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A STUDY OF CORRELATION BETWEEN LIPID PROFILE AND BODY MASS INDEX IN PATIENTS WITH TYPE 2 DIABETES MELLITUS: A CROSS-SECTIONAL ANALYSIS FROM A TERTIARY CARE CENTRE IN NORTHERN PART OF WEST BENGAL, INDIA

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ABSTRACT

Background: T2DM is commonly linked to obesity and dyslipidemia which are major cardiovascular disease (CVD) riskfactors. BodyMass Index (BMI) is a simple anthropometric parameter associated with changes of lipid metabolism. Knowledge about the interrelation of BMI and lipid profileparameters is important for early identification for risk assessment in diabetic population. The objective is to assess the association between BMI and serum lipid profile elements inT2DM patients and comparison of lipid profile parameters across the category of BMI and the total cholesterol levels.

Materials and Methods: This study was cross sectional in fashion and included 135 T2DM patients attending the out-patient departments ofJalpaiguri Government Medical College, West Bengal. Patients were stratified into BMI (<25 and ≥25 kg/m²) and total cholesterol groups (<200 and≥200 mg/dL). Lipid profiles included total cholesterol, triglycerides,HDL-C, LDL-C, and VLDL-C, were also ascertained after subjects fasting. Statistical analyses of independent t-tests and Pearson correlation coefficients were performed in SPSS version25.

Results: Patients with BMI ≥ 25 had significantly higher total cholesterol (181.7 ± 4.8 vs. 162.5 ± 5.2 mg/dL; p = 0.014), triglycerides (192.6 ± 9.2 vs. 145.3 ± 10.6 mg/dL; p = 0.003), LDL-C, and VLDL-C with significantly lower HDL-C (38.2± 1.1 vs. 43.7 ± 1.8 mg/dL; p = 0.021). High total cholesterol ≥ 200 mg/dL was related to increased TG, LDL andVLDL levels. In the same cohort, BMI was significantly positively correlated with TC (r = +0.27), TG (r = +0.33,), LDL (r = +0.29,),VLDL (r = +0.31,), and negatively with HDL (r = −0.25).

Conclusion: Indeed a higher BMI is associatedwith atherogenicdyslipidemia in T2DM, characterized by increased TC-, triglycerides-, LDL-cholesterol and VLDL and decreased HDL-cholesterol levels. BMI should be employed as a simpleearly marker of dyslipidemia and cardiovascular risk among diabetics. Regular lipid screening and weightcontrol are also important in managing T2DM systemically.

Keywords: Type 2 Diabetes Mellitus, body massindex, Dyslipidemia, lipid profile, triglycerides, HDL, LDL, cardiovascular risk

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a common disease worldwide and leads to chronic metabolic disorders, with insulin resistance, progressive β-cell dysfunction,and chronic hyperglycemia. Rapid urbanization and lifestyle changes in the past few decades have fueled the sharp rise in the burden of

T2DM, especiallyin low- and middle-income countries, like India. As of 2021, the International Diabetes Federation (IDF) projects that more than 537 million people are living with diabetes around the world, with this numberexpected to increase to 783 million by 2045. The country has the world's secondhighest diabetic population (after the US), about 74 million, with an expected influx in the numbers in coming years. This epidemiological transition highlights the importanceof early recognition and treatment of concomitant metabolic derangements in patients with diabetes. Obesity, as measured by body mass index (BMI),has become one of the most significant modifiable risk factors for T2DM. The association between insulin resistance and obesity is well established, particularly accumulation of visceral and central fatleading to insulin signaling abnormalities. Adipose tissue, which was once viewed simply asa static energy storage organ, is now recognized as an active endocrine organ that releases a multitude of adipokines, cytokines and inflammatory mediators implicated in metabolic dysfunction. Rising BMI is closely associated with systemic inflammation, oxidative stress, and lipid disorders, which are all involved in the pathogenesis of T2DM andassociated complications (Baladaniya&Baldania, 2022). Dyslipidemia is also among themost common and clinically important comorbidities in T2DM patients.[1] It is used to describe a cluster of abnormalities in serum lipid profile, usually including elevated triglycerides (TG), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and lowlevels of high-density lipoprotein cholesterol (HDL-C). These abnormalities of the lipidprofile are a cause of development of atherosclerosis and cardiovascular diseases (CVD), which are the most common cause of morbidity and mortality among the diabetics. The development of dyslipidemia in diabetes isa multifactorial process. Insulin resistance results in reduced lipoprotein lipase activity and enhanced hepatic lipogenesis resulting in raised triglyceride and small denseLDL cholesterol levels. HDL alsofails to be synthesized and existing HDL becomes non-functional via glycation and oxidative damage. These alterations in lipid profile progress not only atherosclerosis but also non-alcoholic fatty liver disease (NAFLD), diabetic nephropathy and other vascular complication inlong-term.

