**Page 58** Iron status multiple choice questionnaire

**Page 59** Read Loraine Lindus' practice profile on preventing falls in older people

**Page 60** Guidelines on how to write a practice profile

# Strategies to improve iron status in women at risk of developing anaemia

**NS626 Derbyshire E** (2012) Strategies to improve iron status in women at risk of developing anaemia. Nursing Standard. 26, 20, 51-57. Date of acceptance: October 28 2011.

## Abstract

Iron deficiency is one of the most prevalent nutritional deficiency disorders worldwide, with teenage girls and women of childbearing age, especially pregnant and postpartum mothers, being most affected. Although supplements may be required in some instances, simple dietary and lifestyle changes may also help individuals to establish a healthy iron status. This article presents useful information that nurses and midwives can provide to women during particular life phases such as pregnancy, adolescence and old age to improve their iron status.

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## Keywords

Anaemia, diet and lifestyle, iron deficiency, nutrition, women's health

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## Aims and intended learning outcomes

This article aims to promote an understanding of how simple dietary and lifestyle changes can help to improve iron status. This will be of benefit to those at risk of developing iron deficiency – for example women with low iron stores, women who are planning to become pregnant and those who have been diagnosed with iron deficiency – and can support treatment strategies such as supplementation programmes. After reading this article and completing the time out activities you should be able to:

- Define the terms iron deficiency and iron deficiency anaemia.
- Describe the key symptoms associated with iron deficiency and resultant anaemia.
- Explain how iron deficiency anaemia can affect women's health and the effects this can have on pregnancy outcomes and infant wellbeing.
- Recommend simple dietary and lifestyle strategies that can help to improve iron status.
- Outline how recommended levels of dietary iron can be achieved and, more importantly, how the bioavailability of the iron consumed can be improved.

Complete time out activities 1 and 2

## Introduction

Iron deficiency is a widespread problem, affecting an estimated two billion people worldwide (Zimmermann and Hurrell 2007). Iron deficiency occurs when iron stores, mostly found in the liver, start to become depleted, while iron deficiency anaemia arises

when the production of red blood cells starts to diminish once the iron stores have been depleted (Hughes-Jones *et al* 2009). Anaemia is a low level of red blood cells or less than the normal amount of haemoglobin in the blood (Hughes-Jones *et al* 2009).

Biological markers of iron status are often used to diagnose iron deficiency and iron deficiency anaemia. Non-pregnant women aged 15 and older are often diagnosed as having iron deficiency when their blood haemoglobin levels fall below 120g/L, while a cut-off point of 110g/L is used to define iron deficiency in pregnant women (World Health Organization (WHO) 2001). A cut-off point of less than 70g/L is used as a marker of 'severe' iron deficiency in pregnancy (WHO 2001); the same report does not state any other values for adults. For non-pregnant women and adult men, blood haemoglobin levels above 120g/L and130g/L respectively are regarded as 'normal' (WHO 2001).

The causes of iron deficiency and iron deficiency anaemia can be multifaceted, but common causes are low dietary iron intake, poor absorption of iron from the diet, parasitic infections, which are more common in developing regions, and disease states such as intestinal bleeding (WHO 2008). In addition, increased demands for iron during certain life phases, such as growth spurts, pregnancy and childbirth, increase the risk of iron deficiency anaemia (Milman 2011). As will be discussed in later sections, certain dietary habits such as high intakes of phytates, which are present in nuts, seeds, beans and wholegrains, and low intakes of oily fish, as well as lifestyle factors such as being overweight (often associated with a poor quality diet and inflammation which can reduce the body's absorption of iron), can increase the risk of iron deficiency and subsequent anaemia.

Symptoms of iron deficiency vary between individuals, but generally include fatigue, diminished energy levels, difficulty regulating body temperature, and reduced cognitive performance and concentration (Brunner and Wuillemin 2010). There is emerging evidence that iron deficiency in women of reproductive age could have a negative effect on their children's cognitive development (Murray-Kolb 2011).

