Evaluation of Hematological and Biochemical Parameters in Female Patients with Iron Deficiency Anemia

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Abstract—**Introduction: A significant worldwide public health issue that affects both developed and developing nations is anemia. The most prevalent form is iron deficiency anemia (IDA), which is caused by a lack of iron necessary for heme production. Inadequate nutritional intake, elevated physiological demand, poor absorption, and persistent blood loss are among the causes. Hematological indicators including hemoglobin (Hb) and red cell indices (MCV, MCH, MCHC, RDW) as well as biochemical markers such serum iron and ferritin are used in laboratory diagnostics.**

Objectives:

1. **To evaluate hematological and biochemical parameters in females with iron deficiency anemia.**
2. **To establish the correlation between these parameters.**

Methods:
This cross-sectional study included 100 females diagnosed with iron deficiency anemia. Blood samples were collected from peripheral veins using anticoagulant vacutainers. EDTA samples were used to analyze hematological parameters including Hb, MCV, MCH, MCHC, RDW, and reticulocyte count. Serum samples were obtained using SST tubes and centrifuged at 3000 rpm for 10 minutes for biochemical analysis. IDA was confirmed using serum ferritin, serum iron, total iron binding capacity (TIBC), and transferrin saturation.

Results:
The mean hemoglobin level was found 7.65 g/dL. The average MCV was 66.20 fL, and MCH values were also reduced. Biochemical parameters showed mean serum iron of 31.24 µg/dL, serum ferritin of 9.68 µg/L, TIBC of 457.14 µg/dL, and transferrin saturation of 7.19%.

Conclusion:
Hemoglobin demonstrated a moderate positive correlation with serum ferritin, serum iron, and transferrin levels, indicating that rising Hb concentrations are linked with improved iron stores and availability. In contrast, Hb showed a strong negative correlation with total iron-binding capacity (TIBC). Likewise, mean corpuscular volume (MCV) was positively correlated with serum ferritin and serum iron, whereas an inverse relationship was observed with TIBC. Overall, these findings underscore the significant association between hematological indices and biochemical indicators in Iron Deficiency Anemia.

Index Terms—**Anemia, Iron Deficiency Anemia, Hemoglobin, Serum Iron, Serum Ferritin, MCV, MCH, MCHC**

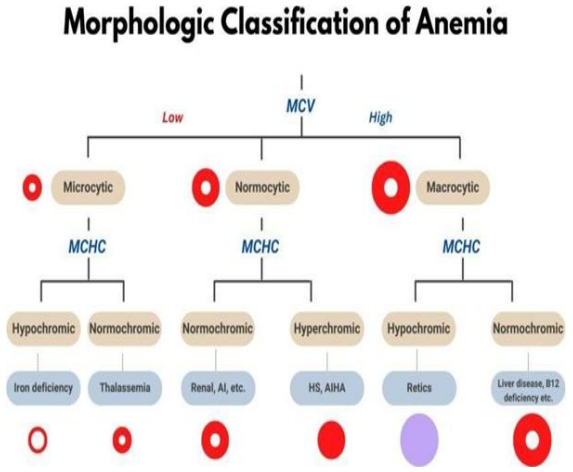
I. INTRODUCTION

Anemia is one of the most widespread public health problems worldwide, affecting individuals across all age groups in both developed and developing nations. Current estimates suggest that nearly 1.62 billion people are affected globally, representing about one-quarter of the world's population. [1] It is characterized by a reduction in red blood cell (RBC) count,

hemoglobin concentration, or hematocrit (HCT) below the normal limits established for age and sex. According to the criteria established by the World Health Organization, anemia is diagnosed when hemoglobin levels fall below 11.5 g/dL in children aged 5–11 years, below 12 g/dL in children aged 12–14 years and non-pregnant women, below 11 g/dL in pregnant women, and below 13 g/dL in adult men. [2]
Hemoglobin is an essential iron-containing protein found within RBCs and is primarily responsible for transporting oxygen from the lungs to body tissues. It also assists in carrying carbon dioxide from tissues back to the lungs for elimination. [3] When hemoglobin levels or RBC numbers decline, the oxygen delivery capacity of blood becomes impaired, leading to symptoms such as tiredness, generalized weakness, pallor, dizziness, and breathlessness. The clinical severity of anemia varies according to its underlying cause, which may include nutritional deficiencies, chronic inflammatory conditions, infections, or inherited disorders. [4]

Among the different forms of anemia, Iron Deficiency Anemia remains the most common nutritional disorder globally. Women of reproductive age, pregnant women, and children are particularly susceptible because of increased iron requirements. Worldwide data indicate that anemia affects approximately 38% of pregnant women and 29% of non-pregnant women, with a greater prevalence observed in low- and middle-income countries. Based on prevalence rates, the WHO categorizes anemia as a mild public health concern when prevalence ranges from 5.0–19.9%, moderate at 20.0–39.9%, and severe when it exceeds 40%. Multiple factors, including age, gender, pregnancy, altitude, and smoking habits, can influence hemoglobin concentration. Beyond its medical consequences, anemia also poses a significant socio-economic burden by reducing physical performance, impairing cognitive function, and lowering work productivity. [5]

