IRON IN ATHLETES

Lindsay Parlee MD

Marshall Family Medicine

Sports Medicine Fellow

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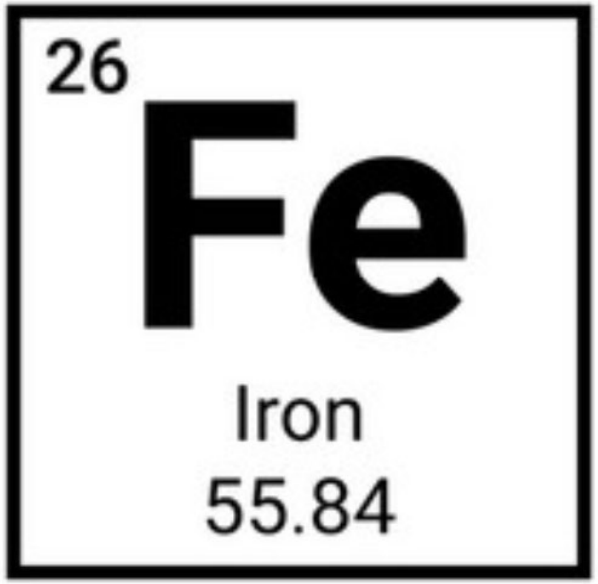
OBJECTIVES:

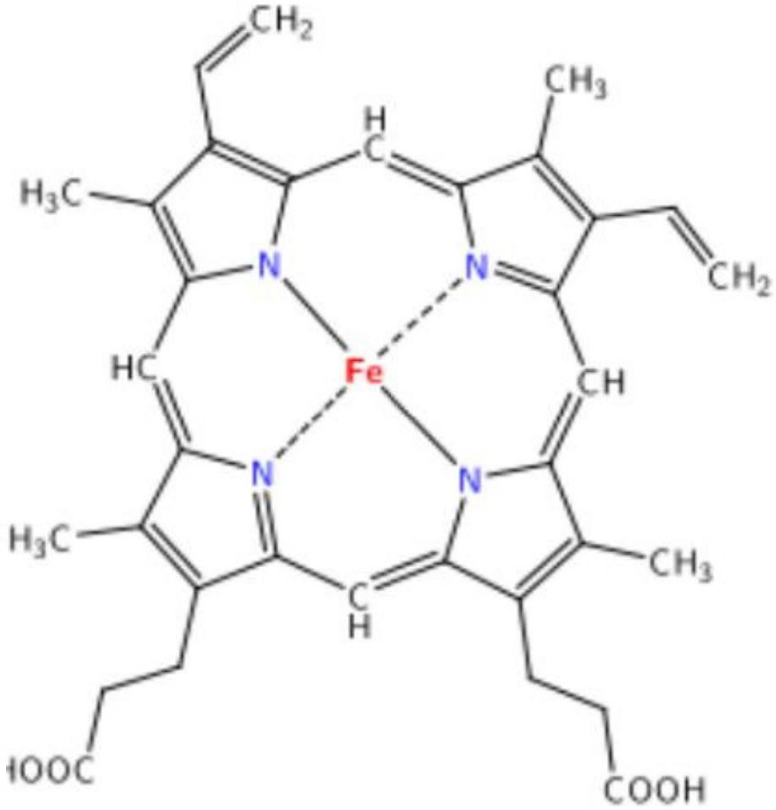
- Differentiate anemia from iron deficiency.
- List potential causes for iron deficiency.
- Recognize athletes with iron deficiency through their history and physical exam.
- Counsel athletes on how to optimize their iron intake to replete stores.

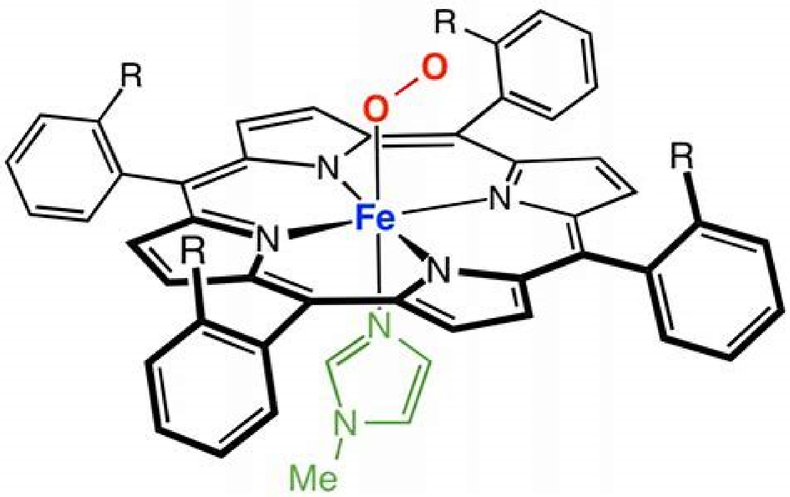
WHAT IS IRON?

