



Research Article

To Evaluate Association of Serum Ferritin Level in Metabolic Syndrome

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Article History

Received: 21.06.2026

Accepted: 16.07.2026

Published: 28.09.2026

doi: 10.61336/jdme.0703.13

Abstract: **Introduction:** Iron has a significant impact on the physiological functions of many organisms, functioning as an essential element for various metabolic processes, including oxygen transport and DNA synthesis. **Aim:** To study association between serum ferritin level & Metabolic syndrome with help of Mets Severity Score (Met SS). **Methodology:** This cross-sectional study was carried out at a tertiary care hospital, in central Rajasthan among 120 cases of metabolic syndrome getting admitted in Medicine wards of JLN Medical college & Associated Hospitals, Ajmer after prior written and informed consent. **Result:** The study showed a high prevalence of overweight/obesity and progressive worsening of metabolic parameters with increasing MetS components, while serum ferritin increased significantly from 285.62 to 437.16 ng/mL and showed a strong positive correlation with Met S score ($r = 0.62$, $p = 0.001$). **Conclusion:** Elevated serum ferritin was significantly associated with greater metabolic syndrome severity, suggesting its potential role as a marker of metabolic dysfunction and cardiometabolic risk.

Keywords: Serum Ferritin, Metabolic Syndrome, Cardiometabolic Risk

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INTRODUCTION

Iron has a significant impact on the physiological functions of many organisms, functioning as an essential element for various metabolic processes, including oxygen transport and DNA synthesis [1]. The serum ferritin level serves as an indicator of iron stores inside the human system, as ferritin binds and stores ferrous iron in multiple biological systems. Insufficient serum ferritin levels are associated with conditions such as fatigue restless leg syndrome, telogen effluvium, iron deficiency anemia (IDA), and reduced bone mineral density [2]. Conversely, elevated serum ferritin levels have been Linked to a heightened likelihood of cardiovascular disease, insulin resistance, and metabolic syndrome (MetS). In mammals, ferritin primarily serves as an intracellular iron storage protein rather than an iron transporter. However, serum ferritin (SF) levels are widely utilized as indicators of iron status [3]. Beyond its contribution to iron storage, SF levels can rise significantly as a reaction to inflammation and various diseases. Ferritin functions not only as a clinical biomarker for assessing iron levels but also has a significant impact on metabolic disorders. Elevated SF levels have been closely associated with chronic conditions such as type 2 diabetes (T2D) and cardiovascular disease. Correlation analyses have demonstrated a negative relationship between SF levels and high-density lipoprotein cholesterol (HDL-C), while positive correlations have been observed between SF levels and triglycerides (TG), total cholesterol (TC), and low-density lipoprotein cholesterol (LDL-C) [4-5]. Additionally, randomized trials exploring the outcomes of iron modulation supplementation on metabolic syndrome progression may help identify potential therapeutic strategies. Emerging evidence suggests that elevated ferritin levels contribute to oxidative stress and inflammation, further aggravating Impaired insulin sensitivity and heart-related risk factors. An important research gap is the limited number of intervention studies evaluating whether altering ferritin levels can directly impact the progression of metabolic syndrome [6]. Additionally, ethnic and demographic variations in ferritin levels have not been sufficiently explored, restricting the broader applicability of existing findings across diverse populations.

Aim

To study association between serum ferritin level & Metabolic syndrome with help of Mets Severity Score (MetSS).

MATERIALS AND METHODS

This cross-sectional study was carried out at a tertiary care hospital, in central Rajasthan among 120 cases of metabolic syndrome getting admitted in Medicine wards of JLN Medical college & Associated Hospitals, Ajmer after prior written and informed consent. Ethical approval was obtained from the Ethical Committee of this institution. The study period was from May 2023 to May 2024. Inclusion criteria involved Patients aged more than 18 years with metabolic syndrome, as per the criteria of the National Cholesterol Education Panel ATP 3. Exclusion criteria involved Cardiac, renal, hepatic and other systemic diseases, Any endocrinological abnormalities like thyroid disorders, diabetes mellitus etc, H/O or clinical evidence of haemochromatosis, thalassemia, Serum ferritin >500 ng/ml, Anaemia (Hb below 12 g/dl). H/O blood transfusion, blood donation, iron therapies in the last six months, Any Acute illnesses or current evidence of infective, inflammatory diseases, H/O drug or alcohol abuse.