Morphological classification of Anemia based on size and Hemoglobin concentration in RBCs[6]



Approximately half of all anemia cases worldwide are linked to iron deficiency, making it the most prevalent micronutrient deficiency globally. [7] Iron Deficiency Anemia has a substantial impact on health and quality of life, particularly among women and children. In adults, iron deficiency is associated with reduced physical performance, decreased work productivity, and persistent fatigue. Studies have also demonstrated that iron deficiency, even in the absence of clinically evident anemia, may adversely affect cognitive performance in adolescent girls. In children, prolonged iron deficiency has been associated with impaired mental development as well as disturbances in auditory and visual function. [8]
Iron deficiency anemia develops when the supply of iron is insufficient to meet the demands of heme and hemoglobin synthesis, ultimately leading to depletion of body iron reserves. Iron is a critical component required for erythropoiesis, and a major proportion of absorbed iron is utilized for the continuous production of red blood cells. Reduced hemoglobin synthesis lowers the oxygen-carrying capacity of blood, causing inadequate oxygen delivery to tissues and the characteristic manifestations of anemia. Before overt anemia develops, iron depletion may already impair the function of organs such as skeletal muscles and the myocardium, where iron is essential for myoglobin formation and cellular energy production. [9]
Pregnancy is accompanied by physiological alterations that influence hemoglobin concentration and iron metabolism. During early pregnancy, hemoglobin levels commonly decline because of plasma volume expansion and increased fetal iron requirements. A mild increase may occur later in

gestation as physiological adaptation progresses. According to the World Health Organization, anemia in pregnancy is defined as hemoglobin levels below 11 g/dL. The likelihood of developing IDA during pregnancy largely depends on maternal iron reserves before conception and the adequacy of dietary iron absorption throughout gestation. [10]

Iron deficiency remains one of the most common nutritional disorders worldwide and affects more than two billion individuals, particularly in low- and middle-income countries. However, it is also frequently encountered in developed nations, especially among women of reproductive age because of menstrual blood loss and increased physiological demands. Iron deficiency is often associated with chronic disorders such as Inflammatory Bowel Disease, Chronic Kidney Disease, chronic heart failure, and malignancies. In inflammatory conditions, iron may become trapped within the reticuloendothelial system, resulting in functional iron deficiency despite apparently adequate iron stores. [11]

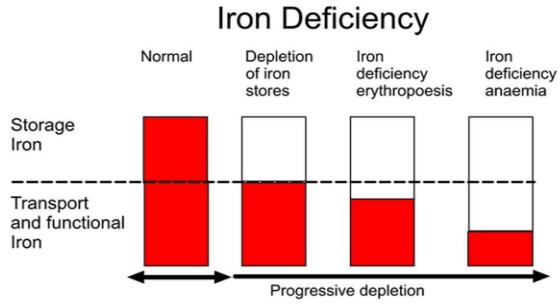
In patients with inflammatory bowel disease, iron deficiency represents a major contributor to anemia and frequently coexists with anemia of chronic disease. Management therefore requires both correction of iron deficiency and effective control of the underlying inflammatory process. [12]

The causes of iron deficiency are multifactorial and may involve increased physiological requirements, such as those occurring during growth, pregnancy, and lactation, or pathological factors including chronic blood loss and impaired intestinal absorption. Gastrointestinal disorders such as Celiac Disease, Helicobacter pylori Infection, and autoimmune atrophic gastritis are recognized contributors to refractory iron deficiency anemia, even in patients without obvious symptoms of malabsorption. [13]

Globally, iron deficiency is estimated to affect nearly 3.5 billion individuals, with the greatest burden observed in developing countries. Clinicians should suspect iron deficiency in individuals presenting with chronic fatigue, unexplained weakness, pica, hair loss, or a history suggestive of chronic blood loss. Classical manifestations such as koilonychia and Plummer–Vinson Syndrome are now encountered less frequently, particularly in developed regions. Nevertheless, laboratory investigations often identify iron deficiency even in asymptomatic individuals. [14]

Women of reproductive age remain especially susceptible because of menstrual blood loss combined with inadequate dietary intake. The recommended daily iron requirement is approximately 18 mg for women and 8 mg for men, increasing to nearly 27 mg during pregnancy. Although iron is indispensable for normal physiological processes, excessive accumulation may produce toxic effects; therefore, maintaining a balance between iron intake, absorption, storage, and utilization is essential.

Iron deficiency generally progresses through several stages. Initially, iron stores become depleted while hemoglobin synthesis remains unaffected. This stage is followed by iron-deficient erythropoiesis, in which iron-dependent metabolic functions are impaired despite the absence of overt anemia. Eventually, persistent deficiency leads to iron deficiency anemia, characterized by microcytic and hypochromic red blood cells with reduced hemoglobin content and abnormal cellular morphology.



