Original Article

Changes in Serum Lipid Profile with Treatment of Iron Deficiency Anaemia: A Prospective Observational Study

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Abstract

Background: Iron deficiency anaemia (IDA) is a prevalent nutritional disorder leading to reduced haemoglobin synthesis and impaired oxygen delivery. Beyond its haematological effects, IDA may also alter lipid metabolism, potentially impacting cardiovascular risk. While dyslipidaemia is a recognised CVD risk factor, the effect of iron repletion on lipid parameters remains incompletely understood. This study aimed to evaluate changes in the serum lipid profile of adults with IDA before and after iron therapy. **Material and Methods:** This prospective, observational study was conducted on 50 adults (18–60 years) diagnosed with IDA at a tertiary care centre. Patients with alcohol-related liver disease, chronic hepatitis, diabetes, or lipid-altering therapy were excluded. Baseline haemoglobin, haematological indices, iron parameters (serum iron, ferritin, TIBC, % saturation), and lipid profile (total cholesterol, triglycerides, LDL, VLDL, HDL) were measured. Participants received oral iron supplementation for three months, after which all parameters were reassessed. Data were analysed using paired t-test and McNemar's χ^2 test, with $p<0.05$ deemed significant. **Results:** Post-treatment, significant improvements were noted in haemoglobin (9.96 ± 1.13 to 13.14 ± 0.65 g/dL, $p<0.00001$), serum iron, ferritin, and % saturation, with a reduction in TIBC. Among lipid parameters, triglycerides decreased significantly (218.2 ± 67.69 to 156.2 ± 77.38 mg/dL, $p=0.00041$), while total cholesterol showed a non-significant decline (236.2 ± 98.48 to 193.8 ± 81.76 mg/dL, $p=0.099$). LDL, VLDL, and HDL levels did not change significantly. The proportion of patients with normal triglyceride levels increased from 36% to 80% ($p=0.00001$). **Conclusion:** Oral iron therapy in IDA patients not only corrects anaemia but is also associated with a significant reduction in serum triglycerides, suggesting a favourable shift in lipid metabolism. These findings support further exploration of iron repletion as a means to mitigate atherogenic risk in iron-deficient individuals.

Keywords: Iron deficiency anaemia, Lipid profile, Triglycerides, Iron therapy.

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Introduction

Iron Deficiency Anaemia (IDA) remains the most widespread nutritional disorder globally and is responsible for nearly half of all anaemia cases worldwide, contributing to over 841,000 deaths annually according to WHO estimates.[1] It affects about 30% of the global population, with a disproportionately high burden in developing countries like India, where 56% of women and 70% of children are anaemic despite several national health initiatives.[2]

IDA occurs due to insufficient iron levels, leading to impaired haemoglobin synthesis and reduced oxygen-carrying capacity of red blood cells.[3] It may result from poor dietary intake, chronic blood loss, malabsorption, or increased physiological demands.[4] Beyond haematological effects, IDA contributes to impaired cognitive function, decreased physical capacity, maternal and perinatal mortality, and exacerbation of comorbid conditions.[2]

In parallel, dyslipidemia — an abnormal lipid profile — is a well-established modifiable risk factor for cardiovascular disease (CVD), the leading cause of mortality worldwide and a growing concern in India.[5] Traditionally, hyperlipidemia has been linked to increased CVD risk, while hypolipidemia has been associated with immunosuppression, increased intracranial haemorrhage, and higher mortality in hospitalized patients.[6–8]

While both IDA and dyslipidemia independently impact public health, their interrelationship remains inadequately understood. Several studies have explored how iron status may influence lipid metabolism, with inconsistent findings. Some report increased total cholesterol (TC), LDL, and triglyceride (TG) levels in IDA patients, while others observe the opposite.[9,10] Furthermore, iron therapy appears to modulate these lipid parameters, suggesting a potential therapeutic benefit.

Experimental and clinical studies suggest that iron affects lipid homeostasis through:

- Enzymatic pathways requiring iron as a cofactor,
- Regulation of hepatic lipid synthesis and β-oxidation,

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- Modulation of lipoprotein lipase and lecithin-cholesterol acyltransferase (LCAT) activity.[11–13]

Given the potential dual burden of IDA and dyslipidemia on cardiovascular risk, and the unclear mechanisms linking the two, further investigation is warranted. Understanding this relationship could open avenues for improving cardiometabolic outcomes through simple, cost-effective interventions like iron supplementation.

