ORIGINAL ARTICLE

Frequency of Iron Deficiency among Sudanese Female Blood Donors in Childbearing Period

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ABSTRACT

Background: Blood donations have a great impact in medicine. Annually, large amounts of financial funding are expended to ensure the safety of recipients, but very little attention is given to the state of well-being of blood donors.
Aim: To determine the extent of iron deficiency state (ID) in Sudanese blood donors to predict the possible occurrence of iron deficiency anaemia after donation.
Methods: One hundred Sudanese female blood donors from different universities volunteered to join the study. Their ages ranged from 18 years old to 27 years old. Complete cell count (CBC) was determined by using a haematology analyser (Mindary 3000) and serum ferritin using Minividas, whereas serum iron and total iron binding capacity were measured by using a chemistry analyser (Mindray BS-200). The participants were divided into three groups according to their haemoglobin (HGB) and serum ferritin levels. Group I comprised 45 normal subjects with normal HGB and ferritin level. Group II comprised 35 subjects with ID and with normal HGB and low ferritin levels. Group III comprised 20 subjects with ID anaemia (IDA) with low HGB and ferritin levels.
Results This study revealed a significant decrease in HGB level (*p*-value=0.000) and serum ferritin level (*p*-value=0.000) in female blood donors who had ID and IDA when compared with those with normal iron stores.
Conclusion: Blood collection centres should assess the iron stores of female blood donors who are of childbearing age. Iron replacement treatment needs to be offered to female blood donors with low ferritin to minimise the risk of iron depletion. Moreover, donors with low HGB levels can choose to defer their donation to a later date
Keywords: Female Donors, Hemoglobin, serum ferritin, iron Deficiency.

INTRODUCTION

Blood donation is a vital part of worldwide healthcare. Over one hundred million units of blood are donated each year throughout the world. Iron deficiency is a global problem in women of child bearing age and is related with adverse maternal and newborn outcomes[1,2].

Iron deficiency anemia is common, mainly in women, for whom pregnancy and menstruation are the dominant causes. Blood donation in this already vulnerable population can cause or contribute to ID and IDA, with recurrent donation increasing the risk. Women of childbearing age with ID or IDA should decrease donations to twice a year, once iron and hemoglobin levels have returned to normal[3].

To improve the general health of the donor population, a better understanding of the health implications of blood donation is needed. Blood donors are at increased risk of iron deficiency. A link between anemia and a reduced quality of life is well recognized. However, the current knowledge on health-related consequences or manifestations of iron deficiency without anemia is limited[4].

Although iron deficiency is surprisingly prevalent in first-time donors, its prevalence is even higher in the particularly frequent donor volunteers, especially among women of childbearing age. In the Recipient Epidemiology Donor Evaluation Study (REDS)-II Donor Iron Status Evaluation (RISE) study, up to 49% and 66% of male and female frequent donors, respectively, had either iron depletion (i.e., absent iron stores) or iron-deficient erythropoiesis[5,6].

According to American Association of Blood Banks (AABB), to be eligible to donate blood potential donors must be at least 16 years of age, weigh at least 50 kilograms and not be currently ill, have unregulated hypertension, diabetes, or be anemic. The donor's vital signs should also be monitored. The minimum allowable hemoglobin level for blood donation in the United States set forth by the United States Food and Drug Administration for men and women is 13.0 and 12.5 g/dL, respectively[7].

While iron deficiency is still the most common cause of anemia, iron deficiency (ID) without anemia frequently remains undiagnosed. Iron stores can be depleted entirely without causing anemia, as there is still enough iron in the body from the daily turnover of red cells that the body can use for RBC production. Iron is essential for synthesis of haemoglobin (HGB), myoglobin, DNA and for generating energy from mitochondria. In cells, iron is stored in ferritin[8,9].

Hemoglobin is the most abundant iron-containing protein in humans. More than one-half of total-body iron is contained within hemoglobin. Based on the location of haemoglobin in erythrocytes, anemia is a characteristic trait of iron deficiency[10].

Ferritin reflects true iron stores and is not susceptible to the short-term variations that occur with serum iron levels and TIBC. Iron deficiency anemia is likely if the ferritin level is less than 15 ng per mL (15 mcg per L) in an otherwise healthy child[11].

