Disorders of Iron Metabolism

Iron status and anemia in a population-based study of women with and without disability living in the community: the Women's Health and Aging Studies

Iron status and associated risk factors were assessed in a population-based study of 684 community-dwelling women, 70-79 years old. Iron deficiency, iron deficiency anemia, and elevated iron stores were found in 5.8%, 3.8%, and 9.0% of women, respectively. The prevalence of both anemia and iron deficiency anemia increased significantly with increasing disability.

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Anemia is common among older adults and is associated with fatigue, impaired physical function, and a decreased sense of well being.[1] Iron deficiency and iron deficiency anemia have not been well characterized in older women and are important because of their adverse effects on aerobic capacity and physical endurance.[2] Older adults are also at risk of the anemia of chronic disease.[3] We investigated iron status in a population-based sample of older women living in the community in order to characterize risk factors for iron deficiency and elevated iron stores, and to investigate the relationships between iron status, chronic disease, and disability.

The subjects were women, 70-79 years old, who participated in two population-based complementary studies, the Women's Health and Aging Study (WHAS) I and II. The sampling and methods of these two studies have been described in detail elsewhere;[4,5] the two studies were combined to represent the one-third most disabled and the two-thirds least disabled women living in the community.[6] Complete blood count, serum ferritin, serum iron, transferrin, total iron-binding capacity, liver function tests, and C-reactive protein were measured. A ferritin concentration <30 μg/L was used as an indicator of iron deficiency.[7] Iron deficiency anemia was defined as iron deficiency and hemoglobin <120 g/L. Elevated iron stores were defined as serum ferritin >200 μg/L with C-reactive protein <6 mg/L.[8] Chronic disease was defined as C-reactive protein >6 mg/L, white blood count >11.0×10^9/L, elevated liver function enzymes, infection, or liver disease[8] or by self report of a validated physician's diagnosis of rheumatoid arthritis, osteoarthritis, or cancer.[4,5] Inflammation was defined as C-reactive protein >6 mg/L. Infection was considered consistent with a white blood cell count >11.0×10^9/L or <3.5×10^9/L.[8] Liver disease was considered consistent with an alanine aminotransferase level >74 U/L and alkaline phosphatase >154.5 U/L, or aspartate aminotransferase >68 U/L.[8] Study-specific probability weights were used to reference inferences derived from population-based sampling.[6] χ^2 and trend tests were used to examine the associations between indicators of iron status and dichotomized co-variates. Multivariate logistic regression models were fitted to determine risk factors which were independently predictive of iron status after adjustment for other factors.

Hemoglobin and iron status are shown by domain of disability in Table 1. Overall, iron deficiency, iron deficiency anemia, and elevated iron stores was found in 5.8%, 3.8%, and 9.0% of the women, respectively, and anemia was found in 13.3%. Iron deficiency accounted for more than one quarter of the total cases of anemia found among the women in the study. Iron status and anemia were compared in women with and without chronic disease (Table 2). Univariate and multivariate models were used to examine risk factors for iron deficiency. In a final multivariate model, only the lowest tertile of income compared to the highest tertile was associated with iron deficiency (O.R. 3.52, 95% C.I. 1.44-8.62), after adjusting for race. In univariate models for elevated iron stores, only black race was significantly associated with ele-

Table 1. Iron status indicators by domain of disability.

