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Iron status in 358 apparently healthy 80-year-old Danish men and women: relation to food composition and dietary and supplemental iron intake

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Abstract In Denmark, the intake of dietary iron has decreased since 1987, when the mandatory iron fortification of flour (30 mg carbonyl iron/kg) was stopped. Since there have been no studies of iron status in elderly Danes after the abolishment of iron fortification, there is a need to assess actual iron status in the elderly population. The objective was to evaluate iron status and the relationship with food composition and dietary and supplemental iron intake in an elderly population in Copenhagen County. Participants in this health examination survey were 358 subjects (171 men, 187 women) 80 years of age from a 1914 cohort study. Blood samples included serum ferritin and hemoglobin (Hb). A dietary survey was performed in 232 subjects (120 men, 112 women) using a dietary history method. Median serum ferritin was 100 $\mu\text{g/l}$ in men and 78 $\mu\text{g/l}$ in women ($p < 0.001$). Ferritin concentrations $< 16 \mu\text{g/l}$ (i.e., depleted iron stores) were found in three men (2%) and in ten women (5%). Median Hb was 140 g/l in men and 131 g/l in women ($p < 0.001$). Three subjects (0.84%) had iron deficiency anemia (i.e., ferritin $< 13 \mu\text{g/l}$ and Hb < 5 th percentile for iron-replete subjects

(121 g/l in men, 114 g/l in women). Ferritin concentrations $> 300 \mu\text{g/l}$ (i.e., iron overload) were found in 15 (9%) men and in 5 (3%) women. Median dietary iron intake was higher in men (8.7 mg/day) than in women (7.3 mg/day) ($p < 0.001$). Serum ferritin was positively correlated to dietary intake of iron, meat, and alcohol and to body mass index in men. Serum ferritin displayed a negative correlation to the consumption of tea. The use of vitamin-mineral supplements containing iron had no influence on iron status. Dietary intake of iron and/or the bioavailability of dietary iron were adequate to maintain a favorable iron status in 80-year-old subjects displaying a low prevalence of iron deficiency and a moderate prevalence of iron overload.

Keywords Aged · Body mass index · Diet surveys · Ferritin · Hemoglobins · Iron deficiency · Iron metabolism · Iron overload · Men · Women

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Introduction

In the Danish population, body iron balance and iron status display characteristic age- and gender-related changes [1]. In Denmark, the composition of the daily diet and the intake of dietary iron have changed since 1987, when the mandatory iron fortification of flour (30 mg carbonyl iron/kg flour) was abolished. Previous studies of iron status in elderly Danish subjects [2, 3] had been performed in the iron fortification era, so there is a need to assess actual iron status after the abolishment of fortification. The purpose of the present study was to evaluate iron status and its relationship to food composition as well as dietary and supplemental iron intake in apparently healthy 80-year-old subjects.

Material and methods

Subjects

The study was approved by the Ethics Committee in Copenhagen County. It is part of a longitudinal study of the 1914 birth cohort in Glostrup in Copenhagen County, described in detail by Schroll et al. [4]. Subjects born in 1914 were invited to an initial health examination in 1964 and subsequently examined every 10th year—and after the age of 70 years—every 5th year. After the age of 70 years, the participants were visited in their home by an occupational therapist, and the visit was followed by a medical health examination. Our study was performed when the subjects were recruited for the 80-year follow-up examination in 1994–1995. All subjects having attended at least one of the previous examinations were invited.

By letter, 653 subjects were invited to participate in the home visit; 505 of 653 (77%) accepted the invitation. Of these 505, 362 (72%) subjects (172 men, 190 women) participated in a subsequent health examination. Blood samples were available in 358 subjects who were included in the iron status survey, and in 232 of these subjects nutritional status was assessed as well.

During the period 1964–1984 the non-participants had higher morbidity and mortality, poorer socioeconomic status, and a higher prevalence of smoking [5, 6]. In 1994–1995 the non-participants had a poorer self-rated health than the participants [7]. Therefore, the participants in this study are 80-year-old subjects with a relatively good health status, i.e., they are not representative for the entire elderly Danish population.

