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ORIGINAL CONTRIBUTION

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Iron status of adults in the capital area of Finland

Summary *Background* Enrichment of wheat flour with iron, which commenced in Finland in the mid-1970s, ceased in 1994. No data on iron status among adults have been published since 1993. *Aim of the study* To assess the iron status, adequacy of iron intake and dietary sources of iron in Finnish adults. *Methods* A random sample of adults aged 25–64 years in the capital area of Finland was stratified for sex and 10-year age groups. Food consumption was measured with 24-h recall and a 38-item food frequency questionnaire. Iron status was evaluated by haemoglobin (Hb) concentration and other haematological variables from venous blood samples in both genders (n = 239 men and 190 women), and serum ferritin (SF) for women (n = 137). *Results* The mean Hb concentration was 133 ± 12 g/l and 137 ± 10 g/l for women aged < 50 years and ≥ 50 years, respectively, and 150 ± 10 g/l for men. In younger women, the mean SF level was 32 ± 30 μg/l and 20 % of women showed iron depletion (SF < 12 μg/l), whereas in older women, the respective results were 62 ± 59 μg/l and 11 %. The prevalence of anaemia was 5.8 % for women (Hb < 120 g/l) and 1.3 % for men (Hb < 130 g/l). The respective mean intakes of iron were 10 mg/d and 13 mg/d. Cereals and meat were the major dietary sources of iron. *Conclusions* While iron status is fairly good among Finnish males, especially in younger women it is suboptimal, with iron intake failing to reach recommended levels. Food consumption was poorly associated with iron status.

Key words iron status – ferritin – haemoglobin – iron intake – dietary sources – Finland

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Introduction

Dietary habits in Finland have improved over the past few decades. Most of these changes in food consumption, such as increased consumption of sources of haeme iron (meat) and foods rich in vitamin C (vegetables and fruits) should have been favourable regarding iron status. However, cereal consumption has decreased [1]. In addition, the fortification of white flour with inorganic iron (4 mg ferrum reductum/100 g flour), which began in 1974, ceased in 1994.

Although iron deficiency is typical for populations in developing countries, iron depletion and anaemia are also present in Western populations, based on studies carried out in Europe [2]. Some thirty years ago, the prevalence of anaemia was shown to be about 6 % in Finnish women [3]. In a more recent study, the proportion of women with low iron stores was still a matter of concern [4]. However, recent studies on iron status of Finns, particularly men, are lacking.

This study was carried out to assess the iron status in a random sample of adults living in the capital area of Finland. We also investigated the dietary intake and sources of iron and the prevalence of iron supplement use as well as the associations of these with indicators of iron status.

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Subjects and methods

Participants

The data used in this study were collected as a part of the FINDIET 1997 study, which was carried out in Finland between January and March 1997 [5]. The FINDIET 1997 study, in turn, formed a part of the FINRISK 1997 study [6], for which an age- and sex-stratified random sample of 10 000 persons aged 25–64 years was drawn from the population registers of five regions. One of these regions was the capital area, including the cities of Helsinki and Vantaa. The subjects were invited to a health examination at the local health care centre. At the examination, 40 % of these subjects were invited to participate in a more extensive dietary survey. Iron status was assessed in the capital area only.

The original sample for this study included 400 women and 400 men aged 25–64 years living in the capital area of Finland. These subjects were invited to a health examination and were asked to participate in a dietary survey after the examination. In all, 275 women and 266 men participated in the dietary survey and were interviewed by 24-h recall. Blood samples of 190 non-pregnant women and 239 men were obtained. In addition, since iron status is more likely to be poor in women, samples for serum ferritin analysis were randomly taken from 137 women. The final numbers of participants divided in two age groups (aged < 50 years and ≥ 50 years) are presented in Table 1.

This study protocol was approved, as part of the FINRISK 1997 study, by the Ethical Committee of the National Public Health Institute.