Iron status	Normal	Mild deficiency	Marginal deficiency	Severe deficiency
Haemoglobin	Normal	Normal	Normal	Low
Other Fe functions	Normal	Normal/low	Low	Low
Stores (SF)	Normal	Normal/low	Low	Low

Figure. Normal with adequate iron stores; (2) mild deficiency, where the bone marrow's mobilizable iron stores are reduced but the synthesis of iron-dependent proteins continues; (3) marginal deficiency, or iron-deficient erythropoiesis, which affects the production of iron-dependent proteins but preserves erythropoiesis and haemoglobin production; and (4) iron deficiency anemia (IDA), where the synthesis of red blood cells is halted and haemoglobin production is compromised due to a lack of iron for incorporation into erythroid precursors.[15]

According to World Health Organization estimates, Iron Deficiency Anemia caused approximately

273,000 deaths globally in 2004, with nearly 97% occurring in low- and middle-income countries. Southeast Asia accounted for the highest mortality burden (45%), followed by Africa (31%). IDA was also responsible for nearly 19.7 million disability-adjusted life years (DALYs), representing 1.3% of the global disease burden. The condition imposes a major economic burden, causing an estimated annual loss equivalent to about 4% of the gross domestic product (GDP) in developing countries. [514]

Historically, iron deficiency anemia has been recognized for centuries. Hippocrates described symptoms such as pallor and pica, while Johannes Lange later termed the condition “chlorosis” or “green sickness.” Iron therapy was subsequently introduced by Thomas Sydenham and became an established treatment by the 19th century. [16]

Iron deficiency anemia occurs more commonly in women because of menstrual blood loss and increased iron requirements during pregnancy. Chronic gastrointestinal blood loss is another important and treatable cause, particularly in disorders such as liver cirrhosis and peptic ulcer disease. Iron deficiency, even without overt anemia, can negatively affect quality of life and is associated with increased cardiovascular risk and metabolic disturbances. [17]

Diagnosis of iron deficiency anemia requires both clinical assessment and laboratory evaluation. Important hematological parameters include hemoglobin level, red blood cell morphology, and red cell indices such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW). Reticulocyte count and biochemical markers, particularly serum ferritin, are also essential, as reduced ferritin levels indicate depleted iron stores. [18]

II. AIM AND OBJECTIVES OF STUDY

AIM

The aim of study is to Investigate the correlation between haematological and biochemical parameters in females with iron deficiency anemia.

Objective.

1. To evaluate the status of hematological and biochemical parameters in females with iron deficiency anemia.
2. To establish the correlation between haematological and biochemical parameters.

III. MATERIALS AND METHODS

Study Design

The present investigation was designed as a hospital-based cross-sectional study aimed at evaluating the relationship between hematological indices and biochemical parameters among female patients diagnosed with Iron Deficiency Anemia. A cross-sectional study design was considered appropriate as it enables the assessment of clinical, hematological, and biochemical characteristics of the study population at a single point in time. This design also facilitated the analysis of correlations between different laboratory parameters associated with iron deficiency anemia without the need for long-term follow-up.

Study Area

The study was conducted in the Department of Paramedical Sciences, Jeevan Rekha Group of Institutions, Kashipur, Uttarakhand, in collaboration with Ujala Cygnus Hospital. The institution caters to a diverse patient population from urban and rural regions of Uttarakhand and neighboring areas, providing access to patients from different socio-economic backgrounds. The laboratory facilities available at the institution were equipped to perform routine hematological investigations and biochemical assays required for the diagnosis and evaluation of iron deficiency anemia.

Duration of Study

The study was carried out over a period of six months after obtaining approval from the Institutional Ethics Committee. During this period, eligible participants were screened, recruited, and evaluated according to the study protocol. All hematological and biochemical investigations were performed within the defined study duration to ensure consistency and uniformity in data collection and analysis. Ethical principles related to human participation, confidentiality, and informed consent were strictly maintained throughout the study.

Sample Size

The study was carried out over a period of six months following approval from the Institutional Ethics Committee (IEC). A total of 100 participants were enrolled in the study based on the predefined inclusion and exclusion criteria. The selected sample size was considered adequate to evaluate the hematological and biochemical alterations associated with iron deficiency anemia and to determine statistically significant correlations between these parameters. All participants included in the study were female patients within the reproductive age group who had been clinically and laboratory-confirmed to have iron deficiency anemia.

Inclusion Criteria

1. Females aged between 18–35 years
2. Diagnosed cases of iron deficiency anemia as per WHO criteria

Exclusion Criteria

1. Pregnant women
2. Patients with chronic illnesses (chronic kidney disease, cardiovascular diseases, inflammatory disorders)
3. Patients with recent blood transfusion
4. Diabetic patients
5. Leukemia patients
6. Patients with thyroid disorders

Ethical Considerations

The study was approved by the Institutional Human Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study. Confidentiality of all study participants was strictly maintained throughout the study.

