Research Article

Correlation Of Serum Gamma-Glutamyl Transferase With Atherogenic Dyslipidemia In Obese Individuals

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ABSTRACT

Background: Obesity is a significant social health issue and has been linked to the risk of becoming metabolically syndrome-prone, type 2 diabetes mellitus, and cardiovascular diseases. Atherogenic dyslipidemia, which is high triglycerides, low levels of high-density lipoprotein cholesterol (HDL-C) and high levels of low-density lipoprotein cholesterol (LDL-C) is a typical metabolic defect seen in obese patients. Traditionally, gamma-glutamyl transferase (GGT) can be considered a biomarker of hepatobiliary dysfunction, it has recently shown potential as a biomarker of oxidative stress, visceral adiposity, and cardiovascular risk. But its association with atherogenic dyslipidemia in obesity has not been thoroughly comprehended. The study will assess serum gamma -glutamyl transferase levels in obese individuals, contrast parameters of lipid profiles of obese and non-obese adults and establish the relationship between serum GGT and atherogenic dyslipidemia.

Methods: A cross-sectional comparative study was carried out in a hospital setting that involved 200 participants aged between 19 and 40 years with 100 obese and 100 age-matched and healthy non-obese controls. Standard laboratory tests were conducted to measure anthropometric, blood pressure, fasting blood glucose, lipid profile, and serum GGT levels. Continuous variables were compared in terms of independent student t-test, and correlation coefficient of Pearson was used to assess the association between serum GGT and the lipid profile parameters. A p-value of <0.05 was considered statistically significant.

Results: The mean age of participants was comparable between the obese and non-obese groups (29.71 ± 6.62 vs. 29.43 ± 6.52 years; $p = 0.763$). Body mass index, waist circumference, systolic blood pressure, fasting blood glucose, total cholesterol, triglycerides, LDL cholesterol, very low-density lipoprotein cholesterol (VLDL-C), serum GGT were all significantly higher among obese people than among the controls (all $p < 0.001$) and HDL cholesterol was significantly lower ($p < 0.001$). Mean serum GGT was markedly elevated in obese participants (48.90 ± 7.31 U/L) compared with non-obese controls (32.72 ± 6.13 U/L; $p < 0.001$). Serum GGT demonstrated significant positive correlations with total cholesterol ($r = 0.487$, $p < 0.001$), triglycerides ($r = 0.439$, $p < 0.001$), LDL cholesterol ($r = 0.479$, $p < 0.001$), and VLDL cholesterol ($r = 0.437$, $p < 0.001$), while showing a significant negative correlation with HDL cholesterol ($r = -0.330$, $p < 0.001$).

Conclusions: The levels of serum gamma-glutamyl transferase are highly upraised in obese people and strongly linked to atherogenic lipid profile. Positive correlation of GGT with poor lipid parameters and negative association with the HDL cholesterol indicate that GGT might be a simple and cheap biomarker to determine human risk at higher cardiometabolic risk through its obese patients. Routine metabolic screening with the addition of serum GGT might help in making early risk stratification as well as timely preventive actions against cardiovascular diseases.

Keywords: Obesity, Gamma-glutamyl transferase, GGT, Atherogenic dyslipidemia, Lipid profile, Cardiovascular risk, Metabolic syndrome.

INTRODUCTION

Obesity has now become a big world-wide public health issue and has become an epidemic in India mainly due to the interplay of rapid urbanization, sedentary lifestyle and poor diet. It has contributed significantly to the increasing burden of metabolic disorders and cardiovascular diseases to a great extent that affects morbidity, mortality and quality of life [1]. Obesity is defined as the excessive build up of adipose tissue, and is intimately linked to insulin resistance, hyperinsulinemia, dyslipidemia, systemic inflammation, and oxidative stress. Such metabolic abnormalities dramatically raise the chances of type 2 diabetes mellitus, high blood pressure, coronary artery diseases, stroke, among other complications of obesity [2,3]. To classify people as either overweight or obese, the

World Health Organization (WHO) defines people with body mass index (BMI) of 25-29.9 kg/m 2 as overweight and those with 30 or above as obese. After the Adult Treatment Panel III (ATP III) measurements identified central obesity as a waist circumference over 102 cm in males and 88 cm in females, this condition was found to be a more useful predictor of cardiometabolic risk compared to BMI alone due to its association with visceral adiposity, which is closely associated with atherogenic dyslipidemia and cardiovascular disease [4,5].