BMI has been demonstrated to have a direct effect onlipid metabolism. Obese subjects frequently have high levelsof serum triglyceride and LDL-C and low levels of HDL-C, even if they are not hyperglycemic. The atherogenic lipoprotein profile frequently observed inobesity and overweight plays a key role in the higher cardiovascular risk in these patients. Hence, BMI not only reflects body fat content but also it is aderivative of metabolic dysfunction especially in T2DM (Parhi et al., 2025). The double epidemic of obesity and diabetes isincreasing remarkably in India. It has been demonstrated in the literature, that small rises in BMI with South Asians are associated with appallingly greater riskin insulin resistance and metabolic syndrome as compared to Western populations. This is partly because of a higher tendencyfor central obesity and visceral fat accumulation among Indians, who reportedly have lower BMIs in general. Consequently, the World Health Organization (WHO) suggestsa lower BMI cutoff (≥23 kg/m² for overweight and ≥25 kg/m² for obesity) for Asians to reflect more accurately the risk for metabolic diseases.[2,3]

A number of local studies too have made an effort to estimate prevalence of dyslipidemia in diabetics in different partsof India. However, there is a dearth of focused studies determining the actual relationship between the BMI values and different lipid profiles in diabetic individuals, especially in eastern andnortheastern states including West Bengal. The district of Jalpaiguri in northern part of the state of West Bengal is currently undergoing rapidlifestyle transition, urbanization and dietary changes which might also affect the burden of diabetes and obesity. This requires the availability of regional datato advise on region-specific interventions, public health strategies, etc. The potential mechanistic connection from BMI to lipids to diabetes is likely to be through multiple physiological and molecularroutes. In obese subjects, enhanced adiposity causes hypertrophy and hypoxiaof adipocytes, which results in the increase of macrophage influx into adipose tissue and secretion of pro-inflammatory cytokines such as TNF-α, IL-6, and resistin. These cytokines inhibit insulin receptor signaling and stimulate hepatic VLDLoverproduction, which leads to an increase in circulating TG. In addition, elevated influxof free fatty acids to the liver increases hepatic lipogenesis de novo and impairs the metabolism of lipoproteins. Insulin resistance also influences thestructure and function of HDL particles. HDL's capacity to efflux cholesterol is diminished, and HDL particles are smaller, denser, and protect lesswell against oxidation. LDL particles also becomes smaller and moreprone to oxidation, which increase endothelial dysfunction and plaque production. These changes constitutethe biochemical basis of the increased cardiovascular risk in diabetics with overweight and obesity. Clinically, the association of BMI andlipid profile is important in diabetics for several reasons. We witnessed that not only highlights the importance of performing routine BMI tracking and anthropometric measures in the care of patients withdiabetes. Secondly, it underscores thecentral role that lifestyle modification (specifically, weight reduction) plays in treating diabetic dyslipidemia. Third, it enables clinicians to predict lipid disorders and begin interventions (such as dietary counselling, physical activity advice, pharmacotherapy) based on thepatient's BMI status.[4,5]