Blood samples

Blood samples were drawn by venipuncture in the non-fasting state between 0800 and 1100 hours. Hemoglobin (Hb) was measured on Cell-Dyn 3500 (Abbott Laboratories, Abbott Park, Ill., USA). The conversion factors for Hb are $\text{Hb in mmol/l} \times 16.115 = \text{Hb in g/l}$; $\text{Hb in g/l} \times 0.062054 = \text{Hb in mmol/l}$. Serum ferritin was measured by a microparticle enzyme immunoassay (Abbott AxYM ferritin, Abbott Laboratories, Abbott Park, Ill., USA) [8]. The total assay variation is 5.4% at a serum ferritin concentration of 20 $\mu\text{g/l}$, 4.8% at a concentration of 150 $\mu\text{g/l}$, and 6.0% at a concentration of 390 $\mu\text{g/l}$ [9]. The kit is calibrated closely to the WHO international human liver ferritin standard 80/602 [8]. Ferritin AxYM concentrations of 13, 16, and 32 $\mu\text{g/l}$ correspond to WHO ferritin standard concentrations of 12, 15, and 30 $\mu\text{g/l}$ [8]. The results are described using three critical serum ferritin concentrations, <13 $\mu\text{g/l}$, <16 $\mu\text{g/l}$, and <32 $\mu\text{g/l}$ (corresponding to WHO standard ferritin concentrations of 12, 15, and 30 $\mu\text{g/l}$) as an indicator for small or absent iron stores. As proposed by Worwood [10], small or absent body iron reserves were considered present at serum ferritin concentrations <15 $\mu\text{g/l}$ and as suggested by Cook and Skikne [11], a ferritin cutoff concentration of <12 μl was considered to indicate absent iron stores. Iron stores were considered “small” at ferritin concentrations of 15–30 $\mu\text{g/l}$. Serum ferritin concentrations of $\leq 32 \mu\text{g/l}$ was considered to indicate the absence of stainable hemosiderin bone marrow iron, whereas concentrations of $>32 \mu\text{g/l}$ was considered to reflect “replete” iron stores with the presence of bone marrow hemosiderin iron [12, 13]. Iron overload was considered “moderate” at serum ferritin concentrations 301–700 $\mu\text{g/l}$ and “heavy” at serum ferritin concentrations $>700 \mu\text{g/l}$ [10].

The hemoglobin cutoff concentrations for anemia in men (<130 g/l) and in women (<120 g/l) were defined according to the WHO recommendation [14]. As hemoglobin was measured in mmol/l, we chose a cutoff concentration in men of <8.0 mmol/l corresponding to <128.92 g/l and a cutoff concentration in women of <7.5 mmol/l corresponding to <120.86 g/l. Alternatively, we also used the 5th percentiles for hemoglobin in iron-replete subjects with serum ferritin $>32 \mu\text{g/l}$ as cutoff concentrations for anemia: in men 121 g/l (7.5 mmol/l) and in women 114 g/l (7.1 mmol/l).

A serum ferritin of <13 $\mu\text{g/l}$ and a hemoglobin below 129 g/l (men) and below 119 g/l (women) or alternatively below the

gender-specific 5th percentile were considered to indicate iron deficiency anemia.

The presence of an inflammatory disorder was monitored by analysis of serum C-reactive protein (CRP) by an immunoturbidimetric assay (Roche A/S, Hvidovre, Denmark) on Hitachi-704. A serum CRP concentration of $>10 \text{ mg/l}$ was considered elevated.

Anthropometrics

Height and weight were measured without shoes and with light clothing, height to the nearest 0.5 cm and weight to the nearest 100 g. Body mass index (BMI) was calculated as weight (kg)/height (m)².

Dietary survey

Dietary intake was assessed by a modified dietary history method [15]. The method was adapted from the multicenter SENECA study (Survey in Europe on Nutrition and the Elderly: a Concerted Action), which was a mixed cross-sectional and longitudinal study with a baseline study in 1988/1989 [16] and a follow-up study in 1993 [17]. The dietary history method included two parts: a 3-day estimated food record followed by a dietary history method based on a frequency checklist of about 150 of the most commonly eaten foods or dishes [18]. The 3-day food record was performed by estimating in household measures all foods and drinks consumed for 3 consecutive days comprising one weekend day. Participants were given oral and written information about the dietary record. On return of the records, the dietitians clarified ambiguous entries. Standardized recipes developed for Danish elderly people were used when the subject did not supply specific information on the composition of a dish [19]. A dietician performed dietary histories at the participants' residence using the food record as a guide. The method estimated the usual food intake within the past month. The dietary survey was performed January through September 1995. Dietary intakes were calculated using a food database (DANKOST 2000, Danish Catering Centre, Copenhagen, Denmark) based on the Danish food composition tables [20].