RESULTS

The data is categorized into six age groups: <20 years (5.0%), 20–30 years (23.33%), 30–40 years (16.7%), 40–50 years (9.2%), 50– 60 years (21.7%), and over 60 years (24.2%). The most represented age category is those older than 60, followed closely by the 50–60 and 21–30-year groups. Participants were mostly aged above 50 years (45.9% above age 50) Table 1.

The data presents the gender distribution of a sample population comprising 120 individuals. Out of these Male 68 (56.67%) and Female 52(43.33%) Table 2.

None of the participants were underweight, while 6 (6.0%) had normal BMI (18.5–22.9) and 24 (20.0%) had high-normal BMI (23–24.9). Over one-third, 42 (35.0%), were overweight (25–29.9), while 48 (40.0%) were obese (≥30) Figure 1.

The table presents the distribution of waist circumference (WC) among male and female participants. Among males, 9 individuals (13.23%) had a waist circumference of ≤90 cm, while the majority, 59 individuals (86.77%), had a waist circumference >90 cm. In females, all 52 individuals (100%) had a waist circumference ≤80 cm, and none had a measurement above 80 cm Table 3.

Table 1: Age Distribution

Age	Frequency	Percent
<20	6	5.0
20-30	28	23.33
30-40	20	16.7
40-50	11	9.2
50-60	26	21.7
>60	29	24.2
Total	120	100.0

Table 2: Gender Distribution

Gender	Frequency	Percent
Female	52	43.33
Male	68	56.67
Total	120	100.0

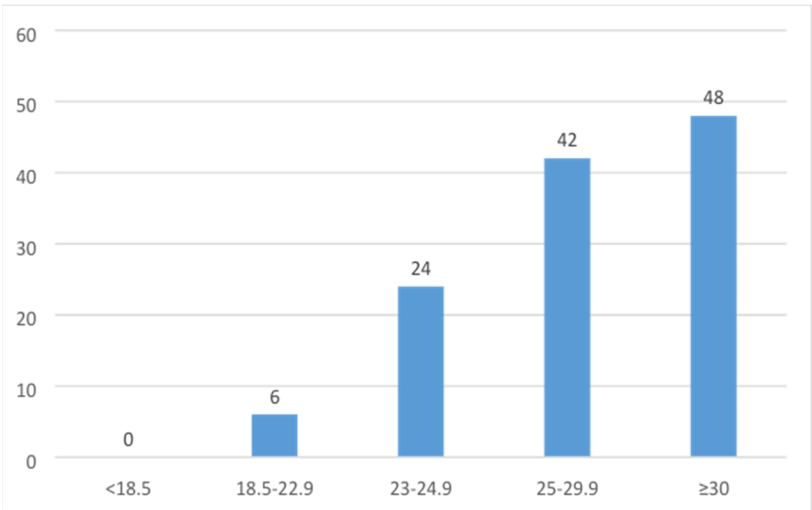


Figure 1: BMI Distribution

Table 3: Waist Circumference

Male Waist circumference	Frequency	Percent
≤90	9	13.23%
>90	59	86.77%
Total	68	100%
Female Waist circumference	Frequency	Percent
≤80	52	100%
>80	0	0%
Total	52	100%

Table 4: Metabolic Syndrome

Metabolic syndrome	Frequency	Percent
3 component	24	20.0
4 component	71	59.2
5 component	25	20.8
Total	120	100.0

Table 5: Lipid Profile and Metabolic Syndrome

Lipid profile	3 Components		4 Components		5 Components		p-value
	Mean	SD	Mean	SD	Mean	SD	
Triglycerides	167.17	41.348	195.39	35.65	195.96	28.289	0.001 (S)
HDL (M)	52.08	9.46	50.58	8.99	36.80	5.17	0.001 (S)
HDL (F)	51.81	9.62	30.61	8.88	39.47	5.53	0.001 (S)