Analyte[1]	*Domain of disability*					
	0 (*n = 233*)	*1* (*n = 162*)	*2* (*n = 129*)	*3* (*n = 73*)	*4* (*n = 82*)	*P*
Hemoglobin (g/L)	133.4±0.7	132.8±1.0	131.8 ±1.1	127.6 ±1.7	129.1±1.6	0.01
Anemia (%)	8.6	11.6	13.9	23.9	20.9	0.007
Mean corpuscular volume (fL)	92.3±0.4	91.7±0.4	93.5±0.4	91.0±0.8	92.6±0.8	0.032
Mean corpuscular volume <80 fL (%)	2.4	1.9	1.6	8.7	5.3	0.07
Log_{10} serum ferritin	4.35±0.05	4.46±0.07	4.33±0.08	4.15±0.12	4.39±0.10	0.22
Serum ferritin <30 μg/L (%)	10.6	10.4	15.6	20.3	13.2	0.22
Serum ferritin >200 μg/L (%)	10.1	12.3	15.5	14.2	15.6	0.53
Total iron-binding capacity (μg/dL)	326.7±2.9	332.0±4.0	320.1±4.1	325.2±7.3	317.7±6.4	0.19
Serum iron (μg/dL)	82.8±2.5	81.1±2.1	75.2±2.0	79.3±3.5	71.5±2.8	0.01
Transferrin saturation (%)	25.4±0.6	24.8±0.6	24.0±0.7	24.8±1.1	23.0±0.9	0.25
Transferrin saturation <15% (%)	8.4	6.8	13.6	15.8	19.1	0.025
Iron deficiency (%)	3.4	5.6	5.7	11.9	8.7	0.11
Iron deficiency anemia (%)	0.7	3.8	2.0	8.9	5.2	0.004
Elevated iron stores (%)[2]	7.1	9.3	7.7	9.3	9.0	0.91
C-reactive protein ≥ 6 mg/L	22.2	28.5	36.9	32.4	44.8	0.0016

[1]For continuous variables, mean±SEM. [2]Defined as ferritin >200 μg/L, excluding those with evidence of acute phase response (C-reactive protein <6 mg/L).[8]

Table 2. Indicators of iron status and anemia in women with and without chronic disease.*

Analyte	*Without chronic disease (n = 400)*	*With chronic disease (n = 279)*	*P*
Hemoglobin (g/L)	133.5±0.6	129.9±0.8	0.0001
Anemia (hemoglobin <120 g/L) (%)	9.5	17.6	0.003
Mean corpuscular volume (fL)	92.3±0.3	92.1±0.3	0.8
Mean corpuscular volume <80 fL (%)	2.6	3.6	0.49
Log10 serum ferritin	4.29±0.04	4.46±0.05	0.022
Serum ferritin <30 μg/L (%)	14.2	9.6	0.07
Serum ferritin >200 μg/L (%)	10.5	15.3	0.07
Total iron-binding capacity (μg/dL)	329.5±2.5	321±2.9	0.025
Serum iron (μg/dL)	84.4±1.8	72.8±1.5	0.0001
Transferrin saturation (%)	25.9±0.5	23.0±0.4	0.0001
Transferrin saturation <15% (%)	7.6	14.8	0.007
Iron deficiency (%)	4.8	6.7	0.31
Iron deficiency anemia (%)	2.3	3.7	0.28
Elevated iron stores (%)°	10.5	4.0	0.003

**Defined as diagnosis of rheumatoid arthritis, osteoarthritis, or cancer or C-reactive protein >6 mg/L, white blood count >11.0 or <3.5×10⁹/L, alanine aminotransferase >74 U/L, alkaline phosphatase >154.5 U/L, or aspartate aminotransferase >68 U/L.[8] °Defined as ferritin >200 μg/L, excluding those with evidence of acute phase response (C-reactive protein <6 mg/L).[8]*

vated iron stores (O.R. 2.07, 95% C.I. 1.01-3.91).

To our knowledge, this is the first study of iron status in a large, population-based U.S. cohort of older women living in the community. Iron deficiency and iron deficiency anemia was found in about 6% and 4%, respectively, of older women living in the community, and the prevalence of iron deficiency anemia increased with disability. These results are consistent with the Third National Health and Nutrition Examination Survey,[9] but the present study additionally shows that older, community-dwelling disabled women are at an especially high risk of iron deficiency anemia.

The prevalence of iron deficiency and iron deficiency anemia did not differ significantly between women with and without chronic disease. The prevalence of elevated iron stores was about twice as high among women without chronic disease than among those with. The risk of iron status abnormalities was not increased among those with chronic disease, a finding consistent with the Framingham Heart Study cohort.[8] Low income was associated with iron deficiency, which might be attributed to the fact that animal sources of bioavailable iron are relatively more expensive. Black race was the only factor associated with an increased risk of elevated iron stores, a risk that may be due to a higher prevalence of thalassemia and hemoglobinopathies among blacks.[10]

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