Vitamin-mineral supplements

In a self-administered questionnaire the participants answered “yes” or “no” to the question: “do you use any dietary supplements?” During the home visit the dietician recorded the medicine including dietary supplements. The amounts of the micronutrients in the supplements were recorded in the entire dietary survey series ($n=232$).

Medicine

All medications, including the use of nonsteroidal anti-inflammatory drugs (NSAID), coumarin anticoagulants, antacids, and proton pump blockers were recorded by the interviewer.

Statistics

Statistical analyses were performed using the SPSS/PC 9.0 package. Data were tested for normality with the Kolmogorov-Smirnov test. Except for serum CRP, all variables were log-normally distributed for which reason geometric means and medians are quoted. The significance of differences was assessed using the Mann-Whitney and chi-square test. Correlations were calculated using Spearman's coefficient of correlation (r_s).

Table 1 Results from the dietary survey in 80-year-old Danes

Variable ^a	Men n=120	Women n=112	p value ^b
Hemoglobin (g/l)	140 (105–160)	130 (95–158)	<0.001
Serum ferritin (µg/l)	98 (24–479)	68 (11–228)	<0.001
Energy intake (MJ)	9.2 (6.8–14.2)	7.4 (5.3–10.0)	<0.001
Dietary iron (mg/day)	8.7 (5.2–16.2)	7.3 (4.5–10.4)	<0.001
Alcohol (g/day)	12 (0–61)	2 (0–40)	<0.001
Meat (g/day)	97 (31–190)	75 (18–127)	<0.001
Calcium (mg/day)	921 (379–1770)	894 (433–1565)	NS
Coffee (ready to drink g/day)	479 (0–1332)	349 (0–1047)	0.003
Tea (ready to drink g/day)	53 (0–911)	221 (0–1066)	0.016

^a Median (5–95 percentile)^b Mann-Whitney test**Table 2** Biochemical analyses and body mass index in 80-year-old Danes (Copenhagen 80-year-old iron status survey 1994–1995)

	Men n=171		Women n=187		p value ^a
	Median	Range	Median	Range	
Hemoglobin (g/l)	140	98–168	131	76–164	<0.001
Plasma creatinine (µmol/l)	100	64–208	81	53–147	<0.001
Plasma aspartate aminotransferase (U/l)	23	11–94	21	10–70	0.03
Plasma alkaline phosphatase (U/l)	183	91–434	191	93–1243	NS
Serum C-reactive protein (nmol/l)	39	39–1150	39	39–1105	NS
Body mass index	26	16–35	26	18–43	NS

^a Difference between genders: Mann-Whitney test

Results

Serum ferritin and serum C-reactive protein

There was no difference between serum CRP concentrations in men and women ($p=0.2$). Among the participants, 47 (23 men, 24 women) had elevated serum CRP >10 mg/l. Median serum ferritin concentrations in men with normal and elevated CRP were 100 vs 107 µg/l ($p=0.4$) and in women 77 vs 101 µg/l ($p=0.2$). In the entire series, there was no correlation between CRP and serum ferritin ($r_s=0.02$, $p=0.8$). Median hemoglobin concentrations in men with normal and elevated CRP were 140 vs 135 g/l ($p=0.003$) and in women 131 vs 128 g/l ($p=0.3$). In men, the inverse correlation between CRP and hemoglobin came close to significance ($r_s=-0.15$, $p=0.056$), whereas in women there was no correlation ($r_s=-0.09$, $p=0.3$). Due to the minor differences, we decided to include participants with elevated CRP in the analysis of the results.

Serum ferritin, energy intake, and BMI

The intake of energy was significantly higher in men than in women (Table 1). The positive correlation between serum ferritin and energy intake came close to significance ($r_s=0.13$, $p=0.057$). There was no significant difference in BMI between men and women (Table 2). A positive correlation existed between serum ferritin and BMI in men ($r_s=0.21$, $p=0.025$) but not in women ($r_s=-0.05$, $p=0.6$).

Table 3 Serum ferritin in 80-year-old Danes

	Men n=171	Women n=187	p value ^a
Serum ferritin (µg/l)			
Geometric mean	107	75	
Median	100	78	<0.001
5–95 percentile	25–388	13–252	
Observed range	11–811	7–3494	

^a Difference between genders: Mann-Whitney test

Serum ferritin

Table 3 shows serum ferritin concentrations in the two genders. Men had significantly higher ferritin concentrations than women.

