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(RESEARCH ARTICLE)

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Assessment Of serum ferritin level, hemoglobin concentration and red blood cell indices in apparently healthy Sudanese blood donors attending central blood bank Gezira State –Sudan (2020)

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Abstract

Objectives: To correlate the serum Ferritin level, hemoglobin concentration and red blood cell indices among blood donors.

Material and Methods: This is prospective, cross-sectional analytical study. Conducted in Wad-Madani central blood bank, Gezira state from July to December 2020. Venous blood samples were taken from 140 donors. The blood samples were investigated for various haematological parameters on a fully automated haematology analyzer (Sysmex xp-300). Serum Ferritin was estimated using chemical analyzer (A15).

Results: The mean value of serum Ferritin was found to be (141.46 ±97.85). The study showed normal serum Ferritin level in 122 (87%) of blood donors and low serum Ferritin in 6 of male blood donors (4.3%). 12 of blood donors showed serum Ferritin level above the normal range (8.6%).

Conclusion: The study concluded that regular blood donation had less effect on serum ferritin level.

Keywords: Ferritin; Hemoglobin; Blood Donors; Red Blood Cell

1. Introduction

Regular blood donation may be one of the important causes of iron depletion in blood donors [1], which can lead to iron deficiency. High prevalence rates are seen in blood donors worldwide, despite rational attempts in some jurisdictions to lessen the risk by setting higher pre-donation hemoglobin (Hb) cut-offs, reducing the frequency of donation or restricting the annual limit on the number of times blood donation is permitted. Likewise, the decades-old approach of advising donors to consume iron-rich foods has been an ineffective strategy to ameliorate this condition [2].

Calls to address ID in blood donors have been made for decades and there has always been a societal expectation that blood collectors should advocate for donor health, given the altruistic, voluntary nature of a blood donation. So, why has this issue of mitigating ID in blood donors resurfaced now? First, new information from large-scale studies has confirmed the high prevalence of ID and the subgroups at risk [3]. Second, studies have focused attention on the potential adverse effects of ID, particularly non-anemic ID. Most importantly, controlled trials have refined the dose-response benefits of iron supplementation, and the potential effectiveness of strategies to improve iron balance. While these studies have closed many of the scientific gaps, other, chiefly operational issues remain to be fully worked out. In the US and a few other countries, high school-aged donors are one of the fastest growing donor subgroups, with 15% of

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the blood supply in the US now being donated by teenagers [4], and new information has highlighted the potential impact of ID on adolescent brain development [5]. Forty-three US states allow donation by 16-year-olds; given that 16- to 18-year-olds are still maturing physically and cognitively, the donor and public health implications of ID in young individuals are considerable.

Maintaining donor health and vitality, as well as patient safety, are key goals for blood collectors and for public health. On top of (or because of) these concerns, increased regulatory attention has been focused on ID in blood donors (US Food and Drugs Administration [6].

1.1. Ferritin

Ferritin is a universal intracellular protein that stores iron and releases it in a controlled fashion. The protein is produced by almost all living organisms, including archaea, bacteria, algae, higher plants, and animals. In humans, it acts as a buffer against iron deficiency and iron overload [7]. Ferritin is found in most tissues as a cytosolic protein, but small amounts are secreted into the serum where it functions as an iron carrier. Plasma ferritin is also an indirect marker of the total amount of iron stored in the body; hence, serum ferritin is used as a diagnostic test for iron-deficiency anemia [8].

Ferritin is a globular protein complex consisting of 24 protein subunits forming a nanocage with multiple metal–protein interactions. It is the primary intracellular iron-storage protein in, keeping iron in a soluble and non toxic form. Ferritin that is not combined with iron is called apoferritin. Ferritin genes are highly conserved between species. All vertebrate ferritin genes have three introns and four exons [9]. In human ferritin, introns are present between amino acid residues 14 and 15, 34 and 35, and 82 and 83; in addition, there are one to two hundred untranslated bases at either end of the combined exons. The tyrosine residue at amino acid position 27 is thought to be associated with biomineralization [10].

1.2. Structure of ferritin

Ferritin is a hollow globular protein of mass 474 kDa and comprising 24 subunits. It is present in every cell type. Typically it has internal and external diameters of about 8 and 12 nm, respectively. The nature of these subunits varies by class of organism [11]:

- In vertebrates, the subunits are of two types, light (L) and heavy (H), which have apparent molecular mass of 19 kDa and 21 kDa, respectively; their sequences are homologous (about 50% identical).
- Amphibians have an additional ("M") type of ferritin.
- Plants and bacteria have a single ferritin; it most closely resembles the vertebrate H-type.
- In the case of gastropods of the genus Lymnaea, two types have been recovered, from somatic cells and the yolk, respectively (see below).
- In the pearl oyster Pinctada fucata, an additional subunit resembling Lymnaea soma ferritin is associated with shell formation.
- In the parasite Schistosoma, two types are present: one in males, the other in females.

All the aforementioned ferritins are similar, in terms of their primary sequence, with the vertebrate H-type. In *E. coli*, a 20% similarity to human H-ferritin is observed. Inside the ferritin shell, iron ions form crystallites together with phosphate and hydroxide ions. The resulting particle is similar to the mineral ferrihydrite. Each ferritin complex can store about 4500 iron (Fe^{3+}) ions [12].

Some ferritin complexes in vertebrates are hetero-oligomers of two highly related gene products with slightly different physiological properties.