For teenage girls, large growth spurts, the expansion of blood volume and onset of menses increase iron requirements, which are not often met by changes in dietary intakes or dietary choices (Beard 2000). There is good evidence that iron deficiency in pregnancy, particularly in the third trimester, may affect the child's brain development in the short and long term (Thomas *et al* 2009). Poor intrauterine growth and increased risk of preterm births and low birthweight babies have also been observed among women who had anaemia in pregnancy (Kalaivani 2009). To improve iron status, simple dietary and lifestyle alterations and individualised iron supplementation programmes could help to improve the health of teenage girls, women of reproductive age and their offspring.

Menopause and menorrhagia (menstrual cycles lasting more than seven days) may contribute to excessive blood loss and the development of anaemia (Marret *et al* 2010). Although surgical treatment may be required in some cases of fibroids or endometriosis (the presence of endometrium in ectopic sites), women may also benefit from lifestyle advice during their premenopausal years to help prevent secondary outcomes such as the anaemia that may be associated with these conditions.

Although supplements may be prescribed to treat iron deficiency anaemia, compliance is often poor and side effects may be experienced (Derbyshire 2010). It is therefore important that supporting strategies are put in place to prevent the condition recurring. The purpose of this article is to explain how simple dietary and lifestyle modifications can go some way towards helping to improve iron status, particularly in women who are at risk of developing anaemia.

## Dietary strategies

In the UK it is advised that women aim to consume 14.8mg iron daily (Department of Health (DH) 1991). However, it is also important to consider that recommendations are set at higher thresholds in other countries; for example, consumption of 18mg of iron daily is recommended in the United States (Institute of Medicine 2001). Studies show that the average iron intake in women in their childbearing years in the UK is about 8-10mg/day, which is significantly lower than the recommended targets, particularly in low-income groups (Nelson *et al* 2008, Bates *et al* 2010). Table 1 provides a list of some iron-rich foods.

Before outlining the dietary factors that can affect iron status, it is important to consider the concept of bioavailability. The bioavailability of iron has been defined as 'the amount of iron that is absorbed from the gastrointestinal tract


1 Briefly define and differentiate between the terms 'iron deficiency' and 'iron deficiency anaemia'. List the most common causes of these conditions and check your answers with the information provided in the text.

2 Outline some of the key symptoms associated with iron deficiency, and think of examples of patients in your clinical practice who are most at risk of developing this condition.

which can then be utilised by the body' (Rickard *et al* 2009). The amount of iron that is absorbed in the body can be influenced by a number of enhancers and inhibitors present in the diet (Table 2). As a general rule of thumb, individuals should be guided to eat diets that contain a broad range of foods to enable the absorption of iron from the diet (Gautam *et al* 2008). Key factors that can enhance and inhibit the absorption of iron will now be outlined. **Complete time out activity 3**

**TABLE 1**

**Iron-rich foods**

| Food source | Iron (mg per 100g) |
|---|---|
| Cockles | 26 |
| Black pudding | 20 |
| Sesame seeds | 10 |
| Liquorice allsorts | 8.1 |
| Mussels | 7.7 |
| Pine nuts | 5.6 |
| Sardines | 4.6 |
| Figs (dried) | 4.2 |
| Raisins | 3.8 |
| Tofu (steamed or fried) | 3.5 |
| Rye crisp bread | 3.5 |
| Lean beef | 2.8 |
| Prunes (ready to eat) | 2.6 |
| Spinach (raw) | 2.1 |
| Curly kale (boiled) | 2.0 |
| Egg (boiled) | 1.9 |

(Food Standards Agency 2002)

**Enhancers**

***Lean red meat*** Dietary iron generally exists in two forms: haem iron and non-haem iron. In animal derived foods, iron is often attached to proteins called haem proteins, and referred to as haem iron. In plant derived foods, iron is not attached to haem proteins and is classified as non-haem iron. Non-haem iron is not as well absorbed in the body as haem iron (Scientific Advisory Committee on Nutrition 2010).

Women in the UK generally have low meat (haem iron) intakes compared with men. Evidence from the latest National Diet and Nutrition Survey shows that women aged 19-64 and girls aged 11-18 eat around 57g red meat/day and 54g red meat/day, respectively (Bates *et al* 2010). Men ate on average 96g red meat/day (Bates *et al* 2010). Low meat intake in women may, in part, result from media publicity about the fat content and health risks linked to high meat diets. However, meat is also an important source of essential nutrients, such as iron, which can have health benefits provided that the meat eaten is lean, unprocessed and consumed in moderation (Ruxton 2011).