Test Procedure

This cross-sectional study included 100 female patients aged 18–35 years diagnosed with iron deficiency anemia. Venous blood samples were collected under strict aseptic precautions.

Blood Sample Collection

Blood samples were collected by venepuncture from the antecubital vein or dorsal vein using appropriate anticoagulant vacutainers.

- Ethylenediaminetetraacetic acid (EDTA) was used as an anticoagulant for hematological investigations.
- Hematological parameters were analyzed using an automated hematology analyzer.
- Proper quality control measures were followed to ensure accuracy and reliability of results.
- Hematological and biochemical analyses were carried out in the hematology and biochemistry laboratories, respectively.

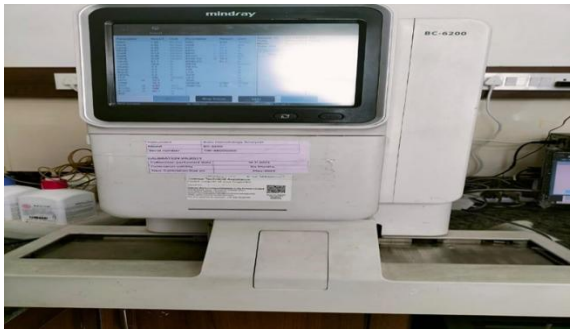
Serum Sample Preparation

- Blood was collected in plain (red-top) tubes without anticoagulant.
- The sample was allowed to clot at room temperature for 15–30 minutes.
- The clot was separated by centrifugation at 1000–2000 × g for 10 minutes.
- Serum Separator Tubes (SST) with gel were also used for biochemical analysis.
- Samples in SST were centrifuged at 3000 rpm for 10 minutes.

1. Haematological parameters:

Red cell indices count:

Well mixed EDTA blood samples had their red blood cell indices (MCV, MCH, MCHC), including Hb, haematocrit, RDW and other relevant indicators determined by electronic haematology analyzer (MindrayBC-6000). Calibration of analyzer and processing of the samples were done according to the standardized methods. The blood is well mixed (though not shaken) and placed on a rack in the analyzer. This instrument has many different components to analyse different elements in the blood. the cell counting component counts the number and types of different cells within the blood. the result are printed out or sent to computer for review.



Blood film

Place a drop of fresh blood on a clean glass slide 1 to 2 cm from one end and prepared blood film using spreader then move spreader forward rapidly over the slide. Thus blood film of fresh blood is prepared. Dried it and stained by Leishman stain (Rabans Lane Ind-UK) for red cell morphology assessment.

Haemoglobin analysis:

Haemoglobin analysis carried out using automated haematological analyzer (BeneSphera-H33s)

2.Biochemical parameters

Estimation of serum iron and TIBC:

Serum iron and total iron-binding capacity (TIBC) measured using commercial kits on the COBAS C311 analyzer (Roche diagnostics, Germany) and transferrin saturation was calculated by the ratio of serum iron concentration to total iron binding capacity.

Statistical analysis: Data were collected and statistical analysis were performed by SPSS software and analysed for descriptive statistics. The appropriate statical tool will be applied to Calculate quantitative data were expressed as mean and standard deviation. Student t test were used to determine correlation coefficients (e.g., Pearson correlation) between haematological and biochemical parameters and distribution of the collected data.

IV. RESULTS AND DISCUSSION

The study included 100 females patient who were suffering from iron deficiency anemia. All female were between the age group 18-35 age, this study carried out in the Department of Paramedical sciences, Jeevan rekha Group of Institutions, Kashipur. A total of 100 patients (female) data regarding haematological and biochemical parameters was recorded. The analysis of haematological and biochemical parameters was analyzed with showed in tables.

Age groups (in years)	No. of patients	Percentage
18-23	17	18%
24-29	25	25%
30-35	58	58%
Total	100	100%

Table 1: Age Group Distribution of Ida Patients

Table 1: Age distribution with frequency and percentage representation are shown in this table. In this study out of 100 female patients. 18 % patient were in age group between 18-23 years, 25% in age group between 24-29 years, 58% in age groups between 30-35 years. Most common prevalence of iron deficiency anemia seen in 30 – 35 years age group of females.