Depleted iron stores

Table 4 shows the prevalence of low serum ferritin concentrations in the two genders. Ferritin concentrations of <16 µg/l were found in 1.8% of the men and in 5.4% of the women.

Iron deficiency anemia

Men had significantly higher median hemoglobin concentrations than women (Table 2). Six subjects (one man, five women), i.e., 1.7% of the entire series, fulfilled the

Table 4 Distribution of serum ferritin values in 80-year-old Danes. Figures indicate percentage of subjects (read vertically) in each gender group. Ferritin values of 13, 16, and 32 $\mu\text{g/l}$ correspond to WHO standard ferritin values of 12, 15, and 30 $\mu\text{g/l}$. Difference between genders: chi square-test with Yates correction: $p=0.004$

Serum ferritin ($\mu\text{g/l}$)	Men $n=171$ (%)	Women $n=187$ (%)
<13	0.6	4.3
<16	1.8	5.4
16–32	5.3	7.5
33–300	84.2	84.5
301–700	7.0	1.6
>700	1.8	1.1
Total (%)	100	100

criteria for iron deficiency anemia (i.e., serum ferritin <13 $\mu\text{g/l}$ and hemoglobin <130 and 120 g/l for men and women, respectively). Using the <5th percentile hemoglobin for each gender resulted in iron deficiency anemia in one man and two women, i.e., 0.83% of the entire series.

Small iron stores

Serum ferritin concentrations of 16–32 $\mu\text{g/l}$, i.e., small iron stores, were present in 5.3% of the men and in 7.5% of the women (Table 4).

Iron overload

The prevalence of serum ferritin concentrations >300 $\mu\text{g/l}$ was 8.8% in men and 2.7% in women (Table 4). Serum ferritin concentrations of 301–700 $\mu\text{g/l}$, indicating a moderate iron load, were present in 8.6% of the entire series. A heavy iron load, defined as serum ferritin >700 $\mu\text{g/l}$, was observed in 2.9% of the entire series.

Serum ferritin and medication

Among the subjects, 55 of 358 (15%), 21 men and 34 women, used NSAID other than acetylsalicylic acid. Users had lower median serum ferritin concentrations than nonusers, but the difference reached significance only in women: men 93 vs 110 $\mu\text{g/l}$ ($p=0.3$), women 51 vs 84 $\mu\text{g/l}$ ($p=0.011$). There was no significant difference in median hemoglobin concentrations between NSAID users and nonusers either in men ($p=0.7$) or in women ($p=0.6$). Acetylsalicylic acid ($n=124$), antacids ($n=23$), proton pump blockers ($n=11$), and coumarin anticoagulants ($n=5$) had no significant influence on serum ferritin or hemoglobin concentrations.

The dietary survey ($n=232$)

Serum ferritin and dietary iron intake

Dietary iron intake (without supplements) was slightly, but significantly higher in men than in women (Table 1). In 25 men (21%) and in 9 women (8%) dietary iron intake was below the lower limit of the recommended daily allowance (RDA), i.e., 7 mg in men and 5 mg in women [21]. Median serum ferritin concentrations in men and women with a dietary iron intake below the lower limit of RDA were not significantly different from ferritin concentrations in subjects having a dietary iron intake equal to or above the lower limit of RDA: men 89 vs 100 $\mu\text{g/l}$ ($p=0.7$), women 83 vs 66 $\mu\text{g/l}$ ($p=0.5$).

In the entire dietary series, there was a positive correlation between dietary iron intake ($r_s=0.14$, $p=0.03$) and serum ferritin. However, there was no correlation between supplemental iron intake and serum ferritin ($r_s=0.001$, $p=0.8$) or between dietary + supplemental iron intake and serum ferritin ($r_s=0.10$, $p=0.15$).

In the entire dietary series there was a positive correlation between serum ferritin and the intake of meat ($r_s=0.16$, $p=0.013$). When analyzed by gender, the correlation was present in men ($r_s=0.16$, $p=0.08$), but not in women ($r_s=-0.01$, $p=0.95$).

Serum ferritin vs alcohol intake

Men had a significantly higher alcohol intake than women (Table 1). In the entire dietary series, a positive correlation existed between serum ferritin and alcohol intake ($r_s=0.25$, $p<0.001$).