Aims and Objectives

This study was undertaken to investigate the relationship between iron deficiency anaemia (IDA) and serum lipid profile in Indian adults. Given the clinical and public health significance of both conditions, the study aimed to assess whether correction of IDA could influence lipid parameters that are known to contribute to cardiovascular risk.

Specific Objectives:

- To analyze the baseline serum lipid profile in adults diagnosed with iron deficiency anaemia.
- To evaluate the effect of oral iron therapy on serum lipid parameters—total cholesterol, triglycerides, LDL, VLDL, and HDL—after three months of treatment.
- To compare pre- and post-treatment lipid values and determine whether any statistically significant changes occurred following IDA correction.

Materials and Methods

Study Design and Setting: This was a prospective observational study conducted in the Department of Medicine at the Teerthanker Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India. The study was carried out over a period of 17 months, from November 2015 to March 2017.

Participants: A total of 50 adult patients (aged 18–60 years) diagnosed with iron deficiency anaemia (IDA) were enrolled based on predefined inclusion and exclusion criteria. All participants provided informed written consent prior to inclusion in the study.

Inclusion Criteria

- Adults aged 18 to 60 years of either sex
- Haemoglobin levels <12 g/dL for non-pregnant females and <13 g/dL for males
- Peripheral smear showing microcytic hypochromic anaemia
- Iron profile suggestive of IDA: low serum iron, low transferrin saturation, high total iron-binding capacity (TIBC), and low serum ferritin

Exclusion Criteria

Patients were excluded if they had any of the following:

- Pregnancy
- Diabetes mellitus
- Chronic kidney or liver disease
- Hemoglobinopathies
- Acute or chronic blood loss
- Use of steroids, oral contraceptives, diuretics, beta blockers, or lipid-lowering drugs
- Smoking, alcohol use, or AIDS
- Thyroid disorders

Procedure: At baseline, all participants underwent detailed clinical history, physical examination, and laboratory investigations. Fasting blood samples were collected to assess the haematological and biochemical profile, including complete hemogram, peripheral smear, ESR, liver and kidney function tests, and iron studies (serum iron, TIBC, ferritin, transferrin saturation). Serum lipid profile was evaluated using standardized enzymatic methods.

Following baseline assessment, each patient was prescribed oral ferrous sulphate tablets (200 mg twice daily). Compliance was monitored throughout the study period. After three months of therapy, all haematological and lipid parameters were re-evaluated. Only patients who completed therapy and showed correction of IDA were included in the final analysis.

Lipid and Iron Parameter Measurement

- **Total Cholesterol:** Measured by enzymatic method (Randox kit)
- **Triglycerides:** Enzymatic colorimetric method
- **HDL Cholesterol:** Phosphotungstate precipitation method
- **VLDL:** Calculated by dividing triglycerides by 5
- **LDL:** Derived using the Friedewald formula

LDL = Total Cholesterol – (HDL + VLDL)

Reference Ranges

- **Total Cholesterol:** 130–230 mg/dL
- **Triglycerides:** 50–200 mg/dL
- **HDL:** 30–65 mg/dL
- **LDL:** 50–150 mg/dL
- **VLDL:** Up to 40 mg/dL

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 21.0. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Normality of data was assessed using the Kolmogorov–Smirnov test. Paired t-test or the Wilcoxon signed-rank test was used for pre- and post-treatment comparisons, depending on data distribution. A p-value of <0.05 was considered statistically significant.

Results

Baseline Characteristics of Study Participants

A total of 50 patients with iron deficiency anaemia (IDA) were included in the study. The mean age of the participants was 46.44 ± 10.37 years, with a range of 23 to 60 years. The majority of patients (76%) were between 41 and 60 years of age. There were 28 males (56%) and 22 females (44%) in the study population.

Based on baseline haemoglobin levels, 32 patients (64%) had moderate anaemia and 18 patients (36%) had mild anaemia, as per WHO criteria. All patients had a microcytic, hypochromic picture on peripheral blood smear, and iron studies were consistent with IDA.

