

Iron deficiency in Europe

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Abstract

In Europe, iron deficiency is considered to be one of the main nutritional deficiency disorders affecting large fractions of the population, particularly such physiological groups as children, menstruating women and pregnant women. Some factors such as type of contraception in women, blood donation or minor pathological blood loss (haemorrhoids, gynaecological bleeding,...) considerably increase the difficulty of covering iron needs. Moreover, women, especially adolescents consuming low-energy diets, vegetarians and vegans are at high risk of iron deficiency.

Although there is no evidence that an absence of iron stores has any adverse consequences, it does indicate that iron nutrition is borderline, since any further reduction in body iron is associated with a decrease in the level of functional compounds such as haemoglobin.

The prevalence of iron-deficient anaemia has slightly decreased in infants and menstruating women. Some positive factors may have contributed to reducing the prevalence of iron-deficiency anaemia in some groups of population: the use of iron-fortified formulas and iron-fortified cereals; the use of oral contraceptives and increased enrichment of iron in several countries; and the use of iron supplements during pregnancy in some European countries.

It is possible to prevent and control iron deficiency by counseling individuals and families about sound iron nutrition during infancy and beyond, and about iron supplementation during pregnancy, by screening persons on the basis of their risk for iron deficiency, and by treating and following up persons with presumptive iron deficiency. This may help to reduce manifestations of iron deficiency and thus improve public health. Evidence linking iron status with risk of cardiovascular disease or cancer is unconvincing and does not justify changes in food fortification or medical practice, particularly because the benefits of assuring adequate iron intake during growth and development are well established. But stronger evidence is needed before rejecting the hypothesis that greater iron stores increase the incidence of CVD or cancer. At present, currently available data do not support radical changes in dietary recommendations. They include all means for increasing the content of dietary factors enhancing iron absorption or reducing the content of factors inhibiting iron absorption. Increased knowledge and increased information about factors may be important tools in the prevention of iron deficiency in Europe.

Keywords
Iron deficiency
Iron intake
Serum ferritin
Anemia

The burden of disease due to iron deficiency in Europe

Although iron deficiency is a problem mainly in developing countries, it is also well known to affect large fractions of populations in the industrialized world. In Europe, iron deficiency is considered to be one of the main nutritional deficiency disorders¹. To understand the epidemiological data, it is essential to take into consideration the different levels of possible iron status in individuals:

- Iron depletion is the stage at which there is no storage of iron in the body. There is no conclusive

evidence that an absence of iron stores has negative consequences, but in case of aggravation of the iron balance, this may lead to a rapid decrease in the level of functional compounds.

- Iron deficient erythropoiesis is the stage at which the requirement of the erythroid marrow for iron is no longer fully met, and such unmet needs are associated with a rise in erythrocyte protoporphyrin and serum transferrin receptor levels. At this stage, individuals have lower haemoglobin levels than they should have had even if it may still be above the arbitrary cut-off point for anaemia; but with time, frank anaemia develops.

Table 1 Prevalence of depleted iron stores and anaemias in menstruating women in European countries

Countries	Town/area	Age	n	Depleted iron stores* %	Anaemia† %	Reference
Sweden	Göteborg	38	372	33	6.6	3
		38	122	29.5	7.4	3
Finland	Helsinki	17–50	446	11	n.i.	4
		Oulu	20–23	82	11	n.i.
Denmark	Copenhagen	30–50	595	17.2	2.8	3
		Aarhus	20–23	77	4	n.i.
Norway	Oslo	18–48	147	21.8	4.1	3
Northern Ireland	Coleraine	18–44	192	18.2	13.5	6
UK	Surrey	16–50	125	15	9	3
Holland	Zeist	20–49	111	16	n.i.	7
		20–23	96	11	n.i.	5
France	Paris area	17–42	476	16	1.3	8
		16–53	203	20	2.9	9
	Val-de-Marne	18–50	352	11	2.5	10
	Whole country	35–50	6648	23	4.4	11
Italy	Rhône-Alpes Marseille	20–23	74	8.1	n.i.	5
		Calabre	20–23	99	8.2	n.i.

n.i. = not indicated.