The ratio of the two homologous proteins in the complex depends on the relative expression levels of the two genes [12].

A human mitochondrial ferritin, MtF, was found to express as a pro-protein. When a mitochondrion takes it up, it processes it into a mature protein similar to the ferritins found in the cytoplasm, which it assembles to form functional ferritin shells. Unlike other human ferritins, it appears to have no introns in its genetic code.

An X-ray diffraction study has revealed that its diameter is 1.70 angstroms (0.17 nm), it contains 182 residues, and is 67% helical. The mitochondrial ferritin's Ramachandran plot shows its structure to be mainly alpha helical with a low prevalence of beta sheets [12].

1.3. Function of ferritin

1.3.1. Iron storage

Ferritin serves to store iron in a non-toxic form, to deposit it in a safe form, and to transport it to areas where it is required. The function and structure of the expressed ferritin protein varies in different cell types. This is controlled primarily by the amount and stability of messenger RNA (mRNA), but also by changes in how the mRNA is stored and how efficiently it is transcribed. One major trigger for the production of many ferritins is the mere presence of iron; an exception is the yolk ferritin of *Lymnaea sp.*, which lacks an iron-responsive unit [13].

Free iron is toxic to cells as it acts as a catalyst in the formation of free radicals from reactive oxygen species via the Fenton reaction. Hence vertebrates have an elaborate set of protective mechanisms to bind iron in various tissue compartments. Within cells, iron is stored in a protein complex as ferritin or the related complex hemosiderin. Apoferritin binds to free ferrous iron and stores it in the ferric state. As ferritin accumulates within cells of the reticuloendothelial system, protein aggregates are formed as hemosiderin. Iron in ferritin or hemosiderin can be extracted for release by the RE cells, although hemosiderin is less readily available. Under steady-state conditions, the level of ferritin in the blood serum correlates with total body stores of iron; thus, the serum ferritin FR5Rl is the most convenient laboratory test to estimate iron stores [14]. Because iron is an important mineral in mineralization, ferritin is employed in the shells of organisms such as molluscs to control the concentration and distribution of iron, thus sculpting shell morphology and colouration. It also plays a role in the haemolymph of the polyplacophora, where it serves to rapidly transport iron to the mineralizing radula [15].

Iron is released from ferritin for use by ferritin degradation, which is performed mainly by lysosomes [16].

1.3.2. Ferroxidase activity

Vertebrate ferritin consists of two or three subunits which are named based on their molecular weight: L "light", H "heavy", and M "middle" subunits. The M subunit has only been reported in bullfrogs. In bacteria and archaea, ferritin consists of one subunit type. H and M subunits of eukaryotic ferritin and all subunits of bacterial and archaeal ferritin are H-type and have ferroxidase activity, which is the conversion of iron from the ferrous (Fe^{2+}) to ferric (Fe^{3+}) forms. This limits the deleterious reaction which occurs between ferrous iron and hydrogen peroxide known as the Fenton reaction which produces the highly damaging hydroxyl radical [17]. The ferroxidase activity occurs at a diiron binding site in the middle of each H-type subunits. After oxidation of Fe(II), the Fe(III) product stays metastably in the ferroxidase center and is displaced by Fe(II), a mechanism that appears to be common among ferritins of all three kingdoms of life. The light chain of ferritin has no ferroxidase activity but may be responsible for the electron transfer across the protein cage [18].

1.3.3. Immune response

Ferritin concentrations increase drastically in the presence of an infection or cancer. Endotoxins are an up-regulator of the gene coding for ferritin, thus causing the concentration of ferritin to rise. By contrast, organisms such as *Pseudomonas*, although possessing endotoxin, cause plasma ferritin levels to drop significantly within the first 48 hours of infection. Thus, the iron stores of the infected body are denied to the infective agent, impeding its metabolism [19].

1.3.4. Diagnostic use of serum ferritin

Serum ferritin levels are measured in medical laboratories as part of the iron studies workup for iron-deficiency anemia. The ferritin levels measured usually have a direct correlation with the total amount of iron stored in the body. However, ferritin levels may be artificially high in cases of anemia of chronic disease where ferritin is elevated in its capacity as an inflammatory acute phase protein and not as a marker for iron overload [19].

1.3.5. Normal ranges

A normal ferritin blood level, referred to as the reference interval is determined by many testing laboratories. The ranges for ferritin can vary between laboratories but typical ranges would be between 30–300 ng/mL (=µg/L) for males, and 30–160 ng/mL (=µg/L) for females. A value less than 50 is considered as iron deficiency [19]

Table 1 Normal Ferritin blood levels according to sex and age (Carmona et al 2014)

Men	20–270 nanograms per milliliter (ng/mL)
Women	30–160 ng/mL
Children (6 months to 15 years)	50–140 ng/mL
Infants (1 to 5 months)	50–200 ng/mL
Neonates	25–200 ng/mL

1.3.6. Deficiency

If the ferritin level is low, there is a risk for lack of iron, which could lead to anemia or iron deficiency without anemia. In the setting of anemia, low serum ferritin is the most specific lab finding for iron-deficiency anemia. However it is less sensitive, since its levels are increased in the blood by infection or any type of chronic inflammation, and these conditions may convert what would otherwise be a low level of ferritin from lack of iron, into a value in the normal range. For this reason, low ferritin levels carry more information than those in the normal range. Low ferritin may also indicate hypothyroidism, vitamin C deficiency or celiac disease. Low serum ferritin levels are seen in some patients with restless legs syndrome, not necessarily related to anemia, but perhaps due to low iron stores short of anemia [20].

