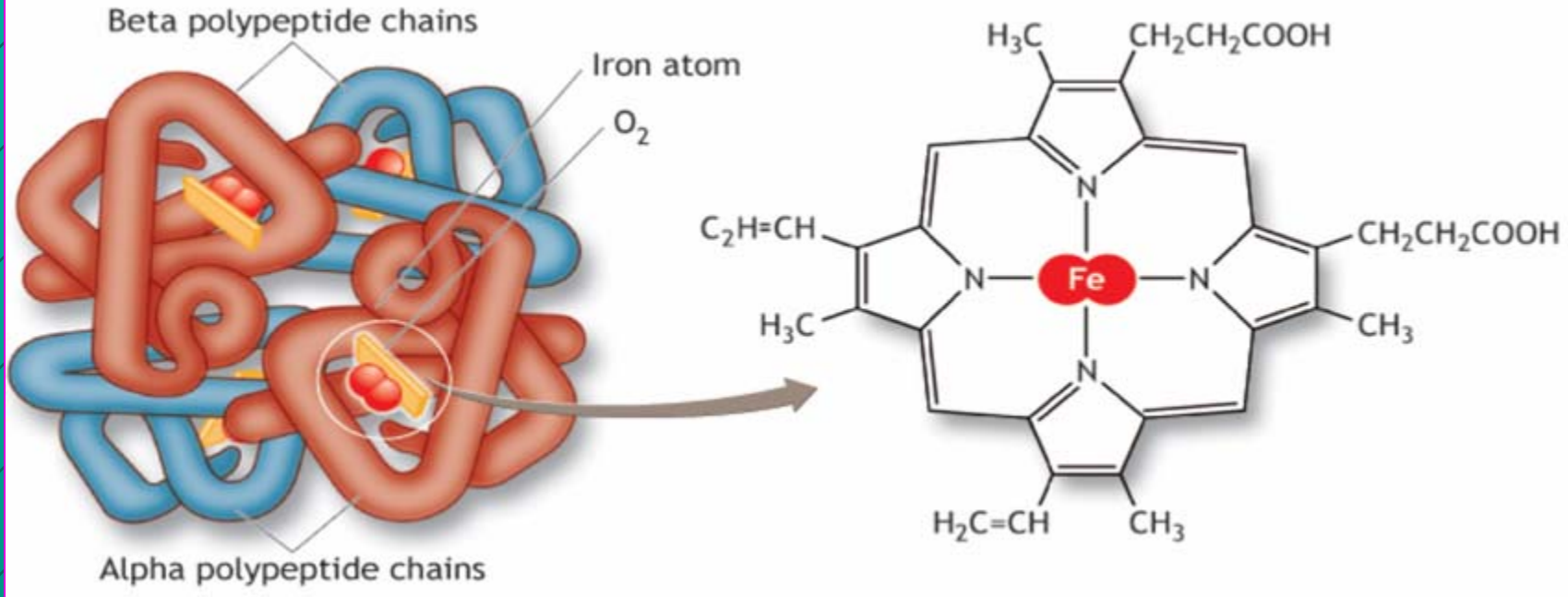
Oxygen Transport and RBCs

- **Erythrocytes Red Blood Cells (RBC)**
- Leukocytes White blood cells (WBC)



Hemoglobin

- Hb is a heme protein whose central **iron (Fe^{++}) atom** binds reversibly with oxygen
- Oxygen bound to Hb is oxy-hemoglobin **(HbO_2)**



INTRODUCTION Cont'd

- We had previously found decreased iron status in both male and female nordic skiers … (very aerobic athletes).
- Then we observed that Acute High-Intensity Interval Training (HIT) resulted in decreased whole body iron stores in male university team cyclists.
- These non-critical changes in iron status occurred despite a more than adequate nutritional iron intake.

Iron Status in Cyclists During High-intensity Interval Training and Recovery

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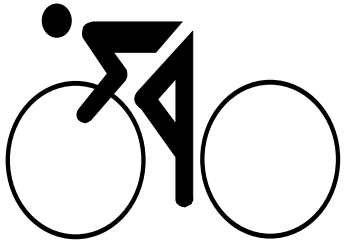
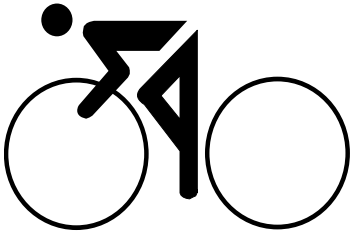
(Funded in part by a grant from Quaker Oats Company)





(Wilkinson et al, *Int J Sport Med*, 2002)

Purpose:

- This study was designed to evaluate the effects of 6 weeks of Aerobic High-intensity Interval Training (HIT) and 2 weeks recovery on cycling performance and iron status in 11 male university road cyclists.

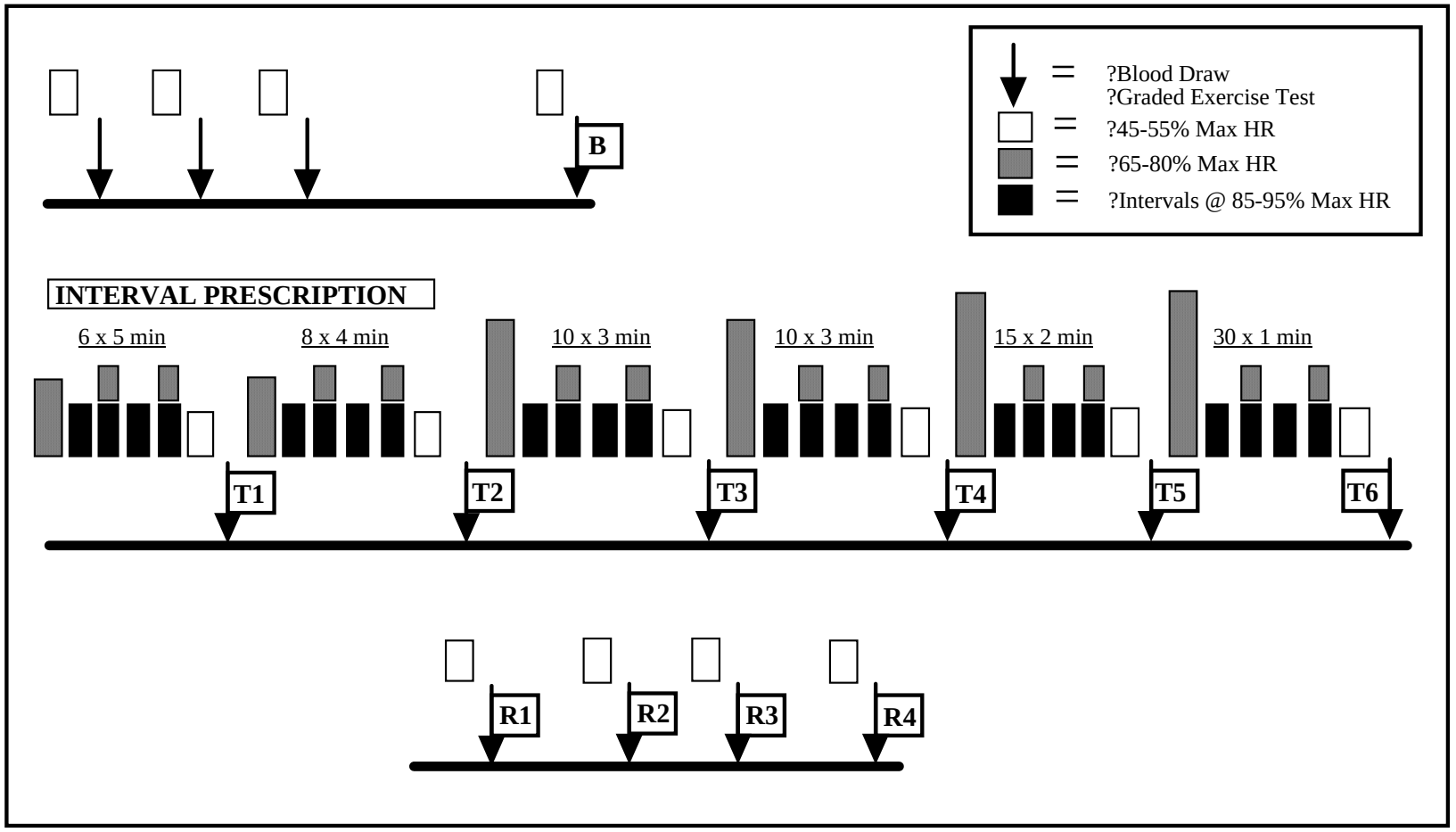


Figure 1 A Schematic Representation of the Training Protocol with Reference to Data Collection.

