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Iron status of South African women working in a fruit-packing factory

P Wolmarans[1,*], MA Dhansay[1], EPG Mansvelt[2], JA Laubscher[3] and AJS Benadé[1]
[1]Nutritional Intervention Research Unit, Medical Research Council, PO Box 19070, Tygerberg 7505, South Africa:
[2]Department of Haematological Pathology, University of Stellenbosch, PO Box 19063, South Africa:
[3]Biostatistics Unit, Medical Research Council, PO Box 19070, Tygerberg 7505, South Africa

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Abstract

Objective: The aim of this study was to determine the iron status, and the risk factors for iron deficiency (ID) and iron-deficiency anaemia (IDA), of non-pregnant adult women working in a fruit-packing factory.

Design: A cross-sectional analytical study was done on 338 women, 18 to 55 years of age. Information on demographic data, risk factors for ID, smoking, and the consumption of red meat, chicken and fish was collected by questionnaire. Height and weight were measured and the body mass index (BMI) calculated. A non-fasting venous blood sample was analysed for haemoglobin (Hb), serum ferritin (SF), serum iron, serum transferrin and C-reactive protein; transferrin saturation (TFS) was calculated.

Setting: Fruit-packing factory in the Western Cape, South Africa.

Results: The mean value for Hb was 13.06 (standard deviation (SD) 1.16) $g\,dl^{-1}$ and for SF 48.0 (SD 47.8) $\mu g\,l^{-1}$ (geometric mean 26.44 $\mu g\,l^{-1}$). Women ($n = 325$) were categorised on the basis of iron status: 60% had a normal iron status (NIS); 12.6% had low TFS (<16%) but normal Hb ($\geq 12\,g\,dl^{-1}$) and SF ($\geq 12\,\mu g\,l^{-1}$) concentrations (LTS); and 27.4% had low iron status (LIS), defined as combinations of low SF ($<12\,\mu g\,l^{-1}$ or $<20\,\mu g\,l^{-1}$), low TFS (<16%) and low Hb ($<12\,g\,dl^{-1}$). More than 30% of the women were obese (BMI $\geq 30\,kg\,m^{-2}$). The risk ratio for LIS (LIS vs. NIS) was 3.8 (95% confidence interval (CI) 1.9–7.6) if women were still menstruating or 3.2 (95% CI 1.6–6.2) if they were pregnant during the past 12 months. Women with LIS consumed significantly smaller portions of red meat, chicken and fish than did women in the other two groups.

Conclusions: IDA (low Hb, SF and TFS) and ID (low SF and TFS) did not seem to be a major problem. Women who were still menstruating or were pregnant during the past 12 months were at greater risk for ID. The consumption of smaller portions of red meat, chicken and fish was related to LIS. A high prevalence of obesity, which demonstrated the coexistence of both under- and overnutrition, was observed.

Keywords
Anaemia
Iron deficiency
Iron-deficiency anaemia
Iron status
Women

Iron deficiency (ID) is a major problem world-wide, and it is known that the prevalence of ID is higher in non-industrialised than in industrialised countries[1]. 'Iron deficiency is defined as a condition in which there are no mobilizable iron stores and in which signs of a compromised supply of iron to tissues, including the erythron, are noted'[1]. Infants, young children, pregnant women, women of childbearing age, adolescents and the elderly are most at risk for developing ID. Risk factors for the development of ID are: (1) chronic blood loss, e.g. haemorrhoids, parasites, malignancy, etc.; (2) an inadequate intake of dietary iron or factors influencing the bioavailability of iron; (3) an expanding blood volume, as seen in infancy, adolescence and pregnancy, which leads to an increased iron requirement[2]; and (4) in non-pregnant women, heavy menstrual blood loss.

Many studies have focused on the iron status of pregnant women because their iron status may impact negatively on pregnancy outcome[3,4]. Less, however, is known about the prevalence of ID and iron-deficiency anaemia (IDA) in non-pregnant adult women, although they also constitute a population at risk. It is estimated that the prevalence of anaemia in non-pregnant women in Africa is about 40%, with southern Africa the least affected[1]. Information on the iron status of South African non-pregnant women is scanty[5–9] and there is a need to know more about their iron status. In a cross-sectional study of urban black South African women 15–64 years of

*Corresponding author: Email petro.wolmarans@mrc.ac.za

age, the prevalence of anaemia (haemoglobin (Hb) $<12\,g\,dl^{-1}$) varied between 22.7 and 37.2%, with the highest prevalence in women 35–44 years of age[8]. The prevalence of low serum ferritin (SF) concentrations ($<12\,\mu g\,l^{-1}$) varied between 17.5 and 24.2%. In a clinic-based study on South African women of mixed ancestry (European–African–Malay), Kruger *et al.* showed that 10% of non-pregnant women (17–39 years of age) had anaemia and 22% had low SF concentrations[7]. A cross-sectional study done in the 1970s on the Indian population of metropolitan Durban, South Africa showed that 33% of the women (up to 70+ years) had ID and 38.1% had anaemia[5].

