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**Original Research Article**

# Correlation between glycemic control markers and lipid profile in type 2 diabetes mellitus and impaired glucose tolerance

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## ABSTRACT

**Background:** Many studies have compared and correlated glycemic control markers with lipid profile in type 2 diabetes mellitus (T2DM) patients, but very few studies correlate them in impaired glucose tolerance (IGT) individuals. Thus, the aim of this study was to find comparison and correlation between FBG, PPBG and HbA1c with lipid profile in T2DM patients and IGT individuals.
**Methods:** The study was conducted at tertiary care hospital in north Karnataka. The diagnosis of T2DM and IGT was based on WHO criteria. 99 apparently healthy controls, 101 T2DM patients and 100 IGT subjects participated in the study.
**Results:** All the biochemical parameters were significantly raised in IGT and T2DM patients as compared to controls. In T2DM, FBG showed significant positive correlation with TC (p=0.048) and significant negative correlation with HDL (p=0.000). PPBG and HbA1c showed significant positive correlation with TGL, TC VLDL and LDL and significant negative correlation with HDL, p value was 0.000 for all parameters. The correlation in IGT, FBG showed significant positive correlation with TC (p=0.000) and LDL (p=0.004), significant negative correlation with HDL (p=0.000). PPBG showed significant positive correlation with TGL, TC and VLDL and significant negative correlation with HDL(p=0.000).
**Conclusions:** Diagnosis of T2DM, IGT and associated dyslipidema is necessary as life style modification and pharmacotherapy can control these situations and thereby reduce the cardiovascular risk.

**Keywords:** Impaired glucose tolerance, Lipid profile, Type 2 Diabetes mellitus

## INTRODUCTION

Globally the people suffering from diabetes mellitus were estimated to increase from current 415 million people to 642 million by 2040. The number of type 2 diabetes mellitus (T2DM) patients is increasing in all countries and 75% of people with diabetes mellitus are living in developing countries.[1]

In 2010 World Health Organization (WHO) reported that the number of diabetic patients in India will rise up to 190% over the next 20 years.[2]

In T2DM, chronic hyperglycemia leads to microvascular and macrovascular complications affecting all organs of the body.[3,4] The common macrovascular complications of diabetes are heart disease and stroke, which accounts for about 50% of death in diabetic patients.[5,6] Microvascular complications include diabetic nephropathy, neuropathy, and retinopathy.[7,8]

Diabetes mellitus (DM) is a common secondary cause of hyperlipidemia, particularly, if glycaemic control is poor.[9] Based on the American diabetic association (ADA) abnormal lipid profiles are when total cholesterol level ≥200 mg/dl, triglyceride level is ≥150 mg/dl, HDL level is <40 mg/dl in males and <50 mg/dl in females, LDL level is ≥100 mg/dl. Hence dyslipidemia was defined as the presence of one or more of the above-mentioned abnormalities in serum lipids.[10] The changes in lipid parameters in diabetes mellitus are due to increased free fatty acid flux secondary to insulin resistance.[11-14]

Pre-diabetes or impaired glucose tolerance (IGT) is a condition in which the blood glucose level is above the normal but below the diagnostic threshold of diabetes mellitus. Impaired lipid profile can also occur in IGT.[15] About 5-10% of pre-diabetic patient become diabetic annually and nearly 70 % of pre-diabetics eventually develop diabetes mellitus if not treated in early stage.[16] Macro and micro vascular complications can start in IGT and early detection and treatment of dyslipidemia in IGT will decrease the risk of cardiovascular diseases (CVD).[15]

Fasting blood glucose (FBG), post prandial blood glucose (PPBG) and glycated hemoglobin (HbA1c) are most widely used as glycemic control markers. HbA1c is used as biomarker of glycemic control over a preceding 8-12 weeks. It is used as an indicator for the state of glycemic control, progression of the disease and development of complications in diabetic patients.[17-19] Increased HbA1c has also been regarded as an independent risk factor for CVD, even in non-diabetics.[20]

Many studies have compared and correlated FBG, PPBG and HbA1c with lipid profile in T2DM patients.[9,21-23.] But very few studies are done in IGT in this regard.[15,16]. Thus, the aim of this study was to find comparison and correlation between FBG, PPBG andHbA1cwith lipid profile in T2DM patients and IGT.

## METHODS

The study was conducted at Hanagal Shri Kumareshwara Hospital, Bagalkot from Feb 2015 to July 2017. The study was approved by institutional ethics committee. Informed consent was obtained from all the subjects.

