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Impact of Blood Donation on Iron Homeostasis: A Comprehensive Analysis of Serum Iron and Total Iron-Binding Capacity (TIBC) Levels in Donors

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ABSTRACT

Background and Objective: Blood donation is a vital practice that supports healthcare systems by providing a steady supply of blood for transfusion. However, frequent blood donation may significantly impact iron metabolism, leading to altered biochemical parameters such as serum iron and Total Iron-Binding Capacity (TIBC). This study aimed to evaluate the effect of blood donation on iron homeostasis, specifically by assessing the levels of serum iron and Total Iron Binding Capacity (TIBC) among blood donors. **Materials and Methods:** The study recruited 60 male participants, comprising 30 blood donors and 30 non-donors, with mean ages of 24.8±4.13 and 22.3±2.82 years, respectively. Blood samples were analyzed using paired samples t-tests and results were expressed as Mean±SD. Statistical significance was set at $p<0.05$. **Results:** The findings revealed significantly lower serum iron levels in blood donors (57.64±71.43 µg/dL) compared to non-donors (223.547±172.16 µg/dL) ($p = 0.001$). Conversely, TIBC was significantly higher in blood donors (731.74±166.71 µg/dL) than in non-donors (546.47±96.76 µg/dL) ($p = 0.005$). These differences indicate that frequent blood donation depletes serum iron levels while triggering a compensatory increase in TIBC to enhance iron mobilization and absorption. **Conclusion:** This study highlights the importance of monitoring iron levels in blood donors to prevent deficiency. Preventive strategies like dietary counseling, supplementation and optimized donation intervals can help maintain donor health and a safe blood donation system.

KEYWORDS

Blood donation, serum iron, Total Iron-Binding Capacity (TIBC), iron deficiency, Iron metabolism, blood donors, Niger Delta University Teaching Hospital

INTRODUCTION

Iron is a vital micronutrient required for several physiological processes, including oxygen transport, energy production and immune function. It exists in the body as part of hemoglobin, myoglobin and enzymes, playing a crucial role in maintaining cellular and systemic homeostasis[1]. However, frequent blood

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donation can result in significant alterations to iron stores, as each donation removes a considerable amount of iron along with red blood cells. While blood donation is an essential practice for maintaining a safe and sufficient blood supply, it has been associated with a risk of iron depletion in regular donors, potentially leading to iron deficiency anemia[2].

Serum iron and Total Iron-Binding Capacity (TIBC) are critical parameters in assessing iron status. Serum iron reflects the amount of circulating iron bound to transferrin, while TIBC represents the iron-binding capacity of transferrin, typically elevated in conditions of iron deficiency[3]. The relationship between these parameters is particularly relevant in blood donors, as repeated donations may lead to depleted iron stores and increased transferrin saturation to compensate for reduced availability of iron[4].

The study of iron status in blood donors versus non-donors provides a crucial understanding of how donation frequency affects biochemical parameters. It also informs strategies for mitigating iron loss, including iron supplementation or dietary modifications, to preserve donor health and ensure a sustainable blood donation system[5]. This study aimed to evaluate the impact of blood donation on iron homeostasis by assessing serum iron levels and Total Iron-Binding Capacity (TIBC) in blood donors.

MATERIALS AND METHODS

Study area: The study was conducted from November, 2022 to September, 2023 at the Niger Delta University Teaching Hospital in Okolobiri, Bayelsa State, Nigeria.

Study population: The blood sample used for this study was collected from 30 male donors and 30 male non-donors at Niger Delta Teaching Hospital, Okolobiri, Bayelsa State.

Selection criteria

Inclusion criteria: Subjects that were used for this study from Niger Delta Teaching Hospital Okolobiri, Bayelsa State, between the ages of 18-33 years and who gave consent were included in the study.

Exclusion criteria: Subjects with the following conditions were excluded from the study; males above the age of 34 years and those in iron supplements were not used.

Method of analysis: Serum iron and Total Iron-Binding Capacity (TIBC) were analyzed using the Spectrophotometric method. Data analysis was conducted using the Statistical Package for Social Science (SPSS) version 22 window 10, the results were expressed in Mean±SD (standard deviation). Data was obtained from the analysis using paired samples t-test. Values were considered significant at $p<0.05$ and not significant at $p>0.05$.

