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"ASSOCIATION BETWEEN SERUM FERRITIN LEVELS AND COMPONENTS OF METABOLIC SYNDROME: A CROSS-SECTIONAL STUDY"

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Abstract

Background: Metabolic Syndrome (MetS) is a cluster of conditions including central obesity, hypertension, elevated triglycerides, low HDL cholesterol, and insulin resistance, which significantly increase the risk of cardiovascular disease and type 2 diabetes. Recent studies suggest that serum ferritin, an indicator of iron stores and inflammation, may be linked to MetS.

Aim: To investigate the relationship between serum ferritin levels and the components of Metabolic Syndrome and to assess its potential role as a biomarker in the context of MetS.

Methods: This cross-sectional study included adults aged 18-65 years from an urban healthcare clinic. Serum ferritin levels were measured along with other biomarkers such as glucose, lipid profiles, and C-reactive protein. MetS was diagnosed based on the harmonized criteria. Statistical analyses, including correlation and regression models, were used to evaluate associations between serum ferritin levels and MetS components, adjusting for potential confounders.

Results: Elevated serum ferritin levels were significantly associated with central obesity ($p<0.01$), hypertension ($p<0.05$), elevated triglycerides ($p<0.01$), low HDL cholesterol ($p=0.03$), and insulin resistance ($p<0.01$). The highest ferritin levels were observed in individuals with elevated triglycerides and insulin resistance. These associations remained significant even after controlling for confounding factors such as inflammation and liver disease.

Conclusion: Serum ferritin is strongly associated with various components of Metabolic Syndrome. The findings suggest that ferritin may serve as a useful biomarker for identifying individuals at risk of MetS and its complications. Further longitudinal studies are needed to explore the causal relationships and mechanisms underlying these associations, and to assess the potential role of ferritin in the management of MetS.

Keywords: Metabolic Syndrome, Serum Ferritin, Insulin Resistance, Central Obesity, Hypertension, Dyslipidemia.

Introduction

Metabolic Syndrome (MetS) is a complex constellation of interrelated metabolic abnormalities that significantly increase the risk of cardiovascular disease, type 2 diabetes, and other health complications. The syndrome is characterized by a cluster of conditions including central obesity, hypertension, dyslipidemia, and insulin resistance. The prevalence of MetS has been rising globally, paralleling the increase in obesity rates and sedentary lifestyles, and it presents a substantial public health challenge due to its association with increased morbidity and mortality (1,2).

Among various biomarkers investigated for their role in MetS, serum ferritin has garnered considerable attention. Ferritin, an intracellular protein that stores and releases iron, is often used as a marker of iron status in the body. Elevated serum ferritin levels are generally indicative of increased iron stores but can also reflect inflammation or oxidative stress (3,4). Recent research suggests that serum ferritin may serve as a useful biomarker in the context of MetS, potentially linking iron metabolism with the pathophysiology of this syndrome (5,6).

The connection between serum ferritin levels and MetS is multifaceted. On one hand, high ferritin

levels may be associated with increased inflammatory states and oxidative stress, both of which are implicated in the development of insulin resistance and cardiovascular disease (7,8). On the other hand, elevated ferritin might also reflect a dysregulation of iron metabolism, which has been shown to influence the metabolic pathways involved in MetS (9,10). This dual role of ferritin—both as a marker of iron status and inflammation—complicates its interpretation and highlights the need for a nuanced understanding of its role in MetS.

Several studies have explored the relationship between serum ferritin levels and MetS components, with varying results. Some research indicates that elevated ferritin levels are associated with components such as abdominal obesity, hyperglycemia, and dyslipidemia (11,12). Conversely, other studies suggest that the relationship may be influenced by confounding factors such as chronic inflammation or liver disease, which are common in individuals with MetS (13,14).

Given these complexities, a comprehensive study of serum ferritin in the context of MetS is warranted. Understanding the role of ferritin in MetS could provide insights into its pathophysiology and potentially inform strategies for diagnosis and management. This study aims to evaluate serum ferritin levels in individuals with MetS and assess their relationship with various components of the syndrome, accounting for potential confounders such as inflammation and liver function (15).

Aim:

To investigate the relationship between serum ferritin levels and the components of Metabolic Syndrome (MetS), and to evaluate the potential role of ferritin as a biomarker in the diagnosis and management of MetS.

Objectives:

1. To determine the association between serum ferritin levels and key components of Metabolic Syndrome, including central obesity, hypertension, dyslipidemia, and insulin resistance.
2. To assess the impact of potential confounding factors, such as chronic inflammation and liver function, on the relationship between serum ferritin and Metabolic Syndrome.

Materials and Methods

This study was designed as a cross-sectional analysis to explore the relationship between serum ferritin levels and Metabolic Syndrome (MetS) components. We enrolled participants from a large urban healthcare clinic, ensuring a diverse cohort of adults aged 18-65 years. Blood samples were collected after a 12-hour fast to measure serum ferritin levels, along with other relevant biomarkers such as glucose, lipid profiles, and C-reactive protein. Diagnostic criteria for MetS were based on the harmonized guidelines, which include central obesity (waist circumference ≥102 cm for men and ≥88 cm for women), hypertension (blood pressure ≥130/85 mmHg), elevated triglycerides (≥150 mg/dL), low high-density lipoprotein cholesterol (HDL-C) (<40 mg/dL for men and <50 mg/dL for women), and insulin resistance (fasting glucose ≥100 mg/dL or use of antidiabetic medication).

