



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 phosphorylation)
 - Cytochromes
 - Catalase
 - Peroxidase
 - Pyruvate –malate oxidase
 - Xanthalate 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

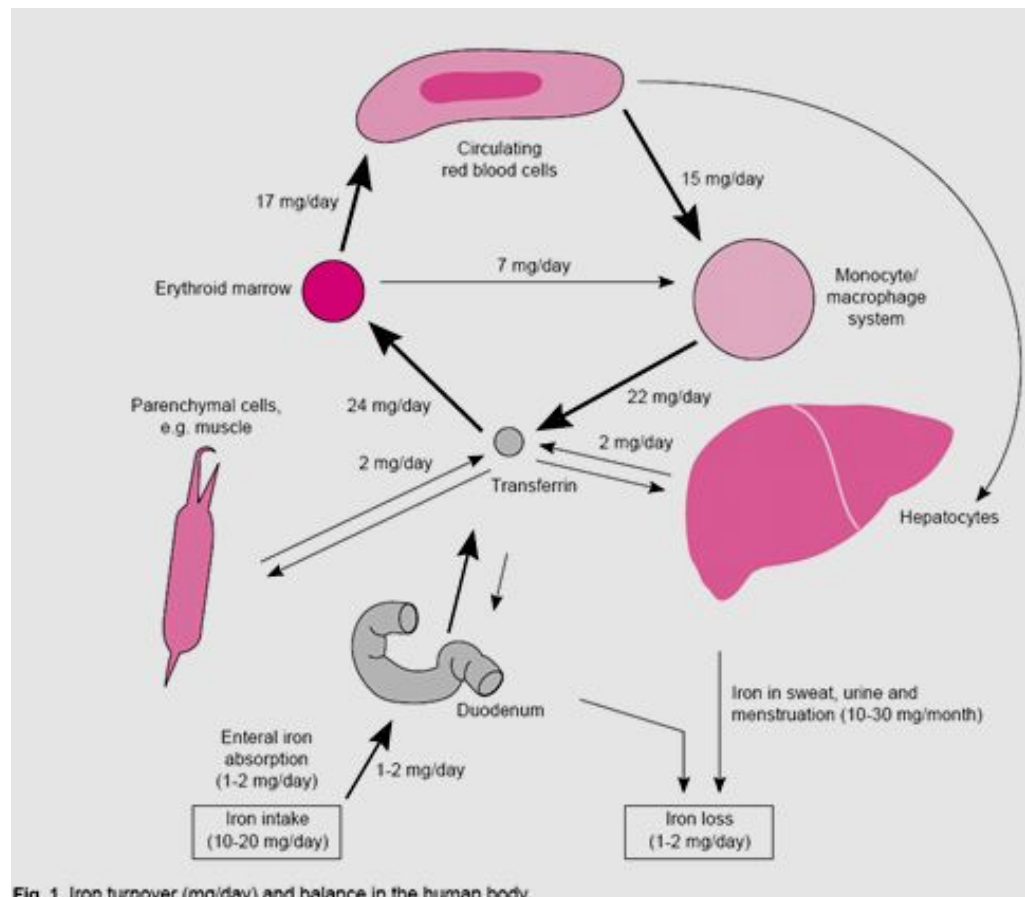


Fig. 1. Iron turnover (mg/day) and balance in the human body.

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

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

Anaemia differentials

- Dilutional Pseudoanaemia – Sports anaemia
- Sideroblastic
- Thalassaemia
- Hereditary spherocytosis
- Haemolytic anaemia's
- Anaemia of chronic disease
- Macrocytic anaemia
 - Hypothyroidism
 - 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 an 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	↑	↑↑↑

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