Adult women make up a significant proportion of the work force in factories in South Africa. These women may be at risk for ID, which could impact negatively on their work performance. It has been shown that work capacity[10] and productivity[11–13] are influenced by ID, and this is especially important for women who do physical labour.

The aim of this study was therefore to determine the iron status of non-pregnant adult women working in a fruit-packing factory, and to determine the risk factors associated with ID and IDA.

Subjects and methods

Design and study population

A cross-sectional analytical study was done on women working in a fruit-packing factory situated approximately 70 km north of Cape Town, South Africa.

Three hundred and forty-two women of mixed ancestry (European–African–Malay), and between the ages of 18 and 55 years, volunteered to participate in the study. At the time of the study, approximately 700 women were working in the factory, which gives a response rate of 48.8%. The women who worked in the factory came from surrounding farms and towns.

Exclusion criteria

Women younger than 18 years of age and older than 55 years of age; pregnant women; diabetics; and women receiving tuberculosis treatment were not included in the study.

Measurements

Questionnaire

Information on age, marital status, number of children, education, income, medical information (number of pregnancies, abortions, menstrual blood loss, oral and other contraceptive use, blood loss due to blood donation and operations in the year preceding the study) and smoking history was collected by six interviewers using a structured questionnaire. Information on the frequency and amount of red meat, chicken and fish consumed was also collected. Hand-made models, representing portion sizes of 30 g, 60 g, and 90 g, were used to quantify the amount of red meat, chicken and fish usually consumed.

Anthropometry

Weight was determined to the nearest 0.1 kg on an electronic load cell scale (Precision Health Scale, UC-300; A&D Company Limited, Japan). Height was determined to the nearest 1 cm with a stature meter (2 m), with a movable bar and a steel tape, mounted to a wall. Body mass index (BMI) was calculated by the formula: weight in kg/(height in m)^2.

Blood sample

Blood was drawn into plain, ethylenediaminetetraacetic acid- and fluoride-anticoagulated tubes by antecubital vein venepuncture. A Coulter® STKS (Coulter Electronics Inc., Hialeah, FL, USA) was used for full blood count and differential white blood cell count analysis. The double-antibody ^{15}I immunoradiometric assay (Becton Dickinson and Company, Orangeburg, NY, USA) was used to determine SF. Serum iron concentration and total iron binding capacity (TIBC) were determined spectrophotometrically on a Technicon RA-1000® instrument with the ferrozine method (catalogue no. 1553 3704; Boehringer Mannheim, Germany). Transferrin saturation was calculated using the formula[14]: TFS (%) = serum iron ($\mu mol\,l^{-1}$)/TIBC ($\mu mol\,l^{-1}$) × 100. The method to determine C-reactive protein (CRP) on the Technicon RA-1000® was based on the reaction between antibody and sample CRP (antibody–antigen reaction) (Technicon Method No. SM4-0183G89).

Statistical analysis of data

The data were analysed using Microsoft® Excel 97 and SAS Version 8 (SAS Institute Inc., Cary, NC, USA), and results are presented as descriptive statistics (mean and standard deviation (SD)). The study population was also categorised into different groups based on iron status. The following criteria were used for categorisation of the women into three groups:

1. *normal iron status* (NIS) – women with Hb $\geq 12\,g\,dl^{-1}$, TFS $\geq 16\%$ and SF $\geq 12\,\mu g\,l^{-1}$;
2. *low transferrin saturation* (LTS) – women with abnormal TFS concentration ($<16\%$) but normal Hb ($\geq 12\,g\,dl^{-1}$) and SF ($\geq 12\,\mu g\,l^{-1}$) concentrations; and
3. *low iron status* (LIS) – women with SF concentration below $20\,\mu g\,l^{-1}$ but normal Hb ($\geq 12\,g\,dl^{-1}$) and TFS ($\geq 16\%$) concentrations; women with ID (normal Hb ($\geq 12\,g\,dl^{-1}$), but low SF ($<12\,\mu g\,l^{-1}$) and low TFS ($<16\%$)); women with IDA (low Hb ($<12\,g\,dl^{-1}$), low SF ($<12\,\mu g\,l^{-1}$) and low TFS ($<16\%$)); women with low Hb ($<12\,g\,dl^{-1}$) and low SF ($<12\,\mu g\,l^{-1}$), but with normal TFS ($\geq 16\%$).