A *falsely low* blood ferritin (equivalent to a false positive test) is very uncommon, but can result from a hook effect of the measuring tools in extreme [21].

Vegetarianism is not a cause of low serum ferritin levels, despite the common myth. The Position of the American Dietetic Association pointed this out in 2009 stating, "Incidence of iron-deficiency anemia among vegetarians is similar to that of non-vegetarians. Although vegetarian adults have lower iron stores than non-vegetarians, their serum ferritin levels are usually within the normal range [21].

1.3.7. Excess

If ferritin is high, there is iron in excess or else there is an acute inflammatory reaction in which ferritin is mobilized without iron excess. For example, ferritins may be high in infection without signaling body iron overload. Ferritin is also used as a marker for iron overload disorders, such as hemochromatosis or hemosiderosis. Adult-onset Still's disease, some porphyrias, and hemophagocytic lymphohistiocytosis /macrophage activation syndrome are diseases in which the ferritin level may be abnormally raised. As ferritin is also an acute-phase reactant, it is often elevated in the course of disease.

A normal C-reactive protein can be used to exclude elevated ferritin caused by acute phase reactions [22].

Ferritin has been shown to be elevated in some cases of COVID-19 and may correlate with worse clinical outcome. According to a study of anorexia nervosa patients, ferritin can be elevated during periods of acute malnourishment, perhaps due to iron going into storage as intravascular volume and thus the number of red blood cells falls [23].

Another study suggests that due to the catabolic nature of anorexia nervosa, isoferritins may be released. Furthermore, ferritin has significant non-storage roles within the body, such as protection from oxidative damage. The rise of these isoferritins may contribute to an overall increase in ferritin concentration. The measurement of ferritin through immunoassay or immunoturbidimeteric methods may also be picking up these isoferritins thus not a true reflection of iron storage status [24].

It has been revealed that a transferrin saturation (serum iron concentration ÷ total iron binding capacity) over 60 percent in men and over 50 percent in women identified the presence of an abnormality in iron metabolism (Hereditary hemochromatosis, heterozygotes and homozygotes) with approximately 95 percent accuracy. This finding helps in the early diagnosis of hereditary hemochromatosis, especially while serum ferritin still remains low. The retained iron in hereditary hemochromatosis is primarily deposited in parenchymal cells, with reticuloendothelial cell accumulation occurring very late in the disease. This is in contrast to transfusional iron overload in which iron deposition occurs first in the reticuloendothelial cells and then in parenchymal cells. This explains why ferritin levels remain relative low in Hereditary hemochromatosis, while transferrin saturation is high [25].

1.3.8. Serum ferritin in relation to blood donation

Regular donation may be one of the important causes of iron loss in blood donors. Bleeding results in movement of iron from body stores. As iron storage reduces, its absorption increases subsequently. With frequent blood donation, an individual either reaches stability at a lower level of iron stores or becomes anemic.

One mL of blood consists of 0.5 mg of iron. Thus, a unit of blood (450 mL) contains nearly 250 mg of iron, representing about 30% of the average body iron stores (BIS) in males and nearly 80% in females [26]. Iron deficiency is often observed in long-term regular blood donors. The frequency of blood donation has been so regulated as to prevent anemia in most donors, but quantitative information regarding the iron status of donors is still limited till date. Screening for hemoglobin concentration (Hb) is a conventional part of the donor selection process, both in order to assure adequate quality of red cell concentrates collected and to safeguard the potential donor's health [27]. It is established that iron-deficiency anemia is the last stage in the pathogenesis of body iron depletion, and it is apparent that Hb levels by themselves are insufficient data for identifying blood donors with iron deficiency without anemia. Accurate diagnosis and detection of iron deficiency at an early phase require further laboratory testing with a high degree of accuracy and precision [28].

It has been predicted that donors deferred for low Hb donate relatively 30% less blood over the subsequent 4-to-5-year period, even after their Hb normalizes in comparison to the donors who have not been deferred. Considering donors deferred for low Hb constitutes a significant percentage of the total donor population. Understanding the prime causes for the deferrals and establishing an action plan to prevent them will help promote the blood donor well-being and improve the ever-declining donor pool. To accomplish the worldwide and nationwide drive to recruit and retain regular and repeat voluntary nonremunerated blood donors, the iron status of the donors must be diagnosed, and essential steps for iron supplementation should be taken [29].

1.4. Causes of iron deficiency

Chronic blood loss

Uterine, Gastrointestinal, e.g. peptic ulcer, esophageal varices, aspirin (or other non - steroidal anti-inflammatory drugs) ingestion, partial gastrectomy, carcinoma of the stomach, caecum, colon or rectum, hookworm, colon or rectum, hookworm, angiodysplasia, colitis, piles, diverticulosis Rarely, hematuria, hemoglobinuria, pulmonary, hemosiderosis, self - inflicted blood loss.

Increased demands

- Prematurity
- Growth
- Pregnancy
- Erythropoietin therapy

Malabsorption

Gluten - induced enteropathy, gastrectomy, autoimmune gastritis

Poor diet:

A major factor in many developing countries but rarely the sole cause in developed countries

1.4.1. Justification

Regular blood donation can lead to pre-clinical iron deficiency as well as iron deficiency anemia. There is a need to increase the national voluntary blood donation for safe blood Supply. Effect of frequent blood donation on iron store.