At the population level, the results can potentially inform the design of public health screening

programs in which BMI is used as a screening tool for triage based on degree of lipid abnormalities, in order to guide subsequent riskassessment and lipid evaluation. Considering the resource limitations in the primary care settings, especially in rural and semi-urban parts of India, suchfocused strategies can enhance cost-effectiveness and efficacy of addressing diabetes. The association between lipid profile anomalies and diabetes patients has been addressed in several studies, while limited studies have focusedon the quantitative association of BMI with the different lipid parameters in Indian population. For example, the researches conducted by Himabindu et al., Sandhu et al., andUgwuja et al. found similarpositive correlations of BMI with total cholesterol, triglycerides and LDL-C, and inverse correlations with HDL-C. Although these report provided important traditional medicine practice knowledge, many of them had small sample sizes, heterogenous group dynamics or no representation of regionalvariation. Additionally, no studies have presented findings stratified by overall cholesterol cutoff points, nor used advanced analyses like Pearson'scorrelation to determine the strength of associations.

Furthermore, updated BMI classification criteria for Asian with higher cutoffs for NFG have not been widely employed in previous studies; this also impairs thegeneralizability of the present findings to Indian population. Thus, thereis an urgent demand to reassess and verify these associations with regional data and appropriate clinical cutoffs. As theprevalence of diabetes and feature of obesity are rapidly increasing in India and dyslipidemia is known to accelerate cardiovascular complications, we aimed to assess the association of lipid profile with BMI in patients with T2DM. Carried outin Jalpaiguri Government Medical College, West Bengal, it offers vital information from an underrepresented area and follows BMI cutoffs recommended by Asian subpopulations.[6,7]

This study aims to elucidate potentially clinically useful patterns within the distribution of lipid profiles of each patient, comparing serum lipid concentrations, including total cholesterol, triglycerides, HDL-C, LDL-C, and VLDL-C, between patients categorized into BMI-based groups (<25 vs. ≥25) to those in the normal population and to develop evidence-based strategies for optimal management of not only the individual patients,but of the vast multiple sectors of the population. In addition, the study aims to obtain a complete view of how adiposity in diabetes impacts on lipid metabolism, by evaluatingcorrelation coefficients and stratifying for cholesterol levels. The aim of the present study is to determinethe relationship between the BMI and lipid profile among the T2DM patients. The secondary objectives of this study are: (1) to compare the lipid profile parameters in patients with normal body mass index (BMI < 25 kg/m²) and those with increased BMI (≥25 kg/m²), (2) to assess lipid abnormalities according to total cholesterol levels, i.e., TC < 200 mg/dL and TC ≥ 200 mg/dL and (3) to analyze the degree of association and direction of relationship between BMI and individual components of lipids(TC, TG, HDL-C, LDL-C, VLDL-C) by Pearson's correlation coefficient.

MATERIALS AND METHODS

Study Design and Setting: It was a cross-sectional, observational studyconducted in the Department of Physiology and General OPD in Jalpaiguri Government Medical College,West Bengal,India over six months. The aim of the study was to assess the association between Body Mass Index (BMI) and lipid profile parametersin patients with Type 2 Diabetes Mellitus (T2DM).One hundred and thirty five adult patients with documented Type 2 Diabetes Mellitus were selected by consecutive sampling techniquefrom outpatient department. Using a medium effect size estimate of r = 0.25 for the relationship betweenBMI and lipid parameters and a 95% confidence level and 80% power, and accounting for drop out and incomplete data, the sample size was determined using a power analysis.Eligibility criteria included adults over 30 years with documented T2DM status (according to 2023 ADA criteria) and writtenconsent. Male and femalepatients were accepted.