The recently emerging oxidative stress molecule of the liver and metabolic disturbance is the previously viewed biochemical marker of hepatobiliary dysfunction and excessive alcohol intake, gamma-glutamyl transferase (GGT) [6,7]. GGT is an ectoenzyme that is membrane-bound and is found in extracellular metabolism of the glutathione, which is the major intracellular antioxidant. High serum GGT concentrations are common in obese (especially central obese) people and have been directly linked to visceral adiposity and with non-alcoholic fatty liver disease. Raised activity of GGT is believed to indicate augmentation of oxidative stress and constant low-grade inflammation, each of which plays a role in the etiology of metabolic syndrome and cardiovascular disease [8].

A number of epidemiological studies have shown that even at normal range of serum GGT levels, multiple elements of a metabolic syndrome, such as dyslipidemia, hypertension, insulin resistance, and impaired glucose metabolism are independently correlated with serum GGT levels [9–13]. Moreover, high baseline GGT levels have been found to be predictive of type 2 diabetes mellitus, hypertension, stroke, and myocardial infarction in the future. The presence of GGT activity in human atherosclerotic plaques has also been found as evidence of a possible direct contribution of GGT activity to the pathogenesis of atherosclerosis by oxidative mechanisms [12,14-16].

Considering the growing evidence that obesity is associated with oxidative stress, dyslipidemia and cardiovascular risk, the current study was conducted to examine the relationship between serum gamma-glutamyl transferase (GGT) and atherogenic dyslipidemia in obese patients. The study objectives included assessing obese patients serum GGT levels, lipid profile parameters between the obese and non-obese patients and the relation between the levels of serum GGT and atherogenic dyslipidemia. This analysis could contribute to determining the possibility of GGT being a cheap biomarker to diagnose obese individuals in the group at higher risk of cardiometabolic complications.

MATERIAL AND METHODS

It was a hospital based cross-sectional comparative study done in the department of general medicine to determine the relationship between serum gamma-glutamyl transferase (GGT) concentrations and atherogenic dyslipidemia in obese patients. The experiment used obese individuals as compared to healthy non-obese control participants of the same age.

An enrolment of 200 individuals (100 obese [study group] and 100 non-obese healthy individuals [control group]) was conducted. Contributors were selected in a consecutive manner in the outpatient and inpatient departments of the Department of General Medicine. The study took place throughout the appointed period of study upon receiving consent of the Institutional Ethics Committee and written informed consent of the subjects.

Inclusion Criteria

Study Group

- Adults aged 19–40 years
- Criteria: Obese persons meeting the study definition of obesity.
- Diagnosed with type 2 diabetes mellitus
- Non-smokers
- Non-alcoholics
- Able to give written informed consent.

Control Group

- Adults (non-obese and healthy): 1940 years old.
- Non-smokers
- Non-alcoholics
- Agreed to be part of the study.

Exclusion Criteria

The following factors are not allowed: participants who had any of the following conditions were excluded:

- Known liver disease
- Past alcohol use.
- Use of hepatotoxic medications.
- Renal failure
- Lack of informed consent.

Data Collection

Demographic information and pertinent clinical history were then documented with the help of a pre-developed case record form after having a written informed consent. A thorough physical examination was carried out on all the participants. Measurement of height (cm), weight (kg), body mass index (BMI; kg/m 2) and waist circumference (cm) were part of anthropometric measures that were done using standardized methods. Clinical assessment was performed by measuring the systolic and diastolic blood pressure using a calibrated sphygmomanometer according to standard procedures. All subjects had these measurements during pre-collection of blood samples to be subjected to biochemical investigations.

The venous blood samples were taken under aseptic conditions 8–12 hours after an overnight fast followed by laboratory investigations.

