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Iron Deficiency in Athletes

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Stages of Iron deficiency

- **Iron Storage depletion**
  - Depletion suggested by Decrease in ferritin
- **Functional Iron depletion** (enzyme function at cellular level)
  - Depletion suggested by increase in sTFR's
  - Enzyme malfunction (all involved with oxidative phosphylation)
    - Cytochromes
    - Catalase
    - Peroxidase
    - Pyruvate –malate oxidase
    - Xanthalte oxidase
    - Alpha –glycophosphate oxidase
- **Anaemia**
  - Depletion suggested by decrease Hb
  - Very rare in elite athletes as would markedly impair performance

Epidemiology in athletes

- **576 elite AIS athletes screened over 3 years** (Fallon 2008)
  - **16%** of females and **33%** of males had minor abnormalities
  - **2.3%** males had iron below 30ng/ml
  - **19%** of females had iron below 30ng/ml (same as general population)

Iron Metabolism

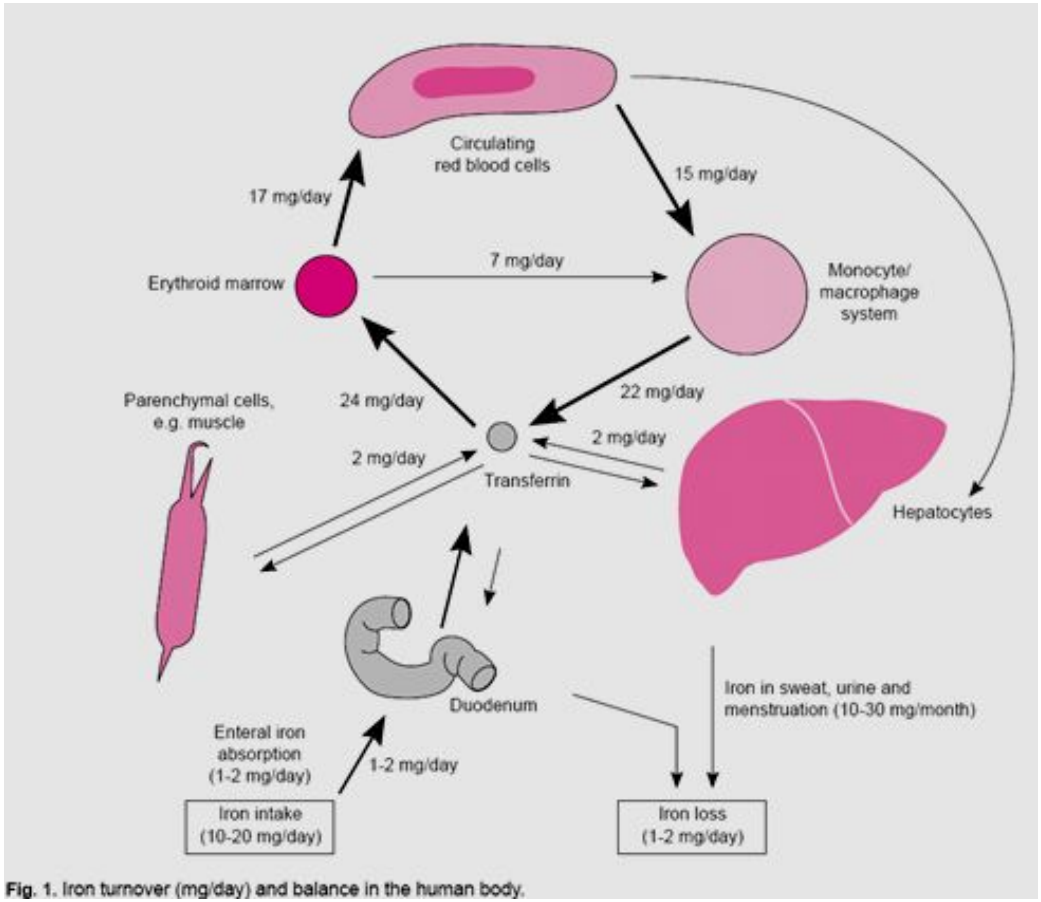

Fig. 1. Iron turnover (mg/day) and balance in the human body.