Low serum ferritin is highly specific for iron deficiency anemia, Canadian Blood Services has begun to study

ferritin levels in blood donors, in addition to the current point-of-care hemoglobin testing, to determine the extent of ID in donors and update recommendations accordingly[12,13].
Few studies have measured the iron store levels in child bearing women blood donors. This study will aim to investigate the extent of the iron deficiency state among Sudanese female blood donors in order to predict the possible occurrence of iron deficiency anemia after donation. Furthermore, the study will measure the iron store status (Ferritin levels) and its association with iron deficiency in female blood donor

METHODS

This cross sectional study was conducted at different universities in Khartoum state in Sudan with Blood donation campaigns of national health laboratory at Sudan University of science and technology in tow branches Weston and East, Al Imam Al hady Collage, Al-Mughtribeen University and Al - Ahfad University for women during the period from July 2017 to August 2020. This study included one hundred (100) female blood donors in reproductive period of life. The female donors, apparently healthy, voluntarily gave their biodata with the aid of a questionnaire, before every blood drive, a medical examination with an interrogation eliminating any suspicion of diseases or visible pathologies. These female donors to be eligible to donate blood potential donors must be at least 16 years of age (though this age may be older in some states), weigh at least 50 kilograms. The minimum allowable hemoglobin level for female blood donation is 12.5 g/dL.
xclusion criteria was lactated or pregnant women, or presence with chronic diseases (such as bronchial asthma, diabetes mellitus, cardiac diseases, hereditary anemia (such as sickle cell anemia or thalassemia), parasitic infections also, psychiatric conditions, and medical treatment or surgical intervention that could interfere with iron absorption. Approval for the study was granted by Committee of scientific Research of Al-Neelain university. In addition, a voluntary informed consent was being obtained from each participant.
Blood sampling: In this study, we followed the standard protocol of collecting blood samples to minimize the interpersonal variability. For every female donor, the blood samples were withdrawn from the antecubital vein, in system Vacutainer of 4ml containing an anticoagulant the EDTA. The complete blood count CBC test was performed the same day within 2 hours of collection. Plain container of 5 ml without anticoagulant for serum iron, serum ferritin and total iron binding capacity (TIBC).
Hematological and chemical analysis: A complete blood count (CBC) and differential was performed on the blood sample using automated haematology analyzer (Mindray 3000).

Serum ferritin was performed using MiniVidas chemistry analyzer. Serum iron and total iron binding capacity were performed by Mindray BS-200 Chemistry Analyzer. Standardization, calibration of the instrument, and processing of the samples were done according to the manufacturer's instructions.

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The precision and accuracy of all methods used in this study were checked each time a batch was analysis by including calibrators and commercial prepared control sera.
Statistical analysis: The data were analyzed by means of the software SPSS version 23.0. The results were presented in tables and figures. The analysis of variance and the difference among the means for significants less than 0.05 level using ***t.* test**, the relationship between variables were determined using correlation test.

RESULTS

This study included hundred (100) subjects, i.e. female blood donors who are in their reproductive period of life. They were divided into three groups according to their haemoglobin (HGB) and serum ferritin levels. **Group I** comprised 45 normal subjects with normal HGB and ferritin levels. **Group II** comprised 35 subjects with iron deficiency (ID) and with normal HGB and low ferritin levels. Group III comprised 20 subjects with iron deficiency anaemia (IDA) with low HGB and ferritin levels. The frequency of ID state among these Sudanese female blood donors was determined. The mean ± standard deviation |(SD) of their ages was 22.4±4.6 years old, and their ages ranged from 17.8 years old to 27 years old. The haematological and biochemical parameters of all female donors in the study group, along with their mean values and standard deviation (SD±), are shown in Table 1**.**

Table 2 shows the distribution of female donors (n=100) according to the frequency of donation. Among those who were one-time donors (n=88), 47% had normal ferritin level, whereas 53% had low serum ferritin. Among those who donated blood for the second time, (n=12), 33% had normal ferritin level, whereas 67% had low serum ferritin level.