- An essential micronutrient that plays a role in many cellular processes
- An element

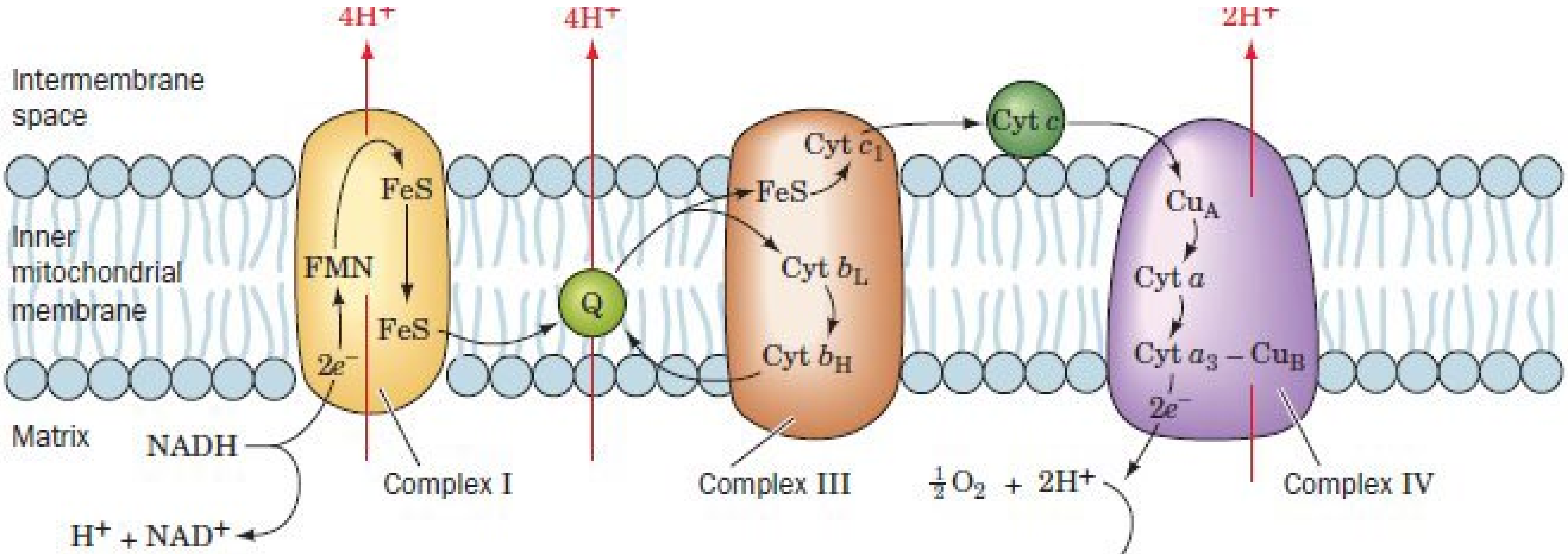


OXYGEN TRANSPORT





ENERGY PRODUCTION



SOURCES

- Animal vs Plant sources
- Iron Skillet
- Supplementation

**Only 5-15% of iron eat is absorbed **

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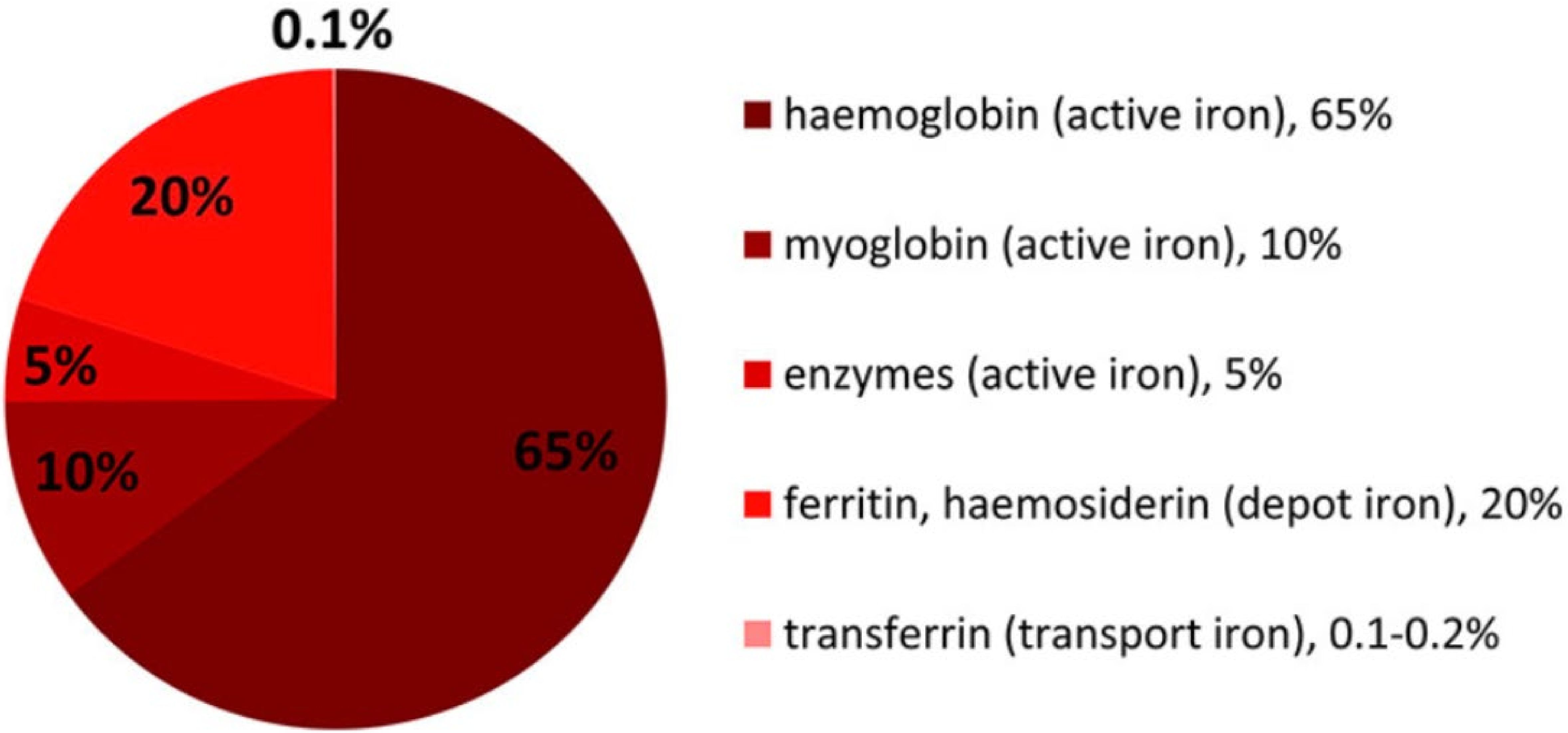
Iron compartments in the human body