Table 1 Number of blood samples and participation rates in women and men in the FINDIET 1997 study in the capital area of Finland

	Variable	
	Haemoglobin	Serum ferritin
Women		
Blood samples (n)		
Women < 50 years of age	118	84
Women ≥ 50 years of age	72	53
All women	190	137
Proportion (%) of total sample (n = 400)	48	34
Proportion (%) of participants (n = 275[a])	69	50
Men		
Blood samples (n)		
Men < 50 years of age	141	
Men ≥ 50 years of age	98	
All men	239	
Proportion (%) of total sample (n = 400)	60	
Proportion (%) of participants (n = 266[a])	90	

[a] Total sample of the dietary study in the capital area of Finland

Measurements

Blood samples were drawn after a four hour fasting from the antecubital vein into EDTA vacuum tubes and a 0.5 ml whole blood sample was taken for assaying blood haemoglobin (Hb) concentration and other haematological variables. The sample was kept at 4 °C in the dark until being transferred to the laboratory (VITA-Terveyspalvelut Oy), where Hb and erythrocyte indices, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were measured with a Coulter Counter Analyser (Sysmex NE 8000).

Serum samples for ferritin measurements were frozen in polyethene tubes at –20 °C at the health care centre. Next, these samples were transferred to the National Public Health Institute, where they were stored at –20 °C until analyzed. Serum ferritin (SF) was determined using AxSYM Ferritin Microparticle Enzyme Immunoassay (Abbott Laboratories, Abbott Park, IL). The accuracy of the ferritin method was –6 % and the precision between series was 3.5 CV%.

Based on conventional cut-off points, anaemia was defined as a Hb concentration of less than 120 g/l for women and 130 g/l for men. The results for serum ferritin levels were described using two cut-off points: < 12 μg/l as an indicator for absent iron stores [7] and < 16 μg/l as an indicator for small iron stores [8]. These cut-off points were also chosen in order for the results to be comparable with earlier Finnish studies [4].

As suggested by Hulthén et al. [9], infections should be considered when using serum ferritin in the diagnosis of iron deficiency. In this study, the subjects were not inquired about their infections but ultrasensitive c-reactive protein (CRP) was used as an indicator of present inflammatory processes. Ultrasensitive CRP was determined by immunoturbidimetry (Orion Diagnostica, Espoo, Finland, kit no. 68025). The results for serum ferritin were analysed both with and without the subjects with high CRP-levels (> 8 mg/l, n = 6). The results did not change materially, however, and all the subjects were included in the final analyses.

Food and nutrient intakes of the participants were calculated on the basis of 24-hour recalls collected at the examination. These dietary interviews were conducted by trained nutritionists. A 126-item picture booklet together with food models were used in estimating portion sizes. The Finnish food composition database (FINELI®), created and maintained at the National Public Health Institute [10], was used for calculating nutrient intakes.

Along with the invitation to the local health care centre, a questionnaire was sent to subjects to be completed at home. It covered questions on socio-economic factors, medical history, health behaviour and psychosocial factors, which were used as background variables in this study. In addition, a 38-item food frequency questionnaire was included. Food frequency data were used in investigating associations between iron status and food consumption. The frequency of food consumption during the past 12 months was assessed with six response alternatives, ranging from "less than once a month or not at all" to "daily". Responses were converted into number of portions for food consumptions per month. Four sum indices were calculated to indicate the consumption of 1) foods rich in haeme iron, 2) foods rich in non-haeme iron, and foods either 3) enhancing or 4) inhibiting absorption of iron. The first group included the consumption of fish, poultry, meat and sausages. The second group included cereal and legume consumption. The third group included fresh vegetables, fruit, berries and juices made with fruit or berries. The fourth group included coffee, tea, chocolate and milk products.

Information on the use of vitamin and mineral supplements, including iron supplements, was collected with a questionnaire in which subjects were asked about use during the past six months. The type of supplements and the regularity of use (occasional, regular) were also queried. This questionnaire was given to the participants after the dietary interview to be completed at home and returned by mail to the researchers. Of the questionnaires, 92 % were returned. Subjects reporting regular use of iron supplements were defined as supplement users.

Statistical analysis

In statistical analysis, Student's t-test and the Mann-Whitney rank sum test were used to evaluate the significance of differences between subgroups in variables indicating iron status and use of iron supplements. The non-parametric test (Mann-Whitney) was chosen when the distribution did not fulfil the assumptions needed for parametric tests. A mixed model for measurement error was used to test differences in nutrient intakes based on 24-h recall. P-values ≤ 0.05 were considered significant.