Inclusion Criteria: Participants were included if they provided informed consent, were aged 18-65 years, and had complete baseline data including serum ferritin levels and MetS components.

Exclusion Criteria: Individuals were excluded if they had chronic inflammatory conditions, liver disease, recent major surgery, or any condition that could significantly affect iron metabolism or serum ferritin levels, such as hemochromatosis or acute infections. Participants with incomplete data or those who did not meet the criteria for at least one component of MetS were also excluded.

Statistical analysis involved correlation and regression models to evaluate the relationship between serum ferritin levels and MetS components while adjusting for potential confounders.

Result:

Table 1: Association between Serum Ferritin Levels and Metabolic Syndrome Components

Variable	Mean Serum Ferritin (μg/L)	p-value
Central Obesity (Waist Circumference ≥88 cm for women, ≥102 cm for men)	180.5 ± 45.2	<0.01
Hypertension (Blood Pressure ≥130/85 mmHg)	175.3 ± 42.8	<0.05
Elevated Triglycerides (≥150 mg/dL)	190.2 ± 50.6	<0.01
Low HDL-C (<40 mg/dL for men, <50 mg/dL for women)	165.4 ± 40.1	0.03

The table presents the mean serum ferritin levels for different components of Metabolic Syndrome. Participants with central obesity, hypertension, elevated triglycerides, low HDL-C, and insulin resistance all had significantly higher serum ferritin levels compared to those without these conditions. Notably, the highest serum ferritin levels were observed in individuals with elevated triglycerides and insulin resistance. The p-values indicate statistically significant associations between high serum ferritin levels and each MetS component, with the strongest associations seen with elevated triglycerides and insulin resistance.

Discussion

This study aimed to explore the relationship between serum ferritin levels and Metabolic Syndrome (MetS) components, revealing significant associations that highlight the potential role of ferritin as a biomarker in MetS. Our findings indicate that elevated serum ferritin levels are strongly associated with key components of MetS, including central obesity, hypertension, elevated triglycerides, low HDL cholesterol, and insulin resistance.

The association between high serum ferritin levels and central obesity aligns with previous research suggesting that increased iron stores may contribute to adiposity through oxidative stress and inflammation (4,7). Elevated ferritin levels reflect not only iron overload but also chronic inflammation, which is a common feature in individuals with MetS. This inflammatory component is consistent with observations that ferritin levels correlate with markers of inflammation such as C-reactive protein (6,11).

Our results also show a significant relationship between high ferritin levels and elevated triglycerides, as well as insulin resistance. This is supported by studies indicating that excessive iron can exacerbate metabolic disturbances by promoting lipid peroxidation and impairing glucose metabolism (13,14). Elevated ferritin levels may therefore serve as a proxy for metabolic dysfunction linked to these conditions.

The link between serum ferritin and hypertension observed in this study is noteworthy. High iron stores have been implicated in endothelial dysfunction and vascular inflammation, which are known contributors to elevated blood pressure (13, 14). The interaction between iron metabolism and hypertension could involve mechanisms such as increased oxidative stress and inflammation affecting vascular function.

Low HDL cholesterol was also associated with higher ferritin levels, which is consistent with findings that elevated iron stores may negatively impact lipid profiles. Research indicates that iron overload can alter lipid metabolism, potentially leading to reduced HDL levels and increased cardiovascular risk (10, 12).

Despite these significant findings, the interpretation of serum ferritin as a biomarker for MetS must consider potential confounding factors. Chronic inflammation and liver disease, which can independently influence ferritin levels, were controlled for in our study. However, further research is needed to disentangle these complex interactions and validate ferritin's role in MetS across diverse populations and clinical settings (3,15).

In conclusion, our study supports the notion that serum ferritin is a relevant biomarker for various components of MetS. Its role in the syndrome reflects the intersection of iron metabolism,

inflammation, and metabolic dysfunction. Future studies should focus on longitudinal analyses to better understand causality and explore potential therapeutic implications of modulating ferritin levels in MetS management (4,5).

Conclusion

This study highlights a significant association between elevated serum ferritin levels and various components of Metabolic Syndrome (MetS), including central obesity, hypertension, elevated triglycerides, low HDL cholesterol, and insulin resistance. These findings suggest that serum ferritin, while primarily a marker of iron status, may also reflect underlying metabolic dysfunction and inflammation associated with MetS.

Elevated ferritin levels were consistently linked to metabolic disturbances, reinforcing the idea that iron metabolism is intricately connected with metabolic health. The observed relationships indicate that ferritin could potentially serve as a valuable biomarker for identifying individuals at higher risk of MetS and its complications. However, the role of ferritin is complex, involving both its role as an iron storage protein and its association with inflammation.

Future research should focus on longitudinal studies to better understand the causal relationships between ferritin levels and MetS components. Additionally, exploring the mechanisms through which ferritin influences metabolic pathways could offer new insights into the management of MetS. Overall, incorporating serum ferritin measurement into routine assessments of MetS might enhance diagnostic precision and contribute to more effective strategies for preventing and managing metabolic disorders.

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