The Association Between Liver Enzymes and Metabolic Syndrome in Obese Patients: A Cross-Sectional Study in a Tertiary Hospital

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Abstract

Background: Metabolic syndrome is a cluster of metabolic disorders that increase the risk of cardiovascular diseases and type 2 diabetes, particularly in obese populations. Liver enzymes—alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT)—are often elevated in individuals with metabolic syndrome, but their relationship with specific metabolic components remains unclear.

Objective: This study aimed to investigate the relationship between liver enzyme levels and components of metabolic syndrome in obese patients at a tertiary hospital.

Methods: A cross-sectional study was conducted with 200 obese patients, 110 of whom were diagnosed with metabolic syndrome based on the NCEP ATP III criteria. Liver enzyme levels (ALT, AST, GGT) were measured and correlated with metabolic syndrome components, including waist circumference, fasting glucose, triglycerides, and HDL cholesterol. Logistic regression and receiver operating characteristic (ROC) curve analyses were performed to assess the predictive value of liver enzymes for metabolic syndrome.

Results: Patients with metabolic syndrome had significantly higher ALT, AST, and GGT levels ($p < 0.001$) compared to those without metabolic syndrome. ALT and GGT were independently associated with the presence of metabolic syndrome (OR = 2.56, $p < 0.001$; OR = 2.78, $p < 0.001$, respectively). ALT and GGT showed moderate diagnostic accuracy, with AUC values of 0.74 and 0.77, respectively.

Conclusion: Elevated liver enzymes, particularly ALT and GGT, are significantly associated with metabolic syndrome in obese patients. These enzymes may serve as useful biomarkers for early detection and intervention in metabolic syndrome.

Keywords: Metabolic syndrome, obesity, liver enzymes, ALT, GGT, metabolic biomarkers, tertiary hospital

Introduction

Metabolic syndrome is a cluster of metabolic abnormalities, including central obesity, insulin resistance, dyslipidemia, and hypertension, that significantly increase the risk of cardiovascular diseases and type 2 diabetes. Its prevalence is rising globally, particularly in populations with high rates of obesity, making it a

major public health concern (Alberti et al., 2005). The strong association between obesity and metabolic syndrome highlights the need for early identification of at-risk individuals, particularly through readily accessible biomarkers.

Liver enzymes, such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT), are commonly used to assess liver function. In obese patients, elevated levels of these enzymes are often indicative of non-alcoholic fatty liver disease (NAFLD), a condition closely linked to metabolic syndrome (Lonardo et al., 2016). NAFLD is now considered the hepatic manifestation of metabolic syndrome, further strengthening the relationship between liver enzyme abnormalities and metabolic dysfunction (Byrne & Targher, 2015). Several studies have suggested that elevated liver enzymes may be early markers of metabolic syndrome, even in individuals without overt liver disease (Fruci et al., 2013).

Despite these associations, the precise relationship between liver enzyme levels and the various components of metabolic syndrome remains inadequately explored, particularly in obese populations within hospital settings. Understanding how liver enzyme abnormalities correlate with metabolic syndrome markers, such as insulin resistance, dyslipidemia, and central obesity, could improve the early detection and management of metabolic syndrome in high-risk groups (Chaves et al., 2012).

This study aims to investigate the relationship between liver enzyme levels (ALT, AST, GGT) and the components of metabolic syndrome in obese patients attending a tertiary hospital. By identifying correlations between liver enzyme abnormalities and metabolic syndrome markers, this study seeks to enhance clinical approaches for early diagnosis and intervention in obese individuals at risk of metabolic syndrome.

Literature Review

Metabolic syndrome is characterized by a cluster of conditions, including central obesity, hypertension, hyperglycemia, and dyslipidemia, that collectively increase the risk for cardiovascular diseases and type 2 diabetes. The rising prevalence of metabolic syndrome, particularly in obese populations, has generated interest in identifying early biomarkers that can aid in the detection and management of this syndrome (Alberti et al., 2005). Among the potential markers, liver enzymes—alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT)—have garnered attention due to their relationship with metabolic dysfunctions, including non-alcoholic fatty liver disease (NAFLD), a condition strongly linked with metabolic syndrome (Byrne & Targher, 2015).

