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ASSOCIATION OF SERUM FERRITIN WITH METABOLIC SYNDROME, INSULIN RESISTANCE, DYSLIPIDEMIA, AND ABDOMINAL OBESITY: A SYSTEMATIC REVIEW.

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ABSTRACT

Background: Metabolic syndrome (MetS) is a cluster of metabolic abnormalities associated with an increased risk of type 2 diabetes mellitus and cardiovascular diseases. Serum ferritin, an indicator of iron stores and inflammation, has been suggested as a potential biomarker of metabolic dysfunction.

Objective: To evaluate the association of serum ferritin with metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity.

Materials and Methods: A systematic review was conducted following PRISMA guidelines. Literature was searched through PubMed, Google Scholar, Scopus, and ScienceDirect. Original human observational studies published in English were considered. Studies investigating serum ferritin in relation to metabolic syndrome, HOMA-IR, glycaemic parameters, lipid profile, BMI, and abdominal obesity were included. Relevant study characteristics and major findings were extracted and analysed descriptively.

Results: The reviewed studies demonstrated a positive association between serum ferritin and metabolic syndrome, insulin resistance, fasting blood glucose, fasting insulin, triglycerides, BMI, waist circumference, and waist-to-hip ratio. Kumar et al. (2026) reported a significant correlation between ferritin and metabolic syndrome severity (r=0.62, p=0.001). Chand et al. (2021) observed positive correlations with HOMA-IR, BMI, waist-to-hip ratio, and triglycerides, along with a negative correlation with HDL cholesterol. Associations with LDL cholesterol, total cholesterol, and blood pressure were inconsistent.

Conclusion: Elevated serum ferritin is associated with metabolic syndrome and its major components, particularly insulin resistance, hypertriglyceridaemia, and abdominal obesity. Serum ferritin may serve as an additional biomarker for identifying individuals at increased cardiometabolic risk. Further prospective studies are required to establish its clinical significance.

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INTRODUCTION

Metabolic syndrome (MetS) is a multifactorial metabolic disorder characterized by abdominal obesity, insulin resistance, hyperglycaemia, hypertension, and dyslipidaemia. It is a major public health concern because of its association with type 2 diabetes mellitus, cardiovascular diseases, and premature mortality [1]. The increasing prevalence of obesity, sedentary lifestyles, and unhealthy dietary habits has contributed to the growing burden of metabolic syndrome worldwide [2].

In India, metabolic syndrome is increasingly prevalent, particularly among South Asian populations who are predisposed to abdominal obesity and insulin resistance even at lower BMI values [3]. The ICMR-INDIAB study by Anjana et al. highlighted the substantial burden of metabolic abnormalities in the Indian population [4]. Insulin resistance plays a central role in metabolic syndrome by impairing glucose utilization and promoting abnormal lipid metabolism, hypertriglyceridaemia, and reduced HDL cholesterol [5,6]. Serum ferritin is an important marker of body iron stores and also acts as an acute-phase reactant during inflammation. Increased ferritin concentrations have been associated with oxidative stress, chronic low-grade inflammation, insulin resistance, and metabolic disturbances [7]. Excess iron may promote the generation of reactive oxygen species, resulting in cellular damage and impaired insulin signalling.8 Several studies have reported higher serum ferritin levels among individuals with metabolic

syndrome compared with healthy controls, suggesting its potential role as a biomarker of metabolic dysfunction [9,10].

Indian studies have demonstrated associations between serum ferritin and metabolic abnormalities, including increased BMI, waist circumference, triglycerides, and HOMA-IR, along with reduced HDL cholesterol. Chand et al. reported significantly higher ferritin concentrations in individuals with metabolic syndrome [11]. Other investigators, including Sam et al. and Arumugam et al., have also highlighted the relationship between altered iron metabolism, insulin resistance, and glycaemic abnormalities [12,13]. Abdominal obesity and dyslipidaemia may further contribute to increased ferritin concentrations through chronic inflammation and altered iron regulation [14]. Inflammatory mediators such as interleukin-6 and tumor necrosis factor-alpha influence hepatic ferritin production and iron homeostasis [15]. A systematic review and meta-analysis published in 2021 also demonstrated a significant association between elevated serum ferritin and metabolic syndrome, including abdominal obesity, hypertriglyceridaemia, and reduced HDL cholesterol [16]. Recent research on metabolic hyperferritinaemia has further emphasized the relationship between iron metabolism, fatty liver disease, and metabolic inflammation [17]. Despite increasing evidence, the association between serum ferritin and individual components of metabolic syndrome remains incompletely understood. Therefore, the present systematic review aims to evaluate the association of serum ferritin with metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity, with particular emphasis on findings from Indian and international studies. The review also explores the potential clinical significance of serum ferritin as an additional biomarker for identifying individuals at increased cardiometabolic risk [18].