Laboratory Investigations

All of the participants were estimated in regard to biochemical parameters of their blood samples, collected after an overnight fast. The biochemical tests involved fasting blood sugar (FBS), serum total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), and serum gamma-glutamyl transferase (GGT). All biochemical analyses were carried out in the central clinical biochemistry laboratory utilizing standardized automated analysis using the right internal quality control measures to ascertain the accuracy and reliability of the test outcomes.

Outcome Measures

The main product was the comparison of the serum levels of GGT among obese people and non-obese.

Secondary outcomes included:

- Comparison of lipid profile parameters of the two groups.
- Correlation of serum GGT with total cholesterol, triglycerides, LDL-C, HDL-C, and VLDL-C.
- A correlation of serum GGT and cardiometabolic risk associated with obesity.

Statistical Analysis

The data obtained were tabulated in Microsoft Excel and observed with Statistical Package for Social Sciences (SPSS) program. As continuous variables, values were stated as mean and standard deviation (SD), as categorical variables, the values were stated as frequencies and percentages. The Student independent t-test between obese and non-obese groups was conducted on continuous variables and Chi-square test done where necessary on categorical variables. Pearson correlation coefficient (r) was used to evaluate the relationship between serum GGT and the parameters of lipid profile. Any p-value lower than 0.001 was regarded to be significant.

RESULTS

The study involved 200 participants, consisting of 100 obese and 100 healthy (non-obese) controls. The mean age of the obese and non-obese groups was comparable (29.71 ± 6.62 years vs. 29.43 ± 6.52 years, p=0.763). Nonetheless, obese individuals were far more obese with respect to body mass index (BMI), waist circumference, blood pressure, fasting blood sugar levels, serum gamma-glutamyl transferase (GGT), and adverse lipid profile in comparison to the non-obese controls[Table 1, Figure 1].

Table 1. Baseline demographic and anthropometric characteristics of the study population

Variable	Obese (n=100) Mean ± SD	Non-obese (n=100) Mean ± SD	p-value

Age (years)	29.71 ± 6.62	29.43 ± 6.52	0.763
Body mass index (kg/m²)	30.19 ± 1.93	23.20 ± 2.08	<0.001
Waist circumference (cm)	99.78 ± 5.01	84.88 ± 4.84	<0.001
Blood pressure (mmHg)	141.00 ± 10.70	118.79 ± 9.55	<0.001

Data are presented as mean ± standard deviation. Student's independent t-test was used for comparison.

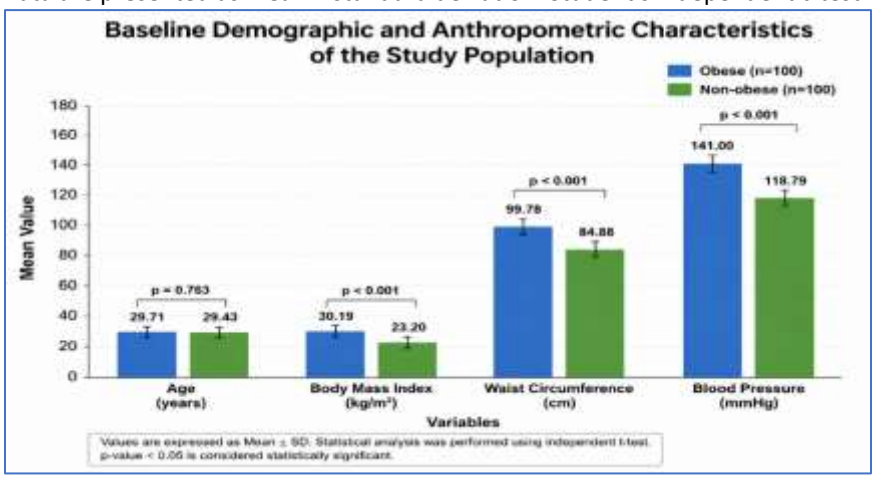

Figure 1: Baseline demographic and anthropometric characteristics of the study population

Obese individuals demonstrated significantly higher fasting blood glucose and serum GGT concentrations than non-obese controls. [Table 2, Figure 2]

Table 2. Comparison of biochemical parameters between obese and non-obese participants

Variable	Obese (n=100) Mean ± SD	Non-obese (n=100) Mean ± SD	p-value
Fasting blood sugar (mg/dL)	140.73 ± 15.07	99.09 ± 13.59	<0.001
Serum GGT (U/L)	48.90 ± 7.31	32.72 ± 6.13	<0.001

Data are presented as mean ± standard deviation. Student's independent t-test was used for comparison.