To test for significant differences between three groups, the Kruskal–Wallis test was used. If a significant difference

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was found, a non-parametric Tukey-type test was used to test for significant differences between two groups.

Ethical approval

The study was approved by the Ethics Committee of the South African Medical Research Council.

Results

Table 1 presents the mean and SD for age, BMI, Hb, haematocrit, SF, serum iron, TIBC and TFS of the women. Data from four women were excluded because of incomplete biochemical data, and therefore information given in Table 1 is for 338 women. The geometric mean for SF was 26.44 $\mu g\,l^{-1}$. CRP was elevated ($>6\,mg\,l^{-1}$) in 54/338 (16%) of the women. In those women with elevated CRP, 46.3% had a cold at the time of blood sampling or had had a cold or flu during the month preceding blood sampling. A cold, flu or infection more than a month before blood sampling was reported by 16.7% of the women, while 37% of those with an elevated CRP concentration did not give any history of these indispositions. In women with LTS, 11/41 (26.8%) had an elevated CRP concentration. With the exception of two of these women, all had had a cold or flu, although in three of them it was more than a month ago. Seventeen per cent (7/41) of the women with LTS had no history of a cold, flu or infection or an elevated CRP concentration.

Table 1 Age, body mass index, haemoglobin, haematocrit and iron status variables of women 18–55 years of age ($n = 338$)

Variable	Mean	Standard deviation
Age (years)	35.0	8.7
Body mass index ($kg\,m^{-2}$)	29.0	6.1
Haemoglobin ($g\,dl^{-1}$)	13.06	1.16
Haematocrit (%)	38.8	3.1
Serum ferritin ($\mu g\,l^{-1}$)	48.0	47.8
Serum iron ($\mu mol\,l^{-1}$)	16.4	7.6
Total iron binding capacity ($\mu mol\,l^{-1}$)	68.9	9.7
Transferrin saturation (%)	24.4	11.7

Women who participated in the study were either employed full time (22.6%) or they were seasonal workers (77.4%). Some of the women worked the day shift (59.6%), while 40.4% worked the night shift. The type of work the women were doing included packing fruit into boxes (49.3%), sorting fruit (29.4%) or making cardboard boxes for packing the fruit (6.8%). The rest of the women (14.5%) were involved in tasks such as labelling the boxes, quality control, supervision and administrative work.

A high percentage of the women smoked (53.2%). The mean age of the women who smoked (34.2 (SD 8.4) years) did not differ significantly from that of non-smokers (36.0 (SD 9.0) years), but the smokers' mean BMI (27.9 (SD 5.9) $kg\,m^{-2}$) was significantly lower ($P < 0.001$) than that of the non-smokers (30.2 (SD 6.2) $kg\,m^{-2}$). The Hb of the smokers (mean 13.29 (SD 1.02) $g\,dl^{-1}$) was significantly higher ($P < 0.01$) than the Hb of the non-smokers (mean 12.88 (SD 1.27) $g\,dl^{-1}$) and the haematocrit of smokers (39.4 (SD 2.7) %) was also significantly ($P < 0.01$) higher than that of non-smokers (38.5 (SD 3.4) %). Although the mean SF concentration of the smokers (49.88 (SD 45.16) $\mu g\,l^{-1}$; geometric mean 29.53 $\mu g\,l^{-1}$) was higher than that of the non-smokers (46.27 (SD 51.56) $\mu g\,l^{-1}$; geometric mean 23.01 $\mu g\,l^{-1}$), the difference was not statistically significant. Comparison between day-shift and night-shift workers showed that, with the exception of SF concentrations, which were significantly higher ($P < 0.01$) in night-shift workers (mean 56.9 (SD 55.7) $g\,dl^{-1}$ vs. mean 42.38 (SD 41.3) $\mu g\,l^{-1}$), there were no significant differences in age, BMI, Hb, haematocrit, serum iron, TIBC and TFS.