Linear regression analysis was used to estimate the effect of food consumption on iron status. These tests were performed using the generalized linear model (GLM) procedure of the SAS statistical package, with indicators of iron status as dependent variables. Four sum indices indicating the consumption of haeme iron sources, non-haeme iron sources, and foods enhancing or inhibiting iron absorption were used as independent variables in the models. These models were controlled for the use of iron supplements. The SAS statistical package was used in other statistical analyses as well.

Results

The mean Hb concentration was 134 g/l for women and 150 g/l for men (Table 2). Also other haemotological parameters of women were lower than those of men. These parameters did not vary much across the age groups in men, whereas in women, the mean Hb concentration was lower in younger women (aged < 50 years) compared with older women (aged ≥ 50 years). Furthermore, the mean serum ferritin level was 32 µg/l in younger women and 62 µg/l in older women.

Fourteen (3 %) subjects proved to be anaemic. Only 3 men had Hb < 130 g/l, whereas 11 women, of which 4 were 50 years of age or older, had Hb < 120 g/l. Thus, the prevalence of anaemia was 5.8 % in women and 1.3 % in men.

Serum ferritin levels were used in defining iron depletion in women. Based on the cut-off point of < 12 µg/l, 23 women (16 %) were observed with depleted iron

Table 2 Indicators of iron status (mean and SD in parentheses) in women and men in the FINDIET 1997 study in the capital area of Finland

	Women			Men		
	Aged < 50 years n = 118	Aged ≥ 50 years n = 72	All n = 190	Aged < 50 years n = 141	Aged ≥ 50 years n = 98	All n = 239
Haemoglobin, g/l	133 (11.5)	137 (10.4)[a]	134 (11.3)	150 (9.1)[b]	150 (11.3)[c]	150 (10.0)[e]
Haematocrit, %	40.1 (3.1)	41.3 (2.9)[a]	40.5 (3.2)	44.0 (2.4)[b]	44.4 (3.2)[c]	44.1 (2.8)[e]
MCV[f], fl	91.9 (5.7)	93.9 (5.0)[a]	92.6 (5.5)	90.6 (3.8)[b]	92.1 (5.2)[d]	91.3 (4.5)[e]
MCH[g], pg	30.5 (2.0)	31.2 (1.8)[a]	30.8 (1.9)	30.9 (1.4)[b]	31.1 (1.6)	31.0 (1.5)
MCHC[h], g/l	331 (12.2)	332 (11.6)	332 (11.9)	342 (9.5)[b]	337 (9.7)[c, d]	340 (9.8)[e]
Leucocytes, x E9/l	5.9 (1.8)	5.9 (1.6)	5.8 (1.8)	5.3 (1.6)[b]	5.8 (1.5)[d]	5.5 (1.6)
Erythrocytes, x E12/l	4.4 (0.4)	4.4 (0.4)	4.4 (0.4)	4.9 (0.3)[b]	4.8 (0.4)[c]	4.9 (0.4)[e]
Serum ferritin, µg/l[i]	32 (30)	62 (59)[a]	44 (45)	–	–	–

[a] Difference in mean values between younger women and older women is significant; [b] between younger women and younger men is significant; [c] between older women and older men is significant; [d] between younger men and older men is significant and [e] between all women and all men is significant ($P < 0.05$).
[f] *MCV* mean corpuscular volume; [g] *MCH* mean corpuscular haemoglobin; [h] *MCHC* mean corpuscular haemoglobin concentration
[i] Number of women in the age groups 84 and 53

stores. Of these, 17 were younger than 50 years of age. The proportion of women with depleted iron stores was 20 % in younger women and 11 % in older women. Of younger women, 27 (32 %) had a serum ferritin level of 16 µg/l or less, whereas in older women, the respective number of women was 7 (13 %).

The mean iron intake did not vary across the age groups, being 10 mg/d for women and 13 mg/d for men, when the intake from iron supplements was excluded (Table 3). Energy-adjusted intake of iron was 1.5 mg/MJ for both genders. The number of subjects using iron supplements regularly was 16 (4 %), 12 of whom were women. For supplement users, the average additional intake of iron from supplements was 80 mg/d.

Meat and cereals were the major sources of iron (Fig. 1). Rye and wheat products comprised 36 % of iron intake in older women, 35 % in older men and 33 % in younger women and men. When all cereals were taken into account, 43 % of iron in women and 40 % in men was derived from cereals. In men and younger women, meat and sausages were the second most important source of iron, whereas in older women, vegetables and potatoes were more important as a source or iron than meat and sausages.