The Scientific Advisory Committee on Nutrition (2010) has advised that eating up to 70g of red meat daily is safe for men and women. A study conducted in teenagers (of both sexes) who ate lean beef over three months showed that this helped to maintain iron status without having any negative effects on health (Snetselaar *et al* 2004).

***Oily fish*** Recent evidence suggests that regular oily fish consumption may also have a role in improving iron status. In one study, 25 women aged 18-30 with low iron stores were randomised to eat either oily fish, for example

**TABLE 2**

**Dietary factors that can enhance or inhibit iron absorption**

| Enhancing factors | Inhibiting factors |
|---|---|
| *Lean red meat (haem iron). | Calcium, particularly from milk and dairy products. |
| Oily fish, such as salmon and sardines. | Phytates, present mainly in cereal bran, grains, legumes, nuts and seeds. |
| Vitamin C, for example, fresh fruit and juices. | Iron-binding phenolic compounds (polyphenols, tannins), which are present in tea and coffee, herbal infusions, leafy green vegetables and certain spices, such as oregano. |
| Fermented products, such as soy sauce and bread (reduce the effect of phytates). | |

*Iron is generally better absorbed when consumed from meat rather than plant-based food sources. Diets should be varied and care taken when choosing certain food combinations, for example, lean red meat should not be accompanied by creamy sauces as the calcium they contain may reduce iron absorption. Equally, drinking fruit juice or eating salad with haem-containing foods may enhance absorption.


**3** Think about two examples of dietary factors that can enhance and/or inhibit the absorption of iron, explaining the reasons for your answers.

salmon, water-packed tuna and sardines, or lean red meat over an eight-week period. Iron status was not significantly different between the two groups (Navas-Carretero *et al* 2009). Another study found that oily fish, when eaten with a phytate-rich, kidney bean-based meal, improved iron levels, suggesting that this food combination helped to increase iron absorption (Navas-Carretero *et al* 2008). In this case, the oily fish appears to be acting as an enhancer to release iron from the phytate-rich meal.

In the UK, the Scientific Advisory Committee on Nutrition and Committee on Toxicity (2004) advised that two portions of fish should be consumed weekly, one of which should be oily. Meeting these guidelines may go some way towards improving the absorption of iron from the diet. However, women planning to become pregnant and pregnant mothers should take care not to exceed these guidelines because some fish species, particularly fresh tuna, can contain environmental contaminants such as mercury, which could harm the developing fetus (Scientific Advisory Committee on Nutrition and Committee on Toxicity 2004). Larger fish higher up the food chain, such as shark, swordfish and marlin, are more likely to contain these agents.

***Vitamin C*** It is well known that vitamin C (ascorbic acid) can enhance iron absorption. This is largely due to the fact that vitamin C can reduce ferric iron to ferrous iron, a form of iron that is more soluble and therefore better absorbed by the body (Hurrell and Egli 2010). Subsequently, vitamin C can assist in overcoming some of the negative effects of iron inhibitors (Table 2) and also has an active role in supporting the body's iron metabolism by enhancing the solubility of iron (Atanassova and Tzatchev 2008).

Making sure that vitamin C-rich foods and drinks, such as fruit juices, are included in the daily diet is an easy way to improve iron absorption, especially when consumed together with iron-containing foods. It is also important to consider that heat from cooking methods and long storage periods can destroy the vitamin C content of foods (de Ancos *et al* 2000). In particular, to avoid vitamin C losses from frozen foods, they should not be thawed before cooking and a double-based pan containing a minimum amount of water should be used. A double-based pan protects against heat stress and helps to preserve the vitamin C content of food (Nursal and Yücecan 2000).

**Inhibitors**

***Calcium*** There is evidence from studies in humans that calcium from supplements and dairy sources can reduce iron absorption (Lönnerdal 2010). Its mechanisms, however, are only thought to have a short-term effect. Adaptations may occur over time as long-term calcium supplementation has been found to have few effects on iron status (Lönnerdal 2010).