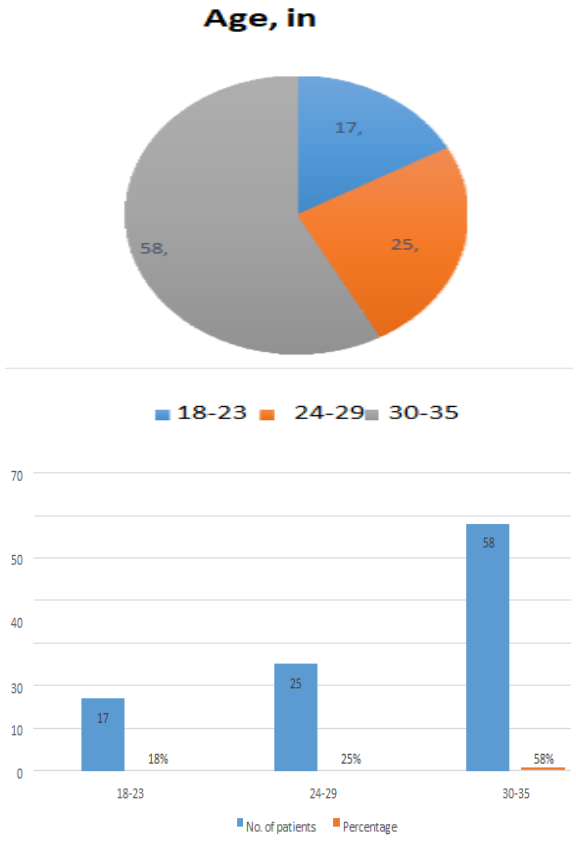


Figure 1: Age group distribution of IDA patients

Table 2: Distribution Of Hemoglobin Concentraion in Patients

Haemoglob in (Hb)gm/dl	No. of patients	Percentage
3-6	29	29%
7-10	51	51%
11-13	20	20%
Total	100	100%

Table 2: 51 of patients had a Hb value of 7-10gm/dl, which is majority. By comparison, Hb value of 3-6 gm/dl are present in 29 number of patients, while haemoglobin value between 11-13gm/dl represents a smaller proportion of the total patient about 20%.

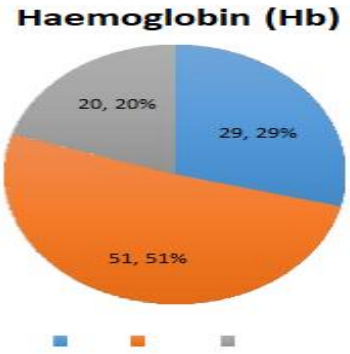


Table 3: Distribution Of Mcv Values In Patients

MCV	No. of patients	Percentage
57-66	57	57%
67-76	37	37%
77-89	6	6%
Total	100	100%

Table 3: displays distribution of MCV value for patients undergoing iron deficiency anemia assessment is shown in table 3, 57 of number of patients. had a value of 57-66 fl, which is majority. By comparison, MCV value of 67-76 fl are present in 37 % of patient, while MCV value between 77 to 89 fl represents a smaller proportion of the total patient.

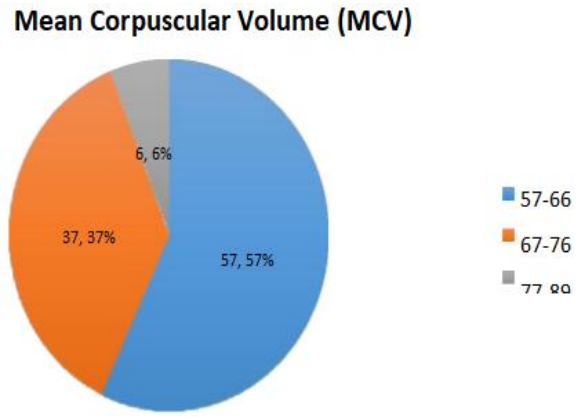


Figure 3: Distribution Of Mcv Values in Patients

Table 4: CORRELATION BETWEEN HB AND SERUM FERRITIN

Parameters	Mean	S.D.	Correlation	P value
Hemoglobin	7.65	2.34	0.639	0.00
FERRITIN	9.68	11.65		

Table 4: Reflects that Hb had average level of 7.65g/dl with standard deviation of 2.34 and ferritin had average level of 9.68 with standard deviation 11.65, (r=0.639, p=0.00) correlation is significant at the <0.01 level.

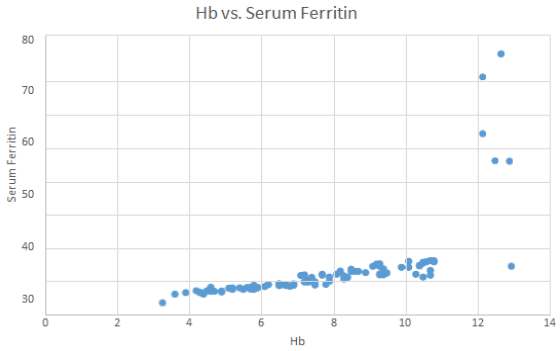


Figure 4: Correlation Between Hb and Serum Ferritin

Table 5: Correlation Between Hb and Serum Iron

Parameters	Mean	S.D.	Correlation (r)	P value
HB	7.65	2.34	0.740	0.00
SERUM IRON	31.24	11.88		

Table 5: Reflects that Hb had average level of 7.65g/dl with standard deviation of 2.34 and serum iron had average level of 31.24 with standard deviation11.88, (r=0.740, p=0.00) correlation between Hb and serum iron is statistically highly significant.