The exclusion criteria were the following: patients with diabetes mellitus type 1, thyroid disease, chronic hepatitis, nephropathy,nephrotic syndrome, and any other metabolic or endocrine pathology known to influence the determination of the lipid profile. Moreover, subjectstreated with lipid-lowering agents (statins, fibrates), subjects with acute infections or systemic inflammation, pregnant or lactating women were excluded.The study protocol was approved by the IEC, Jalpaiguri Government Medical Collegebefore commencement. Informed writtenconsent was taken before study from all patients after explaining the study purpose, methods, the risk and benefits of study in the mother tongue. Patient data are alsoconfidential and anonymous in the study. Clinical and Anthropometric Evaluation Allergic rhinitis inchildren was diagnosed by experienced pediatric allergists based on the following criteria. Demographic variables (age, sex), clinical information (years with diabetes, comorbidities),and medication intake were recorded. Anthropometric assessments were performed according to standardtechniques. Height (in bare feet) was measured by a stadiometer (to0.1 cm) and weight with a calibrated, digital scale (to 0.1 kg). BMI was defined by dividing weight in kg with the square of height in m(kg/m²). Participants were classified according to BMI < 25 kg/m² as normal and ≥ 25 kg/m² as overweight/obese,following the WHO Asia-Pacific recommendations. Venous blood (3 mL) was drawn from each subject, using aseptic

precautions,in an overnight fasted condition (minimum fasting of 12 h). Aftercentrifugation (3000 rpm, 10 min), the serum was measured for lipid profile using an automatic chemistry analyzer (Siemens Dimension RXL Max). Analyzed parameters: total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C)and low-density lipoprotein cholesterol (LDL-C). VLDL-C was calculated by the Friedewald formula:VLDL = TG/5, which is valid when TG < 400 mg/dL.

Statistical Analysis: Data Analysis Thedata obtained was analyzed with SPSS (IBM Corp., USA) version 25 and Excel program. Resultswere presented with mean ± SEM. The t-test for independent samples was used to compare lipid profile parameters of BMI categories (BMI < 25 and BMI ≥ 25) and total cholesterol categories(<200 mg/dL and ≥200 mg/dL). The association of BMI with each lipid parameter (TC, TG, HDL, LDL,VLDL) was determined by Pearson's correlation coefficient. A statistical significance levelof $p < 0.05$ was regarded as significant.

Outcome Measures: The principal endpoint wasthe association between BMI and lipid profile plus the secondary endpoints as lipid profile across BMI categories or in total cholesterol levels. Results were presented under descriptive and comparison tables, followed byvisual trends presentation with scatter plots and regression lines to support statistical correlations.

RESULTS

A total of 135 patients diagnosed with Type 2 Diabetes Mellitus (T2DM) were included in the study. Among them, 58 (42.9%) participants had a BMI less than 25 (Group A), while 77 (57.1%) had a BMI of 25 or more (Group B). The mean age of participants was 49.3 ± 8.7 years, with a nearly equal gender distribution. All subjects underwent fasting lipid profile testing, and results were stratified based on BMI and total cholesterol levels.

Association Between BMI and Lipid Profile Parameters

Participants were grouped based on BMI to determine the effect of body mass on lipid profile abnormalities. The mean values of total cholesterol, triglycerides, HDL, LDL, and VLDL were significantly different between BMI groups.

Table 1: Comparison of Lipid Profile Parameters Based on BMI Groups (n = 135)

Parameter	Group A (BMI < 25)(n = 58)	Group B (BMI ≥ 25)(n = 77)	p-value
Total Cholesterol (mg/dL)	162.5 ± 5.2	181.7 ± 4.8	0.014*
Triglycerides (mg/dL)	145.3 ± 10.6	192.6 ± 9.2	0.003**
HDL (mg/dL)	43.7 ± 1.8	38.2 ± 1.1	0.021*
LDL (mg/dL)	91.2 ± 4.1	106.3 ± 3.7	0.009**
VLDL (mg/dL)	29.1 ± 2.2	38.5 ± 1.7	0.002**

*Values are expressed as Mean ± SEM. $p < 0.05$ considered significant; **$p < 0.01$ considered highly significant.

Group B (BMI ≥ 25) demonstrated significantly elevated mean levels of total cholesterol, triglycerides, LDL, and VLDL compared to Group A. HDL levels were notably lower in overweight/obese individuals, indicating a dyslipidemic pattern in those with higher BMI.

Stratified Lipid Profile Based on Total Cholesterol Levels

Participants were further stratified by total cholesterol levels to evaluate the associated variations in triglycerides, HDL, LDL, and VLDL.