***Phytates*** Phytates are components found in plants that can interfere with the body's absorption of nutrients such as iron, generally in a dose-dependent fashion. In other words, the higher the phytate content of the food, the greater the reduction in iron absorption (Hurrell *et al* 1992). For vegetarians, elimination of meat along with high intakes of phytate-rich foods, such as wholegrains, can mean that rates of iron absorption are lower than average, therefore increasing their risk of iron deficiency (Hunt 2003). Food preparation methods are important – soaking and cooking foods such as beans and lentils can help to reduce their phytate activity to some extent (Egli *et al* 2002). Eating cereals and foods that are fortified with extra iron may also help to compensate for some of these effects (Derbyshire *et al* 2010).

***Iron-binding phenolic compounds (polyphenols)*** It is also well known that tea drinking can limit iron absorption, especially that consumed from non-haem sources, which is mainly attributed to its polyphenol content (Fairweather-Tait 2004). For these reasons the general advice has been to recommend that individuals at risk of iron deficiency drink tea between meals, or wait at least one hour after eating before drinking tea (Nelson and Poulter 2004). For those individuals who like to drink tea with their meals, they should make sure that they are consuming enough iron-rich foods at other times of the day (Table 1).

As well as being present in tea and coffee, polyphenols are also found in red wine, fruits, vegetables, cereals, olives, dry legumes and chocolate (D'Archivio *et al* 2007). Good sources of polyphenols include red grapes, plums, raspberries, dark chocolate, rye bread and apple juice. Research has shown that high intakes of polyphenols inhibit absorption by binding iron, especially from plant-based foods, such as beans, that also contain high phytate levels (Petry *et al* 2010). Women, particularly vegetarians and vegans who eat

a predominantly plant-based diet, may benefit from taking a daily multivitamin and mineral supplement that contains iron (Waldmann *et al* 2004).

Complete time out activity 4

### Ways to achieve dietary targets

Table 3 suggests some recommended foods that could be integrated into the diet on a daily basis to improve iron status. In addition, simple strategies such as soaking beans and lentils before consumption and drinking orange juice or other drinks high in vitamin C with meals such as a cereal-based breakfast can all help to improve the amount of iron that is absorbed by the body (Gibson *et al* 2006). Eating calcium-rich foods as snacks rather than with meals, which may reduce iron absorption, may also go some way towards improving iron reserves. With regard to red meat, as mentioned previously, a daily portion of up to 70g has been approved by the Scientific Advisory Committee on Nutrition (2010). This is the equivalent to one lamb chop, two slices of roast lamb or beef, two lean standard beefburgers or three slices of unprocessed ham (DH 2011).

Complete time out activity 5

## Lifestyle strategies

### Healthy body weight

Overweight individuals have a higher risk of iron deficiency than normal-weight individuals. Possible explanations include low dietary iron intakes, increased iron requirements, dilution of iron reserves in the bloodstream and impaired iron absorption (Cepeda-Lopez *et al* 2010). Higher rates of intestinal inflammation are also present in overweight/obese individuals (inflammatory agents are secreted by adipose tissue), which can reduce intestinal absorption of iron (McClung and Karl 2009, Cepeda-Lopez *et al*

**TABLE 3**

**Suggested list of foods to be included in the daily diet of women at risk of iron deficiency**

| Food source | Iron (mg)* |
|---|---|
| One medium bowl of fortified cereals (40g) with semi-skimmed milk (can be diluted with water) | 3.2 |
| Glass of fresh orange juice (200mL) | 0.4 |
| Salmon and bean salad with lemon juice | 3.0 |
| Cup of tea with skimmed milk (one to two hours after lunch) | Negligible |
| A low-fat fruit yoghurt | 0.2 |
| Fortified cereal bar (40g) | 2.6 |
| A handful of raisins (50g) | 2.0 |
| Liquorice allsorts (50g) | 4.2 |
| Lean braised steak (180g) (but avoid creamy sauces) | 4.9 |
| Fresh carrots, broccoli and potatoes (not frozen) | 1.0 |
| One glass of red wine | Negligible |
| **Total** | **21.5** |

*Values are estimates.