Women were categorised into different groups on the basis of their Hb and iron status variables. Seven women who had non-iron-deficiency anaemia and six women with incomplete risk data were excluded, and results are therefore reported for 325 women (Table 2). Three distinct

Table 2 Categorisation of women into different groups based on haemoglobin and iron status variables

			Iron status		
Group	*n*	%	Haemoglobin	Transferrin saturation	Serum ferritin
Normal	195	60.0	Normal*	Normal†	Normal‡
Low transferrin saturation	41	12.6	Normal*	Low§	Normal‡
Low iron status					
Serum ferritin $<20\,\mu g\,l^{-1}$	49	15.1	Normal*	Normal†	Low¶
Iron deficiency	15	4.6	Normal*	Low§	Low‖
Iron-deficiency anaemia	21	6.5	Low**	Low§	Low‖
Low haemoglobin and ferritin	4	1.2	Low**	Normal†	Low‖

* $\geq 12\,g\,dl^{-1}$.
† $\geq 16\%$.
‡ $\geq 12\,\mu g\,l^{-1}$.
§ $< 16\%$.
¶ $< 20\,\mu g\,l^{-1}$.
‖ $< 12\,\mu g\,l^{-1}$.
** $< 12\,g\,dl^{-1}$.

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groups were identified: (1) 60% of the women had NIS; (2) 12.6% of the women had LTS; and (3) 27.4% of the women had LIS. The latter group included 15.1% of women who had an SF concentration below 20 $\mu g\,l^{-1}$, but normal Hb and TFS concentrations. ID was found in only 4.6% of the women. IDA was observed in 6.5% of the women, while 1.2% (four women) had normal TFS but decreased Hb and SF concentrations. In those women with LTS, TIBC concentrations varied between 57.99 and 88.35 $\mu mol\,l^{-1}$ (normal range 49.1–88.5 $\mu mol\,l^{-1}$; Boehringer Mannheim, package insert, September 1994).

The mean and SD for age, BMI, Hb, haematocrit, SF, serum iron, TIBC and TFS of the women in the different iron status categories are given in Table 3. Although the NIS women were older than the women with LTS or LIS, the difference was not statistically significant. Women with LIS had a significantly lower BMI than those with LTS; however, the mean BMI was above 25 $kg\,m^{-2}$. In NIS women, 26.7% had a normal BMI (BMI $\geq$ 18 and $<$25 $kg\,m^{-2}$) and 30.8% were overweight (BMI $\geq$ 25 and $<$30 $kg\,m^{-2}$), while 41.5% were obese (BMI $\geq$ 30 $kg\,m^{-2}$). Only 2/195 of the NIS women were underweight (BMI $<$ 18 $kg\,m^{-2}$). The prevalence of obesity was high in women with LTS at 58.5%, while 26.8% were overweight and 14.6% had a normal BMI. Obesity was also a problem in the women with LIS, although 36% had a normal BMI, 29.2% were overweight and 33.7% were obese. Only one of the 89 women with LIS was underweight. Significant differences between the NIS, LTS and LIS women were observed for Hb, haematocrit, SF, serum iron, TIBC and TFS (Table 3).

The menstrual history of the women is given in Table 4. Significantly more women with LIS were still menstruating compared with those with NIS or LTS. The majority of women menstruated once per month while a small percentage menstruated more than once per month (77.2 % vs. 16.7% of NIS women, 95.8% vs. 4.2% of LTS women, 78.6% vs. 16.3% of LIS women). The questionnaire was used to determine quantitatively how heavily the women menstruated and the majority indicated that they had light or normal menstrual blood loss (77.9% of NIS women, 83.3% of LTS women, 63.8% of LIS women). A higher percentage (36.3%) of women with LIS than with NIS (22.1%) or LTS (16.7%) indicated that they menstruated heavily. The relative risk for low iron status (NIS vs. LIS) was determined and the risk ratio for LIS was 3.8 (95% confidence interval (CI) 1.9–7.6) if the women were still menstruating. Significantly more women with LIS or LTS were pregnant during the past 12 months compared with those with NIS, and the relative risk for low iron status (NIS vs. LIS) was 3.2 (95% CI 1.6–6.2) if the women were pregnant during the last 12 months. Women were asked by questionnaire about their iron status and the use of iron supplements. Only 19.1% of the women with LIS indicated they were of the opinion that they had 'too little iron in the blood'. A small percentage of the women (4.5%) with LIS were using iron supplements at the time of the study, while 28.1% of them received iron supplements previously. Of the four women who had low Hb and low SF but normal TFS concentration, one received iron supplements six months and two received supplements more than a year before the study (Table 2). None of them were using iron supplements at the time of the study.

