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COMPARATIVE ASSESSMENT OF HAEMATOLOGICAL PARAMETERS AMONG FIRST-TIME AND REPEAT BLOOD DONORS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Repeated blood donation can cause recurrent red cell loss and may progressively affect iron availability and erythropoiesis. Although haemoglobin is routinely used for donor screening, changes in red cell indices may occur before clinically evident anaemia. This study aimed to assess selected haematological parameters among first-time and repeat blood donors and to evaluate their relationship with donation frequency.

Materials & Methods: This cross-sectional study was conducted among 200 voluntary male whole-blood donors at a tertiary-care hospital blood centre from October 1, 2023, to March 31, 2024. All prospective blood donors were screened according to the donor selection criteria given by the National Blood Transfusion Council, Director General of Health Services, Ministry of Health and Family Welfare & Government of India, and only donors who fulfilled all eligibility criteria and were found fit for donation were included in the study. Female donors and donors receiving iron supplementation were excluded. Donors were categorised according to the number of previous donations during the preceding five years into four groups: first-time donors (n=100), 2–5 donations (n=40), 6–10 donations (n=28), and >10 donations (n=32). Complete blood count parameters, including haemoglobin, hematocrit, RBC count, MCV, MCH, MCHC, RDW, WBC count, platelet count, MPV, and PDW, were analysed using an automated haematology analyser. First-time and repeat donors were compared, and differences across the four donation-frequency groups were assessed using an independent-samples t-test and one-way ANOVA with Tukey's post-hoc analysis. Correlation analysis was used to assess the relationship between donation frequency and selected red cell indices.

Results: Repeat donors demonstrated a significantly lower mean MCV compared with first-time donors (84.9 vs. 91.2 fL; mean difference, 6.3 fL; 95% CI, 2.9–9.6; $p<0.001$). Mean RDW was significantly higher among repeat donors (14.5% vs. 12.9%; mean difference, 1.45; 95% CI, 1.01–2.03; $p<0.001$). Across the four donation-frequency groups, MCV showed a progressive decline from 91.2 ± 4.5 fL among first-time donors to 83.7 ± 3.8 fL among donors with >10 previous donations, whereas RDW increased from 12.9 ± 1.1% to 14.5 ± 1.4%, respectively. ANOVA demonstrated significant differences in both MCV and RDW across the groups ($p<0.001$). Tukey's analysis showed significant differences, particularly between first-time donors and those with ≥6 previous donations. No significant differences were observed in MCH, MPV, WBC count, or platelet count between first-time and repeat donors.

Conclusion: Repeat blood donors demonstrated significant changes in red cell indices, characterised by lower MCV and higher RDW, with progressively greater changes observed with increasing donation history. These findings may indicate altered erythropoiesis associated with repeated blood donation and could precede clinically evident anaemia. However, because biochemical markers of iron status were not assessed, iron deficiency cannot be confirmed from these findings alone. Routine monitoring of haemoglobin and red cell indices, particularly among frequent donors, together with appropriate donor counselling and follow-up, may help support long-term donor health and a safe, sustainable blood supply.

KEYWORDS: Blood donors; repeat blood donation; MCV; RDW; iron deficiency; red cell indices; donor health; haematological parameters.

INTRODUCTION

Blood transfusion is an integral part of healthcare systems worldwide and plays a crucial role in the medical and surgical management of patients. The safety and effectiveness of transfusion depend on the availability and adequate supply of safe blood from healthy and eligible donors.[1]

The effectiveness of blood transfusion depends significantly on the quality of the blood being transfused. Although haemoglobin concentration is routinely used to assess donor eligibility, it may not provide a comprehensive assessment of the donor's haematological status. Other haematological parameters, including red cell indices and platelet parameters, may provide additional information regarding the donor's physiological status and the effects of repeated blood donation.[2] Assessment of these haematological parameters provides important information about the overall health of blood donors and may help in identifying underlying abnormalities that could influence donor well-being. Such monitoring is particularly relevant among repeat blood donors, in whom repeated blood loss may progressively affect iron stores and erythropoiesis[3]