Table 3 shows the results of a comparative study between groups, i.e. group I versus II, group II versus III and group I versus III, for the mean values and standard deviation (SD±) of the following haematological and biochemical parameters: HGB, MCH, MCHC, RBCs, MCV, HCT, RDW, WBCs, platelet, serum ferritin, serum iron and TIBC. Groups I and II showed highly statistically significant differences in serum ferritin (p-value=0.000), but no significant difference was found for HGB, MCH, MCHC, RBCs, MCV, HCT, RDW, WBCs, platelet, serum ferritin, serum iron, and TIBC (p-value=0.72, 0.36, 0.26, 0.46, 0.11, .36, 0.18, 0.28, 0.07, 0.43, 0.37, respectively).

Groups II and III showed a highly statistically significant difference for HGB, MCHC, RBCs, HCT, RDW and serum ferritin (p-value=0.000, 0.000, 0.000, 0.000,0.005, 0.011, respectively), but no significant difference was found for MCH, MCV, WBCs, platelets, serum iron and TIBC (p-value=0.052, 0.54, 0.83, 0.84, 0.961, respectively).

Groups I and III showed a highly statistically significant difference for HGB, MCH, CHC, RBCs, HCT, RDW and serum ferritin (p-value=0.000 ,0.000 ,0.000 ,0.002, 0.000, 0.000, 0.000, respectively), but no significant difference was found for MCV, WBCs, platelet, serum iron and TIBC (p-value=0.154, 0.555, 0.534, 0.468, 0.387, respectively)

Table 1: Mean values with standard deviation (SD±) and range of initial hematological and biochemical parameters among all the 100 female donors

Parameters	Mean± SD	Range
HGB(g/dl)	12.3±0.83	13.1 – 11.5
MCH Pg	27.8±5.9	33.7 - 22
MCHC (%)	31.6±1.4	33 - 30.2
RBC×10^{12}/L	4.47±0.34	4.8 - 4.1
MCV/ fl	85.1±8.8	94 - 76.3
HCT(%)	38.4±2.7	41.1 - 36
RDW (%)	14.2±0.86	15.1 - 13.3
WBC	6.2± 1.96	8.2 - 4.2
Platelets	287.0± 88.0	375 - 199
Serum Iron	64.6± 24.4	89 - 40.2
Serum ferritin	25.7±22.2	48 - 3.5
TIBC	195.3± 74.4	120.9-269.7

Table 2: Distribution of studied female donors according to the frequency of donation.

Serum Ferritin	Frequency of donation	
	One-time donation (N=88/100)	More than one-time donation (N=12/100)
Normal	47%	33%
Low	53%	67%

Table 3: Comparative study between Group I (**Normal subjects**) versus II(**Irion deficiency state)** , II versus III (Irion deficiency anemia(IDA) and I versus III regarding mean values and standard deviation (SD±) of hematological and biochemical parameters

Parameters	Mean± SD (Range)			P-value		
	Group (I) N=45/100 (45 %)	Group (II) N=35/100 (35%)	Group III N=20/100 (20%)	Group (I and II)	Group (II and III)	Group (I and III)
HGB(fl)	12.78±0.48 (13.3 -12.3)	12.75±0.43 (13.2 -12.2)	11.19±0.56	0.724	0.000	0.000
MCH(pg)	27.68±1.76 (29.4 -25.6)	27.45±1.46 (28.9 – 25.9)	26.45±1.92	0.363	0.052	0.000
MCHC(%)	31.78±1.24 (33 -30.5)	32.09±1.20 (33.3 -30,9)	30.58±0.72	0.267	0.000	0.000
RBC(10^{12}/l)	4.55±0.37 (4.9 – 4.2)	4.60±0.30 (4.9 – 4.3)	4.23±0.34	0.463	0.000	0.002
MCV(g/dl)	87.11±5.69 (92.8 – 81.4)	84.21±9.59 (93.8 – 74.6)	81.80±12.07	0.119	0.536	0.154
HCT(%)	39.46±2.63 (42.1 – 36.8)	38.95±2.26 (41.2 – 36.7)	36.40±1.83	0.363	0.000	0.000
RDW-(%)	13.97±0.76 (14.7 – 13.2)	14.19±0.73 (14.9 – 13.5)	14.86±0.82	0.177	0.005	0.000
WBC(10^9/l)	6.31±2.33 (8.6 – 3,9)	5.87±1.26 (7.1- 4.6)	5.98±1.99	0.281	0.831	0.555
Platelet	297.29±76.39 (373.7 – 220.9)	258.83±102.27 (361,1 -156.6)	311.45±86.98	0.068	0.049	0.534
Serum Ferritin (ng/ml)	40.79±15.89 (56.7- 24,9)	12.24±3.85 (16.1 -8.4)	9.21±4.14	0.000	0.011	0.000
Serum Irion (mg/dl)	62.26±28.28 (90.5 – 33.9)	66.53±19.59 (86.2 – 46,9)	67.80±24.37	0.427	0.844	0.468
TIBC (µg/ dl)	186.78±84.86 (271.6 – 101.9)	201.99±59.73 (261.7 – 142.2)	202.95±73.71	0.368	0.961	0.387