EPIDEMIOLOGY

General population

- IDNA 12-16% premenopausal women and 2% of men
- IDA 3-5% of women and <1% of mem

Athletes

- IDNA 35% female and 11% male
- IDA 18% of female and 7% of male

RECOMMENDED INTAKE

Recommended Daily Intake General Population

- Male 8 mg
- Female 18 mg

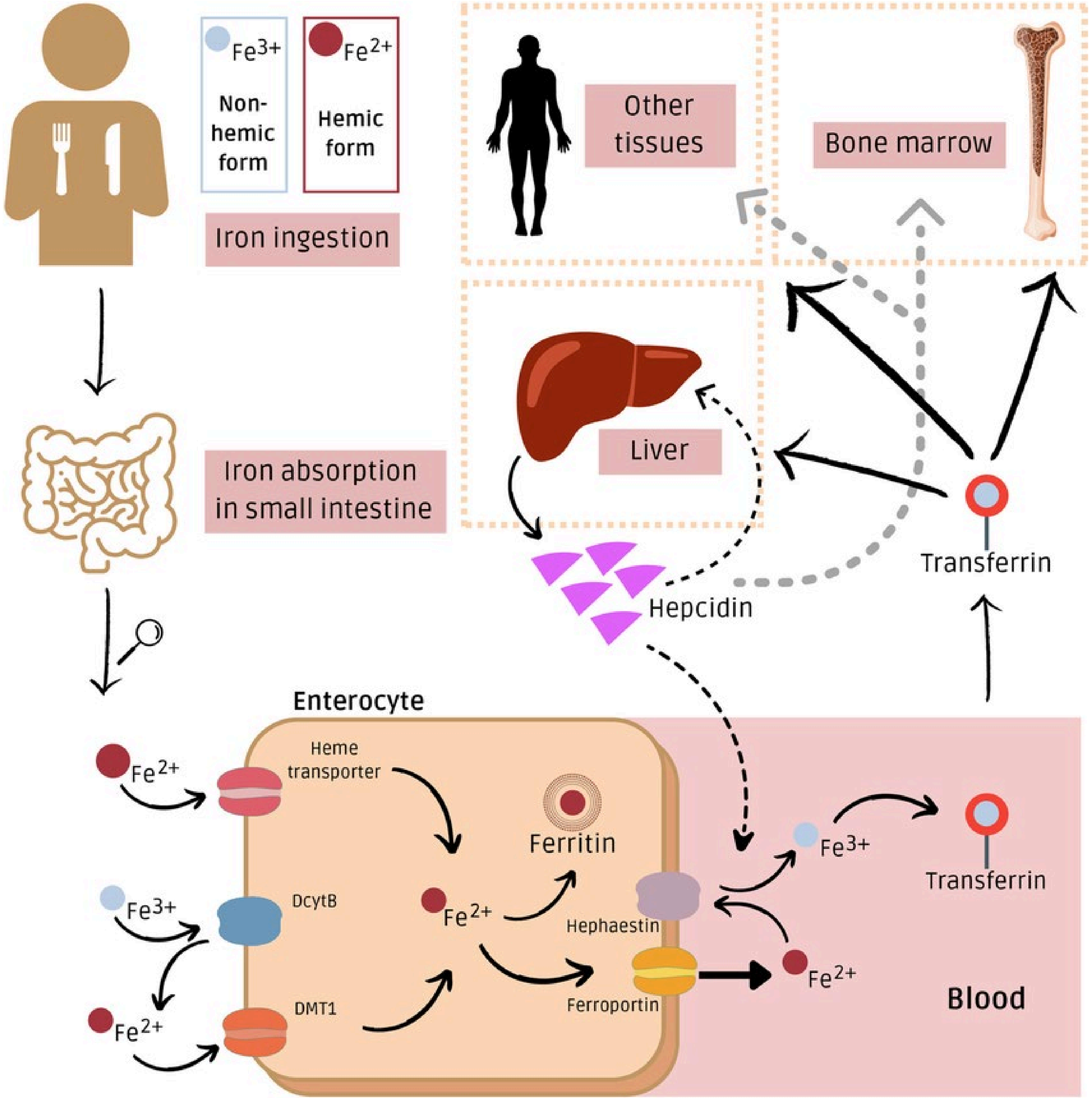
Average Western diet is ~6 mg of iron per ~4200 calories