Methods: Analysis

- **Iron intake was determined from 3 day dietary recalls (IBM Nutritionist III program).**
- **Serum Iron and Total Iron Binding Capacity (TIBC) were determined using Sigma colorimetric kits.**
- **Serum ferritin was measured by Radioimmunoassay.**
- **Data were analyzed by repeated measures ANOVA.**

Fig 1. Cycling Performance Time to Fatigue following 6 Weeks of Aerobic HIT and Recovery

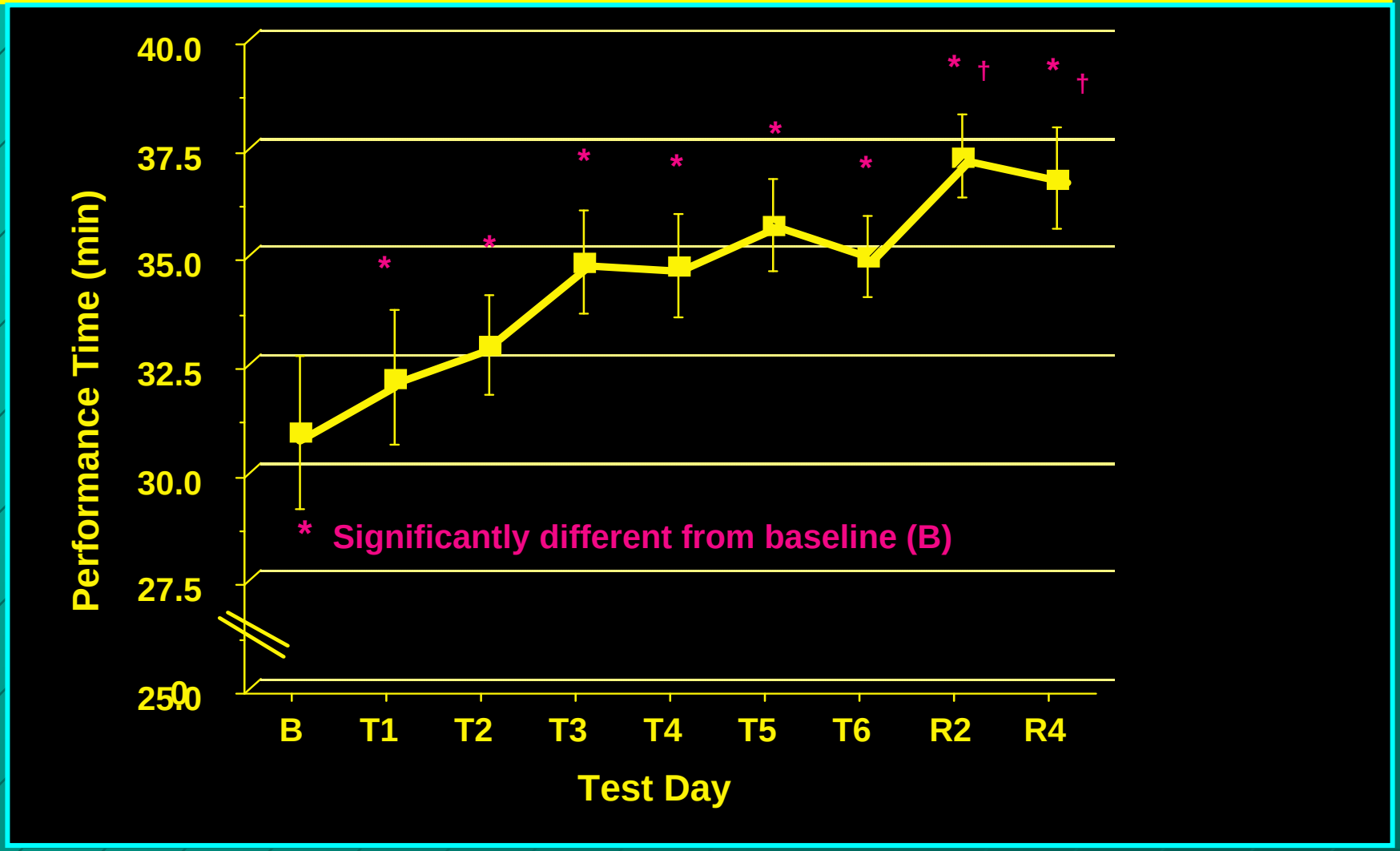


Fig 2. Serum Iron following 6 Weeks of Aerobic HIT and Recovery in Collegiate Cyclists