RESULTS

Table 1 shows the demographic and characteristics of donors and non-donors at Niger Delta University Teaching Hospital, Okolobiri, Bayelsa State with a mean age of 24.8±4.13 and 22.3±2.82, respectively. All donors and non-donors are male.

Table 2 shows a comparison of serum iron and total iron binding capacity between blood donors and non-blood donors. Serum iron in non-blood donors (223.547±172.16 µg/dL) was significantly higher than in blood donors (57.64±71.43 µg/dL) ($p<0.05$). However, total iron binding capacity in non-blood donors (546.47±96.76 µg/dL) was significantly lower than blood donors (731.74±166.71 µg/dL) ($p<0.05$).

Table 1: Demographic and characteristics of blood donors and non-blood donors

Characteristic	N	Ages (years)	Percentage (%)	Mean±SD
Blood donors	30	19-33	50	24.8±4.13
Non-donors	30	18-27	50	22.3±2.82

N: Number

Table 2: Comparison of serum iron and Total Iron-Binding Capacity (TIBC) between blood donors and non-blood donors (N = 30)

Parameter	Blood donors	Non-blood donors	t-value	p-value
Serum iron (µg/dL)	57.64±71.43	223.547±172.16	4.06	0.001
TIBC (µg/dL)	731.74±166.71	546.47±96.76	3.29	0.005

Significant at p<0.0, t-value and p-value are both statistical terms and Total Iron-Binding Capacity (TIBC)

DISCUSSION

Non-donors exhibited significantly higher serum iron levels than blood donors. The marked reduction in serum iron among donors may be attributed to the physiological demands of regular blood donation, which leads to iron depletion and necessitates recovery periods for replenishment. This finding is consistent with previous research indicating that frequent blood donors often exhibit lower iron reserves compared to non-donors[6,7]. The substantial mean difference aligns with expectations of decreased iron stores among donors due to repeated blood loss.

The impact of blood donation on iron homeostasis has been widely studied, with significant findings regarding serum iron and Total Iron-Binding Capacity (TIBC) levels. Previous studies have shown that regular blood donation leads to a temporary decrease in serum iron, with some research indicating a compensatory increase in TIBC to maintain iron availability for erythropoiesis[8,9].

Conversely, TIBC levels were significantly higher in blood donors compared to non-donors. Elevated TIBC in donors is indicative of compensatory mechanisms for lower serum iron levels. The body increases TIBC to enhance iron transport and storage efficiency, ensuring adequate supply for essential physiological processes despite reduced serum World Health Organization, 2016). The higher TIBC among donors suggests an adaptive response to maintain iron homeostasis. These findings collectively underscore the potential need for nutritional supplementation or monitoring in frequent donors to prevent iron deficiency anemia[10].

These results have important clinical implications for blood donation policies and donor health management. Routine screening for iron status and counseling on dietary iron intake may be beneficial, particularly for frequent donors. The data further highlights the physiological differences that blood donation induces, emphasizing the importance of balancing donor health with the demand for blood products.

CONCLUSION

This study demonstrates significant differences in serum iron and Total Iron-Binding Capacity (TIBC) between blood donors and non-donors. Blood donors exhibited significantly lower serum iron levels and higher TIBC values compared to non-donors. These findings highlight the physiological impact of regular blood donation, including potential iron depletion and compensatory increases in TIBC to facilitate iron transport and storage. The demographic analysis reveals that blood donation predominantly involves young male participants in the Niger Delta University Teaching Hospital. The results emphasize the importance of addressing the nutritional and health needs of donors to prevent adverse outcomes, such as iron deficiency anemia, particularly in frequent donors.

SIGNIFICANCE STATEMENT

This study highlights the impact of blood donation on iron metabolism, emphasizing the need to address iron depletion in regular donors. Key recommendations include pre-donation iron screening, iron supplementation and personalized donation frequencies to maintain donor health. These insights are crucial for blood donation centers and clinicians managing donor health, ensuring a sustainable and safe blood supply.

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