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Various Iron Deficiency Stages among Male Blood Donors in Donor Bleeding Bay Calabar, Cross River State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author DCO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors EJA and OEO managed the literature searches and analysis of data. Authors EEO and EAU managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Iron deficiency is one of the most common nutritional disorders in the world, and blood donation may cause iron depletion. This study assessed the incidence and stages of iron deficiency in male subjects donating blood in a bleeding bay in Calabar, Nigeria.
Methodology: One hundred and eighty-four male blood donors attending University of Calabar Teaching Hospital (UCTH) bleeding bay were used for the study. The donors were divided into 5 groups namely; control [n = 35; (19.0%)], first time donors [n = 32; (17.4%)], second time donors [n = 35; (19.0%)], third time donors [n = 41; (22.3%)] and forth time donors [n = 41; (22.3%)]. Blood samples were taken from all the donors and their iron–related parameters namely, haemoglobin concentration (Hb), transferrin saturation (TS), serum ferritin level (SF) and serum transferrin

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receptor level (STfR) was determined as indicators of iron stores.
Results: The prevalence of anaemia 49 (26.6%), iron depletion 60 (32.6%), iron deficiency without anaemia 106 (57.6%) and iron deficiency anaemia 60 (32.6%) was significantly ($p<0.05$) increased in 184 male blood donors. The percentage value of the various iron deficiency stages was observed to be higher in 2nd, 3rd and 4th timers when compared with control and first time groups. The higher prevalence of iron deficiency may be caused by more frequent and larger volumes of blood donated by 2nd, 3rd and 4th timers when compared to control and first time groups.
Conclusion: It is concluded that, to avoid the differences in the prevalence among these donors, regular supervision of their haematocrit levels and introducing haemoglobin estimation (using autoanalyser) and serum ferritin be made for them before donating or else, 2nd timers and those above second should not be allowed to donate blood in a year. Moreover, adequate iron supplement should be given in order to prevent the development of iron deficiency.

Keywords: Anaemia; blood donation; ferritin; iron deficiency; transferrin.

1. INTRODUCTION

A blood donor can be defined as one who gives blood for transfusion purposes. An adult who is in good condition and had no illness is suitable as a donor. Transfusion services have particular rules which outline the guideline for the protection of the donor or the recipient [1]. A blood donor must be between the ages of 18 and 65 years of either sex and they should conform to the national standard of fitness as laid down by the Act of Parliament in UK [2]. Blood donor's health is important in fruitful delivery of health care. A lot has been ascertained about guarding the recipients from the capability of blood transfusion hazards. Huge financial outlays for the screening of donors to protect recipients have been spent but no concentration has been given to the wellbeing of the donors. This is probably because of fret of losing the donors in the season where the need of the donors is high and scarce [3].

Precise rules have been put in place in some countries for the selection of blood donors that integrate benchmark to save both subjects giving and taking blood from harm [4]. Four hundred and fifty milliliters is collected from a subject when donating blood, in which 3.6 mg of iron is in 1 g of haemoglobin. In an average person with 15 g of haemoglobin per dl, 100 ml of blood holds 50 mg of iron, while 2 ml of blood bear 1mg of iron [1]. If 450 ml of blood is taken in a donation, approximately 225 mg of iron will be lost. If the donor has no iron deficiency, the erythrocytes and the haemoglobin level will generally return to normal within 3-4 weeks. Hence, adequate iron stores are very important in maintenance of the donor's health [5].