Athletes have an increased need

Daily iron loss

- Male 1 mg/day
- Female 2 mg/day

IRON METABOLISM



IRON DEFICIENCY

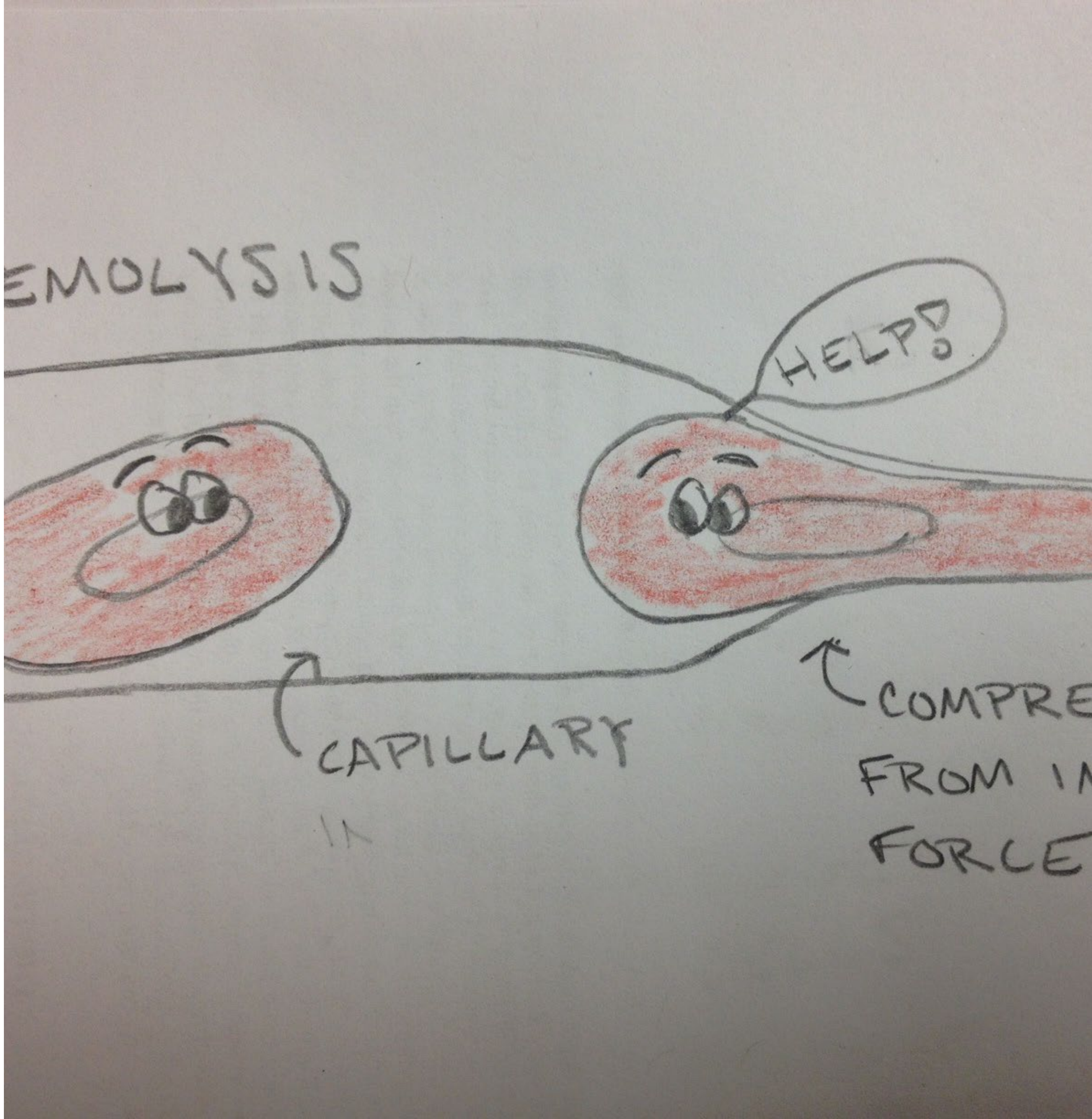
Stage	Physiology	Hb (g/dL)	Ferritin (µg/L)	TIBC%
1 Iron Deficiency	Depleted stores in -spleen -bone marrow -liver	>11..5	<35	>16%
2 Iron Deficient Non-anemic	Erythropoiesis diminished Iron supply to erythroid marrow reduced	>11.5	<20	<16%
3 Iron Deficiency Anemia	Fall in Hb production Microcytic anemia	<11.5	< 12	<16%