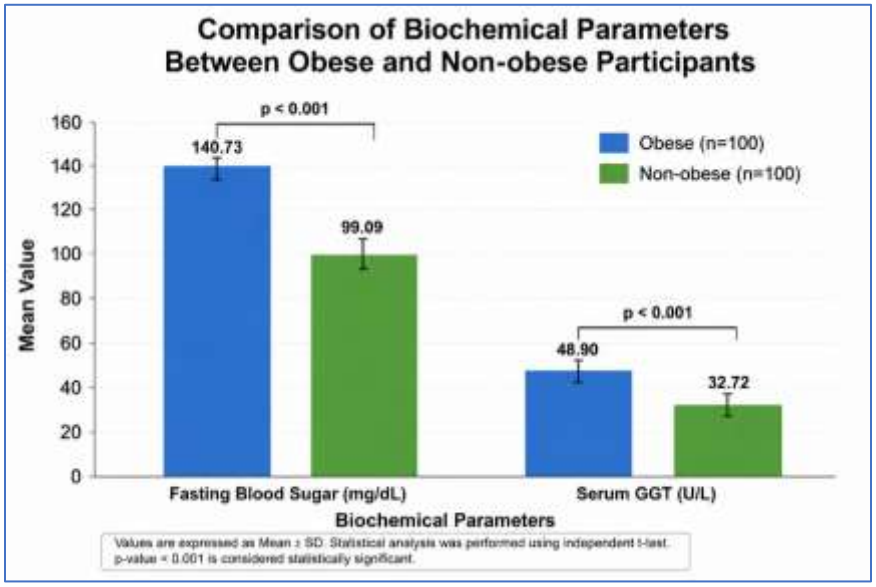

Figure 2: Comparison of biochemical parameters between obese and non-obese participants

The lipid parameters showed signs of statistically high values of total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol in obese individuals but extreme low levels of HDL cholesterol which related to those of the non-obese controls. [Table 3, Figure 3]

Table 3. Comparison of lipid profile between obese and non-obese participants

Lipid parameter	Obese (n=100) Mean ± SD	Non-obese (n=100) Mean ± SD	p-value
Total cholesterol (mg/dL)	222.55 ± 13.01	180.14 ± 15.99	<0.001
Triglycerides (mg/dL)	204.28 ± 20.77	146.98 ± 19.57	<0.001
LDL cholesterol (mg/dL)	139.46 ± 12.34	104.56 ± 12.17	<0.001
VLDL cholesterol (mg/dL)	40.86 ± 4.16	29.40 ± 3.91	<0.001
HDL cholesterol (mg/dL)	38.83 ± 5.91	50.77 ± 5.72	<0.001

Data are presented as mean ± standard deviation. Student's independent t-test was used for comparison.