The donation of blood is accepted commonly two or three times in 12 months and the loss is excess in expectant age females than males [5]. Iron loss can be depleted in males when they give blood up to 5 units yearly, while females may likely become iron deficient if they donate more than 1 unit per year [6]. In Nigeria, haemoglobin values are customized at 125g/L for all blood donors [7,8]. Deficient iron status occurs when iron in the body is less than average, and this occurs in three stages [9]. The earliest stage is iron depletion which reduces stored iron without any effect on essential body iron [9]. Dwindling stored iron is may instigate dysfunctions that evolves to stage two of iron deficient erythropoiesis. Iron deficient erythropoiesis (also called iron-deficiency-without-anaemia) occurs when adequate iron availability to erythroid marrow as well as tissues for normal biochemistry function is abnormal which may be perceived by low iron, reduced transferrin saturation levels, raised serum transferrin and high levels of erythrocyte protoporphyrin, transferrin receptor, microcytic cells as well as low haemoglobin values that result to mild anaemia, which is difficult to detect using an arbitrary cut off value [10]. The last stage is iron deficiency with anaemia detected by reduction in haemoglobin and haematocrit levels; decease in mean corpuscular volume, decreased or absent iron stores, dropped iron, transferrin level and microcytic hypochromia. Iron deficiency is a common clinical problem that, in most instances, is relatively simple to diagnose using such conventional laboratory tests of iron status as serum iron, total iron binding capacity, transferrin saturation and ferritin. However, these tests are considerably influenced by acute phase responses, making difficult the distinction between iron deficiency anaemia and anaemia that accompanies infection, inflammation or malignancy [11]. Some of these biochemical iron-related parameters have been studied in frequent blood donors among Caucasians. It is therefore

easy to justify maximum blood donation of twice a year for male and once for female for Caucasians. Such data are lacking for the Africans, especially Calabar, Nigeria. This study therefore aimed to evaluate the percentage of blood donors with various stages of iron deficiency at the University of Calabar Teaching Hospital by carrying out the following test: Haemoglobin, serum iron, total iron binding capacity, transferrin saturation, serum ferritin and serum transferrin receptor.

2. MATERIALS AND METHODS

One hundred and eighty-four male blood donors within the range of 18–49 years of age attending University of Calabar Teaching Hospital (UCTH) bleeding bay were recruited for this study by random sampling. The donors were divided into 5 groups namely; control group [n = 35; (19.0%)], first time donors [n = 32; (17.4%)], second time donors [n = 35; (19.0%)], third time donors [n = 41; (22.3%)] and forth time donors [n = 41; (22.3%)].

There were four hundred and fifty (450) donors who came to the UCTH bleeding bay during the four months of gathering samples in the year 2011 and they all donated blood once or repeatedly within the period of two months of sample collection. After selection of donors using questionnaire, 184 male blood donors' samples were analysed. Meanwhile, about seventy-five of the 184 participants were commercial donors (those who received money to donate). Seven milliliters of venous blood sample was collected by a clean venepuncture from donors between 9:00 am–12 noon into 2 sample containers. Two milliliters of blood was delivered into potassium Ethylene Diamine Tetra Acetic Acid (K_2EDTA) bottle containing 4mg of the anticoagulant for the analysis of Hb using complete automated cell counter model (ERMA INC. Tokyo PCE-210, 5.10 version) while the remaining 5 ml was delivered into sterile iron-free screw-cap bottle, allowed to clot within one to two hours at room temperature and centrifuged to obtain the serum used for analysis of SI and TIBC SI and TIBC determined by colorimetric method (TECO diagnostic U.S.A, Lot number 1592). TS was determined by computation of SI and TIBC while SF (Catalog number: BC-1025) and STfR (BioVendor-Laboratoni medicina a.s. Cat. Number: RD194011100 Czech Republic) was determined using ELISA method.

The inclusion criteria were as follows;

a) The donors must have the packed cell volume of > 0.400 L/L.
b) Those who donated blood in a previous period of less than two months (for control group and first timers).
c) (c) Sero-negative HIV 1 & 2, hepatitis B and C then *Trepanoma pallidium*.

The exclusion criteria were as follows;

a) Those that were taking iron supplement or had gone through major surgery in the past three years.
b) Those that had a history of recent blood transfusion in the past two years.

Blood donor subjects with normal serum iron levels (>50 µg/dl), but with decreased serum ferritin concentration (<15 ng/ml), were classified as the earliest stage of iron depletion. Iron-deficiency without anaemia was defined as a reduction in body iron beyond the point of depleted iron stores and serum transferrin receptor <3.5 µg/ml was used [12]. Iron deficiency anaemia as SF<15 ng/ml, TS<16%, Hb<125 g/L [13] and sTfR>3.5 µg/ml [14].

2.1 Statistical Analysis

Chi–squared analysis (PRIMER software version 10) was used for percentages and proportions of the male blood donors. The level of significance was set at $p<0.05$.