* Defined by an abnormal serum ferritin level.

† Haemoglobin <120 g/l.

- Iron deficiency anaemia is the most severe degree of iron deficiency. At this stage, the restriction in haemoglobin production is severe enough to lead to distortion of red cells, with microcytosis and hypochromia and with its series of deleterious effects on health.

Most epidemiological data on iron status in European countries were published in the 80s and the beginning of the 90s. Some of these data are not valid because they are only based on haemoglobin determination. Few data concern southern European countries, in which, moreover a high frequency of genetic disorders may be a confounding factor in assessment of the prevalence of iron-deficiency anaemia if based only on determination of haemoglobin concentration.

In any case, the available studies point out that iron depletion is the most widely observed form, but iron-deficient erythropoiesis and even iron deficiency anaemia are also present in large groups of populations. Nutritional

studies performed in adults, using serum ferritin as a marker of iron stores, show that serum ferritin levels are 3 times lower in women of reproductive age than in men. In women, medians of serum ferritin levels vary according to country, from 24 to 35 µg/l, corresponding to true levels of iron stores of 240 to 350 mg². These data underline the fact that large fractions of females do not have iron stores.

This is confirmed by epidemiological surveys performed in European countries which show that iron depletion concerns 10–30% of menstruating women and iron deficiency anaemia 1.5 to 14% (Table 1). The prevalence of iron deficiency in women in the fertile age period is significantly higher in northern European countries where the dietary composition is less favourable for iron nutrition, with particularly meat intake lower than in the remaining parts of Europe.

In pregnant women, the prevalence of iron deficiency anaemia is 6 to 30% (the highest levels are observed in countries where routine iron supplementation is not usually given during pregnancy) (Table 2).

In children, the prevalence of depleted iron stores varies from 2 to 48% and anaemia from 2 to 4% according to age group and country (Table 3). In adolescents, prevalences are respectively 5–43% and 7–8% (Table 4). Adolescents constitute a group with particularly high risk due to marked iron requirements.

In adult men, the prevalence of depleted iron stores varies from 0 to 3%.

Some factors such as type of contraception in women, blood donation or minor pathological blood loss (haemorrhoids, gynaecological bleeding) may considerably increase the difficulty of covering iron needs. For example, in Danish blood donors²⁷, prevalence of depleted iron stores vary from 1.3% to

Table 2 Prevalence of iron depleted stores and iron deficiency anaemias in pregnant women in European countries

Countries	n	Depleted iron stores*	Iron-deficiency anaemias †	Reference
Holland	796	n.i.	6–28%	12
United Kingdom	576	25%	6%	13
Denmark				14
–supplemented	100	54%	0%	
–not supplemented	107	92%	18%	
France	332	67%	9%	15
	359	77%	10%	16
	191	54%	30%	17

n.i.= not indicated.

* Defined by an abnormal serum ferritin level.

† Haemoglobin <110 g/l.

Table 3 Prevalence of iron depleted stores and iron deficiency anaemias in children in European countries

Countries	Age	n	Depleted iron stores*	Iron-deficiency anaemias†	Reference
Denmark	9 months	84	2%	n.i.	18
Italy	6–24 months	228	24.6%	n.i.	19
	2–12 years	985	7.2%	n.i.	
Spain	1 year	138	39.8%	n.i.	20
France	10 months	99	48%	n.i.	21
	2 years	106	38%	n.i.	
	4 years	102	17%	n.i.	
	6–24 months	38	29.2%	4.2%	
	2–6 years	44	13.6%	2.0%	

n.i. = not indicated.

* Defined by an abnormal serum ferritin level.

† Haemoglobin <120 g/l.

7.9% in adult men, from 12.5% to 42.2% in premenopausal women and from 5.0% to 30.2% in postmenopausal women according to the frequency of blood donation. In French menstruating women, the frequency of iron depletion reached 28.1% in women using intrauterine devices, but only 13.6% in those using oral contraceptives¹¹.

Healthy elderly people are not considered as a group at high risk of iron deficiency. The relatively high frequency of anaemia observed in elderly people is more likely related to inflammatory syndromes (very common in this population) than to iron deficiency.