No statistically significant associations were found between iron status (Hb or SF) and the consumption of haeme iron sources, non-haeme iron sources, or foods either enhancing or inhibiting iron absorption (data not shown).

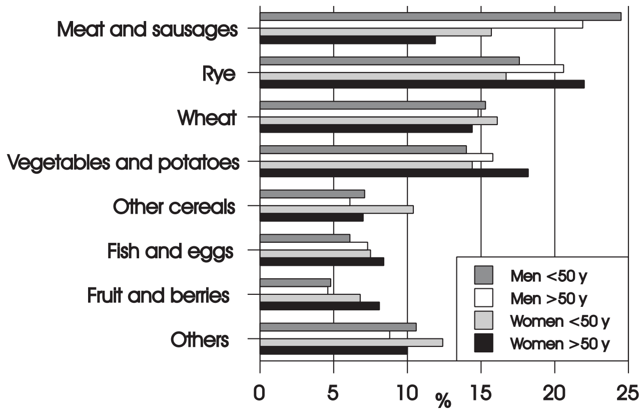

Fig. 1 The main sources of iron among women and men in the FINDIET 1997 study in the capital area of Finland

The mean serum ferritin level in anaemic women (37 ± 79 µg/l) was not significantly lower than in women without anaemia (45 ± 44 µg/l). About half of the

Table 3 Mean intake of iron, haemoglobin and serum ferritin according to use of iron supplements

	Iron from food		Iron from supplements mg/d	Haemoglobin g/l (mean ± SD)	Serum ferritin µg/l (mean ± SD)
	mg/d	energy adjusted, mg/MJ			
Iron supplement users[a]					
Women (n = 12)	10.3	1.6	72.8	131 ± 7.8	31.6 ± 22.5[d]
Men (n = 4)	20.4	2.7	99.7	146 ± 13.0	–
All (n = 16)	12.8	1.8	79.5	134 ± 11.2	–
Non-users					
Women, aged < 50y (n = 111)	10.3[b]	1.5	0	133 ± 11.6[b]	32.7 ± 30.4
Women, aged ≥ 50 y (n = 67)	9.1[b]	1.5	0	137 ± 10.7[b]	64.5 ± 60.4
All women (n = 178)	9.8[b]	1.5	0	135 ± 11.4[b]	44.9 ± 46.9[d]
Men, aged < 50 y (n = 140)	12.8	1.4	0	150 ± 9.0	–
Men, aged ≥ 50 y (n = 95)	12.3	1.5	0	150 ± 11.3	–
All men (n = 235)	12.6	1.5	0	150 ± 10.0	–
All (n = 413)	11.4	1.5	0	143 ± 13.1[c]	–
Total					
Women, aged < 50y (n = 118)	10.2[b]	1.5	19.1	133 ± 11.5[b]	32.4 ± 30.0
Women, aged ≥ 50 y (n = 72)	9.2[b]	1.5	6.4	137 ± 10.4[b]	62.3 ± 58.7
All women (n = 190)	9.9[b]	1.5	13.4	134 ± 11.3[b]	44.0 ± 45.2
Men, aged < 50 y (n = 141)	13.0	1.5	13.3	150 ± 9.1	–
Men, aged ≥ 50 y (n = 98)	12.3	1.5	2.6	150 ± 11.3	–
All men (n = 239)	12.7	1.5	8.5	150 ± 10.0	–
All (n = 429)	11.4	1.5	3.0	143 ± 13.1	–

[a] Of the supplement users 5 women and 3 men were 50 years of age or older
[b] Mean values between men and women differed significantly (P < 0.05)
[c] Mean values between iron supplement users and non-users differed significantly (P < 0.05)
[d] Number of women in groups 10 and 127, respectively

anaemic women had a serum ferritin level of 16 μg/l or lower. Neither the intake nor the sources of iron differed between these groups (data not shown).

Discussion

In this random urban population study, the iron status of Finnish men was fairly good, with only three men having haemoglobin levels of less than 130 g/l. The number of anaemic women was not alarming (n = 11; 6 %), although the prevalence of low serum ferritin levels was 20 % in younger women and 11 % in older women.