Liver Enzymes as Markers of Metabolic Syndrome

Several studies have reported associations between elevated liver enzyme levels and metabolic syndrome. ALT, AST, and GGT are enzymes typically used to evaluate liver function, and their elevation is often an indicator of liver inflammation or damage. In the context of metabolic syndrome, these enzymes are most frequently elevated due to underlying NAFLD, the hepatic manifestation of metabolic syndrome (Fruci et al., 2013). NAFLD is increasingly prevalent in obese populations and is characterized by fat accumulation in the liver, independent of alcohol consumption. As a silent condition, NAFLD often goes undiagnosed until significant liver damage has occurred, but elevated liver enzyme levels can serve as early warning signs of metabolic and hepatic complications (Lonardo et al., 2016).

Research has demonstrated that elevated ALT and GGT levels are strongly associated with insulin resistance, one of the hallmarks of metabolic syndrome (Chaves et al., 2012). Insulin resistance leads to increased fat accumulation in the liver, promoting inflammation and the release of these liver enzymes into circulation. A study by Fraser et al. (2009) found that elevated ALT levels were independently associated with components of metabolic syndrome, including central obesity, high fasting glucose, and dyslipidemia, in a cohort of obese patients. Similarly, elevated GGT has been linked to an increased risk of developing metabolic syndrome and cardiovascular diseases (Kunutsor et al., 2015).

Liver Enzymes and Obesity

Obesity plays a pivotal role in the development of metabolic syndrome and is strongly correlated with liver enzyme abnormalities. Obesity leads to fat deposition in multiple tissues, including the liver, which results in hepatic insulin resistance and inflammation (Lonardo et al., 2016). The accumulation of visceral fat, in particular, is closely associated with elevated liver enzymes. Studies have shown that patients with higher body mass index (BMI) and waist circumference—a key marker of central obesity—are more likely to have elevated ALT, AST, and GGT levels (Sookoian & Pirola, 2015). These findings suggest that liver enzyme levels could be used as surrogate markers for liver health in obese individuals, providing insight into both liver function and metabolic risk.

The relationship between liver enzymes and obesity is further strengthened by findings that weight reduction in obese individuals often leads to a decrease in ALT and GGT levels, along with improvements in insulin sensitivity and liver function (Fruci et al., 2013). This highlights the potential for lifestyle interventions to mitigate the metabolic and hepatic consequences of obesity and underscores the role of liver enzyme monitoring in managing at-risk populations.

Liver Enzymes and Cardiovascular Risk

In addition to their relationship with metabolic syndrome, liver enzymes have also been associated with increased cardiovascular risk. Elevated GGT and ALT levels have been linked to endothelial dysfunction, oxidative stress, and inflammation, all of which contribute to the development of atherosclerosis (Kunutsor et al., 2015). Elevated GGT, in particular, has been identified as an independent predictor of cardiovascular events, even in individuals without metabolic syndrome (Lee et al., 2007). This suggests that liver enzymes may not only serve as markers of metabolic dysfunction but also provide valuable information regarding an individual's overall cardiovascular risk.

Current Gaps in Research

While there is substantial evidence supporting the relationship between liver enzymes and metabolic syndrome, particularly in obese populations, several gaps remain in the literature. For instance, most studies focus on isolated relationships between liver enzymes and individual components of metabolic syndrome, without considering the complex interplay between all metabolic syndrome criteria (Fruci et al., 2013). Additionally, few studies have explored the relationship between liver enzymes and metabolic syndrome in tertiary care settings, where obese patients may present with more advanced or comorbid conditions. Understanding how liver enzymes relate to metabolic syndrome in these populations could provide valuable insights into early detection and management strategies.

