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A Cross-Sectional Analysis of Correlation Between Lipid Profile and HbA1c Among Non-Diabetics, Diabetics and Prediabetics

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ABSTRACT

Background: Diabetes mellitus (DM) leads to chronic increase in blood glucose levels which is measured by glycated haemoglobin (HbA1c) levels. Dyslipidaemia also increases risk of DM. Objectives: To identify correlation between HbA1c and lipid profile in normal, prediabetic and diabetic individuals.

Methods: A cross-sectional study was conducted for a duration of one month at a tertiary care hospital. Individuals diagnosed with diabetes and pre-diabetes based on their blood glucose levels for the first time were included in the study. Subjects with normal levels of glucose were included for comparison. Pearson correlation test was used to check correlation between HbA1c and lipid profile among three groups. P<0.05 was considered significant.

Results: 30 subjects were recruited in each of the three groups. HbA1c, fasting and postprandial blood glucose levels were significantly elevated in diabetic and prediabetic groups as compared to normal subjects (P <0.001). Among the lipid parameters, total cholesterol and triglycerides (TG) were significantly elevated in diabetic groups as compared to normal (P <0.05). Correlation assessment revealed significant weak positive correlation between HbA1c and total cholesterol among diabetics and pre-diabetics and between HbA1c and TG in diabetics (P <0.05).

Conclusion: Total cholesterol and TGs are correlated significantly with HbA1c in diabetic patients. Long-term studies must be conducted to understand the chronic implications of this correlation.

Keywords: Cholesterol, Glycated Haemoglobin, Triglycerides, Type 2 diabetes mellitus

INTRODUCTION

Diabetes mellitus is a chronic endocrinopathy which is characterised by elevated blood glucose levels with or without insulin deficiency. It is a metabolic disorder which can be classified into many subtypes, such as, type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM) and gestational diabetes. In T1DM, there is deficiency of insulin leading to underutilisation of glucose and hence, higher blood glucose levels. The hallmark of T2DM is insulin resistance, in which, the response of target organs to insulin is defective leading to inefficient glucose utilisation and hyperglycaemia. According to World Health Organisation (WHO), out of total diabetics, approximately 95% have T2DM.[1] The most common causes of insulin resistance are age more than 35 years and obesity.[2] WHO as well as American Diabetes Association (ADA) recommends using glycated haemoglo-

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bin (HbA1c) as a screening tool for diagnosis of prediabetes and diabetes.[3] HbA1c indicates the average blood glucose concentration of an individual over a period of three months.[3] Thus, it predicts the risk of diabetes in prediabetics and indicates long-term glycaemic control in diabetics. The recommended cut-off point for HbA1c for the diagnosis of diabetes is 6.5%.[4]

Dyslipidaemia is an independent risk factor for T2DM.[5] The most important lipids to consider in this regard are total cholesterol, triglycerides (TG), low density lipoprotein (LDL) and high density lipoprotein (HDL). Dyslipidaemia over a few years has been shown to cause impaired survival and activity of β-cells of pancreas.[6,7] There is limited data on the correlation of dyslipidaemia, HbA1c and the risk of T2DM. It has been reported in few studies that HbA1c can serve as a predictor of dyslipidaemia, especially in diabetic patients.[8,9] Thus, it can be used for early diagnosis of dyslipidaemia and help in the prevention of cardiovascular disease (CVD) development in T2DM patients.[8] Thus, this study was conducted with an aim to identify correlation between HbA1c and lipid profile in normal subjects as well as in prediabetic and diabetic individuals.