Iron Metabolism

- Average daily intake **15-25 mg/day**
  - About 10% of dietary Fe is absorbed
  - Can be increased up to 40% in Fe deficient states
  - Typical Western diet contains 6mg Fe/ 1000kcal

Recommended daily intake

- **Athletes** -15mg

- **Children, males, post menopausal females**
  - 10mg/day - to absorb 0.7-1mg/day
- **Menstruating females**
  - 15mg/day - to absorb 1.5mg/day
- **Lactating females**
  - 15mg/day
- **Adolescence** – 15mg
- **Pregnancy** - 30mg/day - to absorb 3mg/day

Male athletes normally achieve the RDI's, female athletes do not

Dietary iron sources

- Haem Fe – 23% absorbed
  - Red meat (4.5mg/100g)
  - Pork (4.1mg/100g)
  - Chicken (0.9mg/100mg)
  - Fish and liver (6mg/100mg),
  - Spleen, bone marrow

- Non haem Fe – 5% absorbed
  - Cereals, fruits, green leafy vegetables

Iron absorption - Facilitation

Facilitated by

- Vit C
- Gastric Acids
- Alcohol
- Iron deficient state
- Haem iron
- Ferrous iron

Iron absorption - Inhibition

Inhibited by

- Coffee
- Tannins - tea
- Antacids – carbonates
- Phytates – unprocessed bran
- Phosphates
- Oxalates
- Luminal Ca
- Iron overload state
  - Blood transfusions, haemochromatosis
- Presence of gastric / duodenal dx – Crohn's, celiac

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Presentation

Symptoms

- **Iron Deficiency**
  - Often Asymptomatic
  - Fatigue, slow recovery
  - Decreased performance
- **Anaemia**
  - SOBOE
  - Palpitations
  - Malaena, PR bleeding
  - Macrohaematuria

Signs

- **Iron Deficiency**
  - Likely nothing
- **Anaemia**
  - Pallor – palmer crease and conjunctival (<70mg)
  - Tachycardia
  - Tachyopnoea
  - Angular stomatitis
  - Glossitis
  - Flow murmur
  - Koilonychia - spoon shaped nails

Aetiology in athletes

- **Normal daily losses**
  - Skin desquamation 0.2 mg/day
  - Urine 0.1 mg/day
  - Faecal 0.6 mg/day
  - Sweat 0.1-0.4 mg/L (can double loss with 2L of sweat)

- **Decreased intake**
  - Inadequate haem Fe
  - Most common cause in female athletes
    - esp. vegetarian diets
  - Consider in weight category and body image sports
    - beware disordered eating + amenorrhoea

Aetiology in athletes

- Decreased absorption
  - Intake of inhibitors
  - Lack of facilitators
  - Decreased gastric acid availability due to antacids, PPI's, previous partial gastrectomy
  - Proximal duodenal Disease – Coeliac Dx, Crohn's Dx

- Increased requirements
  - Pregnancy
  - Adolescent growth spurt
  - Altitude
    - Epo increases at altitude
  - Lactation
  - Malignancy

Aetiology in athletes

- Increased blood loss
  - Menstrual
    - Normal 20mg/month, 0.7mg.day on average
    - Menorrhagia due to fibroids, uterine polyps, malignancy
  - GIT
    - Caecal slap syndrome
      - Trauma associated with distance running
      - 85% Faecal occult blood +ve following intense exercise
    - GIT bleed
      - NSAID's induced ulceration
    - Polyp's / Crohn's / AV malformations / tumour
    - Chronic parasitic infection – Hookworm in developing countries
    - Superior mesenteric artery syndrome
      - Ischaemic changes with loss of the mucosal and red cells

Aetiology in athletes

- **Increased blood loss**
  - Haemoglobinuria
    - Foot strike haemolysis in a distance runner – release of Hb in urine
  - Haematuria
    - Bladder slap syndrome – posterior wall and base hit together
      - Red cells microscopic haematuria
    - Ruptured renal capillaries 2° to dehydration
  - Bleeding disorder