Various subgroups of people are more likely to become iron deficient. Women, especially adolescents consuming low-energy diets, are at high risk of iron deficiency: anaemia is 3 times more frequent in adolescent girls who

have tried to lose weight during the preceding 12 months compared with those who have not²⁸. Vegetarians and vegans women and adolescents may be at risk of iron deficiency. For example, 25% of British schoolchildren on a vegetarian diet exhibited anaemia compared to 7% of a control population on a normal diet²⁸. Other studies performed in young women²⁹ and adults³⁰ have demonstrated that vegetarians had lower iron stores than omnivorous subjects. Unfortunately, few epidemiological data are available concerning this subject, in European countries.

Thus, depleted iron stores are widely observed in populations in European countries. Although there is no evidence that an absence of iron stores has any adverse consequences, it does indicate that iron nutrition is borderline, since any further reduction in body iron is

Table 4 Prevalence of iron depleted stores and iron deficiency anaemias in adolescents in European countries

Countries	Age	n	Depleted iron stores*	Iron-deficiency anaemias†	Reference
Ireland	girls 14.5–18.4 years	86	43%	7%	22
UK	girls 12–13 years	34	28%	n.i.	23
	boys 12–13 years	32	8%	n.i.	
	girls 13–14 years	35	21%	n.i.	
	boys 13–14 years	19	11%	n.i.	
Finland	girls 11–15 years	165	4.7%	n.i.	5
Sweden	girls 14–17 years	395	15%	n.i.	25
	boys 14–17 years	472	5%	n.i.	
	girls 15–16 years	220	40%	n.i.	
	boys 15–16 years	207	15%	n.i.	
	girls 15 years	209	13.9%	0%	
Denmark	boys 15 years	185	3.7%	0%	26
	boys 12–13 years	89	16%	n.i.	
	girls 12–13 years	101	15%	n.i.	
	boys 14–15 years	104	15%	n.i.	
	girls 14–15 years	123	20%	n.i.	
	boys 16–17 years	76	7%	n.i.	
	girls 16–17 years	81	20%	n.i.	
France	girls 11–15 years	165	1.7%	n.i.	5
	boys 14–18 years	28	0%	0%	
	girls 14–18 years	25	15.4%	7.7%	
Italy	girls 11–15 years	167	3.1%	n.i.	5
	girls 11–15 years	197	11.5%	n.i.	

n.i. = not indicated.

* Defined by an abnormal serum ferritin level

† Haemoglobin <130 g/l (in boys); <120 g/l (girls).

associated with a decrease in the level of functional compounds such as haemoglobin.

At the stage of anaemia (which concerns a non negligible percentage of persons in European countries, especially children and pregnant women), deleterious consequences on health are classically well recognized. In the human body, iron is present in all cells and has several vital functions – as a carrier of oxygen to the tissues from the lungs in the form of haemoglobin, as a facilitator of oxygen use and storage in the muscles as myoglobin, as a transport medium for electrons within the cells in the form of cytochromes, and as an integral part of enzyme reactions in various tissues. Numerous studies suggest that iron deficient erythropoiesis in itself (and possibly iron depletion) could result in a decrease in intellectual performance and in physical capacity during exercise, and could produce alterations in temperature regulation, immune functions, development of gestation, and other fundamental metabolic activities³¹. Several controlled studies with placebo have shown in teenagers that iron deficiency without anemia is associated with symptoms^{32–35}.

In pregnant women, maternal iron-deficiency anaemia and perhaps iron deficiency alone can be harmful to both the mother and the infant^{36,37}. A growing body of research suggests that the effects of iron deficiency on work capacity, short term memory, attention span, ability to maintain body temperature and resistance to infection may impact negatively on the health and well-being of pregnant women. Moreover, perinatal maternal mortality is substantially higher in anemic pregnant women, especially if their anaemia is severe, but even in cases of moderate anaemia. Several studies have also described a positive correlation between maternal haemoglobin level and birthweight, Apgar score (reliable measure of the degree of intrapartum stress evaluated in newborns) and placental weight^{36,37}. A controlled study without intervention found that iron-deficient anaemic women had shorter pregnancies than non-anaemic or even anaemic but not iron-deficient pregnant women³⁸.