MATERIALS AND METHODS

This was a cross-sectional and observational study conducted at a tertiary care hospital in India from April 2025 to May 2025. The study was started after obtaining approval from Institutional Ethics Committee. The approval letter number was GSMCH/2025/IEC/02. During the one-month study duration, reports of all the samples which were received for blood sugar estimation were obtained. Out of which, adults aged 30 to 60 years diagnosed with T2DM for the first time belonging to either gender were enrolled in the study after obtaining their consent. The first 30 diabetic study participants who consented for participation were included. After this, 30 pre-diabetic and 30 non-diabetic individuals as per blood sugar estimation reports were also enrolled in a similar manner. Exclusion criteria included the patients with other endocrinopathies including T1DM, hepatic and renal disorders. Pregnant females as well as patients taking hypolipidemic drugs were also excluded. The diagnosis of T2DM, prediabetes and normal was made based on the criteria of American Diabetes Association.[10] The following table 1 provides the cut-off values for various parameters for T2DM, prediabetic and normal.

Study procedure: The demographic profile of all the patients and relevant history regarding clinical symptoms and drug intake were recorded on a pre-approved and pre-validated patient data sheet. Blood samples were taken from all the adult patients aged between 18 to 60 years in the diabetic group for fasting blood glucose and postprandial blood glucose estimation. HbA1c and lipid profile were also simultaneously estimated. Venous blood samples were collected from all the patients after overnight fasting in the central laboratory of the hospital using standard technique.

Table 1: Cut-off values for T2DM, prediabetic and normal (Reference: American Diabetes Association)

Parameter	T2DM	Pre-diabetic	Normal
HbA1c (%)	≥6.5	≥5.7 - <6.5	<5.7
Fasting blood glucose (mg/dL)	≥126	≥100 - <126	<100
Oral GTT (mg/dL)	≥200	≥140 - <200	<140

GTT - Glucose Tolerance Test

Patients were called two hours after lunch for postprandial blood sample. All the samples were processed in the biochemistry laboratory and the results were recorded for analysis. Blood sugar and lipid profile were analysed using Beckman AU 480 Analyser with Beckman Coulter reagent for lipid profile analysis and Beckman reagent for blood sugar measurement. Blood glucose was determined by the enzymatic glucose oxidase (GOD)/ peroxidase (POD) method using the reagent kit (Autopak, Ames. Miles India ltd.). Serum was used for the determination of blood glucose immediately after collection. Reagent for lipid profile were purchased from Roche Diagnostics. HbA1c was analysed using G21 HPLC Analyser and reagent from B and E Diagnostics was used. The quantitative determination of HbA1c was done using the glycated haemoglobin kit (Sigma diagnostics, St. Louwas, USA) in whole blood at 415nm.

Statistical analysis: Statistical analysis was done using IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23 Armonk, NY: IBM Corp. Descriptive statistics were addressed, such as mean and standard deviation. Pearson correlation test was used to check correlation between HbA1c and lipid profile among normal, pre-diabetic and diabetic. For the comparison of differences between two means, independent-t test was used. $P < 0.05$ was considered statistically significant and $P < 0.001$ was considered highly significant.

RESULTS

Total 90 participants were included in the study; 30 each in diabetic, pre-diabetic and non-diabetic group. The average age of the participants was 48.35 ± 6.58 years. 64.44% (n = 58) participants were male.

In the present study fasting blood glucose, postprandial blood glucose and HbA1c level was assessed among normal, pre-diabetic and diabetic study subjects. The average values of all the three groups for all three parameters are mentioned in table 1.

Table 2: Comparison of glucose levels among three groups (N=30 in each group)

Group	FBG (mg/dL) (Mean ± SD)	PPBG (mg/dL) (Mean ± SD)	HbA1c (%) (Mean ± SD)
Normal	92.7 ± 10.8	118.57 ± 13.2	5.37 ± 0.52
Pre-diabetic	117.40 ± 8.9	168.40 ± 12.6	6.51 ± 0.30
Diabetic	179.4 ± 53.5	267.80 ± 101.6	8.83 ± 2.22
P Value	0.000**	0.000**	0.000**

FBG- Fasting blood glucose; PPBG- Post prandial blood glucose; **Highly significant