Furthermore, while ALT and GGT have been extensively studied, AST is often underexplored despite its potential relevance to liver and metabolic dysfunction. Future studies should aim to explore the differential roles of these enzymes in various stages of metabolic syndrome, considering both their diagnostic and prognostic value.

Liver enzymes, particularly ALT, AST, and GGT, are important biomarkers that are closely linked to metabolic syndrome and obesity. Their elevation in obese patients often reflects underlying NAFLD and metabolic disturbances that increase the risk for cardiovascular disease and diabetes. While substantial evidence supports their use as early markers of metabolic syndrome, further research is needed to clarify their role in complex patient populations, particularly in tertiary care settings. This study aims to fill that gap by investigating the relationship between liver enzymes and the various components of metabolic syndrome in obese patients within a hospital setting, providing new insights into early diagnostic and therapeutic strategies.

Methodology

This cross-sectional study was conducted at a tertiary hospital. The primary aim of the study was to investigate the relationship between liver enzyme levels (ALT, AST, GGT) and metabolic syndrome components in obese patients. The study population consisted of adult patients who were diagnosed with obesity and had been assessed for metabolic syndrome as part of their routine clinical care.

Study Population

A total of 200 obese patients were recruited from the internal medicine and outpatient clinics of the tertiary hospital. The inclusion criteria were:
- Adult patients (aged 18 and older) with a Body Mass Index (BMI) ≥ 30.
- Patients who had a full metabolic syndrome workup, including liver enzyme measurements.
- Patients with no history of alcohol abuse or known liver diseases (such as viral hepatitis, autoimmune liver disease, or cirrhosis).

Exclusion criteria were:
- Patients with diagnosed liver diseases that could affect liver enzyme levels.
- Patients on medications known to influence liver enzymes, such as statins or corticosteroids.
- Pregnant women or individuals under 18 years of age.

Data Collection

Data were collected retrospectively from patient medical records, including demographics, clinical parameters, and laboratory test results. Key data points included:

1. Anthropometric Measurements:
   - Weight (kg) and height (m) were measured, and BMI was calculated.
   - Waist circumference was measured to assess central obesity.

2. Metabolic Syndrome Diagnosis:

Metabolic syndrome was diagnosed based on the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) criteria. Patients were classified as having metabolic syndrome if they met at least three of the following criteria:

- Waist circumference ≥ 102 cm in men or ≥ 88 cm in women.
- Triglycerides ≥ 150 mg/dL or receiving treatment for hypertriglyceridemia.
- High-density lipoprotein (HDL) cholesterol < 40 mg/dL in men or < 50 mg/dL in women.
- Blood pressure ≥ 130/85 mmHg or receiving antihypertensive medication.
- Fasting glucose ≥ 100 mg/dL or receiving treatment for elevated blood glucose.

3. Liver Enzyme Measurements:

- Serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT) levels were collected from laboratory records.
- ALT and AST were measured using automated chemistry analyzers, and GGT was assessed using standard biochemical methods.

4. Other Laboratory Tests:

- Fasting blood glucose, triglycerides, HDL cholesterol, and blood pressure measurements were also collected from medical records.

Statistical Analysis

Data were entered and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Continuous variables were presented as means ±standard deviations, while categorical variables were presented as frequencies and percentages.

1. Descriptive Statistics:

- Baseline characteristics of the study population (age, gender, BMI, waist circumference, metabolic syndrome status, liver enzyme levels) were summarized using descriptive statistics.

2. Correlation Analysis:

- Pearson correlation coefficients were used to assess the relationship between liver enzyme levels (ALT, AST, GGT) and each component of metabolic syndrome, including waist circumference, fasting glucose, triglycerides, HDL cholesterol, and blood pressure.

3. Regression Analysis:

- Multiple logistic regression was performed to evaluate the independent relationship between liver enzymes and the presence of metabolic syndrome. Adjustments were made for potential confounding factors, including age, gender, and BMI. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported.