RBCs=Red blood cells; HGB=hemoglobin Hct=hematocrit; MCV= mean corpuscular volume; MCH= mean corpuscular hemoglobin; MCHC= mean corpuscular hemoglobin concentration; Plts= platelets; WBCs= white blood cells; RDW= red blood cells distribution width; SF= serum ferritin; SD= standard deviation.

Data are expressed as mean and ± SD & comparative analysis using Independent T-test

^{NS} p > 0.05 = NS= not significant.

***p< 0.001 = very highly significant.

** p< 0.01 = highly significant

* p< 0.05 = significant

Figure 1: Comparative results regarding HGB (haemoglobin), SF (serum ferritin) & MCV (mean corpuscular volume) among studied subjects with Normal HGB levels classified into 2 groups: Subjects with ID state & normal iron store.

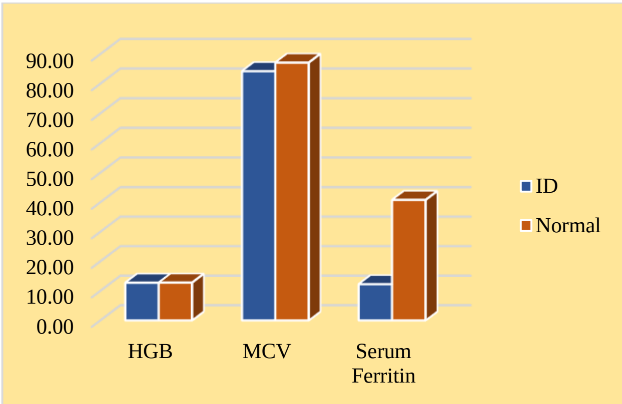


Figure 2: A scattered plot shows strong relationship between the serum ferritin mg /dl and HGB levels per g /dl (r= 0.44, p= 0.00) among female donors

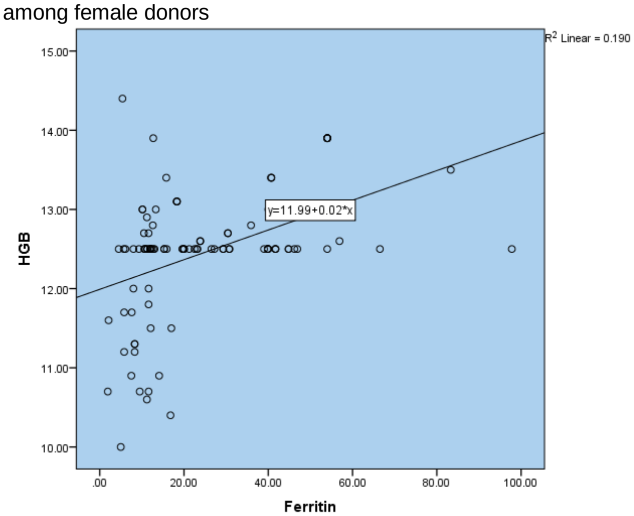
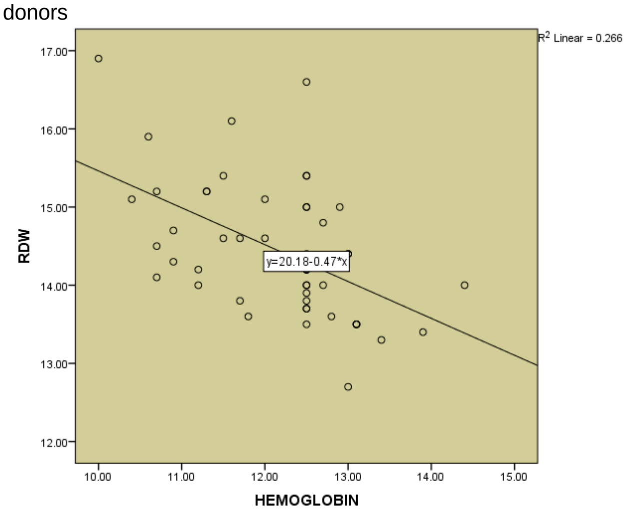