Table 2:Lipid Parameters Stratified by Total Cholesterol Levels (n = 135)

Parameter	TC < 200 mg/dL (n = 97)	TC ≥ 200 mg/dL (n = 38)	p-value
Triglycerides (mg/dL)	159.2 ± 7.9	230.4 ± 10.3	<0.001**
HDL (mg/dL)	41.1 ± 1.3	38.9 ± 1.5	0.081
LDL (mg/dL)	95.8 ± 3.5	128.3 ± 4.6	<0.001**
VLDL (mg/dL)	32.5 ± 1.6	46.1 ± 2.4	<0.001**

*Values are expressed as Mean ± SEM. **$p < 0.01$ is highly significant.

Patients with elevated total cholesterol levels (≥200 mg/dL) also had significantly higher levels of triglycerides, LDL, and VLDL, suggesting a compounding cardiovascular risk. HDL showed a decreasing trend but was not statistically significant.

Correlation Analysis Between BMI and Lipid Components

Pearson's correlation was performed to assess the strength and direction of association between BMI and individual lipid profile parameters.

Table 3: Pearson Correlation Between BMI and Lipid Parameters (n = 135)

Parameter	r-value	p-value
Total Cholesterol	+0.27	0.002**
Triglycerides	+0.33	<0.001**
HDL	−0.25	0.004**
LDL	+0.29	0.001**

VLDL	+0.31	<0.001**

Interpretation: BMI was positively and significantly correlated with all lipid parameters except HDL, which showed a negative correlation. The strongest correlation was observed with triglycerides (r = +0.33), and the inverse association with HDL (r = −0.25) suggests that as BMI increases, protective lipid fractions decrease.

Graphical Representation of BMI and Lipid Correlation

To visualize the relationship, a scatter plot was generated with regression lines showing the correlation between BMI and (A) Triglycerides, and (B) HDL.

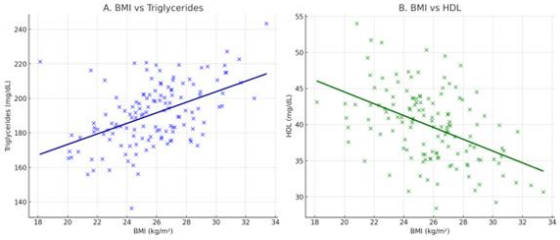

Figure 1: Correlation Between BMI and Key Lipid Parameters

[Figure 1] Scatter plots showing (A) a significant positive correlation between BMI and Triglycerides (r = 0.33, p < 0.001); (B) a significant negative correlation between BMI and HDL levels (r = −0.25, p = 0.004). Each point represents an individual patient. Solid lines represent linear regression with 95% confidence intervals.

The [Figure 1] trends reinforce the statistical findings, emphasizing that rising BMI correlates with worsening atherogenic lipid profiles and diminished HDL levels in T2DM patients.

DISCUSSION

This crosssectional study investigated the association between Body Mass Index (BMI) and dyslipidemia in 135 Type 2 Diabetic Mellitus (T2DM) patients. The results confirm a strong and graded relationship between higher adiposity andmore atherogenicdyslipidemia and provide further support to the evidence that obesity participates in the genesis and exacerbation of features of cardiovascular risk in diabetic subjects.

Interpretation of Major Findings Our study is novel sinceit focused on changes in TV viewing behavior, and the result showed that inadequate adjustment for TV viewing would lead to underestimation on the total lengths of sitting behaviour.[8,9]

We found that disease patients with BMI ≥ 25 (Group B) showed significantly higher mean values of TC (181.7 ± 4.8 mg/dL), TG (192.6 ± 9.2 mg/dL), LDL (106.3 ± 3.7 mg/dL), and VLDL (38.5 ± 1.7 mg/dL) as compared toBMI < 25 (Group A). On the other hand, overweight/obese had lower mean HDL levels (38.2 ± 1.1 mg/dL vs. 43.7 ± 1.8 mg/dL; p= 0.021). These findings (Table 1) are in keeping with the well-documented dyslipidemia pattern of obese-related insulin resistance, characterized by increased lipolysis with aconsequent increase of free fatty acid influx to the liver and higher synthesis of very low-density lipoprotein (VLDL).