Table 6: Metabolic Syndrome with Serum Ferritin

Variables	3 component		4 component		5 component		p-value
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Serum Ferritin	285.62	95.90	335.43	83.27	437.16	33.11	0.001 (S)

Table 7: Variables with Metabolic Syndrome

Variables	3 component		4 component		5 component		p-value
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Hemoglobin (g/dL)	13.98	1.05	13.66	0.96	13.97	1.11	0.25
TSH	3.53	0.81	3.64	0.84	3.48	0.80	0.67
ALT	29.95	6.57	30.29	6.11	30.76	6.20	0.63

Table 8: Correlation Between Serum Ferritin and Other Variables

Correlation	Variable	Correlation Coefficient (r)	p-Value
Serum Ferritin	Waist circumference	0.35	0.001 (S)
	SBP	0.18	0.04 (S)
	DBP	0.42	0.001 (S)
	FBS	0.34	0.001 (S)
	Triglycerides	0.26	0.004 (S)
	HDL	-0.34	0.001 (S)
	HB	-0.12	0.89
	TSH	-0.005	0.95
	ALT	0.063	0.47

Based on the ATP III criteria, metabolic syndrome was classified. Specifically, 24 individuals (20.0%) have 3 components of metabolic syndrome, 71 individuals (59.2%) have 4 components, and 25 individuals (20.8%) have all 5 components Table 4.

The lipid profile across metabolic syndrome groups with 3, 4, and 5 components. Triglyceride levels show a significant rise from 167.17 mg/dL in the 3-component group to approximately 195 mg/dL in the 4- and 5-component groups ($p = 0.001$, significant), HDL cholesterol levels decrease with higher metabolic syndrome severity. In males, HDL reduces from 52.08 mg/dL (3 components) to 36.80 mg/dL (5 components), while in females, HDL decreases from 51.81 mg/dL to 39.47 mg/dL Table 5.

Serum Ferritin levels show a significant upward trend, rising from a mean of 285.62 ng/mL in individuals with three components of metabolic syndrome to 437.16 ng/mL in those with five components Table 6.

The mean hemoglobin levels are relatively stable across the groups: 13.98 g/dL (SD 1.05) for 3 components, 13.66 g/dL (SD 0.96) for 4 components, and 13.97 g/dL (SD 1.11) for 5 components, with no statistically significant difference ($p = 0.25$). Similarly, mean TSH values do not differ significantly: 3.53 (SD 0.81), 3.64 (SD 0.84), and 3.48 (SD 0.80) ($p = 0.67$). ALT levels also show no significant variation among groups: 29.95 U/L (SD 6.57), 30.29 U/L (SD 6.11), and 30.76 U/L (SD 6.20) ($p = 0.63$) Table 7.

Table 9: Correlation Between MetS Score and Serum Ferritin

Correlation	Variable	Correlation coefficient (r)	p-Value
Serum Ferritin	MetS score	0.62	0.001 (S)

Table 10: Correlation Between Mets Score and Age, BMI, Waist Circumference

Correlation	Variable	Correlation Coefficient (R)	p-Value
Mets Score	Age	-0.13	0.15
	BMI	-0.11	0.22
	Waist Circumference	0.58	0.001 (S)

Table 11: Correlation Between MetS Score and FBS, Triglycerides, HDL

Correlation	Variable	Correlation coefficient (r)	p-Value
MetS score	FBS	0.66	0.001 (S)
	Triglycerides	0.32	0.001 (S)
	HDL	-0.47	0.001 (S)

Ferritin showed significant positive correlations with waist circumference ($r = 0.35$), DBP ($r = 0.42$), FBS ($r = 0.34$), SBP ($r = 0.18$), and ALT, while HDL showed an inverse association ($r = 0.34$). Hemoglobin and TSH showed no significant correlations ($p > 0.05$), suggesting a stronger association of ferritin with metabolic parameters Table 8.

Serum ferritin demonstrates a strong positive correlation ($r = 0.62$, $p = 0.001$), suggesting that higher ferritin levels are significantly associated with higher MetS scores potentially indicative of elevated iron stores and a better metabolic or nutritional profile in the sample Table 9.