This has been the first study ever conducted in Gezira state.

Objectives

General objective

To correlate between the serum Ferritin level, hemoglobin concentration and red blood cell indices among blood donors.

Specific objective

- To measure serum Ferritin level in Sudanese blood donors.
- To measure hemoglobin concentration, Mean cell volume (MCV), Hematocrit (HCT), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC).

2. Methodology

2.1. Study design

This is a prospective, cross-sectional analytical study.

2.2. Study area

The study was conducted in Wad-Madani central blood bank, Gezira state and provides services in the state and neighboring villages and cities.

2.3. Study setting

The study was conducted in the medical laboratory faculty of medicine, University of Gezira in the period from July 2020 to December 2020.

2.4. Study population

Voluntary blood donors attending central blood bank during the study period, a total of 140 participants with age (18-60) years old, were included in the study.

2.5. Sample size

The sample size was estimated according to the sample size calculation formula of Cross Sectional studies, the required sample size is calculated by:

$$N = Z\ 2 * (p) * (1-p)\ e2$$

Where:

N =sample size
Z = Z value (1.96 for 95% confidence level)
p = Prevalence
e= margin of error of +/- 5%
N = 1.962 ×1.962 x0.096 (1- 0.096) / (0.05)2 = 140

2.6. Inclusion criteria

Donors were selected according to the accepted criteria for donation:

- Age (16-18)
- Weight 50 kg (110 pounds and more).
- Hemoglobin (12.5-17.5 gm/dl).
- Clinical examination and viral screening.

2.7. Exclusion criteria

- Hemolyzed blood sample.
- Anaemic subject.
- Subject who had surgery, trauma or blood transfusion in the preceding six months.
- Subject who smoked or were on iron supplements.
- Subjects with hematological disorders or chronic diseases like hypertension, diabetes mellitus, liver diseases, renal diseases, cardiac diseases, TB, asthma, thyroid disorders, or with recent acute diseases (Malaria, typhoid fever …etc)were excluded from the study.

2.8. Sampling method

2.8.1. Sample Collection

The blood samples of donors were investigated for various haematological parameters on a fully automated haematology analyzer (Sysmex xp-300).

CBC was done using an automated blood cell counter (Sysmex xp-300).

2.8.2. Making a blood film

Manual spreading of blood films using frosted glass slides were performed. A drop of blood was placed near one end of the slide and spreader was applied at an angle of 45,in front of the drop of blood making a thin blood film and allowed to dry .then there were labeled with sample number .The films were placed horizontally on the stain rack and flooded with Leishman's stain and left for 5 minutes.

A double volume buffer was added with gentle blowing over the surface without touching the film surface. The films were left for another 10 minutes and then washed off with tab water .The back of the slides was cleaned using cotton dipped in alcohol and then left to dry.

2.8.3. Principle

The Ferritin test is based upon the reactions between Ferritin in the sample and latex covalently bound antibodies against human Ferritin.

Ferritin values are determined turbidimetrically using fixed-time measurement with sample blank correction. The relationship between absorbance and concentration permits a multipoint calibration with a measuring range between 0 and 500 µg/L. The measuring temperature is 37ºC. The assay can be performed on different instruments allowing turbidimetric measurements at 500 to 600 nm.

2.8.4. Procedure

- Bring the working reagent and instrument to 37cº.
- Pipette into a cuvette:

Working reagent : 1.0 ml

Standard or sample: 30 ul

Mix and insert cuvette into the instrument, start stop watch.

Record the absorbance at 540 nm after 10 seconds (A1) and after 5 minutes (A2).

2.8.5. Data collection techniques and tools

Specimens

Fresh or deep frozen serum. Ferritin remains stable for 7 days at +2 to +8ºC. If the test should be performed later, it is recommended to freeze the serum. Any additional clotting or precipitation, which occurs due to the freeze/thaw cycle, should be removed by centrifugation prior to assay. Very lipemic specimens, or turbid frozen specimens after thawing, must be clarified before the assay by high-speed centrifugation (15 min at approx. 15.000 rpm).

Equipments and Materials:

- EDTA Containers;
- Cotton and syringes;
- Tourniquet;
- Methanol;
- Centrifuge.
- Sample racks

- Sample cups (Standard)
- Sysmex xp-300 automated hematology analyzer.

Data analysis and interpretation

- The collected data by the data sheet processed in the SPSS program and analyzed considering different variables.
- The results displayed in figures, graphs and tables.