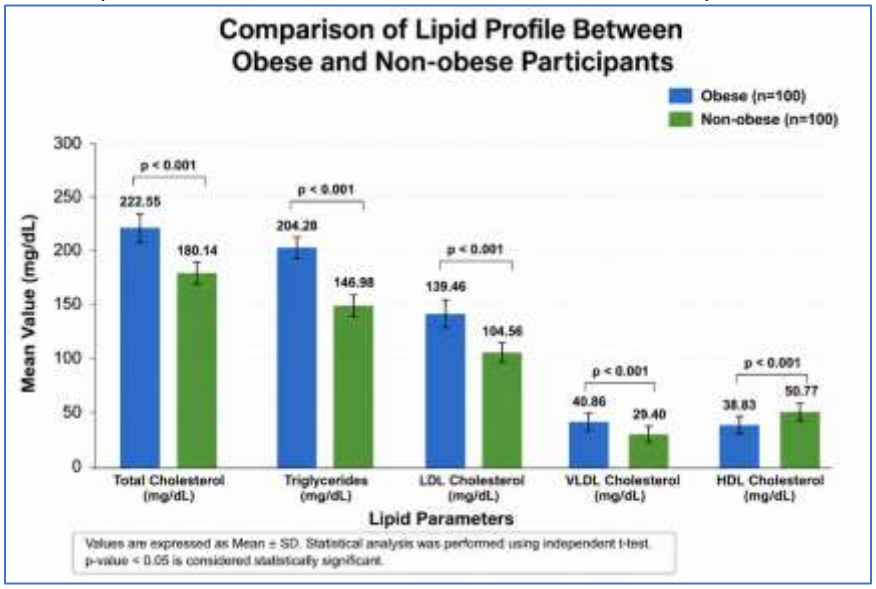

Figure 3: Comparison of lipid profile between obese and non-obese participants

The correlation analysis of the obese subjects by Pearson has shown positive significant correlations of serum GGT with total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol. Conversely, serum GGT exhibited a strong negative correlation with HDL cholesterol, and suggested that higher levels of GGT were linked with more atherogenic lipid profile. [Table 4, Figure 4]

Table 4. Correlation of serum GGT with lipid profile among obese participants (n=100)

Variable	Pearson's correlation coefficient (r)	p-value
Total cholesterol	0.487	<0.001
Triglycerides	0.439	<0.001
LDL cholesterol	0.479	<0.001
VLDL cholesterol	0.437	<0.001
HDL cholesterol	-0.330	<0.001

Pearson's correlation coefficient was used to determine the relationship between serum GGT and lipid profile parameters.

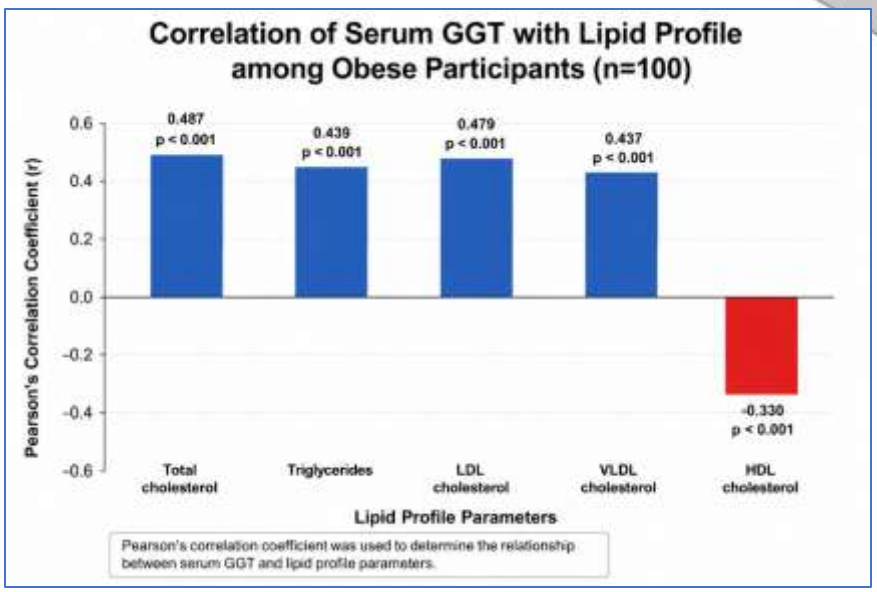

Figure 4. Correlation of serum GGT with lipid profile among obese participants (n=100)

Table 5. Summary of major study findings

Outcome	Observation
Anthropometric parameters	BMI and waist circumference were significantly higher in obese individuals.
Blood pressure	Obese participants had significantly higher blood pressure than controls.
Glycemic status	Fasting blood sugar was significantly elevated in the obese group.
Serum GGT	Serum GGT levels were significantly higher among obese individuals.
Lipid profile	Total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol were significantly higher, while HDL cholesterol was significantly lower in obese participants.
Correlation analysis	Serum GGT demonstrated significant positive correlations with total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, and a significant negative correlation with HDL cholesterol.