MATERIALS AND METHODS

Study Design

The present study was designed as a systematic review to evaluate the association between serum ferritin levels and metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity. The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Literature Search Strategy

A comprehensive literature search was performed using electronic databases, including PubMed, Google Scholar, Scopus, and ScienceDirect. Relevant articles published in English were considered, with particular emphasis on studies published during the last 10–15 years. The search included Indian and international studies. The following keywords and combinations were used: serum ferritin, metabolic syndrome, insulin resistance, HOMA-IR, dyslipidaemia, abdominal obesity, waist circumference, iron metabolism, and cardiometabolic risk.

Inclusion Criteria

- Original research articles investigating serum ferritin levels in relation to metabolic syndrome.
- Studies evaluating the association between ferritin and insulin resistance or HOMA-IR.
- Studies assessing the relationship between ferritin and lipid parameters, including triglycerides, HDL-C, LDL-C, and total cholesterol.
- Studies investigating ferritin levels in relation to abdominal obesity and waist circumference.
- Human studies published in English.
- Observational studies, including cross-sectional, case-control, and cohort studies.

Exclusion Criteria

- Animal and experimental studies.
- Case reports, editorials, letters, and conference abstracts.
- Studies without serum ferritin measurements.
- Studies unrelated to metabolic syndrome or its individual components.
- Duplicate publications.
- Articles with insufficient data or unavailable full text.

Study Selection

All identified articles were screened initially by title and abstract to determine their relevance to the review objectives. Potentially eligible articles were subsequently assessed through full-text evaluation. Duplicate records were removed, and studies fulfilling the predefined eligibility criteria were included in the final review.

Data Extraction

Relevant information was extracted from the selected studies, including the first author's name, year of publication, country, study design, sample size, study population, serum ferritin levels, metabolic parameters, and major findings. Particular attention was given to the association between serum ferritin and HOMA-IR, fasting blood glucose, triglycerides, HDL cholesterol, BMI, and waist circumference.

RESULT

The literature review demonstrated a positive association between serum ferritin levels and metabolic syndrome. Most of the reviewed studies reported higher serum ferritin concentrations among individuals with metabolic syndrome compared with healthy controls. Elevated ferritin was frequently associated with insulin resistance, abdominal obesity, dyslipidaemia, and impaired glucose metabolism.

Association of Serum Ferritin with Metabolic Syndrome

Studies by Padwal et al., Chand et al., and other investigators reported increased serum ferritin concentrations among individuals with metabolic syndrome. These findings suggest that elevated ferritin may be associated with the clustering of metabolic abnormalities, including hypertension, hyperglycaemia, central obesity, and altered lipid profiles.

Association with Dyslipidaemia

The reviewed literature demonstrated an association between elevated serum ferritin and an atherogenic lipid profile. Higher ferritin concentrations were frequently associated with increased triglycerides and reduced HDL cholesterol. Some studies also reported associations with LDL cholesterol and total cholesterol, although findings were not consistent across all populations.

Association with Abdominal Obesity

Increased serum ferritin was frequently associated with higher BMI, waist circumference, and waist-to-hip ratio. Individuals with central obesity showed a tendency towards increased ferritin concentrations, potentially reflecting chronic low-grade inflammation and altered iron metabolism associated with visceral adiposity.

Characteristics of Included Studies

The included studies varied in geographical location, study population, sample size, and study design. Most were observational and cross-sectional studies conducted in Indian and international populations. The studies primarily investigated the relationship between serum ferritin and metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity. Overall, the findings suggested that elevated serum ferritin was associated with increased metabolic syndrome severity, higher BMI, increased triglycerides, and insulin resistance, with reduced HDL cholesterol reported in some studies.