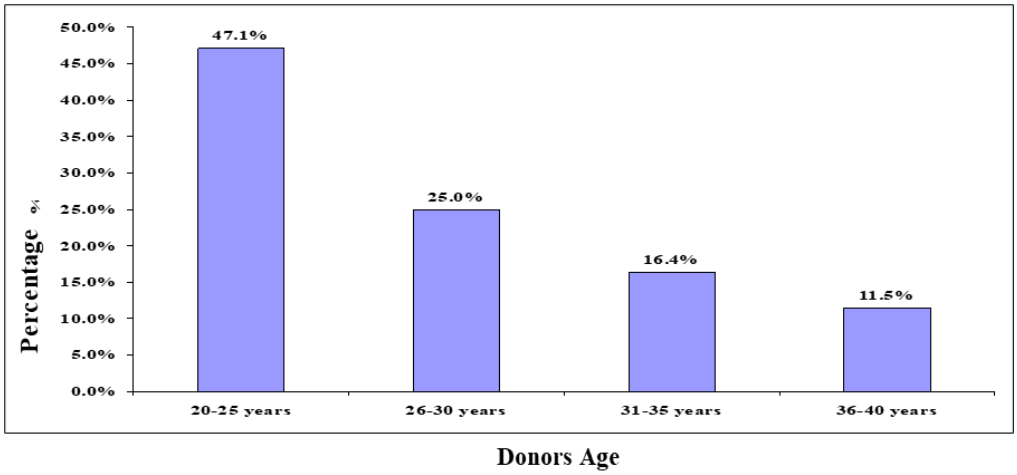
Study variables

- Dependent variable: Change in serum Ferritin, Hb, RBCs Count, HCT, MCV, MCH, MCHC. Donors who were on multiple transfusions.
- Extraneous variables: Demographic variables of blood donors namely age, sex, BMI, residence, occupation.
- Confounding variables: Drug history, educational qualification, nutritional history, physical activity.

Ethical considerations

Ethical approval was obtained from the Ministry of Health (Gezira state). Approval obtained from medical directorates of the health laboratory. Blood donors were informed about the study objectives, consented prior filling questionnaires. Confidentiality and privacy of result cases was granted.

3. Results



According to Figure 1 highest percentage of the donors 66(47.1%), aged 20 – 25 years, followed by age group 26-30 years 35(25%), 31 – 40 years 23(16.4%), and 36 – 40 years 16(11.5%). The mean age was 27.4±5.8 years (Figure 1)

Figure 1 Distribution of the donors according to their age

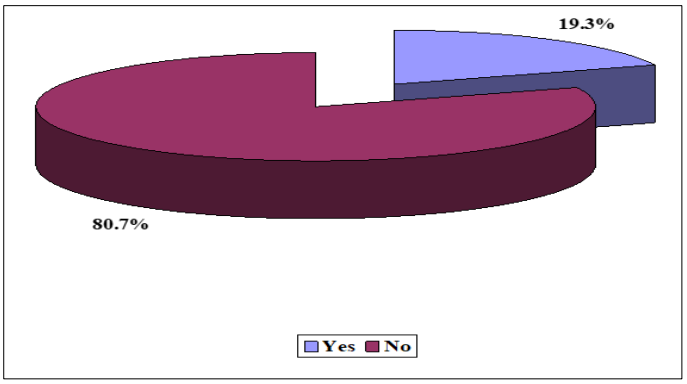


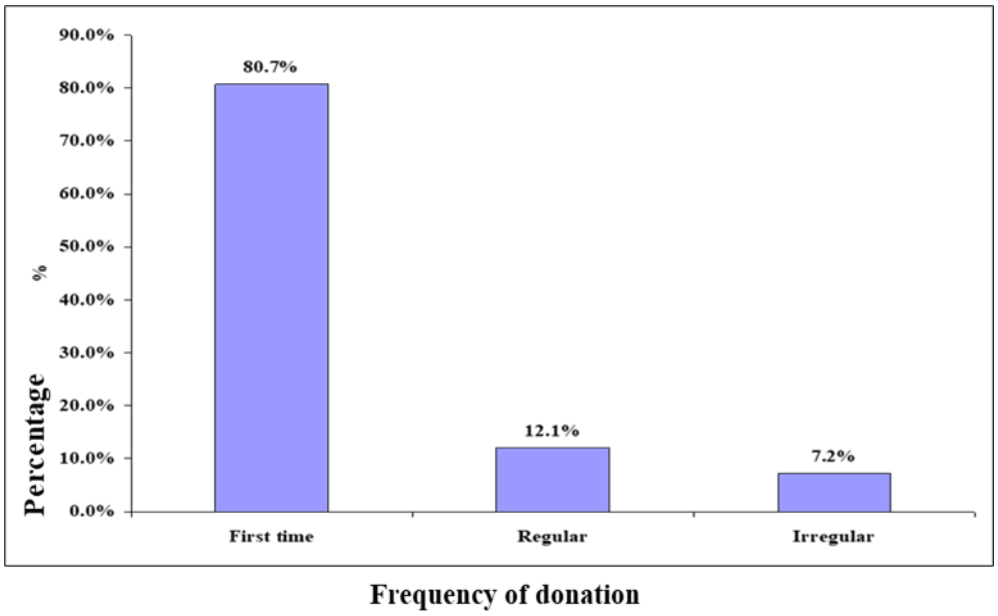
Figure 2 Distribution of the donors according to history of blood donation

History of blood donation reported by 27(19.3%) of the patients (Figure 2)

Table 2 Distribution of the donors according to blood groups

Blood group	N	%
O+ve	50	35.7
O-ve	25	17.9
A+ve	20	14.3
B+ve	18	12.9
A-ve	11	7.9
B-ve	8	5.7
AB+ve	5	3.6
AB-ve	3	2.1
Total	140	100.0

Distribution of donors according to blood groups came as follow: O +ve 50(35.7%), O -ve 25(17.9%), A +ve 20(14.3%), A -ve 11(7.9%), B+ve 18(12.9%), B -ve 8(5.7%), AB +ve 5(3.6%) and AB –ve 3(2.1%) (Table 2).



The frequency of previous blood donation was regular by 17(12.1%) and irregular by 10(7.2%). It should be noted that 113(80.7%) of the donors were firstly donate blood (Figure 3).