ETIOLOGY

- Reduced Availability / Intake
  - Ferritin
  - RED-S
- Increased demand
  - Periods of rapid growth
  - Manses
  - High intensity exercise cycles
  - Endurance
  - Altitude

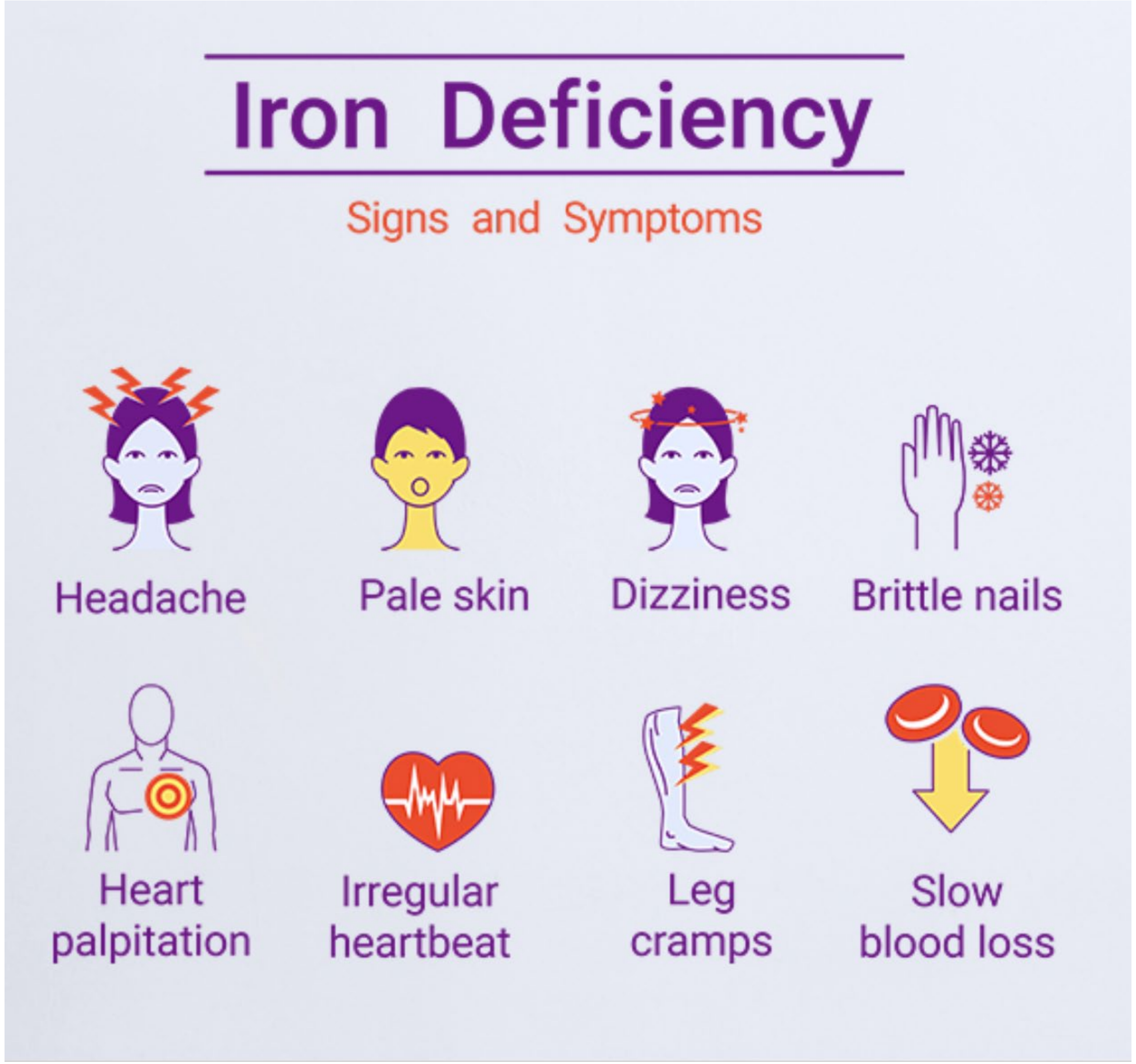
ETIOLOGY

- Absorption
  - Chronic disease
  - Increased Hepcidin
- Blood Loss/Destruction
  - Foot Strike Anemia
  - Gastrointestinal Bleeding
    Other bleeding or hemolysis
  - Frank bleeding



SYMPTOMS

- Lethargy
- Fatigue
- Mood Disturbance
- Reduced Exercise Capacity
- Tachycardia
- Palpitations