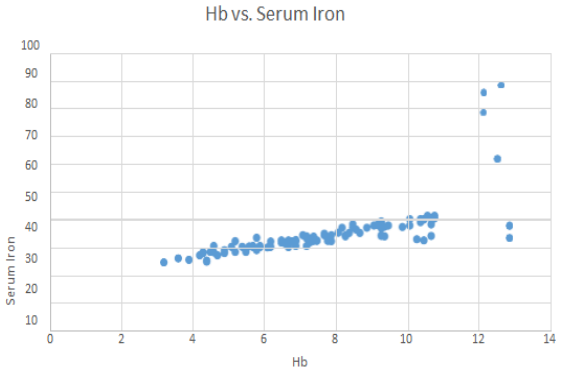


Figure 5: Correlation Between Hb and Serum Iron

Table 6: Correlation Between Hb and Tibc

Parameters	Mean	S.D.	Correlation	P value
HB	7.65	2.34	-0.614	0.00
TIBC	457.14	38.93		

Table 6: Reflects that Hb had average level of 7.65g/dl with standard deviation of 2.34 and TIBC had average

level of 457.14 with standard deviation38.93, (r= -0.614, p =0.00) TIBC has negative correlation with Hb.

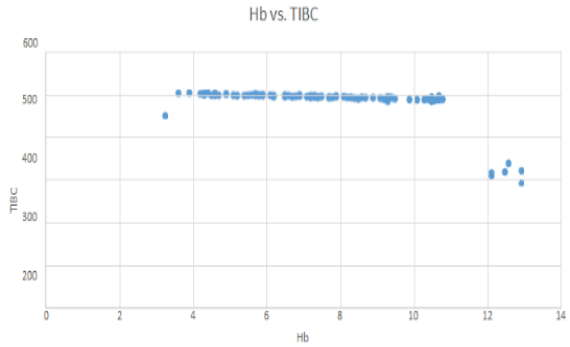


Figure 6: Correlation Between Hb and Tibc

Table 7: Correlation Between Hb and Transferritin

Parameters	Mean	S.D.	Correlation	P value
HB	7.65	2.34	0.663	0.00
TRANSFERRIN	7.19	4.49		

Table 7: Reflects that Hb had average level of 7.65g/dl with standard deviation of 2.34 and transferrin had average level of 7.19 with standard deviation4.49, (r=0.663, p=0.00) correlation between Hb and transferrin is highly significant.

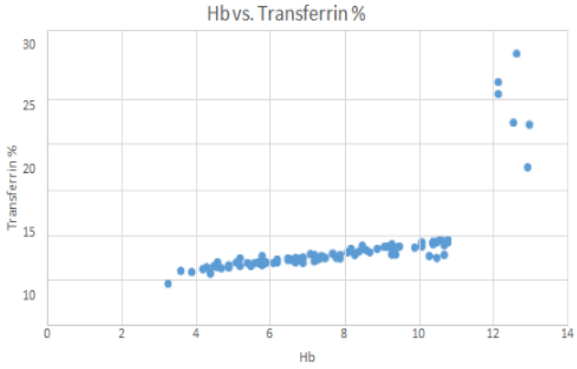


Figure 7: Correlation Between Hb and Transferritin

Table 8: Correlation Between Mcv and Serum Ferritin

Parameters	Mean	S.D.	Correlation	P value
MCV	66.20	6.00	0.756	0.00
FERRITIN	9.68	11.65		

Table 8: Reflects that MCV had average level of 66.20 with standard deviation of 6.00 and ferritin had average level of 9.68 with standard deviation 11.65, (r=0.756, p=0.00) correlation between mcv and ferritin found statistically highly significant.

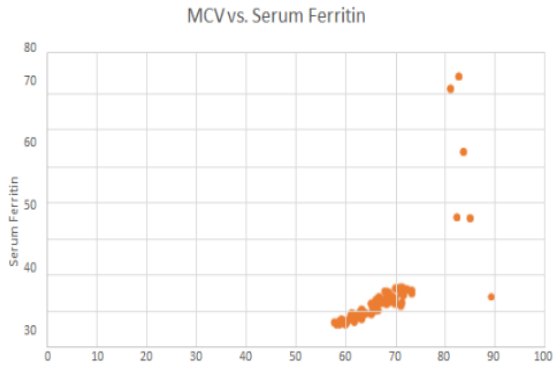


Figure 8: Correlation Between Mcv and Serum Ferritin

Table 9: Correlation Between Mcv and Serum Iron

Parameters	Mean	S.D.	Correlation	P value
MCV	66.20	6.00	0.872	0.00
SERUM IRON	31.24	11.88		

Table 9: Reflects that MCV had average level of 66.20 with standard deviation of 6.00 and Serum iron had average level of 31.24 with standard deviation 11.88, (r=0.872, p=0.00) correlation between MCV and serum iron is statistically significant.