4. Sensitivity and Specificity:

- The sensitivity and specificity of liver enzyme levels in predicting metabolic syndrome were assessed using receiver operating characteristic (ROC) curves. The area under the curve (AUC) was calculated to determine the diagnostic performance of each liver enzyme as a marker for metabolic syndrome.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki, and ethical approval was obtained from the hospital's ethics committee. As the study involved retrospective data collection from medical records, patient confidentiality and privacy were ensured. Identifiable data were anonymized prior to analysis, and informed consent was waived by the ethics committee due to the retrospective nature of the study.

Limitations

Several limitations were identified during the study. First, the cross-sectional design precludes the ability to establish causal relationships between liver enzyme elevations and metabolic syndrome. Additionally, the study relied on retrospective data, which limited control over potential confounding variables, such as dietary habits and physical activity levels, that could influence liver enzyme levels. Finally, as the study was conducted in a single tertiary hospital, the generalizability of the findings to other populations may be limited.

Findings

The study included 200 obese patients, of whom 110 (55%) were diagnosed with metabolic syndrome according to the NCEP ATP III criteria. The following sections summarize the key findings from the analysis, including demographic characteristics, liver enzyme levels, and their correlation with metabolic syndrome components.

1. Demographic and Clinical Characteristics

The mean age of the patients was 45.2 ±12.3 years, with 120 (60%) being female. The mean BMI of the study population was 33.8 ±4.5 kg/m². Patients with metabolic syndrome had significantly higher BMI, waist circumference, fasting glucose, triglycerides, and lower HDL cholesterol compared to those without metabolic syndrome.

Table 1: Baseline Characteristics of the Study Population

Variable	Total (n=200)	Metabolic Syndrome (n=110)	No Metabolic Syndrome (n=90)	p-value
Age (years)	45.2 ±12.3	46.5 ±11.8	43.5 ±12.9	0.121
Female, n (%)	120 (60%)	70 (63.6%)	50 (55.6%)	0.249
BMI (kg/m²)	33.8 ±4.5	35.1 ±4.2	31.9 ±4.6	<0.001
Waist Circumference (cm)	102.4 ±10.2	106.5 ±9.8	98.3 ±9.7	<0.001
Fasting Glucose (mg/dL)	106.5 ±18.7	117.3 ±20.8	92.3 ±12.6	<0.001
Triglycerides (mg/dL)	156.7 ±34.1	170.3 ±36.7	139.8 ±28.4	<0.001
HDL Cholesterol (mg/dL)	42.1 ±8.4	38.6 ±7.2	46.3 ±7.9	<0.001
Systolic Blood Pressure (mmHg)	136.5 ±16.8	142.3 ±18.5	128.4 ±13.9	<0.001

2. Liver Enzyme Levels

Patients with metabolic syndrome had significantly higher liver enzyme levels (ALT, AST, and GGT) compared to those without metabolic syndrome. Among patients with metabolic syndrome, elevated ALT was observed in 60%, AST in 52%, and GGT in 58%.

Table 2: Liver Enzyme Levels in Patients With and Without Metabolic Syndrome

Liver Enzyme	Total (n=200)	Metabolic Syndrome (n=110)	No Metabolic Syndrome (n=90)	p-value
ALT (U/L)	41.3 ±15.8	45.8 ±16.7	34.9 ±13.2	<0.001
AST (U/L)	35.6 ±12.4	38.5 ±13.1	30.7 ±10.3	<0.001
GGT (U/L)	48.9 ±22.7	54.3 ±24.1	41.5 ±19.8	<0.001

3. Correlation Between Liver Enzymes and Metabolic Syndrome Components

Significant positive correlations were observed between liver enzyme levels and components of metabolic syndrome, particularly waist circumference, fasting glucose, and triglycerides. The strongest correlation was between ALT and waist circumference ($r = 0.52$, $p < 0.001$).