Secular trends

The existence of iron deficiency (like other micronutrient deficiencies) in the context of abundance existing in European countries may be related to the rapid evolution of the diet and modifications in the way of life over the last few decades^{1,2}. Indeed, in the last several generations, we have observed, in industrialized countries, a reduction in total calorie intake (due to a reduction in physical activity) which has led to a decrease in iron intake along with that of most other dietary micronutrients. Moreover, the increase in consumption of foods containing only energy, without trace elements or vitamins, has contributed to a decrease in the micronutrient density per unit of energy in diet, and particularly iron density. For these

reasons, the usual diets in European countries may no longer meet the iron requirements of a number of people, particularly those with high iron requirements, including children and menstruating or pregnant women, considered at high risk of iron deficiency. So the evolution of dietary intake in Europe characterized by a gradual decline in iron intakes has tended to contribute to reducing the dietary intake of native iron in recent decades.

Fortunately, some positive factors may have contributed to reducing the prevalence of iron-deficiency anaemia in Europe. Over the last twenty years, the use of iron-fortified formulas and iron-fortified cereals has contributed to improving the iron nutrition of children. In women, the use of oral contraceptives and increased enrichment of iron in several countries may have contributed to a decrease in iron-deficiency anaemia. The widespread use of iron supplements during pregnancy in some European countries has lowered the prevalence of iron deficiency in pregnant women.

Unfortunately, few specific data are available to assess a secular trend in Europe concerning iron deficiency. By comparing data published in 1985 by WHO³⁹, which summarized data from different studies carried out throughout the world and more recent data, it would appear that the prevalence of iron-deficient anaemia has slightly decreased in infants and menstruating women. Cross-sectional studies performed in Sweden in menstruating women described a reduction in the prevalence of iron deficiency anaemia from between 25 to 30% in the 1960s to about 7% in the mid-1970s, while no marked differences were observed during the period 1970–1980⁴⁰.

Pathogenic mechanisms

The iron balance situation in the European population is determined, on the one hand, by iron requirements and their variation in different age and sex groups and, on the other hand, by the absorption of dietary iron and its variation. According to their high physiological iron requirements, women of childbearing age, pregnant women and growing children represent the major groups at risk of iron deficiency in Europe as in all populations in the world.

To address the question of iron balance in European populations, it is important to comprehend that there are two kinds of iron in the usual diet with respect to mechanisms of absorption: haem and non-haem iron. The amounts of total iron absorbed are determined by the amounts of these two kinds of iron and the balance between different factors enhancing or inhibiting the absorption³¹.

Haem iron in haemoglobin and myoglobin in meat, poultry and fish usually constitutes only 10% or less of the total iron intake in European mixed diets, but the average

absorption of haem iron is usually around 25% (but may vary from about 10 to 40%). Non-haem iron in cereals, vegetables, fruits, roots, pulses and beans forms the main part of dietary iron, but its bioavailability is low (1–5%). Experimental assessment of non-haem iron absorption using isotopic iron has demonstrated that its bioavailability is largely influenced by dietary factors such as absorption promoters (meat, fish, ascorbic acid, fermented foods) and inhibitors (phytates present in bran and seeds, polyphenols in tea, coffee and certain vegetables, calcium and dairy products, and soy protein) of dietary iron bioavailability.

Cooking at a high temperature, and particularly roasting, may be responsible for a conversion of haem iron into non-haem iron by a cleavage of the porphyrin ring. Moreover, several investigators have demonstrated a negative relationship between iron stores and non-haem iron absorption.

Recommended dietary allowances in European countries are derived from estimated physiological requirements multiplied by a bioavailability factor assessed based on the relative contribution of haem and non-haem iron and the global iron bioavailability in standard European diets. Dietary surveys performed in European countries show that large fractions of children and women have dietary iron intakes below these recommended dietary allowances. For example, in women of reproductive age, mean intakes vary from 10 to 14 mg/day (slightly higher levels are observed in countries in which iron fortification is pursued) for recommendations of 14 to 18 mg/d.