The correlation coefficient (r) between MetS score and Age is -0.13 with a p-value of 0.15, indicating a weak negative correlation that is not statistically significant. For BMI, r is -0.11 with a p-value of 0.22, also showing a weak negative and non-significant association. In contrast, Waist circumference shows a strong positive correlation with MetS score ($r = 0.58$) and is statistically significant ($p = 0.001$). This suggests that only waist circumference is significantly associated with MetS score, while age and BMI are not Table 10.

The table shows the correlation of MetS score with fasting blood sugar (FBS), triglycerides, and HDL. MetS score has a strong positive correlation with FBS ($r = 0.66$, $p = 0.001$) and a moderate positive correlation with triglycerides ($r = 0.32$, $p = 0.001$), both statistically significant. Conversely, it shows a moderate negative correlation with HDL ($r = -0.47$, $p = 0.001$), also significant. This indicates that higher MetS scores are associated with increased FBS and triglycerides but lower HDL levels Table 11.

DISCUSSION

The mean age of the sample is 45.55 years indicating middle-aged dominance with a standard deviation of 17.88 years, demonstrating considerable variation in ages, while the observed age range extends from 18 to 75 years. Out of these Male 68 (56.67%) and Female 52 (43.33%). Various studies evaluating metabolic syndrome report gender differences in prevalence and metabolic characteristics.

Body mass index (BMI) values ranging from 22 to 35 and a mean BMI of 28.505 ± 3.88 , indicating that the majority of participants fell within the overweight to obese categories. Similarly, Adam W Potter *et al.* [7] used NHANES data to redefine obesity thresholds based on percent body fat. They found that 35% of individuals with BMI >30 had metabolic syndrome, supporting the link between obesity and metabolic dysfunction.

The distribution of waist circumference (WC) among male and female participants. Among males, 9 individuals (13.23%) had a waist circumference of ≤ 90 cm, while the majority, 59 individuals (86.77%), had a waist circumference >90 cm. In females, all 52 individuals (100%) had a waist circumference ≤ 80 cm, and none had a measurement above 80 cm.

Based on the ATP III criteria, metabolic syndrome was classified. Specifically, 24 individuals (20.0%) have 3 components of metabolic syndrome, 71 individuals (59.2%) have 4 components, and 25 individuals (20.8%) have all 5 components. Alexander CM *et al.* [8] found from the NHANES III survey that metabolic syndrome was present in 86% of diabetic individuals, compared to just 26% among those with normal glycemic status. Triglyceride levels show a significant rise from 167.17 mg/dL in the 3-component group to approximately 195 mg/dL in the 4- and 5-component groups ($p = 0.001$, significant), indicating worsening dyslipidemia with increasing metabolic abnormalities. HDL cholesterol levels decrease with higher metabolic syndrome severity. In males, HDL reduces from 52.08 mg/dL (3 components) to 36.80 mg/dL (5 components), while in females, HDL decreases from 51.81 mg/dL to 39.47 mg/dL. Singh O *et al.* [9] found High triglyceride (TG) level to be >200 mg/dL, 44.4% and was the most common dyslipidemia followed by low levels of high-density lipoprotein cholesterol (240 mg/dL, 13.8%) and high low density lipoprotein cholesterol levels (>160 mg/dL, 9.7%) were observed.

Serum Ferritin levels show a significant upward trend, rising from a mean of 285.62 ng/mL in individuals with three components of metabolic syndrome to 437.16 ng/mL in those with five components.

Waist circumference in both males and females increases significantly with the number of components, from 91.95 cm to 112.38 cm in males and from 92.27 cm to 110 cm in females ($p = 0.001$). Fasting blood sugar (FBS) also rises notably, from 126.08 mg/dL in the 3-component group to 146.96 mg/dL in the 5-component group. Systolic blood pressure (SBP) increases from 130.62 mmHg to 144.56 mmHg, while diastolic blood pressure (DBP) rises from 84.17 mmHg to 98.52 mmHg. Dai *et al.* [10] found that higher waist circumference was significantly linked to increased risk of cardiovascular disease and cancer mortality, with hazard ratios reaching 2.69 for cancer mortality in the highest quartile of waist circumference.