The diagnosis of T2DMand IGT were based on WHO criteria. 99 apparently healthy controls, 101 T2DM patients and 100 IGT subjects participated in the study. Alcoholics, smokers, patients with diabetic complications, chronic liver diseases, chronic renal failure and patients with other systemic conditions were excluded from the study. Detailed history, general physical examination and systemic examination were performed for all the participants. Under aseptic precautions, 5 ml of fasting venous sample was collected and biochemical parameters FBG, PPBG, HbA1c, urea, creatinine and lipid profile namely triglyceride (TGL), total cholesterol (TC), low density lipoprotein cholesterol (LDL), very low-density lipoprotein cholesterol (VLDL) and high density lipoprotein cholesterol (HDL) were estimated using Biosystems A 25 biochemistry fully automated analyzer; kits were supplied by Biosystems Pvt Ltd.

### *Statistical analysis*

Study power was calculated (100%) retrospectively based on the mean serum TGL values in cases and controls. SPSS for window version; SPSS, 11.5 Inc, Chicago IL was used for statistical analysis. ANOVA followed by Post hoc Dunnet's test was applied to compare between three groups. Pearson's correlation was done for quantitative data of Cases and Controls. P<0.05 was considered as statistically significant.

## RESULTS

The demographic characteristics are mentioned in table 1, there was significant rise in BMI, waist circumference, systolic blood pressure and diastolic blood pressure in T2DM and IGT patients compared to normal control group. There was significant difference in age when all three groups were compared.

**Table 1: Demographic features of cases and controls.**

| Parameters | Controls | T2DM | IGT | F | p |
|---|---|---|---|---|---|
| Age, years | 47.3±10.1 | 52.4±14.7 | 49.1±5.6 | 5.62 | 0.083 |
| BMI, kg/m$^2$ | 21.2±4.4 | 26.5±4.0 | 23.3±5.6 | 32.0 | 0.000 |
| WC, cm | 83.4±10.7 | 98.2±11.0 | 85.2±9.5 | 60.2 | 0.000 |
| SBP, mm Hg | 113.4±6.9 | 152.0±10.8 | 120.4±10.5 | 462.0 | 0.000 |
| DBP, mm Hg | 74.4±3.4 | 95.1±3.3 | 84.5±3.5 | 926.0 | 0.000 |

BMI: Body mass index; WC: Waist circumference; SBP: Systolic blood pressure; DBP: Diastolic blood pressure

**Table 2: Biochemical parameters in Controls, IGT and T2DM.**

| | Controls | IGT | T2DM | T2DM and IGT | F | p |
|---|---|---|---|---|---|---|
| FBG, mg% | 87.51±12.04 | 117.29±5.10* | 177.90±36.83* | 0.0001 | 414.14 | 0.000 |
| PPBG, mg% | 112.33±14.24 | 176.60±17.83* | 278.11±76.50* | 0.0001 | 326.36 | 0.000 |
| HbA1c, % | 5.30±0.70 | 6.33±0.70* | 7.97±1.46* | 0.0001 | 172.76 | 0.000 |
| Urea, mg% | 20.90±6.42 | 31.61±7.30* | 32.56±9.47* | 0.45 | 67.65 | 0.000 |
| Creatinine, mg% | 0.95±0.19 | 0.89±0.11 | 1.19±0.22* | 0.0001 | 75.69 | 0.000 |
| TGL, mg% | 115.46±37.73 | 122.37±16.45 | 152.35±32.00* | 0.0001 | 42.65 | 0.000 |
| TC, mg% | 188.56±31.20 | 164.92±5.57* | 192.77±36.02 | 0.0001 | 29.36 | 0.000 |
| HDL, mg% | 50.39±5.06 | 36.53±4.04* | 33.50±3.20* | 0.0001 | 464.54 | 0.000 |
| VLDL, mg% | 23.09±7.54 | 24.46±3.28 | 30.46±6.39* | 0.0001 | 42.57 | 0.000 |
| LDL, mg% | 103.92±6.44 | 115.07±25.97* | 123.81±33.41 | 0.04 | 16.31 | 0.000 |

* p <0.05, NS: Not significant; FBG: Fasting blood glucose; PPBG: Post prandial blood glucose; HbA1c: Glycosylated haemoglobin; HDL: High density lipoprotein cholesterol; VLDL: Very low density lipoprotein cholesterol; LDL: Low density lipoprotein cholesterol; Note: * in cases column represents the p value of comparison between the type 2 DM and control, similarly in IGT column represents p value of comparison between the IGT and control. Column title T2DM and IGT represent the p value of comparison between the T2DM and IGT.

All the biochemical parameters viz., FBG, PPBG, HbA1c and lipid profile were raised in IGT as compared to healthy controls, all parameters were still more increased in type 2 diabetes mellitus patients as compared to the IGT group.