Comprehensively, the results showed that obesity was linked to considerable changes in anthropometric values, glycemic conditions, serum GGT concentrations, and lipid profile. High serum GGT levels were greatly linked with an atherogenic lipid profile, which supported its possible use as a biomarker of cardiometabolic risk induced by obesity.

DISCUSSION

Gamma-glutamyl transferase (GGT) has traditionally been regarded as a sensitive biochemical marker of hepatobiliary disease and excessive alcohol consumption. Nevertheless, the increasing evidence in the last two decades has proved that serum GGT is a significant indicator of oxidative stress, chronic inflammation, insulin resistance and metabolic dysfunction which in turn lead to the occurrence of obesity, metabolic syndrome and cardiovascular disease. GGT is a key component of glutathione metabolism which is the main intracellular antioxidant. Oxidative stress that comes with obesity drains glutathione levels in cells, causing an upsurge in GGT activity and its leakage into the bloodstream. Therefore, increased serum GGT has become a candidate biomarker of identifying patients at high cardiometabolic risk despite having no obvious liver disease [17,18].

The current study showed that the body mass index, waist circumference, systolic blood pressure, fasting glycol blood glucose, serum gamma-transferase (GGT) were found to be significantly higher in the factor of obese and VLDL cholesterol levels were found to be much lower than in the factor of non-obese controls. More so, serum GGT was found to be significantly positively correlated with total cholesterol (r=0.487), triglycerides (r=0.439), LDL cholesterol (r=0.479) and VLDL cholesterol (r=0.437) and significantly negatively correlated with HDL cholesterol (r=-0.330).

These results show that high serum GGT is strongly linked to metabolic disruptions and atherogenic dyslipidemia of obesity indicating its possible use as an early cardiometabolic risk biomarker.

The results of the current research agree with those obtained by Latha PJ et al. (2015), who contrasted 100 obese patients and 100 healthy people to seek the connection between serum levels of GGT and atherogenic dyslipidemia. They found elevated fasting blood glucose, serum GGT, total cholesterol, and triglycerides and LDL cholesterol, and lower HDL cholesterol level among the obese participants. Their research also revealed close positive associations of serum GGT with total cholesterol (r=0.72), triglycerides (r=0.662), TC/HDL ratio (r=0.817), and TG/HDL ratio (r=0.814), but this did not hold when considering HDL cholesterol (r= -0.773). Even though the correlation coefficients in the current paper have relatively lower values, the nature and the statistical significance of these associations were similar, showing that the rise in the serum GGT levels is parallel with the deterioration of lipid imbalances in obesity. The authors also came to the conclusion that serum GGT is a cheap and an effective indicator of visceral fat, oxidative stress, lipidemic atherogenesis, and early atherosclerosis, and the results of the present study also confirm this conclusion. [3]

Fernando ML et al. (2023) also reported similar findings in a case-control study that compared 60 metabolic syndrome obese South Indians with 60 controls who are not obese. The researchers showed that the levels of serum GGT were significantly high among the obese individuals whose metabolism was characterized by metabolic syndrome ($p<0.0001$) and that the levels of serum GGT were significantly correlated with elevated blood pressure and poor lipid profile. This was also found in the current research where the obese people were found to have large amounts of increased blood pressure, fasting blood glucose, serum GGT, total cholesterol levels, triglycerides, LDL cholesterol, VLDL cholesterol and much less HDL cholesterol, as compared to the non-obese controls. These standard outcomes in various Indian groups support the strong association between serum GGT and the metabolic syndrome linked with obesity and indicates that serum GGT can be of use as predictor of metabolic and cardiovascular risks. [2]

The correlation between obesity and atherogenic dyslipidemia was recently substantiated by Fotros et al. (2026) who carried out a cross-sectional study of 452 patients who had steatotic liver disease that was associated with metabolic dysfunction as assessed by Fibroscan. On the one hand, they found much more atherogenic indices of obese patients compared to non-obese individuals and, on the other hand, they showed that the insulin resistance gradually increased with body mass index while insulin sensitivity reduced considerably ($p<0.001$). Body mass index also provided quite strong positive associations with both the triglyceride-glucose index and the atherogenic index of plasma, indicating that the adiposity rise will contribute to the aggravation of cardiometabolic risk. The current research confirms these observations and also showed considerably high atherogenic lipid parameters and serum GGT levels in obese subjects, yet again reinforcing the role of the metabolic dysfunction and oxidative stress induced by obesity in cardiovascular disease development. [1]