The p -value of 0.07 indicates that the differences in BMI across the groups are not statistically significant at the conventional threshold of $p < 0.005$. Therefore, while minor fluctuations in BMI exist across levels of metabolic syndrome severity, these variations are not strong enough to imply a consistent or meaningful trend.

The data describes the distribution of HDL cholesterol (HDL) levels among 68 males. Out of these, 20 individuals (29.41%) have HDL levels ≤ 40 mg/dL, which is considered low, while the majority, 48 individuals (70.59%), have HDL levels > 40 mg/dL. The distribution of HDL cholesterol levels among 52 females shows that 26 individuals (50%) have HDL levels ≤ 50 mg/dL, and 26 individuals (50%) have levels > 50 mg/dL. Ryu *et al.* [11] using data from the Korean Genome and Epidemiology Study (KoGES-HEXA), HDL levels were stratified among 173,195 adults. The study found that low HDL-C levels (< 40 mg/dL in men and < 50 mg/dL in women) were significantly associated with increased all-cause mortality.

The distribution of triglyceride levels among 120 individuals are, the majority, 98 individuals (81.6%), have triglyceride levels below 150 mg/dL, while 22 individuals (18.4%) have triglyceride levels exceeding 150 mg/dL. The data shows the fasting blood sugar (FBS) distribution among 120 individuals are, 5 individuals (4.2%) have an FBS level less than 110 mg/dL, whereas the vast majority, 115 individuals (95.8%), have an FBS level of 110 mg/dL or higher.

The mean hemoglobin levels are relatively stable across the groups: 13.98 g/dL (SD 1.05) for 3 components, 13.66 g/dL (SD 0.96) for 4 components, and 13.97 g/dL (SD 1.11) for 5 components, with no statistically significant difference ($p = 0.25$). Similarly, mean TSH values do not differ significantly: 3.53 (SD 0.81), 3.64 (SD 0.84), and 3.48 (SD 0.80) ($p = 0.67$). ALT levels also show no significant variation among groups: 29.95 U/L (SD 6.57), 30.29 U/L (SD 6.11), and 30.76 U/L (SD 6.20) ($p = 0.63$). Additionally, Raya-Cano *et al.* [12] in a meta-analysis found that ALT levels were only modestly elevated in metabolic syndrome populations, with a pooled mean difference of 7.13 IU/L, suggesting that ALT may not vary significantly unless liver pathology is present.

Hemoglobin (HB%) values range from 12.1 to 15.4 g/dL, with a mean of 13.80 and a standard deviation (SD) of 1.01, indicating generally normal to slightly varied red blood cell levels. HDL cholesterol levels vary widely from 30 to 65 mg/dL, with an average level of 48.38 (SD 9.98), reflecting a moderate level of protective cholesterol, though some individuals have values considered low. Triglyceride levels range from 126 to 250 mg/dL, with a mean of 190 (SD 37.11), indicating a tendency towards elevated blood lipids in the group [13].

Serum ferritin demonstrates a strong positive correlation ($r = 0.62$, $p = 0.001$), suggesting that higher ferritin levels are significantly associated with higher MetS scores potentially indicative of elevated iron stores and a better metabolic or nutritional profile in the sample.

CONCLUSION

This study evaluated the association between serum ferritin levels with metabolic syndrome in 120 patients, using the Metabolic Syndrome Severity Score (MetSS). The results demonstrated a significant positive correlation between elevated serum ferritin levels and increasing severity of metabolic syndrome. These findings suggest that ferritin beyond their established roles in iron storage, also play critical roles in metabolic regulation. Elevated ferritin likely reflects underlying oxidative stress and systemic inflammation, both of which contribute to insulin resistance and heightened cardiovascular risk. From a clinical perspective, the study underscores the importance of including serum ferritin assessment in the routine evaluation of patients with metabolic syndrome. Early detection of abnormalities allows timely lifestyle intervention, iron regulation strategies, supplementation—potentially reducing the risk of progression to type 2 diabetes, cardiovascular disease, and related complications.

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