Quantitative information on nutrient intake was not collected as part of the study, but information was collected on the number of times per week the women ate red meat, chicken or fish. Approximately two-thirds of the women consumed animal protein seven days per week, while less than 10% consumed it zero to four times per week. The portion size of red meat, fish and chicken was

Table 3 Age, body mass index, haemoglobin, haematocrit and iron status variables of women with different iron status

	Iron status					
	Normal† ($n = 195$)		Low transferrin saturation‡ ($n = 41$)		Low iron status§ ($n = 89$)	
Variable	Mean	SD	Mean	SD	Mean	SD
Age (years)	36.0	8.5	34.9	9.1	33.2	8.8
Body mass index ($kg\,m^{-2}$)	29.0	6.0	32.3^{a*}	7.0	27.5^{a*}	5.5
Haemoglobin ($g\,dl^{-1}$)	13.5^{ab**}	0.8	13.0^{a**}	0.7	12.2^{b**}	1.5
Haematocrit (%)	39.9^{a**}	2.3	39.0^{b**}	1.9	36.7^{ab**}	3.9
Serum ferritin ($\mu g\,l^{-1}$)	65.7^{a**}	49.4	52.2^{b**}	42.6	8.0^{ab**}	5.8
Serum iron ($\mu mol\,l^{-1}$)	19.0^{a**}	6.9	8.8^{a**}	2.1	14.2^{a**}	8.1
Total iron binding capacity ($\mu mol\,l^{-1}$)	65.8^{a**}	8.5	70.7	8.0	75.1^{a**}	10.1
Transferrin saturation (%)	29.0^{a**}	10.3	12.5^{a**}	2.6	19.6^{a**}	11.3

SD – standard deviation.
† Haemoglobin (Hb) $\geq$ 12 $g\,dl^{-1}$, serum ferritin (SF) $\geq$ 12 $\mu g\,l^{-1}$, transferrin saturation (TFS) $\geq$ 16%.
‡ Hb $\geq$ 12 $g\,dl^{-1}$, SF $\geq$ 12 $\mu g\,l^{-1}$, TFS $<$ 16%.
§ Includes subjects with: iron-deficiency anaemia (Hb $<$ 12 $g\,dl^{-1}$, SF $<$ 12 $\mu g\,l^{-1}$, TFS $<$ 16%); iron deficiency (Hb $\geq$ 12 $g\,dl^{-1}$, SF $<$ 12 $\mu g\,l^{-1}$, TFS $<$ 16%); low SF (Hb $\geq$ 12 $g\,dl^{-1}$, SF $<$ 20 $\mu g\,l^{-1}$, TFS $\geq$ 16%); and low Hb ($<$ 12 $g\,dl^{-1}$, SF $<$ 12 $\mu g\,l^{-1}$, TFS $\geq$ 16%).
Variables with the same superscript differ significantly: *, $P < 0.01$; **, $P < 0.0001$.

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Table 4 Menstrual history of women aged 18–55 years

	Iron status		
	Normal†	Low transferrin saturation‡	Low iron status§
Sample size	195	41	89
How many women menstruated (%)	58.5[a]	58.5[b]	89.9[ab]
Pregnant in the past 12 months (%)	1.1[ab]	9.8[a]	13.5[b]

† Haemoglobin (Hb) $\geq 12\,g\,dl^{-1}$, serum ferritin (SF) $\geq 12\,\mu g\,l^{-1}$, transferrin saturation (TFS) $\geq 16\%$.
‡ Hb $\geq 12\,g\,dl^{-1}$, SF $\geq 12\,\mu g\,l^{-1}$, TFS $< 16\%$.
§ Includes subjects with: iron-deficiency anaemia (Hb $< 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $< 16\%$); iron deficiency (Hb $\geq 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $< 16\%$); low SF (Hb $\geq 12\,g\,dl^{-1}$, SF $< 20\,\mu g\,l^{-1}$, TFS $\geq 16\%$); and low Hb ($< 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $\geq 16\%$).
Values with the same superscript differ significantly, $P < 0.01$.

quantified, and it was shown that those with LIS consumed significantly smaller portions of these foods than those who had NIS (Fig. 1).