Table 3: Comparison of Lipid profile among three groups

Group (N=30)	Total cholesterol (mg/dL) (Mean ± SD)	HDL (mg/dL) (Mean ± SD)	TG (mg/dL) (Mean ± SD)	LDL (mg/dL) (Mean ± SD)
Normal	168.33±14.8	49.50±5.3	127.17±10.3	90.50±17.0
Pre-diabetic	160.47±43.1	43.70±10.3	143.83±66.1	98.79±37.0
Diabetic	188.30±49.5	45.82±11.7	183.25±94.8	95.01±35.0
P-Value	0.020*	0.064	0.005*	0.587

* = Significant

Table 4: P-values for intergroup comparison of various parameters

Group I	Group II	Fasting Blood Glucose	Post Prandial Blood Glucose	HbA1c	Total Cholesterol	TG
Normal	**Pre-diabetic**	.010*	.005*	.004*	.714 NS	.602 NS
	Diabetic	.000**	.000**	.000**	.121 NS	.005*
Pre-diabetic	**Diabetic**	.000**	.000**	.000**	.018*	.064 NS

* = Significant, ** = Highly significant, NS= Non-significant

Inter comparison of all the parameters between the three groups was found to be statistically highly significant (P < 0.001) as depicted in table 2.

In the lipid profile, total cholesterol, HDL, TG and LDL were assessed among normal, pre-diabetic and diabetic study subjects. The average values and their comparison between three groups are mentioned in table 3. Total cholesterol and TG were higher among diabetics as compared to normal subjects which was statistically significant (P <0.05). The differences in HDL and LDL among the three groups were not significant statistically.Table 4 depicts post-hoc analysis for pairwise multiple comparison using post-hoc tukeys test. Fasting blood glucose, post-prandial blood glucose and HbA1c were found to be statistically significant (P <0.05) between normal and pre-diabetic as well as highly significant (P < 0.001) between normal and diabetic and between pre-diabetic and diabetic.

The difference in total cholesterol was found to be statistically non-significant between normal and pre-diabetics and diabetic subjects (P > 0.05) On the contrary, the difference between total cholesterol levels was highly significant (P < 0.001) between pre-diabetic and diabetic subjects.

Pairwise comparison of TG values between normal and diabetics was found to be statistically significant (P <0.05). The correlation between HbA1c and lipid parameters was evaluated in all three groups using Pearson correlation. Pearson correlation coefficient (r) between HbA1c and total cholesterol among normal was found to be 0.271, among pre-diabetic 0.192 and among diabetic 0.168.

As depicted in figure 1 and 2, statistically significant (P <0.05) linear weak positive correlation was found between HbA1c and total cholesterol among diabetics and pre-diabetics. The correlation between HbA1c and total cholesterol was not significant in normal subjects.

Also, highly significant (P < 0.001) linear weak positive correlation was found between HbA1c and TG among diabetic study subjects as shown in figure 3. There was no statistically significant correlation between HbA1c and TG in pre-diabetic and normal subjects.

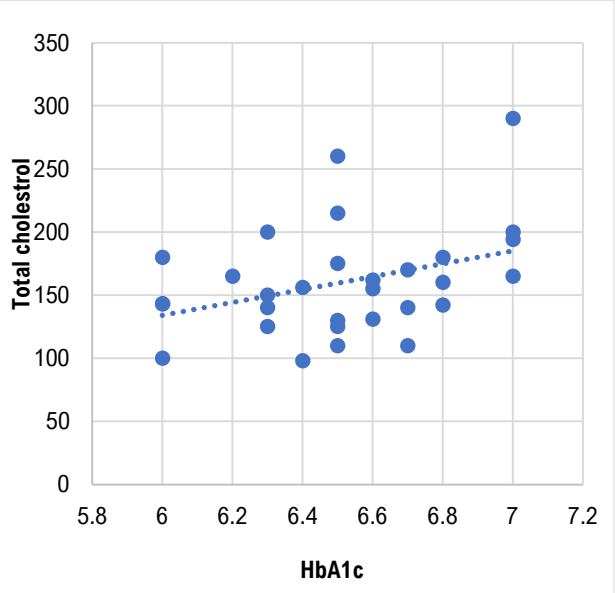

Figure 1: Correlation between HbA1c and total cholesterol in pre-diabetic subjects (r = 0.192)