Figure 3: A scattered plot shows strong relationship between RDW (%) and HGB levels per g /dl (r= 0.52, p= 0.00) among female donors



DISCUSSION

The incidence of iron reduction is high in individuals who donate whole-blood frequently. Low HGB is the most common cause (10%) for whole-blood donation deferral in the United States, but HGB is a poor predictor of iron stores. Nevertheless, in relation with HGB, most of the frequent blood donors have low iron stores or iron-deficient state[14].

This study aimed to measure the level of iron stores among Sudanese female blood donors whose are of childbearing age and to explain its association with iron deficiency state to predict the possible occurrence of iron deficiency anaemia after donation.

The mean HGB level was 12.3±0.8 g/dl, and the mean serum ferritin level was 25.7 ± 22.2ng/ml in the female blood donors. This result agrees with those obtained by Lobier M *et al*., who found that the mean level of serum ferritin in premenopausal woman donors was 26 ng/ml[15].

This result nearly agrees with those of Patel *et al*., who found that the serum ferritin levels were lower in blood donors, and the prevalence of iron deficiency anaemia was higher in blood donors compared with non-donor adolescent females[16].

The current study showed that the percentage of low serum ferritin among donors who are not first-time donors was 67%, while this was 53% among the one-time donors. These findings agree with those of Fouz AA *et al.,* who found that regular blood donors were more prone to having lower body iron stores and to develop latten iron deficiency anaemia compared with first-time donors[17].

The abovementioned results relatively agreed with those of Deepa DG *et al*., who found that there was a definite correlation between the dwindling of serum ferritin level and the frequency of donation[18].

The results also agreed with those of Shastry *et al*., who found that first-time donors have higher serum ferritin levels than repeat donors[19].

The present study revealed that the percentage of group III (iron deficiency anaemia) was 20%. This result disagreed with the result of Shastry et al.**,** who found that 11.2% of donors had iron deficiency; this finding may be related to the difference in sample population and the food habit of the sample population[20].

The present study showed a significant decrease in serum ferritin (p-value=0.000) in donors with iron deficiency and iron deficiency anaemia than in donors with normal iron stores. This result agreed with Shastry *et al.,* who found a significant difference in the mean serum ferritin of regular voluntary blood donors[21].

The present study revealed a significant decrease in HGB levels in iron deficient and anaemic female donors when compared with those with normal iron stores. This result agree with that of Abuaisha, M. *et al*. (2020), who showed that iron deficiency without anaemia was significantly associated with the level of HGB among females. Explicit iron deficiency anaemia developed within the 5 years follow-up period in 14% of females and 0.5% of males. There was a statistically significant association between iron deficiency and menorrhagia. The prevalence of iron deficiency without anaemia was 57.5% among females and 7.6% among males[22].

In the current study, there was a significant positive correlation between the HGB and ferritin levels in female blood donors (*p*-value=0.000, r-value=0.44). This finding agreed with that of Dong-wook Tung MD *et al.* (2017), who found a positive relationship between serum ferritin and HGB levels and bone mineral content[23].

In this study, there was significant negative correlation between the HGB and RBC distribution rate in female blood donors (*p*-value=0.000, r-value=0.52). This result was in accordance with that of Miyamoto, K *et al.* **(**2015), who showed that elevated RDW levels correlated significantly with increased anaemia[24].

Measurement of the serum ferritin in female blood donors, especially in those who regularly donate blood, is preferable. We found that most of the female blood donors, especially those have donated more than once a year may be at risk of developing IDA, and they may need to determine if they need iron supplementation.

CONCLUSION

From the obtained results, 35% of eligible female blood donors of childbearing age suffered from iron deficiency; their mean serum ferritin levels are below the reference range. They are prone to developing iron deficiency anaemia after donation. Simply determining the level of haemoglobin is not a good indicator of the state of iron stores, and it is not enough to ascertain the ability for donation, particularly for women of childbearing ages. Measurement of the ferritin level is the best test to evaluate the iron stores. It can be used as a criterion to determine the donor's fitness and improve donor safety.

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