The strong positive associations noted between serum GGT and total cholesterol, triglycerides, LDL cholesterol and VLDL cholesterol in the current study, in addition, suggest that serum GGT is a measure of severity of obesity-induced metabolic deviations. Historically, GGT has been considered as a hepatobiliary disease and alcohol abuse biomarker; however, due to its involvement in glutathione metabolism, GGT began to appear as a biomarker of oxidative stress. Obesity leads to greater oxidative stress which causes depletion of the intracellular glutathione stocks leading to a rise in the GGT activity and release into the circulation. High serum GGT has since been suggested as an indirect sign of oxidative stress, hepatic steatosis and insulin resistance, which are all involved in lipid metabolism abnormalities and atherogenesis [13,17]. Past literature has also shown the presence of strong correlations between high serum GGT, central obesity, dyslipidemia and metabolic syndrome [8,17,18].

Serum GGT prognostic value has also been proven in a number of large epidemiological research studies. In their cohort study of 163,944 subjects, Ruttmann et al. [19] found that high serum GGT was an independent predictor of cardiovascular death. Equally, Kazemi-Shirazi et al. [20] reported the 12-year follow-up of 283,438 people and implemented results that showed that those in the upper quartile of serum GGT had nearly twice the risk of all-cause death despite the serum GGT being within the normal reference range. What is more, longitudinal studies have indicated that the gradual rising trends of serum GGT are independent predictors of future occurrence of metabolic syndrome irrespective of the initial levels of GGT in serum [21]. These results suggest that serum GGT has prognostic value, much beyond its traditional use as a liver enzyme.

Atherogenic dyslipidemia, an increased level of triglycerides, LDL cholesterol, and VLDL cholesterol and decreased HDL cholesterol, is a symptom of obesity, insulin resistance, metabolic syndrome and type 2 diabetes mellitus [22]. The given lipid profile observed in the present study aligns with this peculiar pattern and highlights the greater cardiovascular risk with obesity. The strong correlation between serum GGT and these lipid abnormalities further indicates the hypothesis that the oxidative stress is a critical mechanism between obesity and atherogenesis.

On the whole, the results of the current research are aligned with the studies conducted by Latha PJ et al. (2015), Fernando ML et al. (2023), and Fotros et al. (2026) and indicate that high GGT levels in the serum are always related to obesity and atherogenic dyslipidemia. Taken together, these studies offer some clinical relevance of serum GGT in the form of an inexpensive, easily accessible, and effective biomarker in the early detection of obese patients who are at a higher risk of developing metabolic syndrome and cardiovascular disease. An early diagnosis of high serum GGT, alongside lifestyle changes, such as weight loss, dietary adjustment, and physical exercise, could lead to improvement of lipid metabolism, less oxidative damage and eventually lower cardiovascular morbidity and mortality in the long-term.

Limitations: Although the present study has put forth useful results in the relationship between serum GGT and atherogenic dyslipidemia in obese patients, it has some limitations. Its cross-sectional and single-center nature, as well as rather small sample size, restricts the broad applicability of the results and cause-interpretation. Also, inflammatory and oxidative stress biomarkers were not assessed to further understand the underlying pathophysiological processes.

CONCLUSION

The characteristics of obesity that are closely linked to increased levels of serum GGT and an atherogenic lipid profile (high levels of total cholesterol, triglycerides, LDL cholesterol, VLDL cholesterol and low levels of HDL cholesterol) are very strong. These strong associations between serum GGT and unfavorable lipid parameters indicate its possible use as a surrogate endpoint of obesity-associated obstructive lipid metabolism and cardiovascular danger. Serum GGT, as a cheap and readily accessible biochemical factor routinely measured, may come in handy with the early detection of obese individuals prone to developing atherogenic dyslipidemia to implement timely lifestyle behavioral modifications and preventive measures to minimize cardiovascular morbidity and mortality in the future.

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