Table 1: Demographic and Baseline Clinical Characteristics of the Study Participants (N = 50)

Characteristic	Value
Age, mean ± SD (years)	46.44 ± 10.37
Age range (years)	23 – 60
Age distribution	
18–40 years	12 (24%)
41–60 years	38 (76%)
Sex	
Male	28 (56%)
Female	22 (44%)
Severity of Anaemia	
Mild (Hb 10–12/13 g/dL)*	18 (36%)
Moderate (Hb 8–10.9 g/dL)	32 (64%)
Peripheral Smear	Microcytic, hypochromic in all cases

*Hb cutoff: <12 g/dL for females, <13 g/dL for males.

Hematological and Iron Parameters Before and After Iron Therapy:

After three months of oral iron supplementation, all haematological and iron-related parameters demonstrated statistically significant improvement. The mean haemoglobin concentration increased markedly, rising from 9.96 ± 1.13 g/dL at baseline to 13.14 ± 0.65 g/dL following treatment ($t = -14.813$, $df = 49$, $p < 0.00001$, Cohen's $d = 2.10$), consistent with a large effect size. Similarly, the serum iron concentration increased from 51.58 ± 6.3 µg/dL to 90.72 ± 22.83 µg/dL ($t = -12.346$, $p < 0.00001$, $d = 1.75$), while transferrin saturation rose from 9.14 ± 2.81% to 30.88 ± 9.44% ($t = -16.544$, $p < 0.00001$, $d = 2.34$), reflecting a substantial restoration of iron transport capacity.

Serum ferritin levels, which are indicative of iron stores, also improved significantly, increasing from 10.32 ± 2.43 ng/mL to 144.52 ± 120.2 ng/mL ($t = -8.805$, $p < 0.00001$, $d = 1.25$). In contrast to these upward trends, total iron-binding capacity (TIBC) showed a significant reduction, decreasing from 463.8 ± 49.77 µg/dL to 332.6 ± 52.79 µg/dL ($t = 13.105$, $p < 0.00001$, $d = -1.85$), indicating normalization of iron metabolism. These findings together confirm effective correction of iron deficiency anaemia in the study population.

Table 2: Haematological and Iron Profile Parameters Before and After Oral Iron Therapy (N = 50)

Parameter	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	t-statistic (df=49)	p-value	Cohen's d
Haemoglobin (g/dL)	9.96 ± 1.13	13.14 ± 0.65	-14.813	<0.00001	2.10
Serum Iron (µg/dL)	51.58 ± 6.3	90.72 ± 22.83	-12.346	<0.00001	1.75
% Saturation	9.14 ± 2.81	30.88 ± 9.44	-16.544	<0.00001	2.34
TIBC (µg/dL)	463.8 ± 49.77	332.6 ± 52.79	13.105	<0.00001	-1.85
Ferritin (ng/mL)	10.32 ± 2.43	144.52 ± 120.2	-8.805	<0.00001	1.25

*All tests performed using paired t-test; $p < 0.05$ considered statistically significant.

Lipid Profile Changes Following Iron Therapy

Among the lipid parameters assessed before and after iron correction, a significant reduction was observed in triglyceride levels, while changes in other lipid fractions were not statistically significant. The mean serum triglyceride concentration decreased from 218.2 ± 67.69 mg/dL to 156.2 ± 77.38 mg/dL ($t = 3.793$, $df = 49$, $p = 0.00041$, Cohen's $d = -0.54$), representing a moderate effect size. Although the mean total cholesterol level declined from 236.2 ± 98.48 mg/dL to 193.8 ± 81.76 mg/dL, the difference did not reach statistical significance ($t = 1.682$, $p = 0.099$).

Low-density lipoprotein (LDL) levels showed minimal change (104.7 ± 61.67 mg/dL to 94.96 ± 46.2 mg/dL, $t = 0.138$, $p = 0.891$), as did very low-density lipoprotein (VLDL; 51.32 ± 26.6 mg/dL to 47.9 ± 21.65 mg/dL, $t = -0.098$, $p = 0.923$). High-density lipoprotein (HDL) levels remained stable, with a negligible increase from 34.32 ± 8.83 mg/dL to 34.64 ± 7.43 mg/dL ($t = -1.095$, $p = 0.279$). These findings suggest that while triglyceride levels responded significantly to iron therapy, other lipid fractions were largely unaffected within the 3-month treatment period.