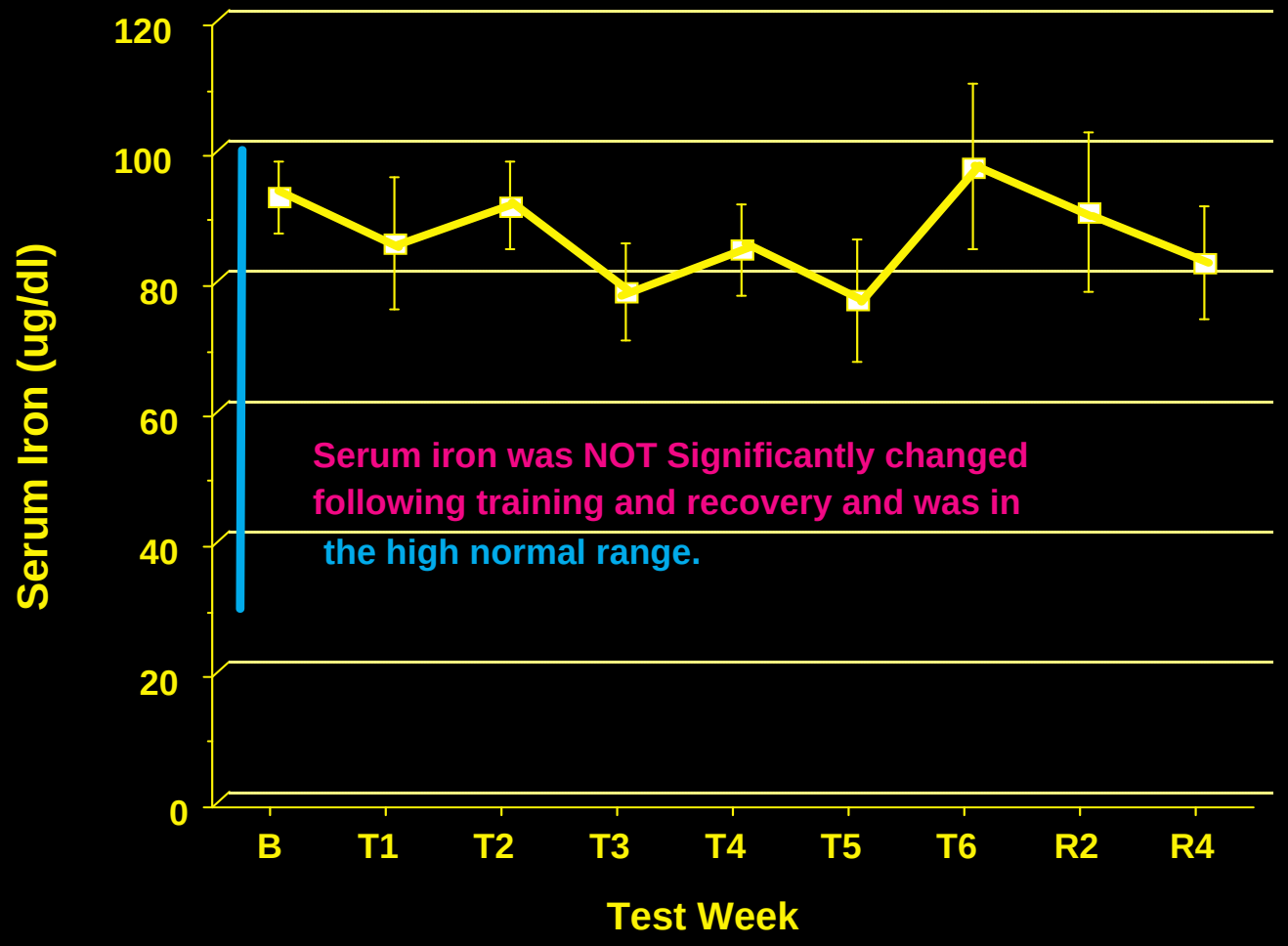
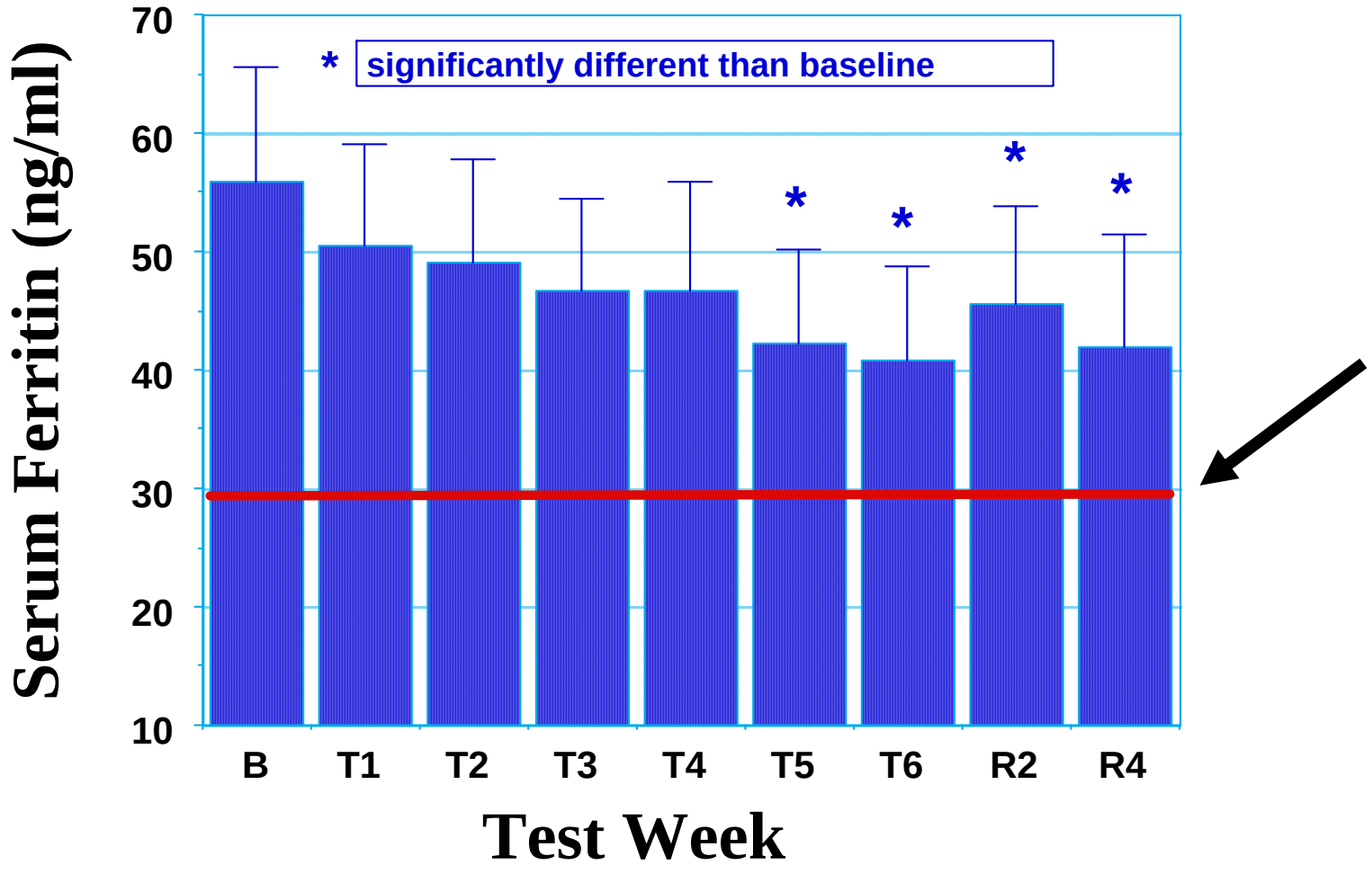


Fig 3. Serum Ferritin following 6 weeks Aerobic HIT and Recovery in Collegiate Cyclists



(Elite *Female athletes : Fallon, *Clin J Sport Med*, 2004)

Discussion & Conclusions:

- We found that whole body Iron stores, (serum ferritin), were significantly reduced in response to 6 weeks of HIT in male road cyclists. (Fallon et al, 2004)

- These changes persisted during an active recovery despite a more than adequate (260 % RDA) nutritional iron intake.

REDUCED IRON STORES FOLLOWING THREE WEEKS OF HIGH-INTENSITY INTERVAL TRAINING AND RECOVERY

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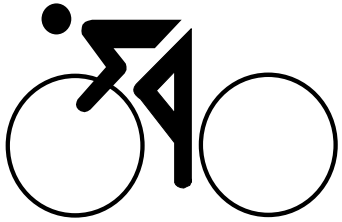
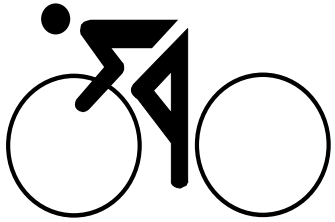
Univ. of Wyoming, College of Health Science,

(Funded by a USOC Science and Technology Grant)





Purpose:

- This study was designed to evaluate the effects of 3 weeks of HIT and 2 weeks recovery on cycling perform-mance and iron status in 8 Olympic development team pursuit cyclists.