LABS

Biomarker	Biomarker Description
Red Blood Cell (RBC)	Total # of RBC in the blood
Hemoglobin (Hgb)	Total # of oxygen-carrying protein in RBC
Hematocrit (Hct)	The percentage by volume of RBC in blood
Mean Corpuscular Volume (MCV)	The average volume of RBC
Mean Corpuscular Hemoglobin (MCH)	The calculated measurement of average weight of Hb per RBC
Mean Corpuscular Hemoglobin Concentration (MCHC)	The calculated average concentration of Hb in the RBC
Red Cell Distribution Width (RDW)	The degree of RBC size variability

LABS

Biomarker	Biomarker Description	Indicator of Low Iron
Serum Iron	Unbound Iron	<10 µmol/L
Ferritin	Iron bound to storage protein	<30 µg/L
% Transferrin Saturation	Shuttle protein between GI absorption and tissues.	>46 µmol/L
Total Iron Binding Capacity (TIBC)	Remaining room to bind more iron	<16%

LAB INTERPRETATION

- Hemoglobin
  - Impacted by plasma volume
  - Pseudo-anemia "sport anemia“
  - Draw 24+ hours post training in hydrated state (urinary sp gravity <1.025)
- Ferritin
  - Be mindful when interpreting because it is an acute phase reactant
  - Elevated after strenuous exercise
  - Elevated in various disease states

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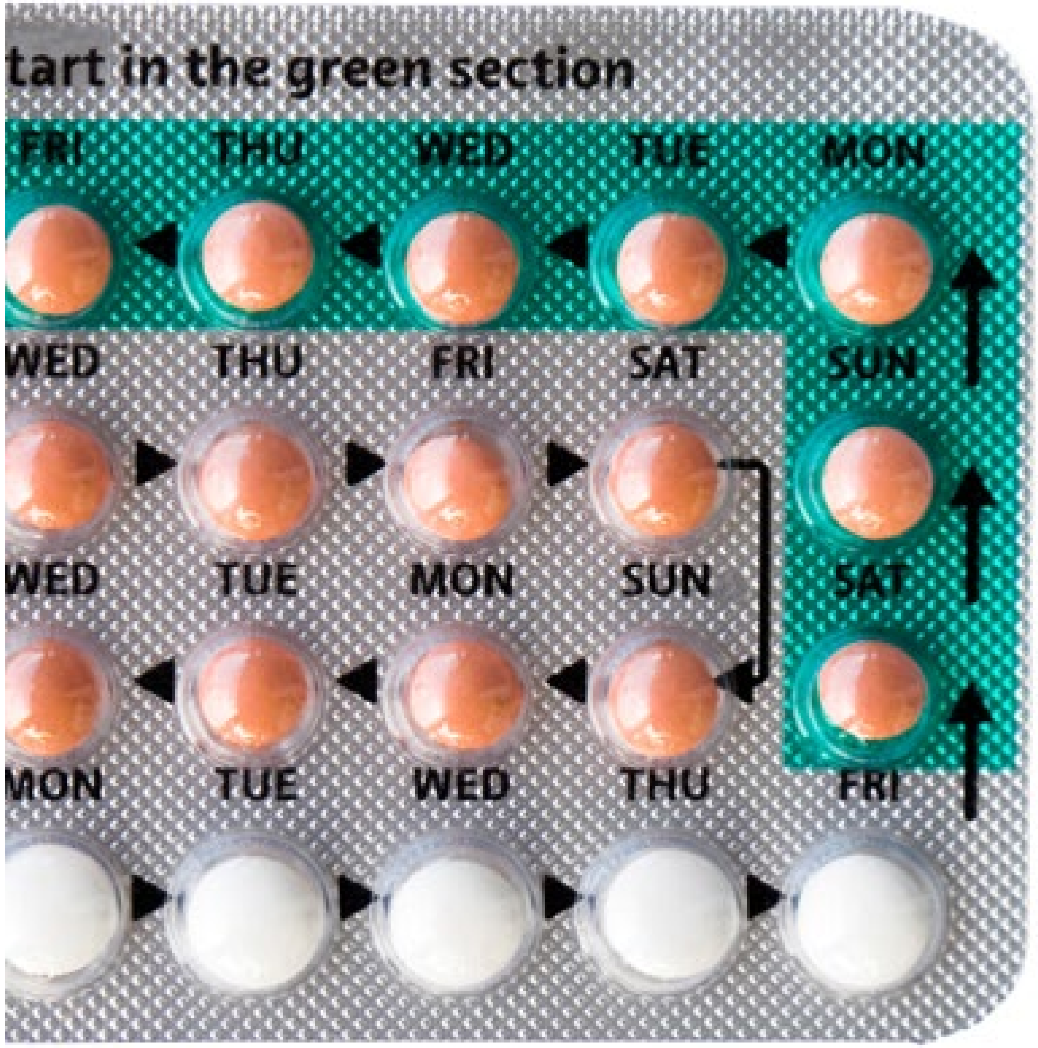
EXERCISE & HEPCIDIN

- Post exercise increase in hepcidin peaks at 3 hr post exercise
- Diurnal variation w/ lowest in the morning w/ steady increase though the day
- Depletion of muscle glycogen stores may amplify hepcidin levels which may prolong post-exercise period of prolonged impaired iron absorption/metabolism
- Important to consume protein with carbohydrates and avoid ultra low carbohydrate diet