Figure 3 Distribution of the donors according to frequency of blood donation

Table 3 Distribution of the donors according to WBC

WBC	N	%
< 4000	34	24.3
4000 - 11000	105	75.0
> 11000	1	0.7
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
WBC	5.25	1.74	5.20	13.50	1.70

WBC (count 103 mm): the mean value 5.25±1.74, median value 5.20, maximum 13.50 and minimum 1.70. Normal WBC reported in 105(75%), low 34(34.3%) and above normal range 1(0.7%) (Table 3).

Table 4 Distribution of the donors according to RBC

RBC	N	%
< 4.5 *1012/l	16	11.4
4.5-6.5*1012/L	123	87.9
> 6.5*1012/L	1	0.7
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
RBC	4.99	0.48	4.93	6.85	3.69

RBC (count 106 µl): the mean value 4.99±0.48, median value 4.93, maximum 6.85 and minimum 3.69. Normal RBC reported in 123(87.9%), low 16(11.4%) and above normal range 1(0.7%) (Table 4).

Table 5 Distribution of the donors according to Hb

Hb	N	%
< 13.0 g/dl	9	6.4
13.0 - 17.0 g/dl	130	92.9
> 17.0 g/dl	1	0.7
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
HGB	14.67	1.06	14.80	18.10	11.90

HGB: the mean value 14.67±1.06, median value 14.80, maximum 18.10 and minimum 11.90. Normal Hb reported in 130(92.9%), low 9(6.4%) and above normal range 1(0.7%) (Table 5).

Table 6 Distribution of the donors according to HCT

HCT range	N	%
< 40 fl	35	25.0
40 - 52 fl	105	75.0
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
HCT	41.60	2.83	41.89	50.60	32.80

HCT (fl): the mean value 41.60±2.83, median value 41.89, maximum 50.60 and minimum 32.80. Normal HCT reported in 105(75%), and low 35(25%)(Table 6).

Table 7 Distribution of the donors according to MCV

MCV range	N	%
< 80	22	15.7
80 – 100	118	84.3
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
MCV	83.79	5.39	84.60	95.90	61.60

MCV (fl): the mean value 83.79±5.39, median value 84.60, maximum 95.90 and minimum 61.60. Normal MCV reported in 118(84.3%) and low in 22(15.7%) (Table 7).

Table 8 Distribution of the donors according to MCH

MCH range	N	%
< 27 pg	13	9.2
27 - 32 pg	116	82.9
> 32 pg	11	7.8
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
MCH	29.40	3.26	30.15	32.80	3.70

MCH (pg): the mean value 29.40±3.26, median value 30.15, maximum 32.80 and minimum 3.70. Normal MCH reported in 116(82.9%), low 13(9.3%) and above normal range 11(7.8%) (Table 8).

Table 9 Distribution of the donors according to MCHC

MCHC range	N	%
< 32 pg	7	5.0
32 - 36 pg	98	70.0
> 36 pg	35	25.0
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
MCHC	35.27	1.18	35.50	37.50	31.30

MCHC (pg): the mean value 35.27±1.18, median value 35.50, maximum 37.50 and minimum 31.30. Normal MCHC reported in 98(70%), above normal 35(25%) and below normal range 7(5%) (Table 9).

Table 10 Distribution of the donors according to Platelet count

Platelet range	N	%
< 150000	17	12.1
150000 - 450000	123	87.9
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
Platelet	236.04	76.28	239.50	423.00	11.00

Platelet (count 10^3): the mean value 236.04±76.28, median value 239.50, maximum 423.00 and minimum 11.00. Normal platelet count reported in 123(87.9%), and low in 17(12.1%) (Table 10).

Table 11 Distribution of the donors according to RDW – CV

RWD-CV	N	%
11.8 - 14.5%	126	90.0
> 14.5%	14	10.0
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
RWD-CV	13.47	0.86	13.30	17.00	12.10

RDW-CV: the mean value 13.47±0.86, median value 13.30, maximum 17.00 and minimum 12.00. Normal RDW-CV reported in 126(90%) and above normal range 14(10%) (Table 11).

Table 12 Distribution of the donors according to Ferritin

Ferritin	N	%
< 20 ng/ml	6	4.3
20 - 270 ng/ml	122	87.1
> 270 ng/ml	12	8.6
Total	140	100.0

	Mean	Std Deviation	Median	Maximum	Minimum
Ferritin	141.46	97.85	114.00	616.00	12.00

Ferritin: the mean value 141.46±97.85, median value 114.00, maximum 616.00 and minimum 12.00. Normal ferritin level reported in 122(87.1%), low in 6(4.3%) and above normal range 12(8.6%) (Table 12).

4. Discussion

In this study 140 healthy male blood donors were recruited to correlate between the serum ferritin level, hemoglobin concentration and red blood cell indices among blood donors who attended Wad Madani central blood bank, Gezira state during the period from July to December 2020.

Several studies indicate that hemoglobin is not a sensitive indicator to detect iron deficiency but is useful in detecting the majority of donors with established iron deficiency [1]. The sensitivity of hemoglobin concentration as an indicator of iron deficiency in repeat donors was only 40% [30].