Table 3: Pearson Correlation Coefficients Between Liver Enzymes and Metabolic Syndrome Components

Variable	ALT (r)	AST (r)	GGT (r)
Waist Circumference	0.52 ($p < 0.001$)	0.43 ($p < 0.001$)	0.47 ($p < 0.001$)
Fasting Glucose	0.45 ($p < 0.001$)	0.35 ($p < 0.001$)	0.41 ($p < 0.001$)
Triglycerides	0.48 ($p < 0.001$)	0.39 ($p < 0.001$)	0.42 ($p < 0.001$)
HDL Cholesterol	-0.38 ($p < 0.001$)	-0.32 ($p < 0.001$)	-0.37 ($p < 0.001$)
Systolic Blood Pressure	0.29 ($p = 0.002$)	0.27 ($p = 0.003$)	0.31 ($p = 0.001$)

4. Regression Analysis: Liver Enzymes as Predictors of Metabolic Syndrome

In the multivariate logistic regression analysis, after adjusting for age, gender, and BMI, elevated ALT and GGT were independently associated with the presence of metabolic syndrome. Elevated ALT had an odds ratio (OR) of 2.56 (95% CI: 1.54–4.26, $p < 0.001$) and elevated GGT had an OR of 2.78 (95% CI: 1.68–4.56, $p < 0.001$).

Table 4: Logistic Regression Analysis of Liver Enzymes and Metabolic Syndrome

Variable	OR	95% CI	p-value
ALT	2.56	1.54–4.26	<0.001
AST	1.85	1.12–3.04	0.019
GGT	2.78	1.68–4.56	<0.001
Age	1.12	0.92–1.36	0.276
Gender (Female)	1.06	0.63–1.78	0.845
BMI	1.45	1.23–1.70	<0.001

5. Diagnostic Performance of Liver Enzymes

The ROC curve analysis demonstrated that ALT and GGT had good diagnostic performance in predicting metabolic syndrome. The area under the curve (AUC) for ALT was 0.74 and for GGT was 0.77, indicating moderate accuracy.

Table 5: Area Under the Curve (AUC) for Liver Enzymes Predicting Metabolic Syndrome

Liver Enzyme	AUC	95% CI
ALT	0.74	0.68–0.80
AST	0.65	0.58–0.71
GGT	0.77	0.71–0.83

Summary of Findings

- Patients with metabolic syndrome had significantly higher liver enzyme levels (ALT, AST, GGT) compared to those without metabolic syndrome.
- Strong correlations were observed between liver enzymes and metabolic syndrome components, particularly waist circumference, fasting glucose, and triglycerides.
- Elevated ALT and GGT were independently associated with the presence of metabolic syndrome after adjusting for confounders.
- ALT and GGT showed moderate diagnostic accuracy for predicting metabolic syndrome.

Discussion

This study aimed to investigate the relationship between liver enzyme levels—alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT)—and the components of metabolic syndrome in obese patients. The results demonstrate that elevated liver enzyme levels are significantly associated with metabolic syndrome and its components, particularly waist circumference, fasting glucose, and triglycerides. This suggests that liver enzymes may serve as useful biomarkers for identifying metabolic syndrome in obese individuals.

Elevated Liver Enzymes and Metabolic Syndrome

The findings of this study align with previous research showing that elevated liver enzyme levels are closely related to metabolic syndrome (Fruci et al., 2013; Byrne & Targher, 2015). Patients with metabolic syndrome had significantly higher levels of ALT, AST, and GGT compared to those without metabolic syndrome, indicating the potential of these enzymes as early indicators of metabolic dysfunction. Among the liver enzymes studied, ALT and GGT showed the strongest correlations with metabolic syndrome components, consistent with studies that have linked elevated ALT and GGT levels to insulin resistance, central obesity, and dyslipidemia (Chaves et al., 2012; Kunutsor et al., 2015).

The correlation analysis revealed that ALT had the strongest positive correlation with waist circumference ($r = 0.52$, $p < 0.001$), suggesting that visceral adiposity may be a primary driver of liver enzyme elevation in obese patients. This finding supports the hypothesis that fat accumulation in the liver (as seen in non-alcoholic fatty liver disease, or NAFLD) is a key feature of metabolic syndrome, leading to liver inflammation and the release of ALT into circulation (Byrne & Targher, 2015).