Table 3: Changes in Serum Lipid Parameters Before and After Iron Therapy (N = 50)

Lipid Parameter	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	t-statistic (df=49)	p-value	Cohen's d
Total Cholesterol (mg/dL)	236.2 ± 98.48	193.8 ± 81.76	1.682	0.099	-0.24
Triglycerides (mg/dL)	218.2 ± 67.69	156.2 ± 77.38	3.793	0.00041	-0.54
LDL (mg/dL)	104.7 ± 61.67	94.96 ± 46.2	0.138	0.891	-0.02
VLDL (mg/dL)	51.32 ± 26.6	47.9 ± 21.65	-0.098	0.923	0.01
HDL (mg/dL)	34.32 ± 8.83	34.64 ± 7.43	-1.095	0.279	0.16

*All comparisons performed using paired t-tests; $p < 0.05$ considered statistically significant.

Normalization of Lipid Parameters Following Iron Therapy

In addition to changes in mean lipid values, the study also examined the proportion of patients whose lipid profiles normalized after three months of oral iron therapy. Before treatment, only 36% of participants had total cholesterol levels within the normal reference range (130–230 mg/dL); this increased significantly to 64% following therapy. A

similar shift was observed for triglycerides, with normalization improving from 36% to 80%. These changes were statistically significant based on McNemar's test (χ^2 = 12.071, p = 0.00051 for cholesterol; χ^2 = 20.045, p = 0.00001 for triglycerides).

In contrast, normalization of LDL, VLDL, and HDL levels did not demonstrate significant changes. The proportion of patients with normal LDL increased from 68% to 74% (p = 0.248), VLDL from 58% to 62% (p = 0.480), and HDL from 74% to 76% (p = 1.000). These findings suggest that while triglyceride and total cholesterol levels are responsive to iron therapy, other lipid fractions may require a longer treatment duration or additional interventions to normalize.

Table 4: Proportion of Patients with Normal Lipid Parameters Before and After Iron Therapy (N = 50)

Lipid Parameter	Normal Range (mg/dL)	% Normal Before	% Normal After	McNemar's χ^2	p-value
Total Cholesterol	130–230	36%	64%	12.071	0.00051
Triglycerides	50–200	36%	80%	20.045	0.00001
LDL	50–150	68%	74%	1.333	0.24821
VLDL	Up to 40	58%	62%	0.500	0.47950
HDL	30–65	74%	76%	0.000	1.00000

Statistical analysis performed using McNemar's test; p < 0.05 considered statistically significant.

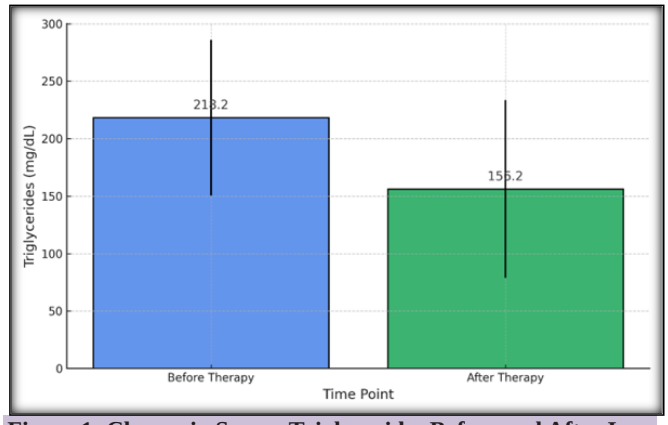

Figure 1: Change in Serum Triglycerides Before and After Iron Therapy

Mean serum triglyceride levels before and after three months of oral iron therapy in patients with iron deficiency anaemia (N = 50). Error bars represent standard deviations. A statistically significant reduction was observed (p = 0.00041, Cohen's d = -0.54), indicating a moderate effect size and a clinically meaningful metabolic improvement.

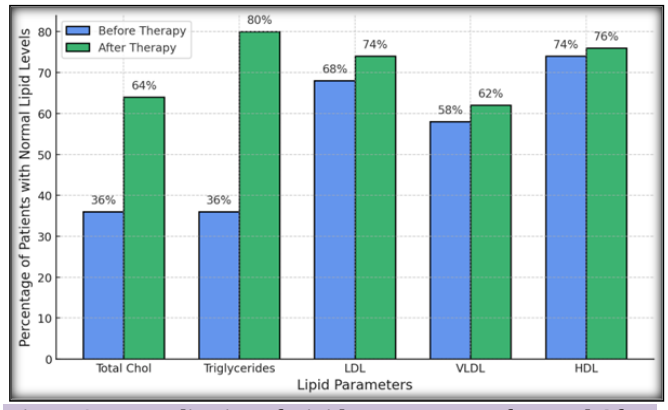

Figure 2: Normalization of Lipid Parameters Before and After Iron Therapy

Percentage of patients with lipid parameters within normal reference ranges before and after three months of oral iron therapy (N = 50). A significant increase in normalization was observed for total cholesterol and triglycerides, whereas LDL, VLDL, and HDL changes were not statistically significant.