**General points to consider:**

| |
|---|
| Drink tea or other polyphenol-containing beverages 1-2 hours after meals. This should not affect absorption as most of the iron will no longer be in the stomach. |
| Include sources of vitamin C with meals where possible, such as lemon juice or a glass of fruit juice. |
| Consume dairy foods as snacks rather than with meals to avoid reducing iron absorption. |
| Individuals should also be encouraged to consume five portions of fruit and vegetables daily, to improve iron absorption while also providing a source of iron; for example, 100g of spinach provides 2.1mg of iron. |
| Eat foods containing iron inhibitors at meals that have the lowest iron content; for example, have tea or milk with toast. |
| (Food Standards Agency 2002) |


4 Give five examples of ways in which the bioavailability of iron can be improved. Which foods could be combined to provide meals that would increase the absorption of iron in the body? You may wish to discuss your answers with a colleague.

5 Explain how lifestyle factors can affect a woman's iron status, providing at least two examples. If possible, spend some time with a dietician and listen to the advice he or she gives to patients about increasing the amount or bioavailability of iron in the diet.

2010). Hepcidin (the main regulator of iron homeostasis) is a protein-based hormone produced primarily by the liver that may also contribute to inflammation in overweight individuals (McClung and Karl 2009), although more research is needed to confirm this theory.

**Physical activity levels**

Active females should also take care to monitor their iron intakes. The combined effects of following a strict diet (Mulvihill *et al* 2002), menstrual blood loss, foot strike leading to haemolysis (the breakdown of red blood cells when the feet hit the ground, for example when running on hard surfaces) and organ movement can all lead to iron losses in this group of women and adversely affect their performance and health (Suedekum and Dimeff 2005).

**Alcohol**

Compared with non-drinkers there is some evidence that the consumption of alcohol in moderation (around two drinks daily) could help to reduce risk of iron deficiency by as much as 40% – iron present in certain alcoholic beverages, such as red wine, may play a role in this, but further research is needed (Ioannou *et al* 2004). Previous studies have shown that levels of serum markers of iron stores (serum ferritin and transferrin-iron saturation) are higher in people who consume small or moderate amounts of alcohol

## References


Atanassova BD, Tzatchev KN (2008) Ascorbic acid: important for iron metabolism. *Folia Medica*. 50, 4, 11-16. (Abstract only in English.)

Bates B, Lennox A, Swan G (2010) *National Diet and Nutrition Survey. Headline Results from Year 1 of the Rolling Programme (2008/2009)*. Food Standards Agency/ Department of Health, London.

Beard JL (2000) Iron requirements in adolescent females. *Journal of Nutrition*. 130, Suppl 2S, 440S-442S.

Brunner C, Wuillemin WA (2010) Iron deficiency and iron deficiency anemia: symptoms and therapy. *Therapeutische Umschau*. 67, 5, 219-223. (Abstract only in English.)

Cepeda-Lopez AC, Aeberli I, Zimmermann MB (2010) Does obesity increase risk for iron deficiency? A review of the literature and the potential mechanisms. *International Journal for Vitamin and Nutrition Research*. 80, 4-5, 263-270.

D'Archivio M, Filesi C, Di Benedetto R, Gargiulo R, Giovannini C, Masella R (2007) Polyphenols, dietary sources and bioavailability. *Annali dell'Istuto Superiore di Sanità*. 43, 4, 348-361. (Abstract only in English.)

de Ancos B, González EM, Cano MP (2000) Ellagic acid, vitamin C, and total phenolic contents and radical scavenging capacity affected by freezing and frozen storage in raspberry fruit. *Journal of Agricultural and Food Chemistry*. 48, 10, 4565-4570.

Department of Health (1991) *Report on Health and Social Subjects 41: Dietary Reference Values for Food Energy and Nutrients for the United Kingdom*. The Stationery Office, London.

Department of Health (2011) *Red Meat Link to Bowel Cancer*. www.dh.gov.uk/en/MediaCentre/Pressreleases/DH_124670 (Last accessed: December 1 2011.)

Derbyshire E (2010) Iron deficiency anaemia in pregnancy: what are the solutions? *Nutrition & Food Science*. 40, 6, 598-607.

Egli I, Davidsson L, Juillerat MA, Barclay D, Hurrell RF (2002) The influence of soaking and germination on the phytase activity and phytic acid content of grains and seeds potentially useful for complementary feeding. *Journal of Food Science*. 67, 9, 3484-3488.