SEX DIFFERENCES

- No difference in hemoglobin but difference in ferritin found in elite German athletes (n=193; 50% female; average age 16.2)
  - female 2x higher incidence of IDA
- Menstrual Cycle
  - 30-50 mL lost; >60 mL can impact iron stores
  - 1.6 mg of iron lost
- Oral Contraceptive
  - higher ferritin
  - higher TIBC % compared to non-users
  - Less blood loss



SEX HORMONES

- Ginsburg et al 2001
  - n=38
  - After completion of Iron man triathlon men had ~58% reduction in testosterone
- Intense exercise
  - inhibits GnRH
  - less LH, FSH and thus less Estrogen and Testosterone
- Testosterone
  - stimulates erythropoiesis in both sexes
- Hepcidin rises
  - less erythropoiesis, less need for iron so hepcidin blocks GI absorption

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PREFORMANCE

Female rowers (n=165) w/ Hb >12.0 dg/L, ferritin <20 μ/L

- retrospective – looked back 2-3 mo
- slower 2 km rowing (~21 sec) on ergometer

Female rowers (n=31) who were IDNA

- supplemented with 100 mg/day iron for 6 weeks
- unchanged 4 km but demonstrated decreased energy expenditure and increase energy efficiency

PREFORMANCE

- No impact on VO2 max (measure of performance) or other performance-based testing (shuttle runs etc).
- -No impact on Hb
- Impact on ferritin
- -Impact on perceived exertion
- -Impact greater in untrained than trained individuals

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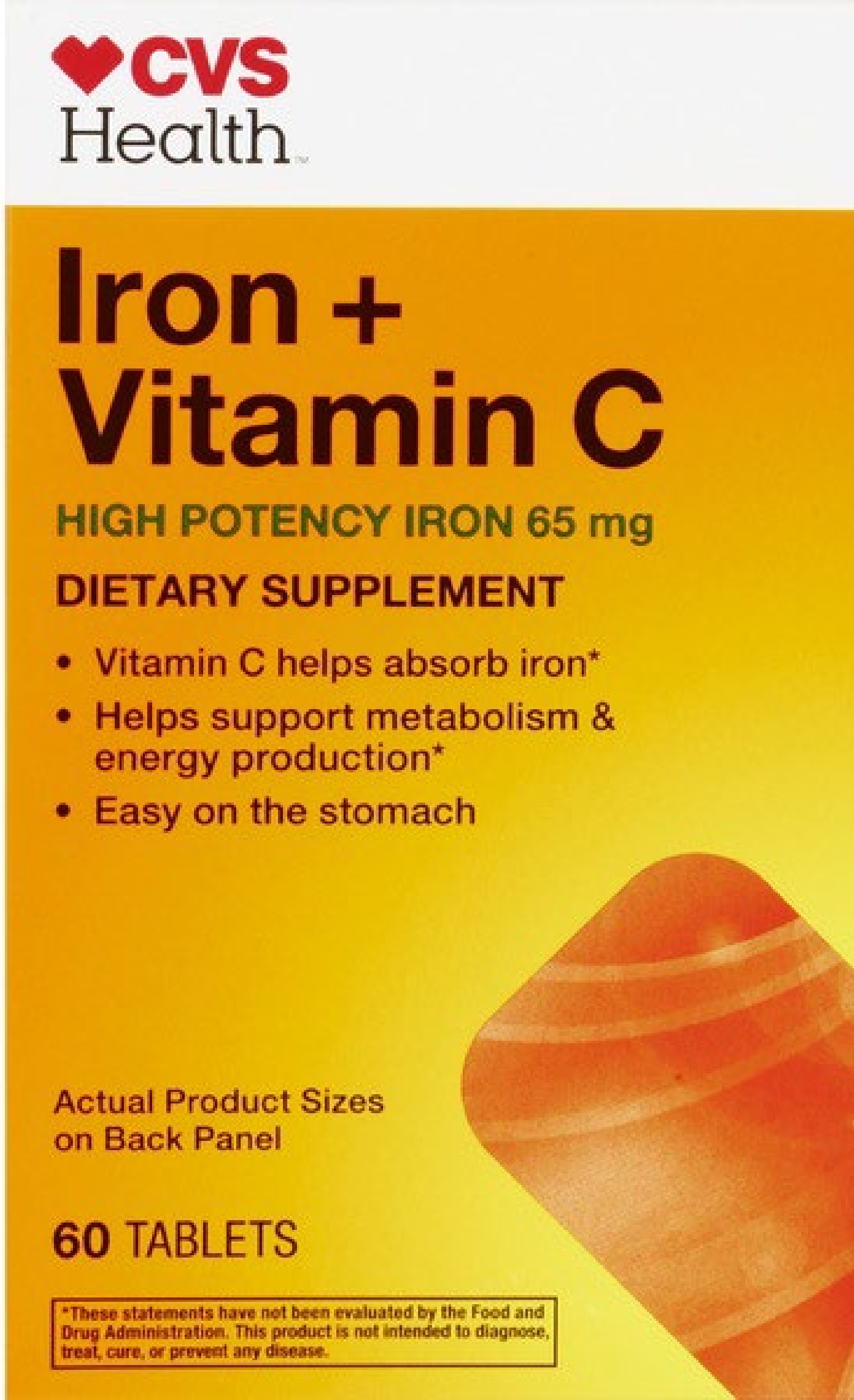
SUPPLEMENTATION