Serum ferritin vs coffee and tea consumption and calcium intake

In the entire dietary series, 88% were coffee drinkers and 57% were tea drinkers. There was a significant negative correlation between serum ferritin and the consumption of tea ($r_s=-0.16$, $p=0.017$). There was no correlation between ferritin and the consumption of coffee or coffee + tea. There was no correlation between serum ferritin and calcium intake.

Serum ferritin and iron supplements

In the entire dietary series 35 (29%) men and 52 (46%) women took ferrous iron supplements. Median iron intake from supplements was 14 mg/day (range: 5–114), similar in both genders. Supplemental iron was most frequently taken as combined multivitamin-mineral tablets containing 10–20 mg of ferrous iron. Serum ferritin concentrations in supplement users were not significantly different compared with nonusers either in men (Table 5). Likewise, the prevalences of iron deficiency, small iron stores,

Table 5 Relationship between serum ferritin and use of dietary iron supplements in 80-year-old Danes

Iron supplement	Supplement (mg/day) ^a	Serum ferritin			
		Median (µg/l)	<16 µg/l (%)	≤32 µg/l (%)	>300 µg/l (%)
Men					
Yes n=35	14 (4–112)	93	3	3	3
<i>p</i> value		0.8 ^b			
No n=85		100	9	14	26
Women					
Yes n=52	14 (5–114)	68	8	8	4
<i>p</i> value		0.5 ^b			
No n=60		68	10	10	0

^a Median (range)

^b Users vs nonusers: Mann-Whitney test

and iron overload were not significantly different in iron supplemented and non-supplemented subjects (Table 5).

Other dietary supplements

In the entire dietary series, dietary supplements were used by 181 (72%) subjects (86 men, 95 women). Among these, 139 used vitamin and/or mineral supplements daily, including 95 taking a combined multivitamin-mineral tablet. There was no significant difference between median serum ferritin or hemoglobin concentrations either in supplement users vs nonusers or in users vs nonusers of combined multivitamin-mineral tablets.

Discussion

The examined population comprised apparently healthy elderly Danes living in their own homes and is therefore not representative of the entire Danish population of 80-year-old subjects. Characteristic age-related changes occur in body iron status [1]. In the two genders, serum ferritin concentrations are similar until adolescence [1]. After adolescence, serum ferritin in men increases gradually reaching a stable level at 30–35 years of age, which remains relatively constant into old age [1, 22, 23]. In women, serum ferritin concentrations are quite constant from menarche to menopause [1, 24, 25]. After menopause, serum ferritin increases gradually to reach a new steady-state level approximately 7 years after menstruation has ceased [26].

Although ferritin concentrations in women of old age approached concentrations in men, they continued to remain significantly lower. In a previous study of 85-year-old subjects in 1982 [2], men likewise had higher median serum ferritin than women (123 vs 105 µg/l), although that difference did not reach a statistical level of significance. In the present study, BMI was similar in the two genders. The higher ferritin concentrations in elderly men compared with women were most likely the consequence of several factors: (1) Men had a significantly higher energy intake than women, which in turn leads to a

higher dietary iron intake. (2) Furthermore, men had a significantly higher intake of meat than women. Meat contains hem iron with a high bioavailability. Furthermore, substance(s) in meat termed “the meat factor” has an enhancing effect on the absorption of non-hem food iron [27]. (3) Men had a significantly higher alcohol intake than women. The intake of alcohol demonstrates a positive correlation with serum ferritin, a finding which was observed in both the present and previous studies [23, 25, 28]. Probably alcohol has an enhancing effect on iron absorption. (4) Men had a significantly lower consumption of tea than women. Tea contains polyphenols, which are potent inhibitors of iron absorption [27]. In the present study, the consumption of tea was negatively correlated with serum ferritin. A previous study of 40- to 70-year-old Danish men demonstrated a negative correlation between serum ferritin and the consumption of coffee + tea [23], whereas a study of 40- to 70-year-old Danish women failed to show any correlation between serum ferritin and coffee or tea intake [25]. Our finding therefore does not confirm a recent meta-analysis, concluding that in Western populations, in which most people have adequate iron status, tea consumption does not influence serum ferritin to a significant extent. However, in populations with marginal iron status there seems to be a negative correlation between serum ferritin and tea consumption [29]. Like in the present study, in the 85-year-old survey in 1982 [2], men had significantly higher median dietary iron intake than women (12 vs 9 mg/day) [2].