HYPOTHESIS

- **Based on previous studies, we hypothesized that HIT would decrease whole body iron stores in these swimmers and that serum ferritin levels would normalize during 10 days of Regeneration/Recovery.**

Methods: Training and Testing

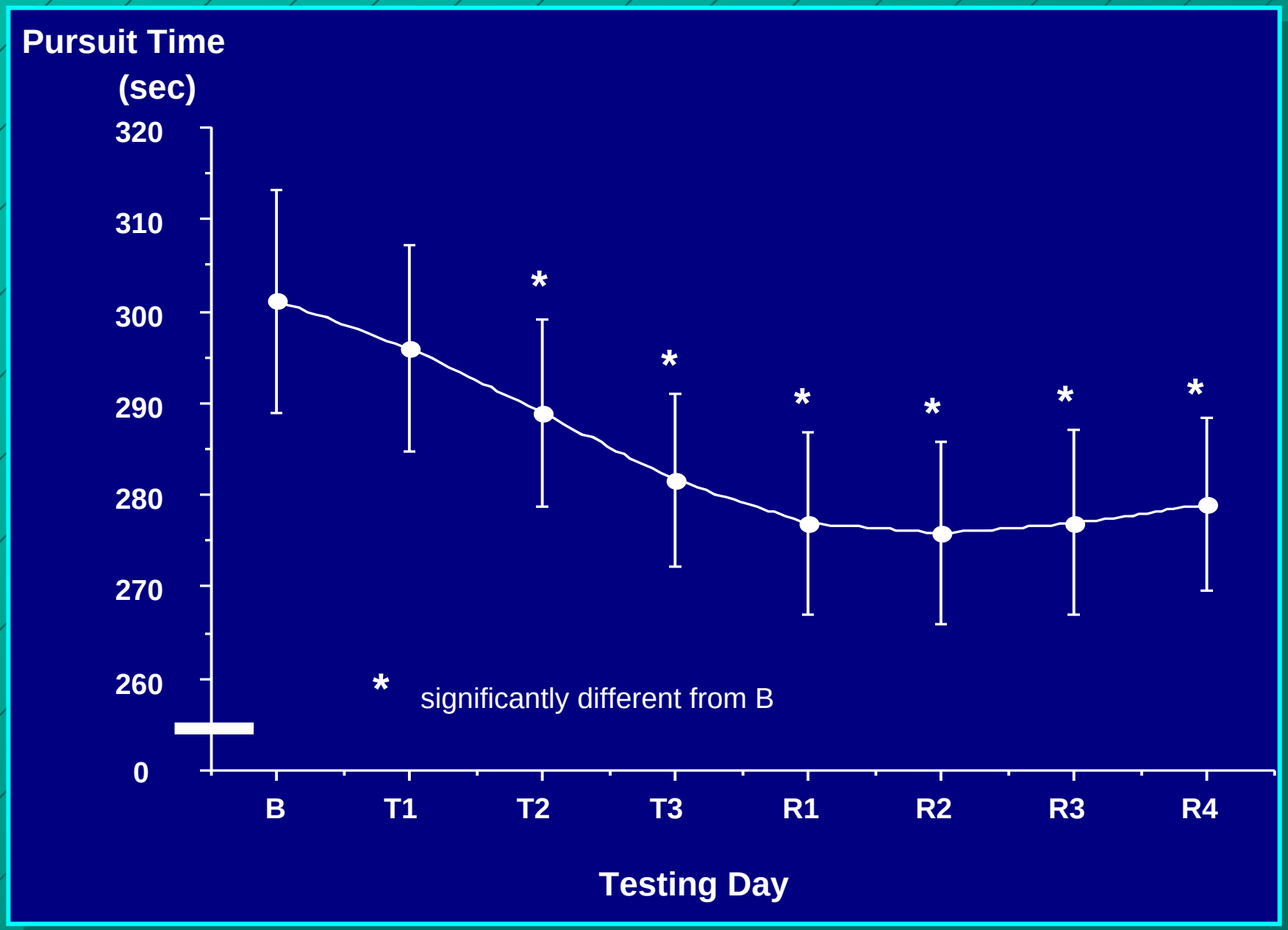
- 2 High-intensity Interval Training sessions/day, 4 days/week, for 3 weeks (T1-T3) aimed at improving 4 km pursuit track cycling performance.

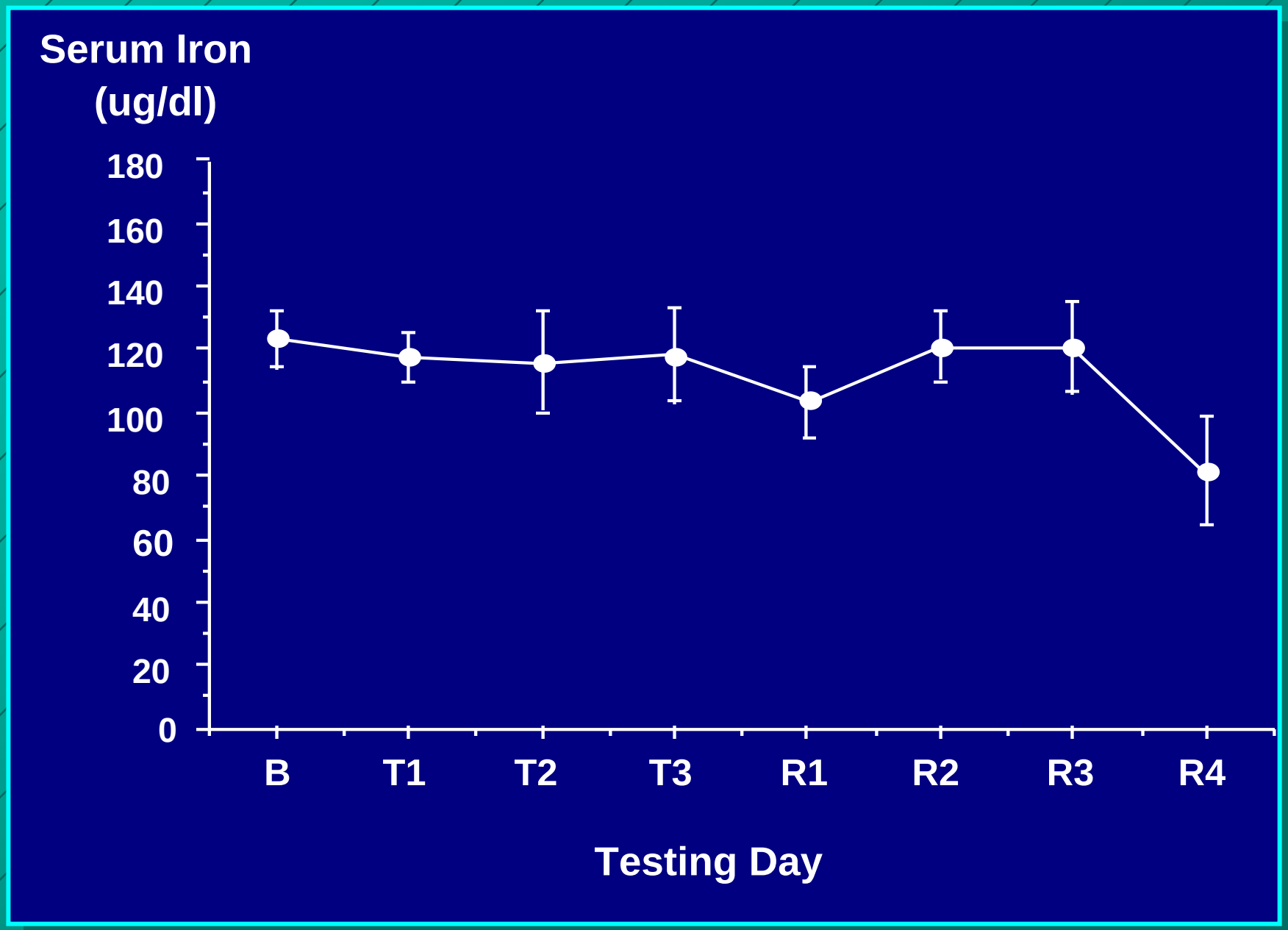
- 2 or 3 minute aerobic work intervals 1:1 work:relief ratio for 1 hour @ mean HR max = 94.0 $\pm$ 0.3 %.