Only a few epidemiological studies have assessed the relationship between iron status and dietary intake of iron and of foods or nutrients known to affect iron absorption. In an adult population in Finland, the total iron binding capacity was negatively related to total iron intake in men and to energy-adjusted iron intake in women⁴¹. Three studies showed a significant positive influence of meat (and fish) intake upon serum ferritin among adults^{9,11,41}. A negative relationship between markers of iron status and several dietary factors that are experimentally known to inhibit non-haem iron absorption was also found in some epidemiological studies: this was the case for dairy products or calcium, coffee or tea, dietary fibers and cereals¹¹.

Risks attributed to different factors

The relative role of biological factors and environmental factors (especially dietary factors) in the determinism of iron status is difficult to evaluate. In a study performed on French menstruating women, menopausal status, mode of contraception and dietary patterns (meat, fish, dairy products) explain nearly 20% of the variability in iron stores assessed based on serum ferritin levels¹¹. Menopausal status appears to be the most important

determinant of the variability in the iron status in the study population.

In a study performed in the Netherlands among men and women, 16% and 13% of variance in haemoglobin level, respectively, could be explained by physiological (age, use of contraceptives) and dietary factors (energy, meat, milk, etc)⁷. For serum ferritin, the proportions were 36% and 34%, respectively.

In women, iron status is dependent mainly on the existence and the magnitude of the menstrual blood losses, which are primarily determined by genetic factors, and secondarily influenced by the method of contraception^{42–45}. In fact, menstrual losses of iron are the main source of variation in the iron requirements in non-pregnant, menstruating women. Studies on menstrual blood losses were performed in several populations in different parts of the world. All studies showed the same skewed distribution. Median menstrual blood losses in European women are about 30 ml, equivalent to daily iron losses of 0.45 mg^{27,42–44}; 25% had menstrual iron losses exceeding 0.85 mg/d, and 5% had losses exceeding 1.75 mg/d^{42–44}. Several studies have found a significant inverse correlation between the iron stores (assessed by serum ferritin measurements) and the duration of menstruation^{8,27,40,41}. In Danish menstruating women, the prevalence of depleted iron stores was 5% in women bleeding less than 4 days, 11% in those bleeding 4–6 days and 20% in those bleeding more than 6 days^{27,45}.

Menstrual blood loss is influenced by the type of contraception, with anovulatory pills reducing losses by about 50% and intrauterine devices increasing losses to the same extent⁴⁶. In Danish women^{44,45}, the prevalence of depleted iron stores was lower in hormonal contraceptive users (15.4%) than in non users (24.2%). Likewise, in French women, the frequency of iron depletion reached 28.1% in women using intrauterine devices, but only 13.6% in those using oral contraceptives¹¹.

No admitted model exists to predict the relative contribution of dietary factors toward the iron status of populations. But several models have been developed to predict their relative contribution to the total iron availability in individual meals^{47–49}. Zheng *et al.*⁴⁹ have described model enabling calculation of the total iron availability of individual meals, considering main enhancing and inhibiting factors (meat, fish and poultry, ascorbic acid, tea and phytate concentration) and the level of iron stores. Recently, Hallberg *et al.*⁵⁰ have proposed an algorithm for calculating absorption and bioavailability of dietary iron and predicting the effects of factors known to influence iron absorption from meals and diet. Each model presents limitations, but combining them with results of measured iron absorption studies (using isotopic iron), we can consider that iron absorption of meals may vary in European countries from 3 to 18% according to the consumption of haem iron, ascorbic acid, tea, coffee, dairy products and phytates and levels of iron

stores. One of the most important limitations of this approach is linked to the fact that iron bioavailability is calculated or measured based on individual meals. Murphy *et al.*⁴⁸ proposed a model derived from food intake over an entire day. According to this model we can extrapolate that menstruating women, with 250 mg iron stores, consuming 12 mg of total iron, 80–100 mg of ascorbic acid, no or a small amount of tea, coffee and phytates daily need to consume at least an average of 125 g daily of meat, fish and poultry to cover the median iron requirements of non-pregnant woman (1,25 mg of iron/d). Many European menstruating women have an intake of meat, fish and poultry below this level; moreover, they consume, in their usual diet, a number of inhibiting factors of iron absorption. This is particularly true in those who exclude meat and/or fish (vegetarians and vegans).