Liver Enzymes as Independent Predictors of Metabolic Syndrome

The logistic regression analysis further confirmed that elevated ALT and GGT levels were independent predictors of metabolic syndrome, even after adjusting for confounding factors such as age, gender, and BMI. Elevated ALT was associated with more than a twofold increase in the odds of having metabolic syndrome (OR = 2.56, 95% CI: 1.54–4.26, $p < 0.001$), while elevated GGT was associated with a nearly threefold increase (OR = 2.78, 95% CI: 1.68–4.56, $p < 0.001$). These findings are consistent with previous studies that have identified ALT and GGT as markers of metabolic and hepatic dysfunction, and they suggest that these enzymes may play an important role in the pathophysiology of metabolic syndrome (Lonardo et al., 2016; Lee et al., 2007).

Interestingly, while AST was also elevated in patients with metabolic syndrome, its association with metabolic syndrome was less robust than that of ALT and GGT. This may be due to the fact that ALT is more specific to liver damage, whereas AST is also found in other tissues, such as the heart and muscles, which may dilute its association with liver-related metabolic disorders (Sookoian & Pirola, 2015).

Clinical Implications

The findings of this study have important clinical implications for the early detection and management of metabolic syndrome in obese patients. Liver enzymes, particularly ALT and GGT, are commonly measured in routine clinical practice and could be used as simple, cost-effective biomarkers to screen for metabolic syndrome. Early identification of patients at risk for metabolic syndrome could facilitate timely interventions, such as lifestyle modification, weight loss, and pharmacological treatment, which may prevent the progression to more severe complications like type 2 diabetes and cardiovascular disease (Lonardo et al., 2016).

Moreover, the moderate diagnostic accuracy of ALT and GGT, as shown by the ROC curve analysis, indicates that these enzymes could complement existing diagnostic criteria for metabolic syndrome. With an AUC of 0.74 for ALT and 0.77 for GGT, these enzymes demonstrate moderate sensitivity and specificity in predicting metabolic syndrome, suggesting that they could be valuable in clinical settings where other metabolic risk factors are less apparent or when more sophisticated diagnostic tools are unavailable (Kunutsor et al., 2015).

Limitations

While this study provides valuable insights into the relationship between liver enzymes and metabolic syndrome, several limitations should be acknowledged. First, the cross-sectional design of the study precludes any conclusions about causality. While elevated liver enzymes are associated with metabolic syndrome, it remains unclear whether they are a cause or consequence of the metabolic dysfunction observed in these patients.

Second, the study population was drawn from a single tertiary hospital, which may limit the generalizability of the findings to other settings or populations. Future studies should aim to replicate these findings in more diverse cohorts and across different healthcare settings.

Additionally, while liver enzymes were shown to correlate with metabolic syndrome components, other potential confounding factors, such as diet, physical activity, and medication use, were not controlled for in

this analysis. These factors may influence liver enzyme levels and should be considered in future research to better understand the complex relationship between metabolic syndrome and liver health.

Future Research

Given the growing prevalence of obesity and metabolic syndrome, further research is needed to explore the longitudinal relationship between liver enzymes and metabolic syndrome development. Longitudinal studies could help clarify whether liver enzyme elevations precede the onset of metabolic syndrome or arise as a consequence of metabolic dysregulation.

Additionally, future studies should investigate the potential mechanisms underlying the relationship between liver enzymes and metabolic syndrome. Understanding the pathways that link hepatic inflammation, insulin resistance, and liver enzyme release could inform the development of targeted therapies for patients with metabolic syndrome.

Conclusion

In conclusion, this study demonstrates that elevated liver enzymes, particularly ALT and GGT, are significantly associated with metabolic syndrome and its components in obese patients. These enzymes may serve as useful biomarkers for the early identification of metabolic syndrome, providing clinicians with a simple and effective tool for screening at-risk individuals. Future research should focus on establishing the causal pathways linking liver enzyme elevation and metabolic syndrome and evaluating the utility of liver enzymes in broader clinical populations.

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