Discussion

A large percentage of the work force in South Africa is adult women and international studies have shown that ID can impact negatively on work capacity[10]. The aim of this study was to determine whether ID was also present within South African females working in a factory. Results showed that, based on the criteria used in this study, there was not a high prevalence of ID or IDA. However, if those women in whom only SF concentration was low ($< 20\,\mu g\,l^{-1}$) were also taken into account, in total 27.4% of the women had low or depleted iron stores. The

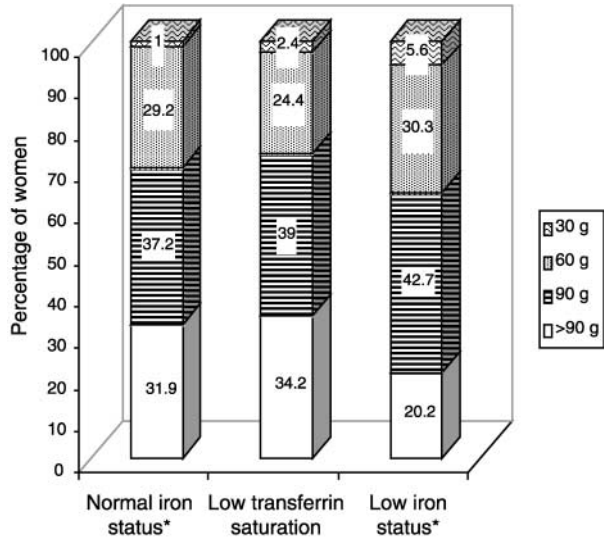

Fig. 1 Percentage of women who consumed different portion sizes of meat, fish and chicken. *Normal iron status*: haemoglobin (Hb) $\geq 12\,g\,dl^{-1}$, serum ferritin (SF) $\geq 12\,\mu g\,l^{-1}$, transferrin saturation (TFS) $\geq 16\%$; *low transferrin saturation*: Hb $\geq 12\,g\,dl^{-1}$, SF $\geq 12\,\mu g\,l^{-1}$, TFS $< 16\%$; *low iron status*: includes subjects with iron-deficiency anaemia (Hb $< 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $< 16\%$), iron deficiency (Hb $\geq 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $< 16\%$), low SF (Hb $\geq 12g\,dl^{-1}$, SF $< 20\,\mu g\,l^{-1}$, TFS $\geq 16\%$) and low Hb ($< 12\,g\,dl^{-1}$, SF $< 12\,\mu g\,l^{-1}$, TFS $\geq 16\%$). * indicates a significant difference ($P < 0.05$)

response rate in this study was low and this could have resulted in a self-selection bias. Women with a health problem or older women could have volunteered for the study. Younger women may be more vulnerable to ID than older women, because of menstruation and pregnancy. However, although the women in this study who had LIS were younger than those with NIS, the difference in age was not statistically significant.

There are indications that Hb concentrations of smokers are higher (0.3 to $0.5\,g\,dl^{-1}$) than those of non-smokers[14]. This study confirmed that the Hb concentrations of smokers were significantly higher than those of non-smokers, and the difference between the means was $0.43\,g\,dl^{-1}$. Carbon monoxide binds with Hb and this interferes with the binding of oxygen to Hb and its subsequent transport in the blood[15]. It has been shown that the carboxyhaemoglobin levels of smokers are much higher than those of non-smokers[15]. Carboxyhaemoglobin shifts the oxygen dissociation curve to the right and leads to tissue hypoxia. Polycythaemia, in which Hb levels are elevated, develops as a result of hypoxia due to chronic carbon monoxide poisoning[16].

Women lose about 25–30 ml of blood during menstruation, which is a median iron loss of $0.5\,mg\,day^{-1}$, but this can be as much as $1.6\,mg\,day^{-1}$ in women with higher menstrual blood losses[17]. A higher percentage of women with LIS than with NIS or LTS indicated that they menstruated heavily, and menstruation was clearly linked to ID in this study. Pregnancy places an additional stress on the iron status of women, with an average pregnancy requiring in total about 840 mg of iron[18]. Women who enter pregnancy with sub-optimal iron status may not – even with supplementation – be able to meet the iron requirements for pregnancy[18], which could result in postpartum ID. Those women who were pregnant during the past 12 months before this study were at risk of ID (risk ratio 3.2, 95% CI 1.6–6.2).