In general, iron status was satisfactory in both men and women. Small + depleted iron stores (i.e., serum ferritin <32 µg/l) were observed in 7.1% of men and in 12.9% of women. However, the prevalence of depleted iron stores was below 2% in men and below 5.5% in women, and the prevalence of iron deficiency anemia in the entire series was below 1%. For comparison, the prevalence of iron depletion in contemporary surveys of 70-year-old Danes was 0.4% in men and 0.8% in women [23, 25].

The prevalence of iron overload (i.e., serum ferritin >300 µg/l) was less than 10% in men and less than 3% in women. These figures are lower than those obtained in contemporary surveys of 70-year-old Danish men (16%)

and women (7%) [23, 25]. Iron overload can be due to a genetic predisposition to hereditary hemochromatosis, which is an autosomal recessive disease with an inappropriately high intestinal iron absorption [30]. Approximately 0.36% of the Danish population are homozygous and 10.6% are heterozygous for the C282Y mutation [31]. Only homozygous subjects may develop clinically overt iron overload with organ damage. Approximately one-third of the heterozygous subjects have minor iron overload without organ damage [30]. The clinical penetrance of the mutation will be enhanced by a high dietary and supplemental iron intake.

Inappropriate elevation of serum ferritin may occur in subjects with liver disease, malignancies, inflammatory diseases, and chronic nephropathy [1]. In this series of apparently healthy elderly subjects we assume that there was a low prevalence of inappropriately elevated serum ferritin.

In the present study, iron status (i.e., serum ferritin) displayed a weak but significant correlation with dietary iron intake. Previous Danish studies [2, 22, 24, 32, 33] have failed to demonstrate a relationship between serum ferritin and dietary iron intake. However, in the study of 85-year-old Danes in 1982 [2] we found significant correlations between dietary iron intake and serum iron, serum total iron binding capacity (TIBC) as well as serum TIBC saturation, but no correlation with serum ferritin. The serum ferritin concentration reflects iron balance on the long term, whereas TIBC saturation reflects iron status on the short term and therefore is more liable to be associated with dietary iron intake measured in close temporary relation to blood sampling. Several factors may obscure the association between serum ferritin and dietary iron intake. First, there exist interindividual variations in the bioavailability of dietary iron due to variations in the composition of the meals, i.e., the absorption from meals with similar iron content may vary due to interaction between enhancers and inhibitors of iron absorption [27]. Second, there may be discrepancies between calculated iron intake using food composition tables and chemically measured iron content in the diet. Third, the reported dietary iron intake may deviate considerably from the true intake, due to diet reporting error with underreporting [33].

In the present study some of these confounders may have been eliminated or diminished. The women were postmenopausal and there were no nonphysiological blood losses, e.g., by blood donation. The calculated iron intake was based on recently updated food composition tables with more reliable iron data than earlier provided. Underreporting was considered to be lower than in other studies, and the ability of the dietary method to rank the intakes of nutrients seemed satisfactory [15].

Ferrous iron supplements were used by approximately one-third of the men and half of the women. These figures are quite similar to the figures in previous surveys in middle-aged Danish men and women [22, 23, 24, 25, 32]. The majority of supplement users took combined vitamin-mineral tablets and had a median intake of ferrous iron of

14 mg/day. Detailed analysis showed that iron supplements did not influence median serum ferritin concentrations and there was no correlation between the amount of iron supplement and serum ferritin. Although there was a trend that iron-supplemented subjects had a lower prevalence of small + depleted iron stores (i.e., serum ferritin <32 $\mu\text{g/l}$), it was not statistically significant. Similar results were obtained in previous iron status surveys in 40- to 70-year-old Danish men and postmenopausal women [23, 25].

In healthy, iron-replete men and in iron-replete premenopausal and postmenopausal women, iron supplements in the range of 14–20 mg/day have a negligible impact on iron status [23, 25], as iron absorption is regulated according to body needs [27]. However, in premenopausal women with small or depleted iron stores, iron supplements have a positive effect on iron status [25] due to the upregulation of iron absorption [27].

In conclusion, despite the abolishment of food iron fortification in 1987, the majority of apparently healthy 80-year-old Danish men and women have a dietary intake of iron and a bioavailability of dietary iron, which is adequate to maintain a favorable iron status with a low prevalence of iron deficiency and iron deficiency anemia.

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