3. RESULTS

The mean ages of male donors were 25±0.89 years, 27±1.04 years, 27±0.78 years, 28±0.92 years and 27±0.66 years for control, first, second, third and fourth time blood donors respectively. It shows no statistical change was found ($p>0.05$) among groups. So, all ages from control group to fourth time were similar. It shows in Table 1, that the percentages of the donors namely 19.0%, 17.4%, 19.0%, 22.3% and 22.3% at the various times namely control group, first, second, third and fourth time respectively of blood donation are insignificant ($p>0.05$). It also shows that bulk of them were 18–25 years of age (45.7%) and 26–35 years (47.3%) while ≥ 36 years (7.1%) were very few (Table 1). Percentages and prevalence of iron stages of repeated male blood donors is shown in Table 2. Anaemia defined as Hb<110 g/L, iron depletion

as SF<15 ng/ml, iron deficiency without anaemia as sTfR>3.5 µg/ml, SF<15 ng/ml and iron deficiency anaemia as SF<15 ng/ml, Hb<110g/L, sTfR>3.5 µg/ml and TS<16% were used to classify iron status of donors in this study. Table 2 also shows that 26.6% of all donors had anaemia which comprises 0.5%, 1.6%, 8.7% and 15.8% in first, second, third and fourth time blood donors respectively. Out of all the blood donors, 32.6% had iron depletion which comprises 0.5% from control group, 4.3% from second time donors, 10.9% from third time donors and 16.4% from fourth time donors. 57.6% of all the blood donors had iron deficiency without anaemia which comprises 4.3% from control group, 4.9% from first time donors, 12.5% from second time donors, 16.4% from third time donors and 19.0% from fourth time donors. Out of all blood donors, 32.6% had iron deficiency anaemia (IDA) which comprises of 0.5% from first time donors, 3.8% from second time donors, 10.3% from third time donors and 17.9% from fourth time donors.

4. DISCUSSION

The ages of control group up to fourth time donors were not significantly different. The percentages of the total number of subjects at various times of blood donation were also not significantly different. They ranged from 17.4 to 22.3% of the total number of 184 at each time of blood donation (Table 1). The similarity in percentages of blood donors at various times of blood donation is good since it ruled out bias when comparing groups. This is consistent with a study also reported in Calabar [15]. However, 45.7% of the total blood donors were in the 18–25 year group and 47.3% were in 26 – 35 year group. Only a few (7.1%) were above 36 years old. The reason for younger subjects, that is, persons below 36 years donating blood is for remuneration. Since most of the donors were paid, blood donation may be promoted by youth unemployment because statistics show that 40 million Nigerians are unemployed and are mainly youths [16].

Table 1. Age groups of repeated blood donors (N = 184)

Age range (years)	Control group n = 35	first Time n = 32	second Time n = 35	third Time n = 41	fourth Time n = 41	%
18 – 25	25	15	14	15	15	45.7
26 – 35	7	15	20	21	24	47.3
≥ 36	3	2	1	5	2	7.1
Total % of Total	35 (19.0%)	32 (17.4%)	35 (19.0%)	41 (22.3%)	41 (22.3%)	

p>0.05

Table 2. Percentage of donors with various states of reduced iron in the body

No of donations	Anaemia (Hb <110g/L)	Iron depletion (SF<15 ng/ml)	Iron deficiency without anaemia (sTfR>3.5 µg/ml, SF<15 ng/ml)	Iron deficiency anaemia (SF<15ng/ml, Hb<110g/L, sTfR>3.5µg/ml, TS<16%)
Control group (n = 35)	0.0%	0.0%	0.5%	0.0%
First time (n = 32)	0.5%	0.5%	4.9%	0.5%
Second time (n = 35)	1.6%	4.3%	12.5%	3.8%
Third time (n = 41)	8.7%	10.9%	16.4%	10.3%
Fourth time (n = 41)	15.8%	16.4%	19.0%	17.9%
All donors (n = 184)	26.6%	32.6%	57.6%	32.6%