Donation-induced iron deficiency (DIID) is an important concern among frequent blood donors. Repeated blood donation results in the loss of iron contained in red blood cells and may progressively reduce the body's iron reserves. Iron is an essential element for erythropoiesis and the production of haemoglobin. With repeated donation, progressive iron depletion may eventually affect red blood cell production and may result in iron deficiency anaemia.[4]

It can progress through three different stages of iron depletion: iron-deficient erythropoiesis (IDE) and non-anemic iron deficiency leading to iron deficiency anemia.4 The development of donation-induced iron deficiency may occur before anaemia becomes clinically evident. The recommended interval between whole blood donations varies internationally, ranging from approximately 8 to 16 weeks, depending on national guidelines and donor eligibility criteria.[4,5] Monitoring of haematological changes in blood donors can be performed using a complete blood count (CBC), particularly through evaluation of red cell indices and red cell distribution width (RDW). A reduction in mean corpuscular volume (MCV) and an increase in red cell distribution width (RDW), may be associated with iron-restricted erythropoiesis and can be markers of early iron deficiency.

Regular blood donors play an important role in maintaining a stable and reliable blood supply. Their familiarity with the donation process, including donor screening, possible adverse effects, and post-donation care, may contribute to a smoother donation experience and better adherence to donor-care recommendations. They also undergo periodic health assessments during the donation process, including evaluation of vital signs, haemoglobin levels, and screening for transfusion-transmitted infections (TTIs).[6] These repeated assessments may help identify certain abnormalities at an early stage and provide an opportunity for appropriate donor counselling. Therefore, maintaining the health of regular blood donors is essential for ensuring a safe and sustainable blood supply.

Hence, this study was done to evaluate the haematological changes in red cell and platelet indices among blood donors and to determine whether the number of previous donations is associated with changes in certain haematological parameters among repeat blood donors.

MATERIALS AND METHODS

The cross-sectional study was conducted on voluntary whole blood donors after getting informed consent in an 1160-bed tertiary care hospital attached blood centre. The study was conducted from October 1st 2023 to March 31st 2024 after getting approval from the Institutional Review Board. Donors were screened using a donor questionnaire as mandated by the Drugs and Cosmetics Act 1945, with the last amendment in March 2020. The details of eligible donors such as age, first donation, the total number of donations, donations within a year, the average time interval between donations, last donation, dietary habits, occupation, educational background, and iron supplement usage were collected. The hemoglobin level was measured using a portable hemoglobinometer, the HemoCue, Sweden.

Since menstrual blood loss could not be quantified, female donors and donors on iron supplementation were excluded from the study. A total of 200 male voluntary blood donors who fulfilled the inclusion criteria, were selected based on convenient sampling. Demographic details of the donors, and other relevant history were obtained from the hospital-wide Medical Information Archiving Software (MIAS) informatics system. Eligible donors were grouped into four based on the number of donations in the past 5 years. The first-time donors served as the control and a representation of the general population. Eligible donors were grouped into four based on the number of donations in the past 5 years as shown in Table 1

Table 1: Grouping of voluntary blood donors.

Groups	No. of donations
Group 1	First-time donors
Group 2	Donated 2-5 times
Group 3	Donated 6-10 times
Group 4	Donated more than 10 times

Following blood donation, venous samples were collected in 5mL K2 EDTA test tubes to measure RBC, WBC and platelet indices. Complete Blood Count (CBC) was performed on an automated haematology analyser (Beckman Coulter DxH 800) utilising the Coulter Principle and VCS technology.

The following haematological parameters were recorded and analysed:

- Haemoglobin (Hb)
- Haematocrit (HCT)
- Red blood cell (RBC) count
- Mean corpuscular volume (MCV)
- Mean corpuscular haemoglobin (MCH)
- Mean corpuscular haemoglobin concentration (MCHC)
- Red cell distribution width (RDW)
- White blood cell (WBC) count
- Platelet count
- Mean platelet volume (MPV)
- Platelet distribution width (PDW)

The haematological parameters of first-time and repeat donors were compared.