Low TFS concentrations were observed in 12.6% of the women and possible reasons for this low TFS concentration could be infection or chronic illness[14]. CRP can be used as an indicator of infection[19], and it was elevated ($> 6\,mg\,l^{-1}$) in 26.8% (11/41) of those with a low TFS

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concentration but normal Hb ($\geq 12\,g\,dl^{-1}$) or SF ($\geq 12\,\mu g\,l^{-1}$) concentration. Infection can result in an elevated SF concentration[19]. Therefore, based on the criteria used in this study to identify women with ID, those women with LTS could have been wrongly classified as not having ID because their SF concentrations may have been elevated as a result of infections, as indicated by elevated CRP concentrations. A large percentage of those with low TFS concentrations had a cold, flu or an infection at the time of the study or in the recent past. In chronic disease states TIBC decreases, and this can help to distinguish between a low TFS concentration indicative of ID and one indicative of disease states such as infection, inflammation or malignancy[14]. In the present study, none of the individuals with a low TFS concentration had a low TIBC. Thus, the 12.6% of women who had a low TFS concentration could possibly also be classified as having ID.

ID and IDA did not seem to be a major problem in this study population but physical work capacity can be influenced by a minimally decreased Hb concentration and non-anaemic iron deficiency, as shown by a study on cotton mill workers in China[10]. Therefore, identification and appropriate treatment, through either dietary diversification for those with LIS or iron supplementation for those with ID or IDA, could have a positive impact on the work capacity of women working in the fruit-packing industry. Li *et al.* showed that energy expenditure at work was reduced significantly by iron supplementation of women with ID and IDA, which will enable workers to do their work without too much fatigue[10]. The study of Li *et al.* also showed that the improvement of iron status had a positive effect on the energy expenditure during leisure time, enabling the women to spend more time on after-work activities[10].

Information collected by questionnaire indicated that approximately one-fifth of the women who had LIS were of the opinion that they had 'too little iron in the blood'. Few of the women with LIS were using iron supplements at the time of the study and less than a third used iron supplements previously. This demonstrates the importance of identifying women who are at risk of ID and the application of appropriate interventions to ensure that those with a problem comply with their treatment.

Although quantitative information on nutrient intake was not collected, women were questioned about the consumption of red meat, chicken and fish, which are important sources of haem iron. The majority of women consumed these sources of haem iron, as indicated above five or more times per week. What was clear, however, was that the mean portion size of the meat usually consumed by women with LIS was significantly smaller than the portion consumed by those with NIS. This suggested that women who consumed less haem iron-rich foods were more vulnerable to ID. Recommendations for the treatment of ID should highlight the importance of haem iron in the diet.

Although it was not the main focus of this study, participants were also weighed and their height was determined. Although the BMI of the women with LIS was significantly lower than the BMI of women with LTS, the mean BMI of all three iron status groups was above $25\,kg\,m^{-2}$, the cut-off point for the identification of overweight. Results clearly indicated a problem with overweight in the study population, which shows that it is imperative to have a holistic approach when planning health programmes for women working in industry and to address both under- and overnutrition. Overweight is not only a risk factor for the development of diseases of lifestyle such as hypertension, coronary heart disease, diabetes and cancer, but there are also indications that body mass can influence productivity. Untoro *et al.*[12] showed that, in Indonesian female factory workers, those with a BMI of 18.5 to $22.5\,kg\,m^{-2}$ had higher productivity than those with a BMI above $22.5\,kg\,m^{-2}$. A higher fat mass may partially explain the lower production, but they showed that lean body mass rather than BMI may be an indicator of low producers.

In conclusion, based on the criteria used, ID and IDA were not a major problem in this study population. There were, however, indications that women with LTS could also be classified as iron-deficient. In addition, on the basis of SF concentrations only, the iron status of 27.4% of the women was compromised and they had no or low iron reserves. This indicates the need for appropriate strategies to identify these women and for implementing dietary diversification and also supplementation programmes where necessary to address the problem. The fortification of staple foods such as maize meal and wheat flour with (among other things) iron will soon be introduced in South Africa. This strategy could help to alleviate the problem of ID in vulnerable women. The study also showed that not only under- but also overnutrition was present, because there were indications of a high prevalence of obesity in the study population. A comprehensive health programme for women working in factories could not only improve productivity but also may improve work capacity, as shown in the literature, and this could be to the advantage of both employer and employee.

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