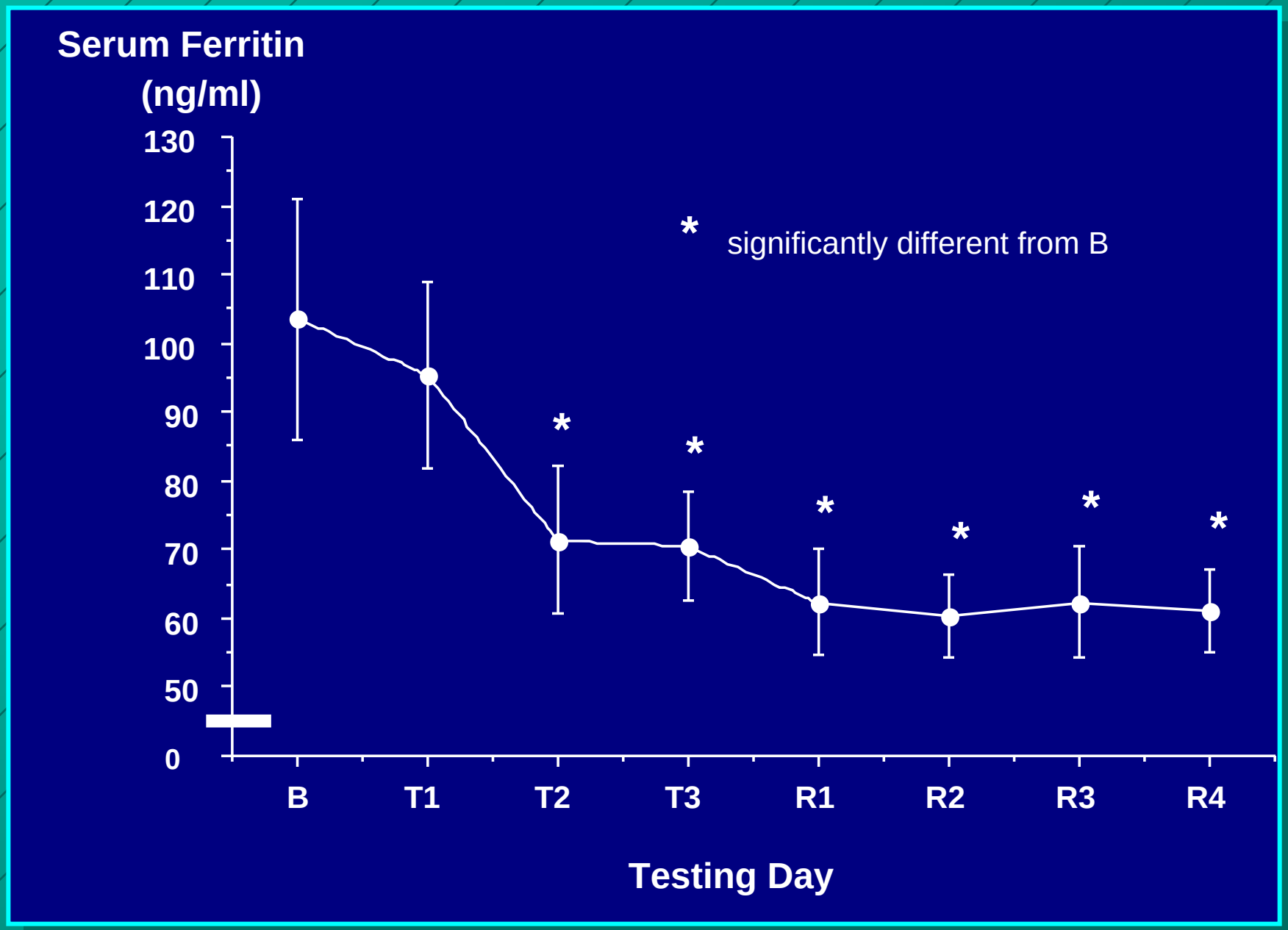
- 7:00 AM resting, fasted venous blood samples were taken weekly 36 hours post interval training.

Results:

- **RBC counts, Hct and Hb were unchanged from a mean baseline values during training and recovery.**
- **Cycling pursuit time was significantly improved with HIT Training and two weeks recovery.**
- **Serum Iron was unchanged, but Serum ferritin levels decreased significantly during training and recovery.**


Pursuit Time
(sec)
320
310
300
290
280
270
260
0
*
*
*
*
*
*
*
* significantly different from B
B
T1
T2
T3
R1
R2
R3
R4
Testing Day


Serum Iron
(ug/dl)
180
160
140
120
100
80
60
40
20
0
B
T1
T2
T3
R1
R2
R3
R4
Testing Day


Serum Ferritin
(ng/ml)
130
120
110
100
90
80
70
60
50
0
* significantly different from B
*
*
*
*
*
*
B
T1
T2
T3
R1
R2
R3
R4
Testing Day

Discussion and Conclusions:

- **Cycling pursuit performance can be significantly improved by a short microcycle of HIT and recovery.**
- **Although Serum Ferritin did not reach critical levels, it was significantly decreased with only three weeks of HIT training and remained low during recovery.**
- **These results along with previous data from our lab suggested that iron status should be monitored carefully in male competitive cyclists.**

IRON STATUS IN ELITE SWIMMERS DURING HIGH-INTENSITY TRAINING AND RECOVERY

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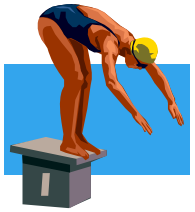
[1]Hong Kong Institute of Education, Hong Kong,
[2]University of Saarland, Saarbrucken, (Germany)
[3]Center for Sport and Preventive Medicine, Hospital Centre de (Luxembourg).



(Wilkinson et al, *APCESS Conference*, 2005)

PURPOSE :

- The purpose of this study was to evaluate the effects of 3 weeks of Endurance (E) training "Control group" or High-intensity Interval Training (HIT) and Recovery on performance and iron status in 19 Olympic Development Team swimmers.

German “Long Course” Swimming Championships

SUBJECTS & Study Design:

- Subjects were young elite swimmers (8 female and 12 male), who were training at the Saarland Olympic Training Center in Germany.
- They were healthy, drug and supplement free and each signed voluntary informed consent.
- The training groups were pair matched for age, gender, and swimming performance. One subject dropped out of the HIT group due to illness. (TABLE 1.)