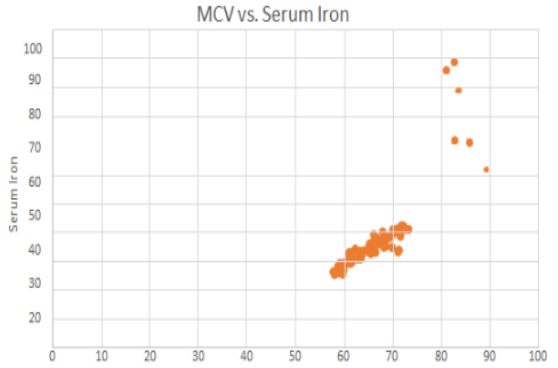


Figure 9: Correlation Between Mcv and Serum Iron

Table 10: Correlation Between Mcv and Tibc

Parameters	Mean	S.D.	Correlation	P value
MCV	66.20	6.00	-0.812	0.00
TIBC	457.14	38.93		

Table 10: Reflects that MCV had average level of

66.20 with standard deviation of 6.00 and TIBC had average level of 457.14 with standard deviation 38.93, (r= -0.812, p=0.00) TIBC is negatively correlated with MCV.

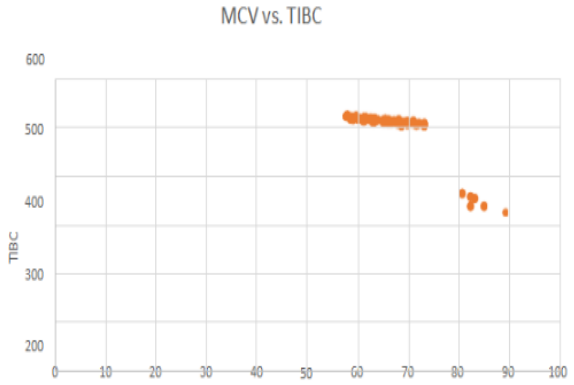
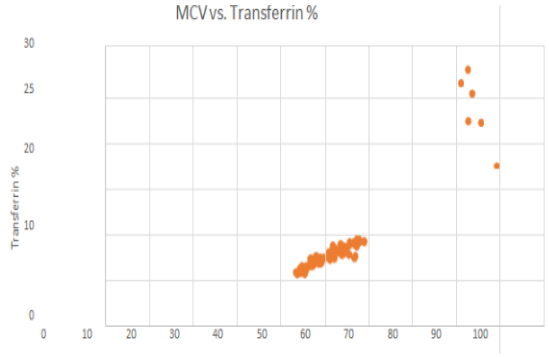


Figure 10: Correlation Between Mcv and Tibc

Table 11: Correlation Between Mcv and Transfeerin

Parameters	Mean	S.D.	Correlation	P value
MCV	66.20	6.00	0.831	0.00
TRANSFEERIN	7.19	4.49		

Table 11: Reflects that MCV had average level of 66.20 with standard deviation of 6.00 and transferrin had average level of 7.19 with standard deviation 4.49. (r=0.831 p=0.00) correlation between MCV and Transferrin is highly significant.



[1] Figure 11: Correlation Between Mcv and Transfeerin

V. DISCUSSION

The present cross-sectional study was conducted among 100 female patients aged 18–35 years diagnosed with Iron Deficiency Anemia at the Department of Paramedical Sciences, Jeevan Rekha Group of Institutions, Kashipur, in collaboration with Ujala Cygnus Hospital. The primary objective of the study was to assess hematological and biochemical alterations associated with IDA and to evaluate the correlation between these parameters in affected females of reproductive age.

Age-wise distribution demonstrated that 18% of participants belonged to the 18–23 years age group, 25% to 24–29 years, and the majority (58%) to the 30–35 years age group, indicating a higher prevalence of iron deficiency anemia among women in the later reproductive years. This observation is consistent with previous epidemiological studies reporting a greater burden of anemia among females, particularly those of reproductive age, due to increased physiological iron requirements, menstrual blood loss, and nutritional insufficiency. Studies by Pudasaini S and others have similarly documented a significantly higher prevalence of anemia in women compared with men.

Evaluation of hemoglobin concentration revealed that the majority of patients (51%) had hemoglobin levels between 7–10 g/dL, consistent with moderate anemia, while 29% exhibited severe anemia with hemoglobin values ranging from 3–6 g/dL. Only a small proportion demonstrated hemoglobin concentrations within the 11–13 g/dL range. These findings highlight the substantial burden of moderate-to-severe anemia among the studied population and emphasize the clinical significance of early detection and intervention.

Assessment of red blood cell indices showed marked microcytosis, with 57% of patients demonstrating mean corpuscular volume (MCV) values between 57–66 fL. The observed reduction in MCV, together with decreased mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC), confirms the characteristic microcytic hypochromic morphology associated with iron deficiency anemia. Elevated red cell distribution width (RDW) further indicated significant anisocytosis, reflecting variability in erythrocyte size and progressive disruption of erythropoiesis with increasing severity of iron deficiency. Similar hematological patterns have been consistently reported in previous studies investigating IDA.