Concerning the coverage of iron requirements of healthy newborns and infants, we have to consider that iron content in human milk is low (0,04/100 g) but it has a bioavailability of about 50% which is much higher than that of other food. The basis for the high absorption of iron from humans is not totally understood, but it may be related to the lower amount of proteins and phosphate in human milk compared to cows milk and the high concentration of the iron-binding protein lactoferrin⁵¹. Due to the iron stores present at birth and the high bioavailability of iron in human milk, exclusively breastfed infants have a satisfactory iron status until about 6 months of age^{52,53}. Despite the relatively low concentration of iron in human milk, the iron is highly bioavailable and there is little risk of iron deficiency anaemia before nine months of age in infants of normal birthweight who are breastfed exclusively for at least four months and who continue to be breastfed on demand⁵⁴.

The preventability of iron deficiency

Taking into account the deleterious effects of iron deficiency on health (particularly iron deficiency anaemia) and its high prevalence, prevention of this disorder is particularly relevant and may be implemented by different but complementary means: information about appropriate dietary habits, iron supplementation of specific groups at high risk (such as pregnant women) and iron fortification of foods (specifically oriented toward certain physiological groups such as children).

Information to improve iron nutrition

The prevention, by dietary means, of iron deficiency, and an improvement in iron status in groups with high iron needs, call attention to three important factors: the quantity of iron, the quality of iron and the composition of the diet. Increasing the total iron and iron density of the diet and improving iron bioavailability may be a useful

means of preventing iron deficiency. The amounts of meat, poultry and fish, the choice of ascorbic acid-rich vegetables and fruits eaten with the meals, the kind of bread and other cereal products consumed, and the selection of drinks with the meal, all strongly influence the bioavailability of dietary iron.

Iron supplementation

There is little doubt that iron supplementation in pregnancy improves maternal iron status^{36,37}. Improvement of iron status by iron supplementation during pregnancy also improves maternal iron status postpartum. For example, in a study performed on⁵⁵ well-nourished Danish women supplied with either a placebo or 66 mg iron per day from 4 months of pregnancy to the end of gestation, in the placebo group, by the end of pregnancy, 92% had exhausted their iron stores, 65% had latent iron deficiency, and 18% had iron deficiency anaemia. Comparable values in the supplemented group were 54%, 6%, and 0%, respectively. Maternal serum ferritin concentrations were higher between 7 months of pregnancy and 2 months postpartum. The differences between groups were most pronounced at 2 months postpartum, when serum ferritin concentrations averaged twice those of the placebo group. Differences in maternal iron stores as a result of pregnancy supplementation may persist to at least 6 months postpartum.

The effects of iron supplementation on newborn iron status have also been documented. In studies performed on supplemented French and Danish pregnant women^{17,55} with either a placebo or iron supplementation, serum ferritin concentrations in cord blood were increased by supplementation compared with controls. Equally striking was the fact that the difference was more clear-cut in the infants at 2 months postpartum.

Moreover, several studies performed in a different context have shown that iron supplementation is associated with a lower frequency of problems during pregnancy and after birth³⁶. In a study performed on pregnant Finnish women randomized into non-routine or routine iron supplementation, newborns had shorter mean length than those born to mothers in the group receiving routine iron supplementation. Significantly longer gestation was observed in the routine iron supplementation group⁵⁶.

The only negative effects of iron supplementation that may be observed under certain conditions during pregnancy are some classical side effects. These occur much less frequently at doses of 30–45 mg per day, but with higher intakes, there is an increase in heartburn, nausea, constipation or diarrhoea and upper abdominal discomfort.

Currently there is interest in the possibility that iron supplementation once a week might be as effective as daily supplementation in improving iron status, with

fewer side effects in pregnant women. But current scientific evidence is insufficient for drawing final conclusions.