There are various states in the body where iron concentration is reduced. These states include; anaemia, iron drain, iron-deficiency-without-anaemia and deficiency with anaemia. In anaemia, it was 26.6%, iron depletion 32.6%, deficient iron without anaemia 57.6% also 32.6% deficient iron with anaemia in 184 male donors (Table 2). Repeated blood donation (second to fourth) gives the highest percentage (57.6%) of donors with iron deficiency without anaemia and gives the least percentage (32.6%) of donors with anaemia. It is probably that haemoglobin synthesis was going on with the available iron in the store. Haemoglobin synthesis reduced when iron stores are exhausted. Cook et al. [17] reported that in deficient iron states, depletion comes before significant changes in ferritin and red cell iron level become noticeable. Although blood donors can regulate their iron demand by physiological means, low ferritin levels at when donating can advance into depletion of their iron reserve [18]. Even when the intervals between donations are monitored thrice in a month for males and 6 months for females, donation does seems to be a basis of iron deficiency. Zaccheaus et al. [19] also reported commonness of anaemia 13.7%, iron deficiency without anaemia was 20.6% while 12.0% iron deficiency theirs and this was found among regular donors in Port Harcourt, Nigeria. Iron deficiency without anaemia Port Harcourt study was lower (20.6%) compared to our study (57.6%). This is owing to small number of blood donors used (96 regular donors) [19]. A high percentage prevalence of the various iron states outlined was noted among fourth, third and second time donors. Concado et al. [20] reported raised frequency of iron deficiency without anaemia among male donors thrice or more donations yearly and women giving out blood twice or more yearly. Depleted iron stores rise in measure up in subjects that do not donate in Danish research [2].

The rate of development of anaemia, lessen of iron, deficient iron without anaemia and deficiency of iron with aneamia appears to be significantly higher in fourth and third time donors as compared to the other groups. The rapid rate at which the third, second and especially and mostly fourth time donors mature into iron deficiency because of frequency donation as compared to the control group and first donors. To avoid these differences in the prevalence among these donors, the cut-off PCV level for donors should be raised from 40% to 42% for those donating for the second, third and fourth time blood donors. Moreover, adequate iron supplement ought to be given counteract the development of iron deficiency and there should also be a three month interval between blood donations with proper documentation of each successive blood donation. Donating frequently, variable percentages of iron deficiency anaemia have been reported in 6% donors three times yearly, 7.9–12.7% donors four times yearly, 8% & 19% giving blood often five and six times respectively [21] to as high as 28% giving average of 17 timers in 4 years [22]. Germany study report that ferritin lowers after 10 donations if donated often. Twenty six percent of regular donors ferritin levels were less than 15ng/l and 12% of them had lessen haemoglobin owed to anaemic [23]. In Brazil, report shows elevated iron deficiency in multi-time blood was 7.6% with thrice or more donations yearly that are obvious in female blood donors [20]. Simon et al. [24] reported 8% men and 38% women had reduced stores of iron when projected by ferritin status. Most repeated blood donors in this study were young persons between the ages of 18–35 years and most of them donated blood for pecuniary benefit. Iron stores were diminished progressively after repeated blood donation. This induces the various iron deficiency states namely; iron depletion, iron deficiency without anaemia and iron deficiency anaemia. The percentages of iron deficiency anaemia and utilization of ferritin reported above by other authors (8,14,15 and 20) were found to be lower than the prevalence observed among blood donors (especially third and fourth time) in this study.

5. CONCLUSION

Of all the states that iron concentration is reduced in the body, iron deficiency without anaemia produced the highest percentage of 57.6% of all the blood donors. Relying on haematocrit or haemoglobin levels alone to screen donors for blood donation as a criterion for donation may not be sufficient to detect iron deficient among repeated male blood donors in Calabar. This is probably because some of the donors may have depleted or exhausted iron even if the PCV was normal. Therefore, Blood banks should determine the Hb levels and some iron-related parameters of donors in addition to the haematocrit cut-off levels (>0.400 L/L) at the time of donor screening since HCT alone may not give adequately the total number of donors having iron deficiency. Blood donation should be limited to maximum of three times a year with proper records and those donating for three

times and more should have a PCV value of 43%.

CONSENT

Consent was obtained from all donors involved in this study.

ETHICAL APPROVAL

Approval was given from the Health Research Ethical Committee (HREC) of the University of Calabar Teaching Hospital, Calabar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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