Biochemical analysis demonstrated markedly depleted iron stores, with a mean serum ferritin concentration of 9.68 ng/mL. Serum ferritin showed a positive

correlation with hemoglobin concentration, MCV, and MCHC, indicating that declining iron reserves are closely associated with worsening hematological abnormalities. Mean serum iron levels were also reduced (31.24 µg/dL) and exhibited a positive correlation with hemoglobin and MCV, reflecting impaired iron availability for effective erythropoiesis.

In contrast, total iron-binding capacity (TIBC) was markedly elevated, with a mean value of 457.14 µg/dL, and demonstrated a negative correlation with hemoglobin and MCV. Increased TIBC is indicative of enhanced transferrin synthesis in response to iron depletion and represents a compensatory physiological mechanism to maximize iron transport. Transferrin saturation was substantially reduced, with a mean value of 7.19%, confirming inadequate circulating iron available for hemoglobin synthesis. These biochemical findings are consistent with the classical laboratory profile of iron deficiency anemia and are in agreement with previous investigations, including those conducted by Lekharu R and Abdelmahmuod E, which reported decreased serum ferritin and serum iron levels accompanied by elevated TIBC in IDA patients.

The mean hematological parameters observed in the present study included hemoglobin of 7.65 g/dL, packed cell volume (PCV) of 22.95%, MCV of 66.20 fL, MCH of 20.53 pg, and MCHC of 28.06 g/dL. Collectively, these findings strongly support the presence of microcytic hypochromic anemia secondary to iron deficiency. The elevated mean RDW value (22.63%) further supports increased erythrocyte heterogeneity, which is recognized as an important hematological feature in IDA. Comparable observations were previously reported by Aulakh R, who identified significant RDW elevation among patients with iron deficiency anemia.

Correlation analysis demonstrated that hemoglobin concentration and MCV were positively associated with serum iron, serum ferritin, and transferrin saturation, while exhibiting an inverse relationship with TIBC. These correlations emphasize the close interrelationship between hematological indices and biochemical markers of iron metabolism. Similar associations have been documented in studies by Loboda AN and others, further validating the diagnostic relevance of combined hematological and biochemical assessment in IDA.

Overall, the findings of the present study reinforce the clinical utility of serum ferritin as a sensitive and reliable biomarker of body iron stores. Furthermore, the combined evaluation of hematological indices and biochemical parameters provides a comprehensive and accurate approach for the diagnosis, assessment of severity, and monitoring of iron deficiency anemia in females of reproductive age.

VI. CONCLUSION

The present study was undertaken to investigate the relationship between hematological indices and biochemical markers in female patients diagnosed with Iron Deficiency Anemia. The findings demonstrate significant alterations in both erythrocyte parameters and iron profile markers, reflecting the profound impact of iron depletion on erythropoiesis and systemic iron metabolism.

The age-wise distribution revealed the highest prevalence of IDA among females aged 30–35 years, indicating increased vulnerability during the later reproductive years. This increased prevalence may be attributed to cumulative menstrual blood loss, inadequate dietary iron intake, repeated pregnancies, and increased physiological iron demands. Hemoglobin assessment showed that the majority of patients (51%) had values between 7–10 g/dL, indicating that moderate anemia represented the predominant clinical presentation within the study population.

Statistical evaluation using Pearson's correlation coefficient demonstrated significant associations between hematological and biochemical parameters. Hemoglobin concentration exhibited a moderate-to-strong positive correlation with serum ferritin ($r = 0.639$), serum iron ($r = 0.740$), and transferrin saturation ($r = 0.663$). These findings indicate that increasing hemoglobin levels are closely associated with improved iron stores and enhanced iron availability for erythropoiesis. Conversely, hemoglobin showed a strong negative correlation with total iron-binding capacity (TIBC) ($r = –0.614$), suggesting that declining hemoglobin levels are accompanied by compensatory elevation of iron-binding proteins secondary to iron depletion.

Mean corpuscular volume (MCV), an important indicator of erythrocyte morphology, also demonstrated strong positive correlations with serum

ferritin (r = 0.756), serum iron (r = 0.872), and transferrin saturation (r = 0.831). These observations confirm that restoration of iron availability is associated with normalization of erythrocyte size and hemoglobinization. In contrast, MCV exhibited a strong inverse correlation with TIBC (r = –0.812), further supporting the association between microcytosis and progressive iron deficiency.

The collective findings of the present study establish a statistically significant relationship between hematological indices and biochemical markers in iron deficiency anemia. The observed correlations emphasize the pathophysiological link between depleted iron stores and defective erythropoiesis. Furthermore, the study highlights the diagnostic value of integrating hematological parameters with biochemical iron profile markers for accurate identification, severity assessment, and therapeutic monitoring of IDA. Combined evaluation of these parameters may therefore provide a more comprehensive and reliable approach for the clinical management of iron deficiency anemia in females of reproductive age.

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