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Anaemia differentials

- Dilutional Pseudoanaemia – Sports anaemia
- Sideroblastic
- Thalassaemia
- Hereditary spherocytosis
- Haemolytic anaemia's
- Anaemia of chronic disease
- Macrocytic anaemia
  - Hypothyroid ism
  - Medication
  - B12 and folate deficiency
- Sickle cell anaemia
- G6PD deficiency

Investigation

- **FBE and film (in anaemia)**
  - Poikilocytosis (change in shape)
  - Anisocytosis
  - Increased reticulocytes
  - Target cells
  - Decreased in MCHC and MCH **(hypochromic)** before decreased MCV **(microcytic)** before decrease Hb

Investigation

- **Serum ferritin**
  - Best test to determine need for Fe supplementation
    - Reflects body stores
    - Is an acute phase reactant - increases with inflammation, training, chronic disease, malignancy

- **Diurnal Variation in Serum Ferritin levels**
  - 27.4% in young women
  - 46% in female athletes
    - (Stupnicki R et al 2003 BJSM 37: 267-269)
  - 14% in young males
    - (Cooper and Zlotkin 1996 Am J Clin Nutr 64: 738-742)

Investigation

- **sTFR**
  - Aren't recommended as an Fe deficiency test, but can be useful where
    - There is a likely acute phase response, or
    - In athletes with a probable low normal ferritin
    - Is and indication of iron deficient erythropoiesis with levels >8.0 mg/L
    - Can be used to monitor Iron supplementation

Investigation

	Normal	Storage Fe Depletion	Functional Fe Depletion	Fe Deficiency Anaemia
Hb (g/dL)	>11.5, >14	>11.5, >14	>11.5, >14	**<11.5, <14**
Ferritin (ng/ml)	50-200	**<30 – start Fe supp** **<12 – no Fe stores**	<22	<12
MCV (fL)	80-100	80-100	80-100	<80
Serum Fe (ug/Dl)	50-100	**<50**	<50	<30
% TF sat	30-50	**<16**	<16	<10
TIBC	300-360	>380	>380	>400
sTFR	normal	normal	↑	↑↑↑

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Investigation

- **Urinalysis**
  - Dipstick
  - Microscopy
    - RBC's bladder slap syndrome
    - Bleeding disorder
    - Nephritis
  - Haemoglobin
    - Foot strike
- **Faecal occult blood**
  - Caecal slap, GIT bleed, GIT disease
- **Coags**
  - Bleeding disorder
- **Haptoglobins**
  - Decrease in haemolysis
  - Decreased in foot strike
- **Free Haemoglobin**
  - Elevated in Foot strike

Management

- **Educate**
- **Correct reversible and treatable factors**
  - Involve sports dietitian
  - Address dietary intake
    - Read meat, pork, fortified cereals
  - Avoid inhibitors
    - tea, coffee, antacids, unprocessed bran with iron rich meals

Athlete related

- **Heel strike**
  - Look at shoes
  - Move to soft surface running
  - Decrease running distance
  - Assess need for orthotics

- **Bladder slap**
  - Running with slightly full bladder

Supplementation

- **AIS recommendation**
  - **Oral**
    - Iron supplementation at Ferritin <30.
      - 100mg/day for 3 months in conjunction with Vit C on empty stomach
      - Ferro-grad – 105mg daily
    - Main side effects
      - Constipation
      - Diarrhoea - caution in OCP pts
      - Decreased Zn, thyroxine, bisphosphonate absorption, Cu2+

Supplementation

- **Intramuscular**
  - Used if poor absorption of Iron
    - Side effects
      - Painful
      - Tattooing – Z technique
      - Local abscess
      - Significant risk of anaphylaxis

Follow up

- **Repeat at 3/12 post supplementation**
  - Must be off Iron supplementation for 1/52 prior

Practical points

- Level of 20ng/ml may have a direct effect on performance
- Diurnal variation in Ferritin is 23-46% in females and 14% in males
- Infection is a common cause of transient decrease in transferrin and iron levels
- Repeat bloods regularly sees a return to normal parameters