Statistical Analysis

The data was obtained, tabulated, and analysed using Microsoft Word and Excel version 2016. Descriptive statistics including mean, standard deviation, and range were calculated. Data were also analysed using IBM SPSS Statistics (Version 29.0, IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation. Haematological parameters were compared between first-time and repeat blood donors. For comparison of two independent groups, the independent-samples Student's t-test was used for normally distributed continuous variables. For comparison of haematological parameters across the four donor groups according to donation history, one-way analysis of variance (ANOVA) was used. The relationship between the number of previous blood donations and selected haematological parameters, particularly MCV and RDW, was assessed using correlation analysis. A p value <0.05 was considered statistically significant. Where applicable, results were reported with 95% confidence intervals

RESULTS

A total of 200 male blood donors were included in the study. Their age distribution is shown in Table 2.

Table 2. Age distribution of study participants

Age group (years)	Number of donors
18–28	78
29–39	70
40–50	44
51–60	8
Total	200

Socio-demographic characteristics

The study population consisted entirely of male blood donors. Of the 200 donors, 100 (50%) were first-time donors and 100 (50%) were repeat/regular donors. Their distribution according to their donation history is shown in Table 3.

Table 3. Distribution of donors according to donation history

Donation group	Previous donations	n	%
Group 1	First-time	100	50.0
Group 2	2–5	40	20.0
Group 3	6–10	28	14.0
Group 4	>10	32	16.0
Total		200	100

Comparative analysis was performed to evaluate differences in haematological parameters between first-time and repeat donors. The relationship between the number of previous donations and the haematological parameters was also assessed. MCV was significantly lower among repeat donors compared with first-time donors, with a mean difference of 6.3 fL. RDW was significantly higher among repeat donors compared with first-time donors, with a mean difference of 2.02%. MCH, MPV, WBC count, and platelet count did not show statistically significant differences between first-time and repeat donors.

The mean platelet count, MPV, and PDW among the study population were 2.5 ± 0.46 lakh/µL, 9.02 ± 1.1 fL, and 10.8 ± 2.04 fL, respectively.

Comparison of MCV and RDW between first-time and repeat donors

For the primary comparison, first-time donors (Group 1) were compared with all repeat donors (Groups 2–4 combined). MCV was significantly lower among repeat donors compared with first-time donors. The mean MCV was 91.2 fL among first-time donors and 84.9 fL among repeat donors, with a reported mean difference of 6.3 fL (95% CI: 2.9–9.6; p<0.0007). RDW was significantly higher among repeat donors compared with first-time donors. The mean RDW was 12.9% among first-time donors and 13.8% among repeat donors, with a reported mean difference of 1.45 (95% CI: 1.01–2.03; p<0.001). No statistically significant differences were observed in MCH, MPV or WBC count between first-time and repeat donors. The mean platelet count, MPV and PDW were 2.5 ± 0.46 lakh/µL, 9.02 ± 1.1 fL and 10.8 ± 2.04 fL, respectively. Platelet count did not differ significantly between first-time and repeat donors. A comparison of MCV and RDW between first time first-time and repeat blood donors is represented in Table 4.

Table 4. Comparison of MCV and RDW between first-time and repeat blood donors

Parameter	First-time donors Mean	Repeat donors Mean	Mean difference (95% CI)	P value
MCV	91.2 fL	84.9 fL	6.3fL (2.9–9.6)	<0.001
RDW	12.9%	14.5%	1.45 (1.01–2.03)	<0.001

Thus, MCV showed a significant decrease, whereas RDW showed a significant increase, among repeat blood donors compared with first-time donors.

A comparison of MCV and RDW according to the donation frequency of the donors is shown in Table 5.