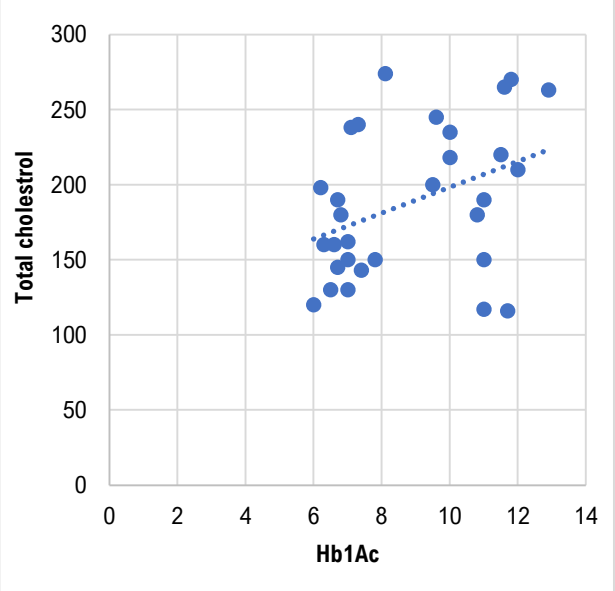

Figure 2: Correlation between HbA1c and total cholesterol in diabetic subjects (r = 0.168)

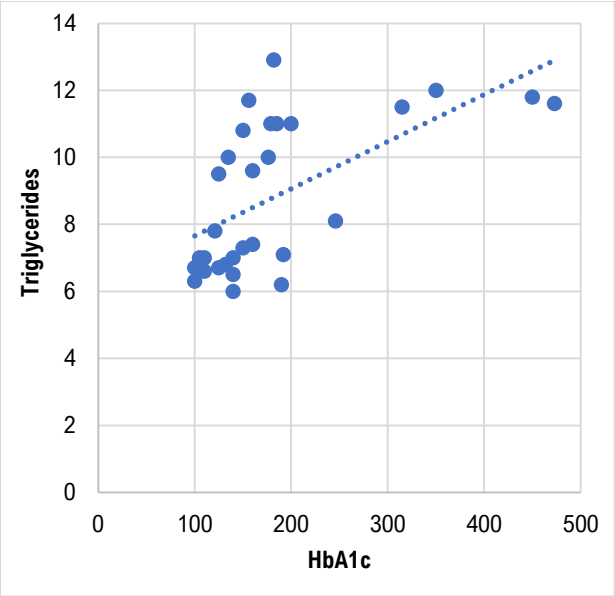

Figure 3: Correlation between HbA1c and triglycerides in diabetic subjects (r = 0.182)

DISCUSSION

T2DM is a very common metabolic disorder affecting millions worldwide. It causes significant morbidity and mortality due to the associated microvascular and macrovascular complications. Dyslipidaemia, is an independent risk factor for the development of diabetes as well as it increases the likelihood of CVS complications in the patients of diabetes.[6,7] Correlating the levels of HbA1c with lipid parameters can predict the occurrence of dyslipidaemia in normal and prediabetics as well as predict the CVS complications in patients of T2DM. Thus, this study was planned to compare the various glucose and lipid parameters in normal, prediabetic and diabetic subjects as well as correlation between HbA1c and lipid parameters among these patients.

