

# Iron deficiency: The developing child at risk

Iron deficiency remains a common condition in children, with research suggesting many negative effects on the developing child, writes **Siobhan O'Sullivan**

**Iron** deficiency is the most common and widespread nutritional disorder in the world.<sup>1</sup> The World Health Organisation (WHO) estimate that iron deficiency accounts for 40-50% of anaemia in children and up to 80% in preschool children (2-5 years old) worldwide.<sup>1</sup> High-risk groups for iron deficiency have been identified as preterm infants, children aged 1½-3½, and girls aged 11-18 years.<sup>2</sup>

Irish research shows that iron intake is a concern among all age groups. These concerns are outlined below:

#### • Infants

At birth, an infant is endowed with iron stores. These usually become depleted within the first four to six months of life. A number of factors determine the rate of depletion, eg. infant stores at birth are highly related to maternal iron stores.<sup>3</sup> Bioavailability of iron in breastmilk is high and formula milks are fortified with iron, however, milk alone will not be sufficient to meet iron requirements in the latter half of the first year of life.

Studies on iron status in infants are limited but research suggests that in Europe (including Irish data) 7.2% of infants at 12 months old are iron deficient with 2.3% having iron deficiency anaemia.<sup>4</sup>

#### • Pre-schoolers

The National Preschool Nutrition Survey 2012<sup>5</sup> found that 23% of one-year-olds, 10% of two-year-olds and 11% of three-year-olds were estimated to have inadequate iron intakes. The main dietary contributors across all one- to four-year-olds were breakfast cereals, with milk/formula intake reducing with age and bread intake increasing with age. Meat products provided 11% of iron intake across all one to four-year-olds.

#### • Children

The National Children's Food Survey 2005<sup>6</sup> reports that one-third of girls between the ages of five and 12 years (34%) had inadequate intake of iron and 13% of boys in the same age group had inadequate intake. The study reported that almost a third of daily iron intake was eaten at breakfast, with ready-to-eat breakfast cereals being the main contributor.

#### • Teens

The average intake of iron for boys aged 13-17 years was 14.1mg/day and for girls aged 13-17 years was 10.7mg/day, according to the National Teens Food Survey 2006.<sup>7</sup> This suggests that 13-17 year old boys are meeting 100% of their requirements for iron, while on average 13-17 year-old girls are meeting only 76% of their daily iron requirements.

#### Consequences of iron deficiency in children

Iron is an essential nutrient. It is a component of haemoglobin and myoglobin which transport and store oxygen around the body. It is also a component of many enzymes which are involved

in the metabolism of energy and protein.<sup>2</sup> Requirements for iron are highest during periods of rapid growth due to its role in cell development. Therefore, children are at greater risk of iron deficiency than full grown adults.

Iron deficiency results in defective erythropoiesis leading to a normocytic or microcytic hypochromic anaemia. Studies suggest that iron deficiency anaemia is a cause of poor motor development in children in the first three years of life. This may be explained by the role of iron in brain development or may be due to behavioural issues.

The amount of iron in the brain increases throughout childhood and early adult life. Suggested roles of iron in the brain include a role in myelin sheath production and acting as a catalyst in the synthesis of neurotransmitters such as dopamine and serotonin. It is thought that iron deficiency may impair certain pathways and this may be a cause of cognitive impairment. Another potential role is the functional isolation which can be associated with iron deficiency due to symptoms such as poorer concentration and less energy to move around and play, thereby reducing cognitive stimulation.

In older children, iron deficiency is thought to effect cognitive development, with studies suggesting that treatment of iron deficiency in this age group (older than three years) can improve school achievement.<sup>2</sup> However, the long-term implications of these findings are unknown, as are thresholds at which these complications occur. The aim would be to maintain iron stores within the range outlined by the WHO (see *Table 1*).

Studies suggest that iron deficiency may also have an effect on physical growth. Improved growth is noted when iron supplementation is commenced in children with iron deficiency anaemia.<sup>1</sup>

#### Identifying iron deficiency in children

Common symptoms of iron deficiency children include paleness, tiredness, irritability and poor appetite. If iron deficiency is suspected it is important that it be diagnosed with a blood test prior to iron supplementation to prevent iron overload, which is associated with its own complications.