Discussion

This study demonstrated that correction of iron deficiency anaemia (IDA) through oral iron therapy significantly improves not only haematological indices but also has a measurable impact on serum lipid profiles. Most notably, serum triglycerides and total cholesterol levels decreased significantly following therapy, while LDL, VLDL, and HDL levels showed statistically non-significant changes. These findings suggest a partial but clinically relevant normalization of lipid metabolism with the correction of iron deficiency.

The significant reduction in triglyceride levels observed in this cohort aligns closely with prior Indian studies. Venkateshwarlu et al. reported elevated levels of total cholesterol, triglycerides, LDL, and VLDL in untreated IDA patients, with significant reductions in triglycerides and VLDL and an increase in HDL following iron therapy.[14] Similarly, Vijaykumar et al. found elevated triglyceride and VLDL levels in IDA patients compared to controls, and noted a significant reduction post-treatment, while LDL showed no substantial change.[15] Udit Verma et al. also corroborated these findings, reporting improvements in lipid parameters after iron supplementation in Indian adults with anaemia.[16]

Our results mirror these studies in showing a statistically significant reduction in triglycerides, but also contribute new insight by showing a concurrent significant decrease in total cholesterol levels—an effect not consistently observed in earlier studies. HDL, LDL, and VLDL levels in our study changed only marginally, a trend consistent with both the Vijaykumar and Venkateshwarlu cohorts. On the other hand, Sandeep et al. reported a generalized decrease in all lipid fractions, including HDL and LDL, in anaemic patients, with levels correlating inversely with anaemia severity.[17] This inconsistency underscores the complexity of lipid regulation in iron-deficient states and suggests potential differences in population, methodology, or underlying comorbidities.

International studies also support a metabolic link between iron status and lipid regulation. Ozdemir et al. found that mean LDL and total cholesterol levels were lower in premenopausal women with IDA compared to non-anaemic controls, and while both parameters increased after iron replacement, they remained lower than those of the control group.[18] Similar trends were noted in animal models: Guthrie et al. and Lewis & Iammarino both demonstrated elevated triglycerides in iron-deficient rodents, which reversed with iron repletion.[19,20]

The biological basis for this interaction remains incompletely understood. Hypotheses include iron's role as a cofactor in enzymes critical to lipid metabolism, modulation of hepatic

lipogenesis, and changes in lipoprotein lipase and carnitine synthesis.[21,22] Iron deficiency may impair oxidative lipid breakdown, alter membrane lipid composition, and impact gene regulation linked to lipid homeostasis.

While our findings are consistent with many previous studies, the study has several limitations. The sample size was modest (n=50), and demographic variables such as ethnicity and dietary patterns were not accounted for. Additionally, familial dyslipidaemias were not evaluated. A randomized, multicentre study with a larger and more diverse population would be necessary to validate these findings and assess the clinical relevance of correcting IDA as a potential means of modulating cardiovascular risk.

Conclusion

In this study of adult patients with iron deficiency anaemia, oral iron therapy administered over three months led to a statistically significant improvement in haematological indices and a concurrent reduction in serum triglyceride and total cholesterol levels. While LDL, VLDL, and HDL levels did not change significantly, the observed lipid improvements suggest that iron repletion may partially reverse the atherogenic profile associated with iron deficiency.

These findings reinforce the potential metabolic consequences of untreated IDA and raise important considerations for cardiovascular risk assessment in anaemic patients. Given the high prevalence of IDA in the Indian population and globally, even modest improvements in lipid profiles through simple iron correction may offer meaningful public health benefits.

However, the study's small sample size and lack of control for demographic and genetic lipid influences warrant caution in interpretation. Future studies should be designed as multicentre, randomized trials with larger and more diverse cohorts to confirm these findings and to explore the mechanisms underlying iron-lipid interactions.

Until such data are available, clinicians should be mindful of lipid profile interpretations in patients with IDA and consider re-evaluating these parameters following iron repletion before initiating lipid-lowering interventions.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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