In the present study, majority of the participants belonged to the age group of 40 to 50 years. The preponderance was of male participants. This demographic profile is similar to the findings of other studies conducted among diabetic participants.[11] The studies have attributed the higher prevalence of diabetes in males to the higher levels of visceral adiposity prevalent in males as compared to females.[12] Abdominal obesity is considered a strong risk factor for insulin resistance, metabolic abnormalities and glucose intolerance.[13]

In the present study, the fasting blood glucose, postprandial blood glucose and HbA1c all were significantly elevated in diabetic patients as compared to prediabetics and non-diabetics. This is well-known fact that diabetes commonly leads to hyperglycemia.[14] Insulin resistance leading to impaired response of hepatocytes, muscles and adipose tissue to insulin is the hallmark of T2DM, leading to impaired glucose utilization by these cells. The cells are not able to take up glucose from blood causing hyperglycemia.[14] Insulin-resistant cells in adipose tissue increases release of free fatty acids which promotes the production of TG when glycogen stores are adequate.[15] This further leads to stimulation of very low-density lipoprotein and apolipoprotein B.[16]

It was observed in the present study that there was significant elevation of total cholesterol and triglycerides in patients with diabetes as compared to other two groups. This is similar to the findings observed in a few other studies. [17,18] In the study by Artha IMJR et al. (2019) reported a statistically significant increase in TGs as well as LDL in the diabetics.[17] The cross-sectional study by Kumar S et al. (2022) reported a significant increase in TG and VLDL with no statistically significant rise in HDL.[18] This is due to the fact that liver converts excess glucose present due to the low activity of insulin, to triglycerides by de novo lipogenesis, which increases the level of TGs and consequently total cholesterol.[19]

A significant positive correlation was observed between HbA1c and total cholesterol in the present study. A positive correlation was also found between HbA1c and triglycerides. This has been reported in a few studies previously.[9,18,20-23] The study by Firdous et al. (2007) reported higher TG levels in 38% patients with T2DM. Similarly, in the study by Hussain A et al. (2017), a significant positive correlation was established between HbA1c and total cholesterol, TGs, LDL-C and LDL-C/HDL-C ratio. Using linear regression analysis, they also reported HbA1c to be a significant risk predictor for hypercholesterolemia, TG and LDL-C.[9] HbA1c is considered as gold standard for measuring glycemic control.[24] A recent study has reported that variations in HbA1c levels significantly increase the risk and severity of CV complications and coronary stenosis in patients with T2DM.[25] Maintaining an HbA1c in the normal range between 5.7% to 6.7% has shown to minimize the risk of various CV complications in individuals with diabetes.[26] Liu et al. (2021) established a U-shaped relationship between HbA1c and the risk of all-cause mortality in patients with coronary artery disease (CAD). They reported significantly increased mortality risk in patients with HbA1c >6.7% and HbA1c $\leq$ 5.7%.[27] Improving the glycemic control in these patients with antidiabetic drugs may help regulate the lipid levels and decrease the risk of consequent CVDs.

The study had certain limitations. Firstly, the sample size of the study was small which makes it difficult to generalize the findings of the study. Secondly, the study design was cross-sectional, which only provides the lipid status of the patients in that particular point of time and does not provide an insight into the changes in lipid levels over a period of time in these patients.

CONCLUSION

In this study, the analysis of fasting blood glucose, postprandial blood glucose and HbA1c level among normal, pre-diabetic and diabetic study subjects revealed a significant statistical increase in all the three parameters among the diabetic subjects. There was a significant in-

crease in total cholesterol and TG among diabetic subjects. The association between HbA1c and lipid parameters revealed significant positive correlation between total cholesterol and triglycerides among diabetic subjects. Thus, this correlation suggests that treatment of diabetes and control of blood glucose levels can lead to normalisation of lipid parameters. Future long-term studies with larger sample size are required to assess the nuances of this correlation between HbA1c and lipid parameters.

Authors contributions: TG contributed to study conception, study design, data collection, data analysis and interpretation, and manuscript preparation. **NK** contributed to study conception, study design, and manuscript preparation. **GJ** contributed to study design, data collection, data analysis and interpretation, and manuscript preparation.

Author's Contribution: The data that support the findings of this study are available from the corresponding author on reasonable request.

Declaration of Non-use of generative AI Tools: The authors affirm that no generative artificial intelligence or automated tools were used in the study.

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