Surprisingly, our findings were in agreement with data collected about 30 years ago when the enrichment of wheat flour with iron had not yet commenced. In that large epidemiological study (n = 6046) carried out in different parts of Finland, the prevalence of anaemia was about 2 % in men and 6 % in women. Serum ferritin level was not evaluated [3]. In a more recent study, performed before the enrichment was ceased, the prevalence of iron depletion (SF 12 μg/l or less) was 11 % in women aged 17–50 years [4]. This prevalence was somewhat lower than in our study, as was the prevalence of anaemia (2.5 %, Hb < 120 g/l) [4]. Although the earlier study was also carried out in the capital area, it should be noted that these subjects were younger than in our study and were not randomly selected but volunteers from an occupational health care clinic. Methodological differences should always be considered when comparing results from different studies [2].

In women, the mean iron intake failed to meet recommendations of 10 mg/d for men and non-menstruating women and 12–18 mg/d for menstruating women [11]. Similar to our findings, the average iron intake in a Dutch study was low compared with recommendations, especially among women aged 20–49 years [12].

Although in some studies [12, 13], iron status has been shown to be positively associated with meat and fish consumption and inversely associated with vegetable consumption, our finding of no association between food intake and iron status is supported by several previous studies [4, 14]. However, dietary intake being a poor predictor of iron status has been suggested, in part, to be caused by reporting error in diet [15]. While we agree that the methods used in our study, i. e. 24-h recall and a food frequency questionnaire, are prone to reporting bias, using both should provide more accurate results. Regardless of the method, no association was found between iron status and dietary intake. As shown in several studies [4, 16], variation in iron status may mostly be explained by blood losses via blood donation or menstrual bleeding. These factors were not investigated in this survey.

Based on the 1997 survey, the current intake of iron in Finland seems to be lower than in the early 1990s. Energy-adjusted intake was 1.7 mg/MJ in men and 1.6 mg/MJ in women in 1992 [17], whereas in 1997, it was 1.5 mg/MJ in both men and women [5]. However, the changes were not statistically significant. Overall, these comparisons should be interpreted with caution because information on dietary intake was collected with 3-d food records in 1992 and with 24-h recall in 1997.

Comparisons between 1992 [17] and the 1997 dietary survey [5] suggest that sources of iron may have changed. The proportion of cereals as an iron source has decreased from 54 % to 47 % in men and from 52 % to 45 % in women, whereas that of meat has increased from 17 % to 22 % and from 15 % to 17 %, respectively. Part of the decreasing role of cereals as an iron source could be explained by iron fortification of wheat flour ceasing in 1994. Cereal consumption did not change over the five-year period. Almost two thirds of cereals consumed consisted of wheat and one fifth of rye. Of cereals, however, rye was the most important source of iron.

When considering iron sources in this substudy and in the larger 1997 dietary survey, variation in food choices across the regions in Finland should be taken into account. In eastern Finland, the consumption of rye products, and thus, its role as an iron source, is greater than in the capital area.

Our data suggest that the decision to discontinue fortification of flour with iron may have been premature; the current iron status among Finnish adults seems to be at pre-enrichment levels. One of the reasons for ceasing fortification was the poor availability of iron in the form of ferrum reductum. Furthermore, an iron supplement was considered unnecessary and potentially even harmful to men and post-menopausal women [18].

In Danish studies, iron status was shown to remain consistent regardless of whether or not iron was taken as a supplement [8, 16]. Our finding of lower iron status of subjects using iron supplementation may indicate caution in the use of these supplements. Iron supplementation was probably used because of a diagnosed poor iron status rather than supplementation merely to be on the safe side or because of health consciousness. Consumption of vitamin and mineral supplements, in general, has been shown to be associated with higher consumption of vegetables, fruits and berries as well as higher intakes of carotenoids and vitamins C and E, i. e. with healthier food choices [19].

To conclude, the iron status of Finnish men seems to be relatively good, despite the lack of iron fortification in wheat flour since 1994. In contrast, based on the number of women with low iron stores, the iron status of Finnish women aged less than 50 years is suboptimal. Average iron intake also failed to reach the recommended levels. It remains to be seen, however, whether this status can be improved by dietary choices since no association was found between iron intake from food or supplements and iron status.

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