Iron fortification

The goal of iron fortification is not just to prevent iron deficiency anaemia but iron deficiency. Iron fortification of foods is a strategy adopted by several European countries to impact on iron nutrition and to provide extra iron to the population groups at risk of iron deficiency. This has taken the form of fortification of a widely consumed product such as wheat flour, which in some countries is mandatory, or the voluntary fortification of other foods^{31,57}. Wheat flour enrichment is mandatory in the UK and was also mandatory in Sweden until 1995. Fortification iron accounts for about 6 to 10% of the dietary intake in the United Kingdom and was 40% until recently in Sweden. It is difficult to assess the impact of iron fortification programs on iron status of populations. One way is to pay particular attention to the changes that have occurred in the prevalence of iron deficiency anaemia in different countries. For example, the prevalence in Swedish women dropped from between 25 to 30% in the 1960s to about 7% in the mid-1970s⁴⁰. But it is difficult to assess the degree to which these improvements can be ascribed to iron fortification per se. This is particularly difficult because the impact of iron fortification is not only linked to the amount of iron added to the foods but also to the bioavailability of the fortificant.

There still exist concerns as to the relevance and relative effectiveness of current fortification programmes in industrialized countries. This aspect, however, has received much less attention than questions relating to the safety of such programmes. In fact, iron deficiency is widespread in some groups of populations in developed countries, with about 10% of Caucasians carrying the mutation for hereditary haemochromatosis. Based on extensive screening studies in Europe, the prevalence of hereditary haemochromatosis is probably below rather than above 0.1% in the general population. Some areas may be considered as genetic superisolates showing a higher prevalence, such as those noted in Brittany (in France), Iceland and Jämtland (in Sweden).

Although increases in iron intake would seem to be contraindicated in persons with haemochromatosis, there is no conclusive evidence that iron fortification of foods or the use of a recommended iron supplementation regimen during pregnancy is associated with increased risk of clinical disease due to haemochromatosis.

The observation that iron overload increases myocardial damage caused by anoxia and reperfusion in animal experiments, and its potential role in lipoprotein oxidation, have provoked renewed interest in the hypothesis that high body iron may be a risk factor for coronary heart disease. The ability of iron to catalyse the production of free radicals, which may increase oxidative stress and

damage DNA, has also raised concern about the possibility that excess body iron may increase the risk of cancer. However, the results of epidemiological studies have been conflicting, and do not provide convincing evidence of an adverse effect of iron. This may be partially related to the wrong consideration that high serum ferritin is equal to high iron stores.

A mass approach consisting of fortifying common foods that are widely consumed by both at-risk populations and others who have little or no requirement for extra iron is not justified in European countries where iron deficiency anaemia is not widespread and iron depletion concerns specific groups of populations. Alternatively, targeted fortification programs, in which specific food products preferentially consumed by one of the at-risk groups are fortified, can be considered.

Conclusion

Finally, iron deficiency affects large fractions of the population in European countries, particularly such physiological groups as children, menstruating women and pregnant women. It is possible to prevent and control iron deficiency by counseling individuals and families about sound iron nutrition during infancy and beyond, and about iron supplementation during pregnancy, by screening persons on the basis of their risk for iron deficiency, and by treating and following up persons with presumptive iron deficiency. This may help to reduce manifestations of iron deficiency and thus improve public health. Evidence linking iron status with risk of cardiovascular disease or cancer is unconvincing and does not justify changes in food fortification or medical practice, particularly because the benefits of assuring adequate iron intake during growth and development are well established. But stronger evidence is needed before rejecting the hypothesis that greater iron stores increase the incidence of CVD or cancer.

Body iron in excess offers no health benefit, and there is evidence that it may be detrimental. Therefore, an important question is whether a moderate elevation in body iron levels leads to an increased risk of cancer or cardiovascular diseases. Further research, including basic research and large-scale epidemiologic studies, is needed to fully assess the association between iron status and the risk of cardiovascular diseases, cancers and other adverse outcomes. At present, currently available data do not support radical changes in dietary recommendations. They include all means for increasing the content of dietary factors enhancing iron absorption or reducing the content of factors inhibiting iron absorption. Increased knowledge and increased information about factors may be important tools in the prevention of iron deficiency in Europe.

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