The WHO threshold for adequate haemoglobin and serum ferritin concentration (see *Table 1*) can be used as a reference guide.<sup>8</sup> Serum ferritin can be a useful marker of iron stores which may be depleted before the development of iron deficiency anaemia.

#### Recommended iron intake for children

The Food Safety Authority of Ireland's recommended dietary allowances (RDA) 1999 for iron<sup>9</sup> are described in *Table 2*. The RDA's describe the amount of iron that should meet the nutritional needs of practically all healthy individuals.

Iron requirements for toddlers and children are higher than those of adults (per kg of body weight) due to the high requirements for growth. These high intakes can be difficult to achieve, so particular attention needs to be paid to iron during weaning and childhood/adolescent years.

**Dietary management of iron deficiency**

Treatment of iron deficiency usually involves taking iron supplements to replace the missing iron and treating any underlying causes (eg. low dietary intake, blood loss). Dietary iron exists in two forms: haem (found almost exclusively in meat) and non-haem sources. Haem iron is two to six times more available for absorption from the diet than non-haem iron.

Sources of haem iron include:

- Red meats, eg. beef, lamb, pork, etc. are excellent sources of haem iron
- Chicken and turkey contain smaller amounts
- Oily fish, eg. salmon, mackerel, sardines
- Eggs, in particular the yolk.

As children's iron stores are usually depleted by the age of six months, it is essential to include sources of haem iron in the weaning diet from six months. For toddlers and older children haem sources of iron should be included in the diet daily, with red meats being given a minimum of three times per week.

Non-haem iron can also contribute to dietary iron intake. Non-haem iron absorption capacity will be improved if taken with a source of vitamin C. This is likely due to prevention of the formation of insoluble iron compounds and the reduction of ferric to ferrous iron, which seems to be a requirement for the uptake of iron into the mucosal cells.

Good sources of non-haem iron include:

- Fortified breakfast cereals
- Wholemeal cereals (eg. brown bread, rice, pasta)
- Green leafy vegetables (eg. spinach, cabbage, broccoli, Brussel sprouts), peas, beans, nuts and dried fruits
- Protein substitutes (eg. textured vegetable protein) and tofu.

Good sources of vitamin C include:

- Most fruits, especially citrus fruit, and their juices, eg. orange juice
- Other sources include tomatoes, broccoli and peppers.

For example, the amount of iron absorbed from a bowl of fortified breakfast can be increased if taken with a glass of orange juice.

Tannins found in tea and coffee may reduce iron absorption as they bind to the iron forming insoluble complexes. Tea is not a suitable drink for young children and is not recommended for those under 12 years old. However, studies suggest that 12% of toddlers are given tea as a main drink. In teenagers, tea should not be given with/directly after a meal.

Excessive cow's milk intake is also a known contributor to iron deficiency anaemia. This is because cow's milk is a poor source of iron and when taken excessively can displace other good sources of iron in the diet (eg. a toddler having a bottle in place of their dinner). Toddlers should limit their intake of cow's milk to no more than one pint per day (full fat milk only should be used in those under two years old due to their high energy needs for growth).

Another concern is the early introduction of cow's milk into the diet. The FSAI recommend that cow's milk is not suitable as

Table 1

Age group (years)	Haemoglobin (g/L)	Serum ferritin (µg/L)
0.5-4.99	110	12
5-11	115	15
12-14	120	15

\* The World Health Organisation threshold for adequate haemoglobin and serum ferritin concentration

Table 2

Age group (years)	Male (mg/d)	Female (mg/d)
1-3	8	8
4-6	9	9
7-10	10	10
11-14	13	14
15-17	14	14

\* Food Safety Authority of Ireland's (FSAI) recommended dietary allowances (RDA) 1999

a main drink in children less than one year old,<sup>3</sup> partly due to its insufficient iron content. Breast milk or infant formula (which is fortified with iron as per EU guidelines) should be used in conjunction with the weaning diet until the child is one year old.

Iron deficiency remains a common condition in children, with research suggesting many negative effects on the developing child. Many children continue to fail to meet their daily iron requirements, however, simple dietary adjustments, along with supplementation where indicated, can help alleviate this problem.

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