Fairweather-Tait SJ (2004) Iron nutrition in the UK: getting the balance right. *Proceedings of the Nutrition Society*. 63, 4, 519-528.

Food Standards Agency (2002) *McCance and Widdowson's The Composition of Foods*. Sixth summary edition. Royal Society of Chemistry, Cambridge.

Gautam CS, Saha L, Sekhri K, Saha PK (2008) Iron deficiency in pregnancy and the rationality of iron supplements prescribed during pregnancy. *Medscape Journal of Medicine*. 10, 12, 283.

Gibson RS, Perlas L, Hotz C (2006) Improving the bioavailability of nutrients in plant foods at the household level. *Proceedings of the Nutrition Society*. 65, 2, 160-168.

Hughes-Jones NC, Wickramasinghe SN, Hatton CSR (2009) *Lecture Notes: Haematology*. Eighth edition. Wiley-Blackwell, Oxford.

Hunt JR (2003) Bioavailability of iron, zinc, and other trace minerals from vegetarian diets. *American Journal of Clinical Nutrition*. 78, 3 Suppl, 633S-639S.

Hurrell R, Egli I (2010) Iron bioavailability and dietary reference values. *American Journal Clinical Nutrition*. 91, 5, 1461S-1467S.

Hurrell RF, Juillerat MA, Reddy MB, Lynch SR, Dassenko SA, Cook JD (1992) Soy protein, phytate, and iron absorption in humans. *American Journal of Clinical Nutrition*. 56, 3, 573-578.

Institute of Medicine (2001) *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. National Academy Press, Washington DC.

Ioannou GN, Dominitz JA, Weiss NS, Heagerty PJ, Kowdley KV (2004) The effect of alcohol consumption on the prevalence of iron overload, iron deficiency, and iron deficiency anemia. *Gastroenterology*. 126, 5, 1293-1301.

Kalaivani K (2009) Prevalence and consequences of anaemia in pregnancy. *Indian Journal of Medical Research*. 130, 5, 627-633.

Lönnerdal B (2010) Calcium and iron absorption: mechanisms and public health relevance. *International Journal for Vitamin and Nutrition Research*. 80, 4-5, 293-299.

Marret H, Fauconnier A, Chabbert-Buffet N *et al* (2010) Clinical practice guidelines on menorrhagia: management of abnormal uterine bleeding before menopause. *European Journal of Obstetrics, Gynecology, and Reproductive Biology*. 152, 2, 133-137.

compared with people who do not drink alcohol, although it is not known exactly how or why this occurs (Milman and Kirchhoff 1996, Whitfield *et al* 2001). However, further research is required and the Royal College of Physicians' (2011) guidelines on the frequency of alcohol consumption should be followed to reduce the risk of liver disease.

Women planning to have a baby or who are pregnant or lactating should be discouraged from drinking alcohol because of possible harmful effects to the fetus. In the UK, the National Institute for Health and Clinical Excellence (2008) advises that women should avoid drinking alcohol in early pregnancy and should limit their intake after the first trimester to no more than one to two units on two occasions a week.

## Conclusion

Iron deficiency remains one of the most prevalent deficiency disorders worldwide. Although supplements and fortified foods have a role to play, simple dietary and lifestyle strategies can also be put in place to help optimise the bioavailability of iron from women's diets. This article provides simple approaches that could help to improve iron status while encouraging positive changes in dietary behaviours that could help to improve women's iron status in the longer term **NS**

**Complete time out activity 6**


**6** Now that you have completed the article, you might like to write a practice profile. Guidelines to help you are on page 60.

McClung JP, Karl JP (2009) Iron deficiency and obesity: the contribution of inflammation and diminished iron absorption. *Nutrition Reviews*. 67, 2, 100-104.

Milman N (2011) Postpartum anemia I: definition, prevalence, causes, and consequences. *Annals of Hematology*. 90, 11, 1247-1253.

Milman N, Kirchhoff M (1996) Relationship between serum ferritin, alcohol intake, and social status in 2235 Danish men and women. *Annals of Hematology*. 72, 3, 145-151.