Additional stratification by total cholesterol concentrations [Table2] supported the clustering of lipid abnormalities. Patients with total cholesterol of 200 mg/dL also had highlyincreased (p < 0.001) levels of triglycerides (230.4 ±10.3 mg/dL), LDL cholesterol (128.8 ±43.6 mg/dL) and VLDL cholesterol (46.1 ±2.4 mg/dL). HDL levels were lower in this group (38.9 ±1.5 mg/dL), but not statistically different (p = 0.081). These findings suggest that as total cholesterol is increased,other pro-atherogenic lipid components are also enhanced, increasing overall vascular risk.

Correlational analysis using Pearson correlation, as is presented in [Table 3], indicated that BMI positively and significantly correlated with TC (r = +0.27), TG(r = +0.33), LDL (r = +0.29) and VLDL (r = +0.31) all at p < 0.01. There wasan inverse correlation between HDL and BMI (r = −0.25, p = 0.004). These results are consistent with the results of priorresearch, such as the studies of Himabindu et al. and Ugwuja etal., on similar associations in diabetic and general populations.[10,11]

The graphic expression [Figure 1] confirms the numerical trends, presenting an upwardslope between BMI and TG and a downslope between BMI and HDL. These visual associations stress the metabolic chaos caused by excessive adipose tissue in diabetic patients, with increased formation of hepaticVLDL and reduced catabolism of TG-rich lipoproteins and suppressed HDL formation.

Clinical Implications: The concurrence of obesity and dyslipidemia in T2DMrepresents not a coincidental relationship; rather it is a coincident on a common pathophysiology based on insulin resistance. Increased BMIaggravates lipid abnormalities leading to the development of macrovascular complications, such as coronary artery disease, stroke, and peripheral vascular disease. Our results implythat regular BMI monitoring can be a proxy predictive marker for detection of dyslipidemia in diabetic patients to enable early health intervention.The strong BMI with HDL negative relationship also demonstrates the opportunity for lifestyle interventions (weight loss, physical exercise, and calorie restriction) for managing T2DM andenhancing the lipid profile. Pharmacological lipid-lowering treatment such as statins may bereasonable in individuals with persistently elevated cholesterol values, particularly in those with BMI ≥ 25.[12,13]

Comparison Against with Literature: The trends are also backed byseveral reports. For example, Sandhu et al. observed a significantly positive

relationship of BMI and total cholesterol, LDL, and a negative one withHDL in patients with T2DM. Similarly, Ali et al. found a gradual increase in triglycerides with increasing BMI, inagreement to our results. Such reproducible trends across studies strengthen therobustness of our results and suggest the wider applicability of the metabolic interrelations observed here.[14,15]

Limitations: Our studyhas limitations, notwitstanding the strengths of a defined sample and the comprehensive profiling of lipids. Firstly, since the examining design was cross-section,lack of causal inference can be claimed. The confounding factors, such as medication, diet,exercise, and genetic background, were not adjusted in this study, either. Third, the study was performed in a single tertiary care center, potentiallylimiting the external validity.

Future Directions: Larger, multicentric, and longitudinal studies are needed to confirmthese relationships and to determine if targeted weight reduction may normalize lipid profiles. Furthermore, inflammatory indices,insulin, and other metabolic syndrome parameters may allow a more comprehensive assessment of cardiometabolic risk in T2DM.

CONCLUSION

To sum up, the current study evidences an independent restrictive association between high BMI and atherogenic lipid phenotype in Type 2DM patients. Overweight and obese diabetic group had higher total cholesterol, triglycerides, LDL and VLDL and reducedconcentrations of HDL. Thepresent findings further support the value of BMI as a simple, non-invasive tool for early identification of dyslipidemia and its cardiovascular complications. BMI stratification of patients could be used in diabetes care for early and patient-specific therapeutic approaches for preventionof future morbidity.

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