Table 5. Comparison of MCV and RDW according to donation frequency

Donation Group	n	MCV, Mean ± SD (fL)*	RDW, Mean ± SD (%)*
Group 1: First-time	100	91.2 ± 4.5	12.9 ± 1.1

Group 2: 2–5 donations	40	87.8 ± 4.2	13.4 ± 1.2
Group 3: 6–10 donations	28	85.6 ± 4.0	13.9 ± 1.3
Group 4: >10 donations	32	83.7 ± 3.8	14.5± 1.4

A progressive decline in mean MCV was observed from first-time donors to donors with increasing previous donation history. The mean MCV was highest among first-time donors and lowest among donors who had donated more than 10 times. In contrast, RDW demonstrated an increasing trend with increasing donation frequency. The highest mean RDW was observed among donors with more than 10 previous donations.

One-way ANOVA demonstrated a statistically significant difference in MCV across the four groups ($p < 0.001$).Tukey's Post-hoc analysis demonstrated that the differences were predominantly between first-time donors and donors with ≥6 previous donations. Similarly, a statistically significant difference in RDW was observed across the four groups ($p < 0.001$), with RDW increasing progressively with donation history. Table 6 shows the post-hic comparison of MCV and RDW between different donation frequencies.

Table 6. Post-hoc pairwise comparison of MCV and RDW according to donation frequency

Comparison	MCV	RDW
Group 1 vs Group 2	NS	NS
Group 1 vs Group 3	<0.01*	<0.01*
Group 1 vs Group 4	<0.001*	<0.001*
Group 2 vs Group 3	NS	NS
Group 2 vs Group 4	<0.01*	<0.05*
Group 3 vs Group 4	NS	NS

NS = Not significant; * = Statistically significant

Post-hoc analysis showed no statistically significant differences in MCV or RDW between first-time donors and donors with 2–5 previous donations. In contrast, first-time donors differed significantly from donors with 6–10 donations for both MCV and RDW ($p<0.01$), and from donors with >10 donations ($p<0.001$). Among repeat donors, the 2–5 donation group differed significantly from the >10 donation group for MCV ($p<0.01$) and RDW ($p<0.05$). No statistically significant differences were observed between the 2–5 and 6–10 donation groups or between the 6–10 and >10 donation groups.An inverse trend was observed between donation frequency and MCV, while a positive trend was observed between donation frequency and RDW. These findings suggest that increasing donation history may be associated with progressive changes in red cell indices.

DISCUSSION

The present study evaluated haematological parameters among first-time and repeat blood donors and demonstrated significant differences in certain red cell indices. Repeat donors showed a lower MCV and higher RDW compared with first-time donors. There were no significant differences observed in other haematological parameters like MCH, MPV and WBC count.

MCV is an important red cell index that reflects the average volume of circulating erythrocytes. A reduction in MCV may occur in several conditions, including iron-deficient erythropoiesis.[7]

RDW reflects the degree of variation in erythrocyte size and may increase when newly produced red cells differ in size from older circulating cells. Therefore, the combination of a lower MCV and higher RDW observed among repeat donors in the present study may indicate altered erythropoiesis among individuals with repeated blood donation.8 The combination of a reduction in MCV and an increase in RDW observed in our study is of particular interest in the context of repeated blood donation. Repeated blood donation results in repeated red cell loss and may progressively affect iron availability for erythropoiesis. These changes can occur before overt anaemia develops.

Our study did not directly assess iron status, and therefore, the observed changes in MCV and RDW can not be interpreted as definitive evidence of iron deficiency. Rather, these findings indicate that red cell indices may serve as useful haematological parameters for identifying donors who may require closer evaluation, particularly among repeat donors.