Regarding serum ferritin level among donors in this study was 141.46±97.85, which fall within the normal male level of serum Ferritin, as the normal range reported in the majority 122(87.1%) of the blood donors and low level reported in 6 (4.3%). This indicates that generally frequent donation had minimum effect on serum ferritin level among healthy male blood donors. Similar to our results a study by [31] in India, showed that among frequent male blood donors low levels of serum ferritin was less common and frequent blood donation had minimum impact on serum ferritin level. Another study by Reddy et al the mean serum ferritin levels in males 75 µg/L within normal range for males (2020). However, [32] in Nigeria reported that 8%) of the regular but none of the first time male donors had depleted iron stores (SF< 12 ng/ml)(p=0.013) (2017).

The study showed that the mean hemoglobin concentration, Mean cell volume (MCV), Hematocrit (HCT), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC) were 14.67±1.06 g/dl, 83.79±5.39 fl, 41.60±2.83 fl, 29.40±3.26 pg, and 35.27±1.18 pg respectively. All of these values were found to be within the normal ranges for healthy male, and indicate that frequent blood donation had a very low impact on the levels of blood indices among blood donors. This study was in agreement with a study reported by [32] in Khartoum State who found that among male blood donors the mean values of hemoglobin (Hb) level ranged, MCV, MCH, and MCV were 14.9 g/dl, 89.8±9.3fl, 28.7±2.8pg and 27.3±4pg g/dl respectively. [33] in Nigeria found that the blood indices including Hb, MCH, MCHC, and MCV among frequent male blood donors showed less common depletion and generally remained within normal ranges. Another study by Abdon et al (2020) in Eretria concluded that mean Hb level was 14.428±1.485g/dl, RBCs count was 4.744±0.482×1012/L, HCT was 41.929 ±3.75%, RDW mean was 13.571±0.744%, MCV was 88.582± 4.0558 Femtoliter, MCH was 30.470±2.188 picogram, and MCHC was a mean of 34.393±1.347g/dl.

Also there was study done in Saudi Arabia by Abdullah (2011) concluded of this study show that an increase in the number of donations results in an increase in the frequency of depleted iron stores and subsequently in erythropoiesis with iron deficiency, although the level of hemoglobin remained acceptable for blood donation. These studies were found to be in agreement with our study.

Another study was done by [34] the number of female donors with deficient iron stores was more as compared to male donors. First time donors had higher mean serum ferritin levels than that in repeat donors. The frequency of donations per year was more predictive of decreased iron stores rather than the number of lifetime donations. An increase in donation frequency was accompanied by a significant decrease in serum ferritin; values. In this above study showed that the high incidence in deficient iron in female donors and this difference in current study because there is no female donation in our central blood bank.

5. Conclusion

- The study concluded that regular blood donation had less effect on serum Ferritin level.
- No effect on serum ferritin level among the first time healthy male blood donors.

The study also showed that the mean hemoglobin concentration, Mean cell volume (MCV), Hematocrit (HCT), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC) remained within the normal ranges which indicate that frequent blood donation had a very low impact on the levels of blood indices among blood donors

Compliance with ethical standards

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Disclosure of conflict of interest

The authors do have not any conflicts of interest in this case report and any financial resources.

Statement of ethical approval

Ethical approval was obtained from the University of Gezira ethical committee and blood bank authority.

Statement of informed consent

Informed consent and verbal permission were obtained from the donor before the submission of this article.

References

[1] Finch CA, Cook JD, Labbe RF, Culala M. (1977). Effect of blood donation on iron stores as evaluated by serum ferritin. Blood, 50: 441.

[2] Newman, B. (2006). Iron depletion by whole-blood donation harms menstruating females: the current whole-blood-collection paradigm needs to be changed. Transfusion, 46, 1667– 1681.

[3] Goldman, M., Uzicanin, S., Osmond, L., Scalia, V. and O'Brien, S.F. (2017b). A large national study of ferritin testing in Canadian blood donors. Transfusion, 57, 564– 570.

[4] Jahanshad, N., Kohannim, O., Hibar, D.P., Stein, J.L., McMahon, K.L., de Zubicaray, G.I., Medland, S.E., Montgomery, G.W., Whitfield, J.B., Martin, N.G., Wright, M.J., Toqa, A.W. and Thompson, P.M. (2012). Brain structure in healthy adults is related to serum transferrin and the H63D polymorphism in the HFE gene. Proceedings of the National academy of Sciences of the United States of America, 109, E851– E859.

[5] FDA. (2016) 114th Meeting of the Blood Products Advisory Committee. Food and Drug Administration, Center for Biologics Evaluation and Research, 2016; USA, Whashington DC.

[6] Casiday R, Frey R. (2014). Iron Use and Storage in the Body: Ferritin and Molecular Representations. Department of Chemistry, Washington University St. Louis.

[7] Wang W, Knovich MA, Coffman LG, Torti FM, Torti SV. (2010). Serum ferritin: Past, present and future. Biochimica et Biophysica Acta (BBA) - General Subjects. 1800 (8): 760–9.

[8] Theil EC. Ferritin protein nanocages-the story. Nanotechnology Perceptions. 8 (1): 7–16.

[9] De Zoysa M, Lee J. (2007). Two ferritin subunits from disk abalone (Haliotis discus discus): cloning, characterization and expression analysis. Fish and Shellfish Immunology. 23 (3): 624–35.

[10] Torti FM, Torti SV. (2002). Regulation of ferritin genes and protein. Blood. 99 (10): 3505–16.