TABLE 1. Subject characteristics & anthropometric data

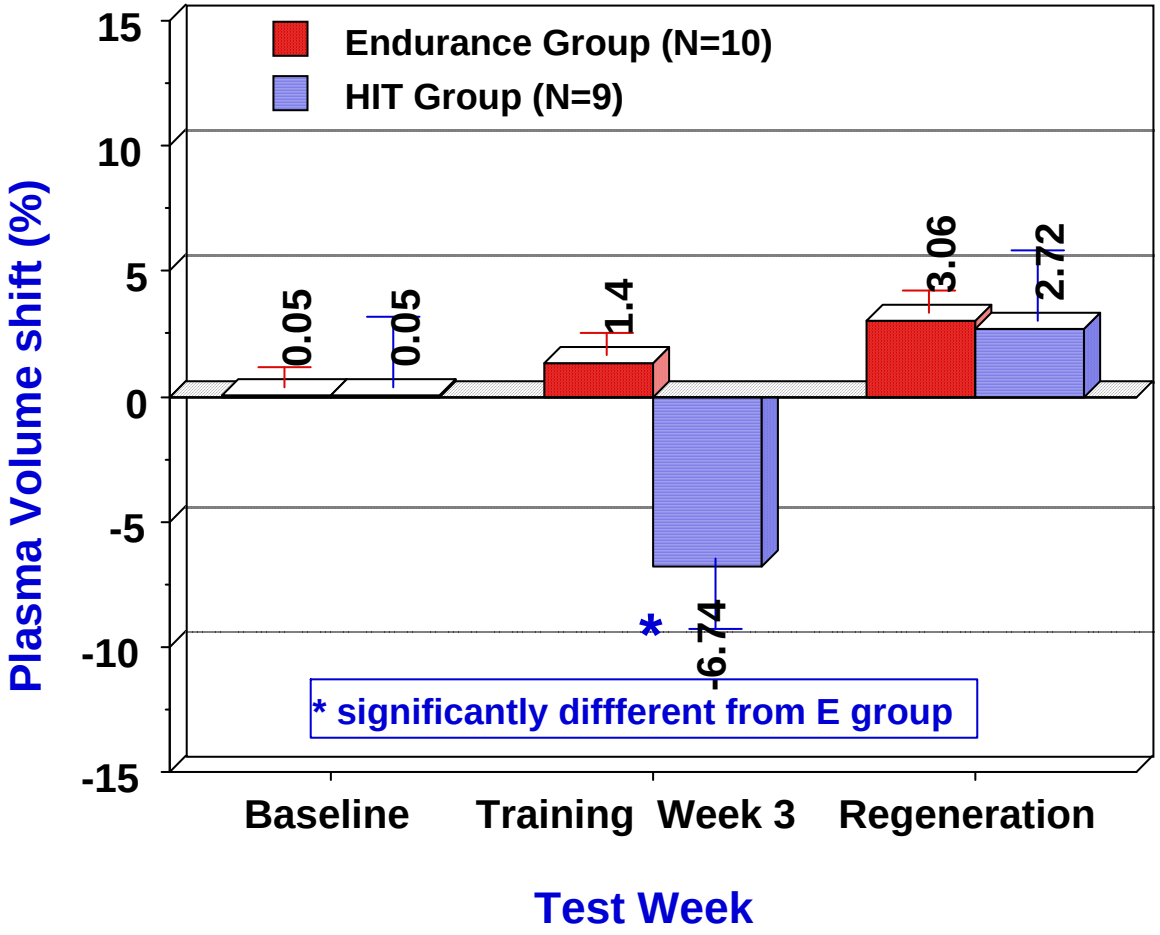
Group	Age (yr)	Height (cm)	Weight (kg)	B-Fat (%)
Endurance (N=10)	16.0 ±1.5	174.8 ±11.4	64.4 ±9.9	14.1 ±4.0
HIT Group (N=9)	15.6 ±2.0	174.2 ±6.7	65.2 ±9.4	14.9 ±5.1

METHODS: Training

- Both groups trained for 2 hrs/day 6 days/week and Sunday was an off day.
- Endurance (5,400m) and HIT (3,100m) training was done 4 days/week (Monday to Thursday). Friday was an "easy" recovery training day (HR < 150 BPM), in preparation for swim performance testing on Saturdays.
- Plasma volume was estimated from HCT and blood concentrations were corrected for significant plasma volume shifts.

Training Venue

Fig 2. Plasma Volume shifts after training and Recovery



METHODS: Data analysis

- **All variables were analyzed by MANOVA followed by repeated measures two-way ANOVA and Student Newman-Keuls *post hoc* analysis with alpha set at $P<0.05$.**

- **All data were reported as means ± Standard error of the mean (SEM).**

Results and Discussion

- Both blood lactate and HR (not shown) were significantly higher in the HIT group vs the Endurance group during training.

- Both training methods resulted in significant improvements in swimming performance.

Fig 3. Blood Lactate during Endurance and HIT training (N = 88 samples)

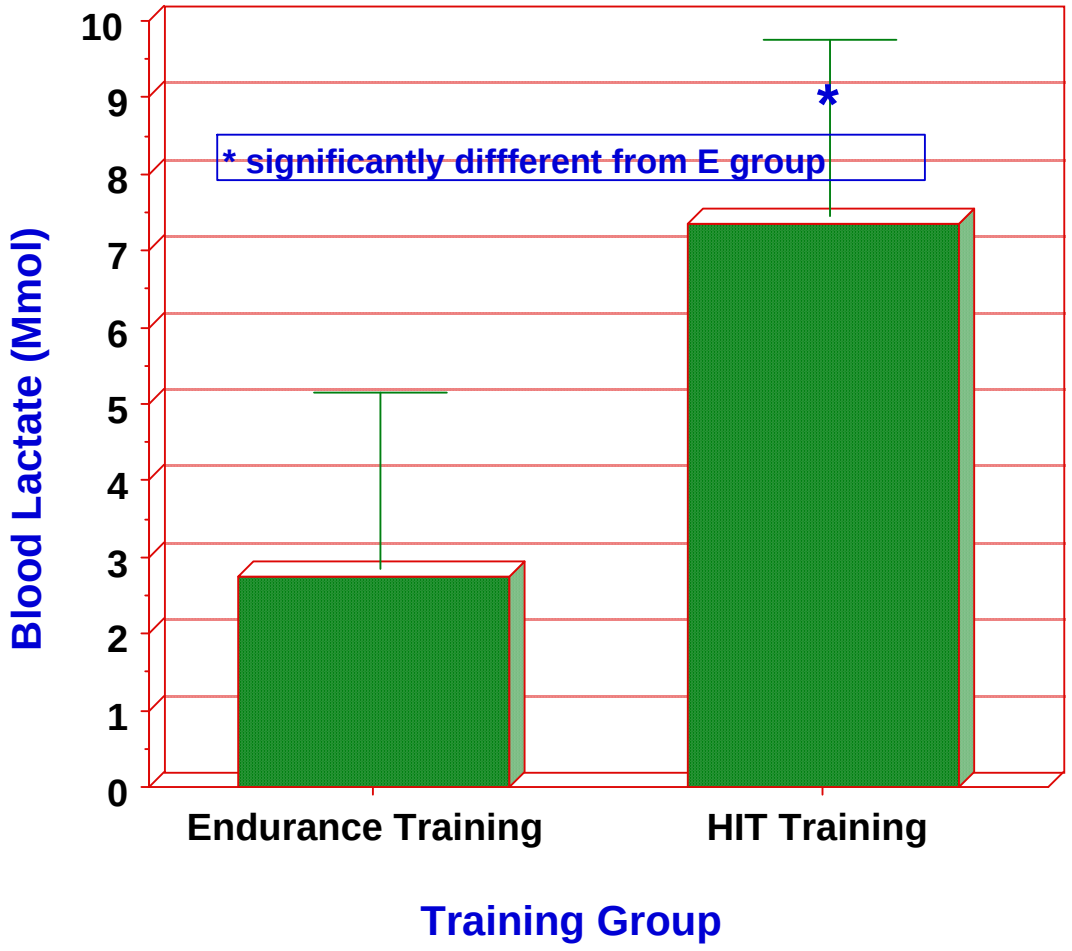


Fig 1. Best 100m Swimming Performance (% change from Baseline = 100%)