Our findings are also similar to other articles describing the usefulness of MCV and RDW in the evaluation of iron deficiency and red cell abnormalities. Bessman et al. described the relationship between red cell indices and different types of anaemia, demonstrating the importance of automated red cell parameters in the evaluation of haematological abnormalities.[9]

Similarly, Rivera et al. reported that changes in CBC parameters, including MCV and RDW, may be useful in identifying iron deficiency and iron deficiency anaemia. Their findings demonstrated that an increase in RDW together with a reduction in MCV may occur during the development of iron deficiency.[10]

Sultana et al. also reported that an elevated RDW may provide an early indication of iron deficiency anaemia, even when other red cell indices remain within normal limits.[11]

In this study, the significant reduction in MCV and increase in RDW among repeat donors therefore raise the possibility of early red cell changes associated with repeated donation. However, because this was a cross-sectional study and iron status was not directly evaluated, a causal relationship between repeated donation and iron deficiency cannot be conclusively established.

Another important finding in our study was the trend toward lower MCV and higher RDW with increasing donation history. Donors were categorised according to previous donations, and this categorisation allowed the possibility of examining whether repeated exposure to blood donation is associated with progressively greater changes in red cell

indices. The findings highlight the importance of continued haematological monitoring of repeat and frequent blood donors. Particular attention may be given to donors with a high cumulative number of donations, especially those with persistently low MCV or elevated RDW.

Donor health should remain an important component of blood donation programmes. Although maintaining an adequate blood supply is essential, this should be balanced with the need to prevent adverse effects of repeated donation on donor health.

Appropriate donor selection, adherence to recommended donation intervals, periodic haemoglobin assessment, and careful review of haematological parameters can contribute to the long-term health of regular donors.[12]

Where clinically indicated, donors with evidence of haematological abnormalities should receive appropriate counselling and medical evaluation. Iron supplementation may be considered in appropriately selected donors according to institutional protocols and clinical assessment, particularly when iron deficiency is suspected or established. Such an approach can help preserve donor health and support continued eligibility for future blood donation.[13]

Our findings are also consistent with the observations of Alexander et al., who reported that red cell indices can provide useful information regarding iron depletion among blood donors.[14] This supports the potential role of routine red cell indices as an accessible and inexpensive means of identifying donors who may require closer evaluation.

However, the interpretation of MCV and RDW should always be made along with haemoglobin concentration, clinical history, donation frequency, and other relevant laboratory findings. These indices are not specific for iron deficiency and may be influenced by several other physiological and pathological conditions.

Overall, this study emphasizes that repeated blood donation may be associated with measurable changes in red cell indices even in otherwise eligible donors. These findings reinforce the importance of donor surveillance and appropriate donor-care strategies within blood transfusion services.

LIMITATIONS

The present study has several limitations. Firstly, the cross-sectional design limits the ability to establish a causal relationship between repeated blood donation and changes in red cell indices. Secondly, serum ferritin, transferrin saturation, soluble transferrin receptor, and other biochemical measures of iron status were not assessed; therefore, iron deficiency could not be directly confirmed. Third, the study included only male donors, limiting the generalizability of the findings to female donors. Fourth, the study was conducted at a single tertiary-care blood centre and used convenience sampling, which may limit external validity. Finally, potential confounding factors such as dietary iron intake, duration of time since the previous donation, and cumulative blood volume donated may have influenced red cell indices.

CONCLUSION

Our study highlights the importance of monitoring red cell indices among blood donors, particularly those who donate repeatedly. A significant reduction in MCV and an increase in RDW were observed among repeat donors compared with first-time donors, whereas platelet count and several other haematological parameters did not show significant differences. These findings suggest that repeated blood donation may be associated with changes in red cell indices that could precede clinically apparent anaemia. Although MCV and RDW cannot independently diagnose iron deficiency, they may serve as useful and readily available parameters for identifying donors who require closer monitoring. Regular monitoring of haemoglobin and red cell indices, together with appropriate donor counselling and strict following of recommended donation intervals, may help protect the health of frequent blood donors. Attention must be given to donors with a high total number of donations, as repeated donation may increase the likelihood of developing haematological changes. Appropriate interventions and follow-up can help maintain donor health while ensuring a safe and sustainable blood supply. Thus, a donor-centred approach to blood donation, balancing the need for an adequate blood supply with the long-term health of donors, is essential for the effective functioning of transfusion services.

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