[11] Zhang Y, Meng Q, Jiang T, Wang H, Xie L, Zhang R. (2003). A novel ferritin subunit involved in shell formation from the pearl oyster (Pinctada fucata).Comparative Biochemistry and Physiology. Part B, Biochemistry and Molecular Biology. 135 (1): 43–54.

[12] Levi S, Corsi B, Bosisio M, Invernizzi R, Volz A, Sanford D, Arosio P, Drysdale J. (2011). A human mitochondrial ferritin encoded by an intronless gene. The Journal of Biological Chemistry. 276 (27): 24437–40.

[13] Orino K, Lehman L, Tsuji Y, Ayaki H, Torti SV, Torti FM. (2001). Ferritin and the response to oxidative stress. The Biochemical Journal. 357(Pt 1): 241–7.

[14] Jackson DJ, Wörheide G, Degnan BM. (2007). Dynamic expression of ancient and novel molluscan shell genes during ecological transitions. BMC Evolutionary Biology. 7: 160.

[15] Zhang Y, Mikhael M, Xu D, Li Y, Soe-Lin S, Ning B, et al (2010). Lysosomal proteolysis is the primary degradation pathway for cytosolic ferritin and cytosolic ferritin degradation is necessary for iron exit. Antioxidants and Redox Signaling. 13 (7): 999–1009.

[16] Honarmand E. K, Hagedoorn PL, Hagen WR. (2015). Unity in the biochemistry of the iron-storage proteins ferritin and bacterioferritin. Chemical Reviews. 115 (1): 295–326.

[17] Watt RK. (2013). A unified model for ferritin iron loading by the catalytic center: implications for controlling free iron during oxidative stress. ChemBioChem. 14 (4): 415–9.

[18] Carmona U, Li L, Zhang L, Knez M. (2014). Ferritin light-chain subunits: key elements for the electron transfer across the protein cage. Chemical Communications. 50 (97): 15358–61.

[19] Mizuno S, Mihara T, Miyaoka T, Inagaki T, Horiguchi J. CSF iron, ferritin and transferrin levels in restless legs syndrome. Journal of Sleep Research. 2005; 14 (1): 43–7.

[20] Craig WJ, Mangels AR. (2009). Position of the American Dietetic Association: vegetarian diets. Journal of the American Dietetic Association. 109(7): 1266–82.

[21] Chen G, Wu D, Guo W, Cao Y, Huang D, Wang H, et al. (2019). Clinical and immunological features of severe and moderate coronavirus disease 2019.The Journal of Clinical Investigation. 130 (5): 2620–2629.

[22] Kennedy A, Kohn M, Lammi A, Clarke S. (2004). Iron status and haematological changes in adolescent female inpatients with anorexia nervosa.Journal of Paediatrics and Child Health. 40 (8): 430–2.

[23] Tran J, Story C, Moore D, Metz M. (2013). Unexpected increased ferritin concentration in patients with anorexia nervosa. Annals of Clinical Biochemistry. 50 (Pt 5): 504–6.

[24] Bacon BR, Adams PC, Kowdley KV, Powell LW, Tavill AS. Diagnosis and management of hemochromatosis: 2011 practice guideline by the American Association for the Study of Liver Diseases. Hepatology. Baltimore, Md. 54 (1): 328–43.

[25] Li M, Viravaidya C, Mann S. (2007). Polymer-Mediated Synthesis of Ferritin-Encapsulated Inorganic Nanoparticles. Small. 3(9): 1477–81.

[26] Vuk T, Magnussen K, De Kort W, Folléa G, Liumbruno GM, Schennach H, et al. (2017). International forum: an investigation of iron status in blood donors. Blood Transfus. 15(1):20–41.

[27] Abdullah SM. (2011). The effect of repeated blood donations on the iron status of male Saudi blood donors. Blood Transfus. 9(2):167-71.

[28] Greer JP, Foerster J, editors (2003). Iron Deficiency and Related Disorders. In: Wintrobe's Clinical Hematology. Lippincott Williams and Wilkins.

[29] Brittenham, G. (2018). Pathophysiology of iron homeostasis. Ch 35. In: Hematology: Basic Principles and Practice, 6th edn. (ed. by R. Hoffman, E.J. Benz, L.E. Silberstein, H. Heslop, J. Weitz, J. Anastasi, M.E. Salama and S.A. Abutalib), pp. 469– 472. Elsevier, Philadelphia, PA.

[30] Jaime JC, Cazarez R, Maress MA, Marfil LJ, Harrison CR. (1988). Irons stores in remunerated blood donors as evaluated by plasma ferritin levels. Transfusion, 28: 62-5.

[31] Mahida VI, Bhatti A, Gupte SC. (2008). Iron status of regular voluntary blood donors. Asian J Transfus Sci. 2(1):9-12.

[32] Oluwayemisi, O. H. Abayomi, B. S. Musbau, A. I. Olasunkanmi, S. A Adenike, D. I. Kehinde, O. M. (2017). Evaluation of iron stores of blood donors in a teaching hospital in North Central Nigeria. Sudan Med J, 53(3):140-146.

[33] Awad KM, Bashir AA, Osman AA et.al. (2019). Reference values for hemoglobin and red blood cells indices in Sudanese in Khartoum state. Int J Health Sci Res. 9(1):210- 214.

[34] Mittal R, Marwaha N, Basu S, Mohan H, Ravi Kumar A. (2006). Evaluation of iron stores in blood donors by serum ferritin. Indian J Med Res. 124(6):641-6