- Increased Dietary Intake
  - Dietary assessment w/ dietitian
- Oral
  - Ferrous Sulfate
  - Ferrous Glycinate
  - Ferrous Sulphate*
- IV
  - Iron Sucrose
  - Iron Dextrose



RESPONSE TO SUPPLEMENTATION

- IV iron
  - 300 to 550 mg given over a period of 1-42 days
  - 200-400% increase in ferritin

-Oral Iron

  - 8-12 weeks 100 mg/day oral iron
  - 40-80% increase in ferritin

SUPPLEMENTATION PEARLS

- Alternate day supplementation may improve absorption and efficacy
- With vitamin C
- Consider increasing dose in extreme environments (ie. Altitude)
- Timing of intake in AM when hepcidin low

ALTITUDE & IRON

- >2 weeks at 1000-2000 m and 2000-3000 m results in hematologic adaptation
  - Hemoglobin mass
  - Iron dependent glycolytic enzymes
- Ex. Hypoxic exposure of 1000 km/h (ie. 21 days at 2000 m) is associated with 3-4% increase in Hb mass
  - Increase in erythroid iron demand by 3-5 fold
  - Response thus may be blunted if iron not available

ALTITUDE & IRON

- EPO increases within 90 min of hypoxic exposure
- Peaks at 48 hours and returns to baseline around 1 week
- Start to see measurable change in Hb mass at 10 days
- Increased intestinal absorption
  - Hypoxia inhibits hepcidin w/in 15 hrs at altitude
- Iron released from storage to help facilitate adaptation
- Increased transport to the erythrocyte

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SUPPLEMENTATION @ ALTITUDE

- Supplement prior to and during altitude exposure
  - 2-6 weeks prior
- Blood screening 3-6 weeks prior to departure
  - Preferred measurement by carbon monoxide-rebreating method
  - CRP, ferritin, serum iron, transferrin saturation
- Hall et al 2019 – single nightly dose 200 mg elemental iron better than split dose with higher Hb response by athletes at 2106 m for 3 weeks
  - Both led to increase
  - More GI side effects with higher dose

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SCREENING

Considerations and frequency of iron blood screening for athletes*

Variables to be considered

- ☐ *Minimum:* Serum ferritin, hemoglobin concentration, transferrin saturation
- ☐ *Desirable:* Serum soluble transferrin receptor, hemoglobin mass, C-reactive protein

Standardisation of blood collection

- ☐ Time of day: Preferably in the morning
- ☐ Hydration state: hydrated preferably assessed by waking urinary specific gravity (< 1.025)
- ☐ Low to moderate activity in the proceeding 24 hours, including no muscle-damaging exercise (e.g. eccentric) in the 2-3 days prior
- ☐ No signs of sickness or infection

Annually

- No history of iron deficiency
- No history of irregular/excessive menses or amenorrhea
- No reports of fatigue after extended rest
- Strength/power-based sports with minimal endurance component
- No iron-related dietary restrictions
- No evidence of low energy availability
- No intention to undertake hypoxic training in the next 12 months
- No underlying pathology (e.g. coeliac or Crohn's disease)

Biannually

- Female
- Previous history (≥ 24 months) of iron depletion (e.g. Stage 1[#])
- Previous history (≥ 24 months) of irregular/excessive menses
- Intention to undertake high training loads especially in endurance and team-based sports
- Minimal (or zero) reports of prolonged fatigue after extended rest
- No iron-related dietary restrictions (e.g. non-vegetarian, non-vegan)
- No evidence of low energy availability
- Intention to undertake hypoxic training in the next 12 months

Quarterly

- Any recent history (<24 months) of iron depletion/deficiency (Stage 1, 2 or 3[#]) irrespective of sex
- Any evidence of irregular/excessive menses or amenorrhea
- High training loads in team and endurance-based sports
- Reporting prolonged fatigue/lethargy even after extended rest
- Reduced work capacity during training
- Unexplained poor athletic performance
- Individuals restricting sources of dietary iron (e.g., vegetarian and vegan) or overall caloric intake
- Any evidence of low energy availability
- Intention to undertake hypoxic training in the next 6 months

TAKE HOME POINTS

- Not all iron deficiency causes anemia. Not all anemia is caused by iron deficiency. But anemia can be caused by iron deficiency.
- Laboratory studies need to be interpreted with caution. Consider whether in range values are too low for the metabolic needs of the athlete.
- Timing of supplementation, frequency of dosing, and method of delivery are important variables when counseling on supplementation
- If an athlete is symptomatic with laboratory evidence of iron deficiency, consider Relative Energy Deficiency and nutrition intervention.

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