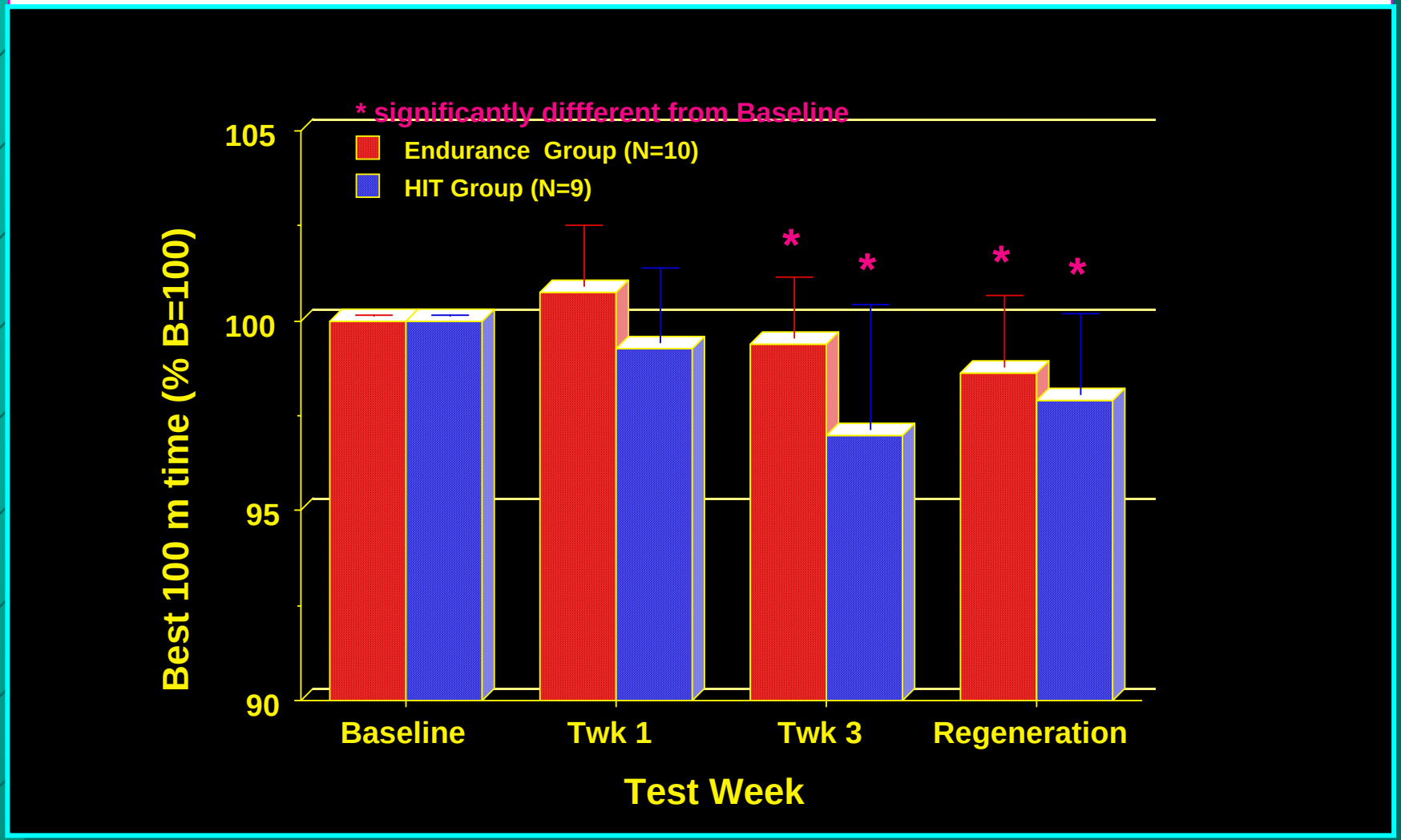


Fig 2. Hematocrit before and after Training and Recovery

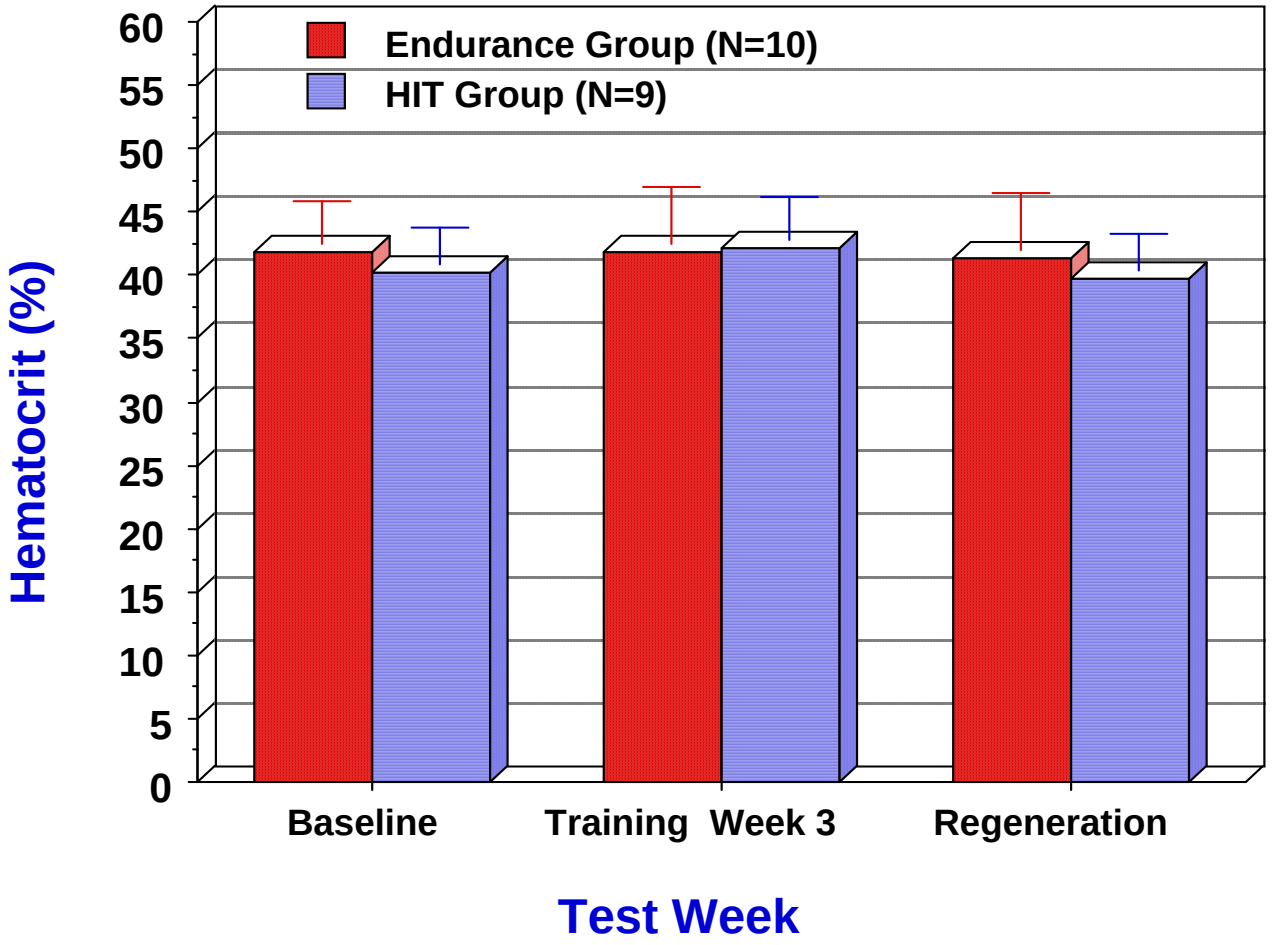


Fig 3. Hemoglobin before and after Training and Recovery

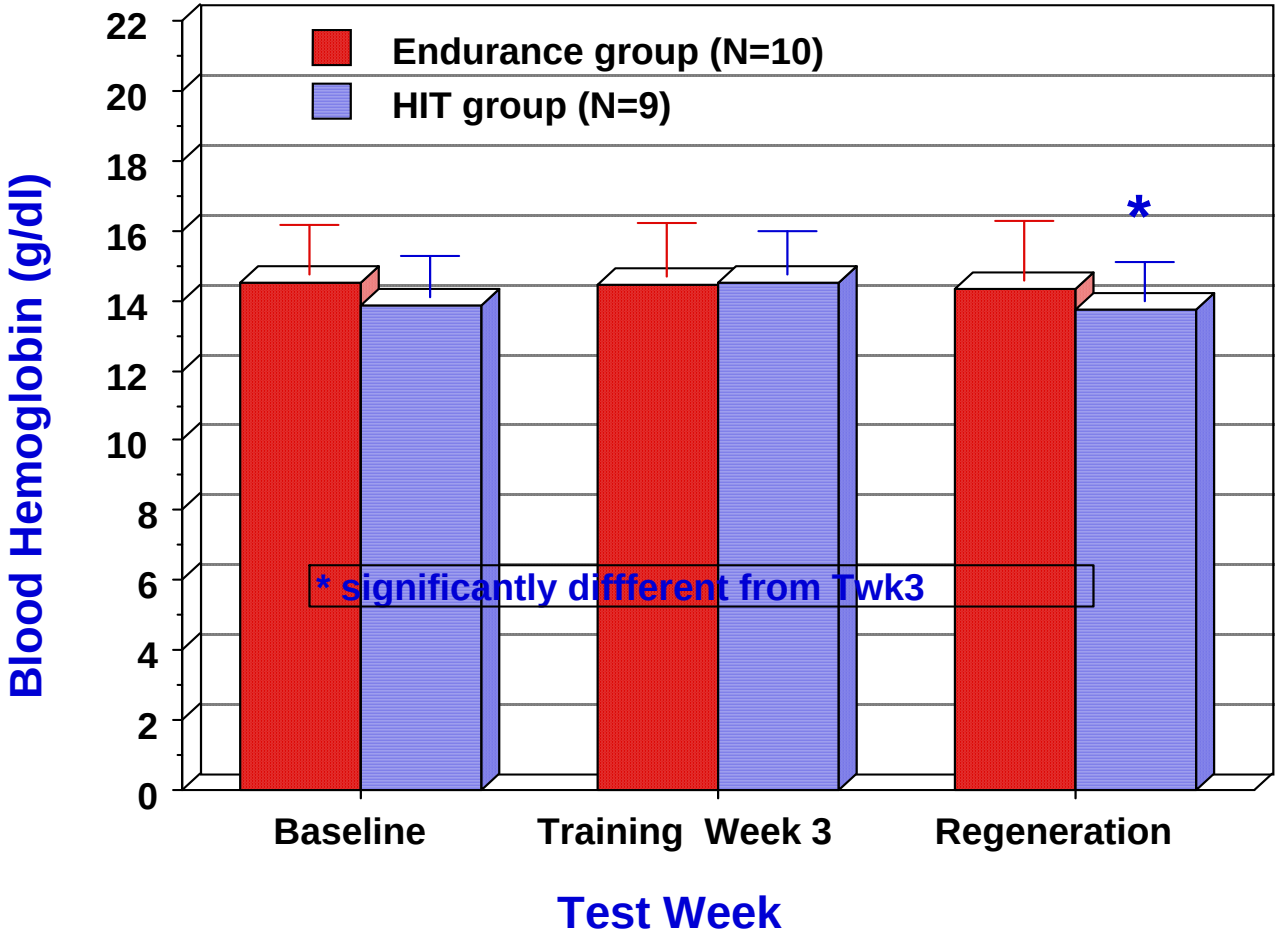
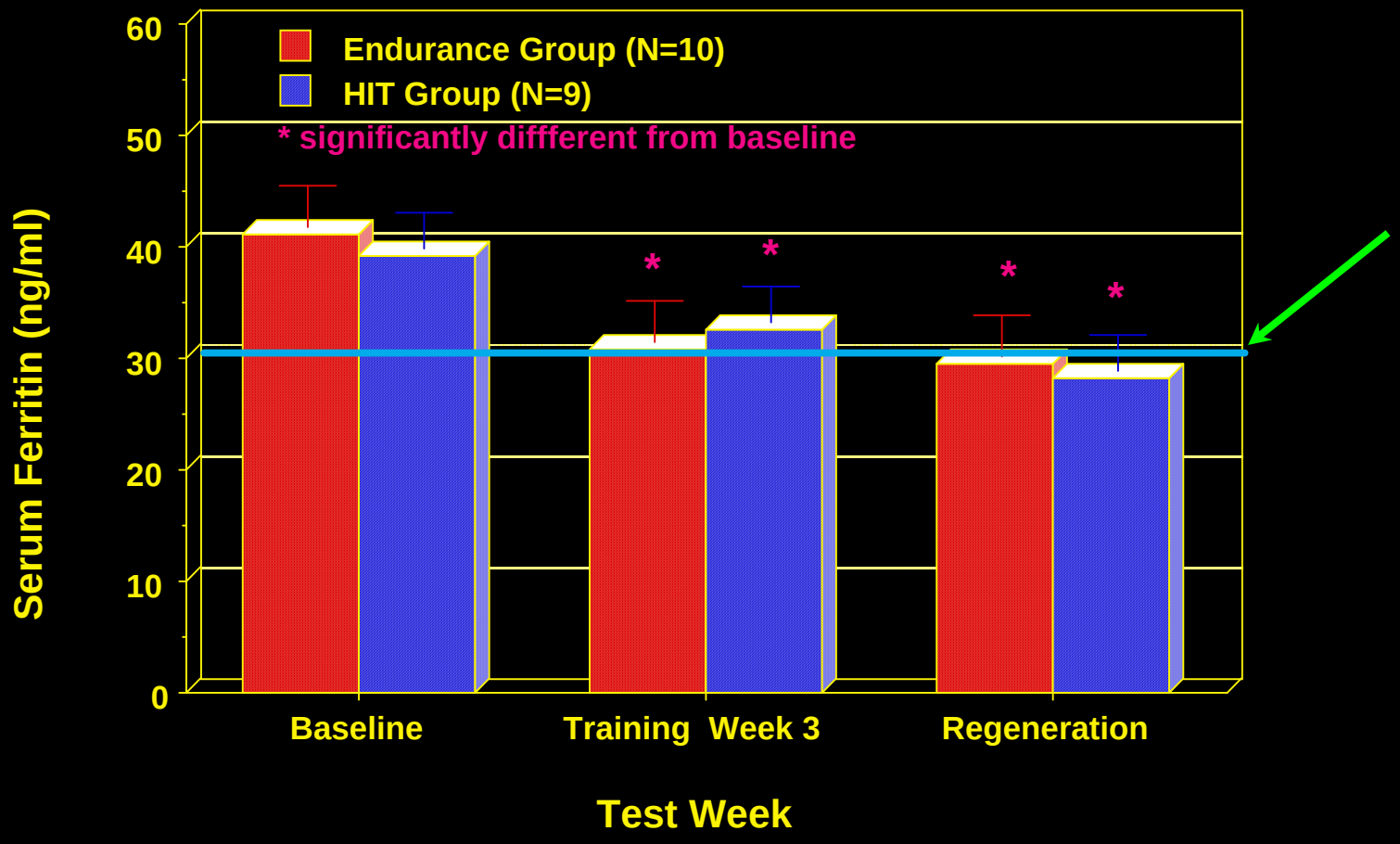


Fig 4. Serum Ferritin in Swimmers before and after Endurance and HIT Training and Recovery



Discussion & Conclusions:

- We have found that serum ferritin was significantly reduced in response to 3 weeks of both High-Intensity Endurance training and HIT in elite swimmers.

- This could be a particularly significant finding in female swimmers with iron deficiency.

- The physiological mechanisms responsible for these changes are not well understood at this time.

Discussion & Conclusions:

- Kuipers and co-workers (2006) have recently suggested that HIT and resulting lactacidosis may change Red Blood Cell-membrane characteristics.

- There has also been some speculation that HIT some how decreases the bioavailability of dietary iron because iron supplementation is often not successful unless training intensity is reduced.

- Athletes engaging in both Endurance and High-intensity Interval Training should have their Iron Stores checked regularly.

Kuipers et al, *Int J Sport Med*, (2006)

Acknowledgments :

Thanks to the swimmers for their time and hard work; to the coaches, Dirk Reinicke and Bjoern Schlick, who supervised and logged training sessions and to Dr. Markus Herrmann and June Wilkinson, who helped with the data collection.