Mulvihill CB, Davies GJ, Rogers PJ (2002) Dietary restraint in relation to nutrient intake, physical activity and iron status in adolescent females. *Journal of Human Nutrition and Dietetics*. 15, 1, 19-31.

Murray-Kolb LE (2011) Iron status and neuropsychological consequences in women of reproductive age: what do we know and where are we headed? *Journal of Nutrition*. 141, 4, 747S-755S.

Navas-Carretero S, Pérez-Granados AM, Sarriá B *et al* (2008) Oily fish increases iron bioavailability of a phytate rich meal in young iron deficient women. *Journal of the American College of Nutrition*. 27, 1, 96-101.

Navas-Carretero S, Pérez-Granados AM, Schoppen S, Sarria B, Carbajal A, Vaquero MP (2009) Iron status biomarkers in iron deficient women consuming oily fish versus red meat diet. *Journal of Physiology and Biochemistry*. 65, 2, 165-174.

National Institute for Health and Clinical Excellence (2008) *Antenatal Care: Routine Care for the Healthy Pregnant Woman*. Clinical guideline 62. NICE, London.

Nelson M, Poulter J (2004) Impact of tea drinking on iron status in the UK: a review. *Journal of Human Nutrition and Dietetics*. 17, 1, 43-54.

Nelson M, Erens B, Bates B, Church S, Boshier T (2008) *Low Income Diet and Nutrition Survey. Three Volume Survey, Executive Summary*. The Stationery Office, London.

Nursal B, Yücecan S (2000) Vitamin C losses in some frozen vegetables due to various cooking methods. *Nahrung*. 44, 6, 451-453.

Petry N, Egli I, Zeder C, Walczyk T, Hurrell R (2010) Polyphenols and phytic acid contribute to the low iron bioavailability from common beans in young women. *Journal of Nutrition*. 140, 11, 1977-1982.

Rickard AP, Chatfield MD, Conway RE, Stephen AM, Powell JJ (2009) An algorithm to assess intestinal iron availability for use in dietary surveys. *British Journal of Nutrition*. 102, 11, 1678-1685.

Royal College of Physicians (2011) *Alcohol*. www.rcplondon.ac.uk/policy/reducing-health-harms/alcohol (Last accessed: December 1 2011).

Ruxton C (2011) The role of red meat in a balanced diet. *Nursing Standard*. 26, 7, 41-48.

Scientific Advisory Committee on Nutrition (2010) *Iron and Health*. The Stationery Office, London.

Scientific Advisory Committee on Nutrition, Committee on Toxicity (2004) *Advice on Fish Consumption: Benefits and Risks*. The Stationery Office, London.

Snetselaar L, Stumbo P, Chenard C, Ahrens L, Smith K, Zimmerman B (2004) Adolescents eating diets rich in either lean beef or lean poultry and fish reduced fat and saturated fat intake and those eating beef maintained serum ferritin status. *Journal of the American Dietetic Association*. 104, 3, 424-428.

Suedekum NA, Dimeff RJ (2005) Iron and the athlete. *Currents Sports Medicine Reports*. 4, 4, 199-202.

Thomas DG, Grant SL, Aubuchon-Endsley NL (2009) The role of iron in neurocognitive development. *Developmental Neuropsychology*. 34, 2, 196-222.

Waldmann A, Koschizke JW, Leitzmann C, Hahn A (2004) Dietary iron intake and iron status of German female vegans: results of the German vegan study. *Annals of Nutrition and Metabolism*. 48, 2, 103-108.

Whitfield JB, Zhu G, Heath AC, Powell LW, Martin NG (2001) Effects of alcohol consumption on indices of iron stores and of iron stores on alcohol intake markers. *Alcoholism, Clinical and Experimental Research*. 25, 7, 1037-1045.

World Health Organization (2001) *Iron Deficiency Anaemia: Assessment, Prevention, and Control. A Guide for Programme Managers*. WHO/NHD/01.3. WHO, Geneva.

World Health Organization (2008) *Worldwide Prevalence of Anaemia 1993-2005: WHO Global Database on Anaemia*. WHO, Geneva.

Zimmermann MB, Hurrell RF (2007) Nutritional iron deficiency. *The Lancet*. 370, 9586, 511-520.