Table 01: Review of Previous Studies on the Association between Serum Ferritin and Metabolic Syndrome

Author (Year)	Study population	Study design	Major findings
Kumar et al. (2026)	120 patients with metabolic syndrome, Rajasthan, India	Cross-sectional study	Serum ferritin increased with metabolic syndrome severity and showed a positive correlation with MetS severity score (r=0.62, p=0.001). jdmeonline.com
Naik et al. (2026)	97 patients with metabolic syndrome, Gujarat, India	Longitudinal observational study	Investigated serum ferritin levels and their correlation with metabolic syndrome. IJHMP
Bitey et al. (2026)	Patients with NAFLD with and without metabolic syndrome, India	Observational study	Investigated serum ferritin differences in relation to metabolic syndrome among patients with fatty liver disease. msjonline.org
Sand et al. (2026)	HUNT2 population with impaired glucose regulation, Norway	Population-based study	Reported an association between metabolic hyperferritinaemia and insulin resistance. Springer Nature Link
Gi et al. (2026)	5,730 Korean adults	Population-based study	Ferritin was positively associated with HOMA-IR and metabolic syndrome, with sex-specific differences. Biomedical Sciences and Clinical Medicine
Kothuru and Hariprasad (2026)	Indian patients with metabolic syndrome	Observational study	Examined the relationship between serum ferritin and metabolic syndrome. European Journal of Cardiovascular Medicine
Bhubaneswar study (2026)	Young adults and adults in academic organisations, India	Observational study	Higher ferritin levels were observed among participants with metabolic syndrome. ScienceDirect
Bhadana et al. (2025)	230 participants, India	Cross-sectional study	Reported significantly elevated ferritin in metabolic syndrome, with positive correlations with BMI, fasting glucose, triglycerides, and inflammatory markers. PubMed
Chatterjee et al. (2025)	Metabolically healthy obese adults, West Bengal, India	Observational study	Investigated serum ferritin in relation to metabolic health among obese individuals. Journal of Heart Valve Disease
Vigneshvar et al. (2024)	128 participants, Puducherry, India	Cross-sectional study	Evaluated serum ferritin as a potential biomarker for metabolic syndrome. Journal of Chemical Health Risks
Chand et al. (2021)	100 cases and 50 controls, India	Cross-sectional study	Ferritin was positively correlated with waist-to-hip ratio, triglycerides, BMI, and HOMA-IR, and negatively correlated with HDL cholesterol.

Table 02: Association of Serum Ferritin with Metabolic Syndrome and Its Individual Components.

Metabolic parameters	Association with serum ferritin	Interpretation
Metabolic syndrome	Positive association	Higher ferritin levels were observed in individuals with metabolic syndrome.
Insulin resistance (HOMA-IR)	Positive association	Increased ferritin was associated with higher insulin resistance.
Fasting blood glucose	Positive association	Ferritin levels tended to increase with impaired glucose regulation.

Fasting insulin	Positive association	Higher ferritin was associated with increased circulating insulin levels.
Triglycerides (TG)	Positive association	Elevated ferritin was associated with increased triglyceride concentrations.
HDL cholesterol	Negative association	Higher ferritin was associated with reduced HDL cholesterol.
LDL cholesterol	Variable association	Findings differed across study populations.
Total cholesterol	Variable association	Inconsistent associations were reported.
BMI	Positive association	Higher ferritin was associated with increased body mass index.
Waist circumference	Positive association	Increased ferritin was associated with central obesity.
Waist-to-hip ratio	Positive association	Higher ferritin was associated with increased abdominal adiposity.
Blood pressure	Variable association	Some studies reported higher ferritin with increased blood pressure.

Elevated serum ferritin was positively associated with metabolic syndrome, insulin resistance, hyperglycaemia, hypertriglyceridaemia, and central obesity, while showing a negative association with HDL cholesterol. Associations with LDL cholesterol, total cholesterol, and blood pressure were inconsistent. Overall, serum ferritin may serve as a potential marker of metabolic dysfunction.

DISCUSSION

The present systematic review demonstrated a positive association between serum ferritin and metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity. Kumar et al. (2026) reported a significant correlation between ferritin and metabolic syndrome severity ($r=0.62$, $p=0.001$). Gi et al. (2026) also observed a positive association between ferritin, HOMA-IR, and metabolic syndrome. Chand et al. (2021) reported positive correlations between serum ferritin, BMI, waist-to-hip ratio, triglycerides, and HOMA-IR, with a negative correlation with HDL cholesterol. Similarly, Bhadana et al. (2025) observed associations between elevated ferritin, BMI, fasting glucose, and triglycerides. Overall, elevated serum ferritin was associated with metabolic abnormalities, particularly insulin resistance, hypertriglyceridaemia, and central obesity. Serum ferritin may therefore serve as an additional marker of metabolic dysfunction.

CONCLUSION

Elevated serum ferritin is positively associated with metabolic syndrome, insulin resistance, dyslipidaemia, and abdominal obesity. It may serve as an additional biomarker for identifying metabolic dysfunction and increased cardiometabolic risk. However, further prospective studies are required to establish its clinical significance.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to this systematic review.

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AUTHOR CONTRIBUTION

All authors are contributed equally

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