ANOVA test showed significant rise in all biochemical parameters when compared in all the three groups, the p value was 0.000 (Table 2).

The correlation between FBG, PPBG, HbA1c with lipid profile in T2DM patients were analysed -FBG showed significant positive correlation with TC (p=0.048) and significant negative correlation with HDL (p=0.000). PPBG and HbA1c showed significant positive correlation with TGL, TC VLDL and LDL, and significant negative correlation with HDL, p value was 0.000 for all parameters (Table 3).

**Table 3: Correlation between glycemic markers and lipid parameters in T2DM patients.**

| | | TGL | TC | HDL | VLDL | LDL |
|---|---|---|---|---|---|---|
| FBG | r | 0.017 | 0.197 | -0.490 | 0.019 | 0.069 |
| | p | 0.863 | 0.048 | 0.000 | 0.850 | 0.495 |
| PPBG | r | 0.485 | 0.665 | -0.693 | 0.486 | 0.627 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| HbA1C | r | 0.573 | 0.602 | -0.632 | 0.574 | 0.527 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

FBG: Fasting blood glucose; PPBG: Post prandial blood glucose; HbA1c: Glycosylated haemoglobin

The correlation results in IGT group were as follows- FBG showed significant positive correlation with TC (p=0.000) and LDL (p=0.004), significant negative correlation with HDL (p=0.000).

PPBG showed significant positive correlation with TGL, TC and VLDL and significant negative correlation with HDL, p value was 0.000. HbA1c did not show significant correlation with any of the lipid profile parameters (Table 4).

**Table 4: Correlation between glycemic markers and lipid parameters in IGT.**

| | | TGL | TC | HDL | VLDL | LDL |
|---|---|---|---|---|---|---|
| FBG | r | -0.038 | 0.677 | -0.440 | 0.040 | 0.289 |
| | p | 0.708 | 0.000 | 0.000 | 0.693 | 0.004 |
| PPBG | r | 0.345 | 0.692 | -0.455 | 0.347 | 0.136 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.178 |
| HBA1C | r | 0.126 | 0.168 | 0.047 | 0.127 | 0.051 |
| | p | 0.211 | 0.095 | 0.641 | 0.208 | 0.615 |

FBG: Fasting blood glucose; PPBG: Post prandial blood glucose; HbA1c: Glycosylated haemoglobin

## DISCUSSION

The present study on T2DM patients showed that there was significant increase in serum TGL and VLDL, the study also showed increased levels of TC and LDL which were not statistically significant as compared to normal healthy control group. There was significant decrease in HDL in T2DM patients compared to normal control group. Previous studies have shown dyslipidemia in T2DM characterized by increase in VLDL, LDL and decrease in HDL.[24,25] Gantala et al also found similar results.[26] In the current study also we found similar results except non-significant increase in LDL and other results were similar to previous studies.

In the current study we also studied the correlation between the lipid parameters and glycemic control markers inT2DM patients, the correlation between FBG, PPBG, HbA1c with lipid profile were analysed, FBG showed significant positive correlation with TC (p=0.048) and significant negative correlation with HDL (p=0.000). PPBG and HbA1c showed significant positive correlation with TGL, TC VLDL and LDL, significant negative correlation with HDL.

Reddy et al in their study showed that FBG had a significant positive correlation with TC(r=0.241), TGL(r=0.171) and LDL(r=0.201). There was negative correlation with HDL but it was not statically significant (r=-0.022, p=0.62)).[21] Thambiah et al also found similar results.[27] Sheikhpour et al found that FBG had significant positive correlation only with TC; PPBG had significant positive correlation with TC and LDL; HbA1c showed significant positive correlation only with TC, whereas HDL did not show significant correlation with any of the lipid parameters.[28] Study done in Nepal by Sapkota LB et al found that FBG, PPBG and HbA1c all these three glycemic control markers showed significant positive correlation with TC,TGL, LDL and VLDL and significant negative correlation with HDL.[29] Reddy AS, et al showed that HbA1c had highly direct significant correlation with TC, TGL and LDL.[21] Worse glycemic control had significantly high TC, TGL and LDL levels, but not in HDL levels.[21]. Mahato et al observed significant correlations between HbA1c and TC and LDL.[22] In various studies, HbA1c level was eminent as showing positive correlation with TC, LDL and TGL in diabetic patients.[30-32]

HbA1c also demonstrated direct and significant correlations with cholesterol (r=0.6445), TGL (r= 0.5426), LDL-C(r=0.3584), VLDL (r=0.2245) - a strong positive correlation; whereas HDL-C showed negative correlation (r=-0.4965).[9] Jayesh et al conducted a prospective study on western Indian population that comprised of 430 T2DM patients and 501 non-diabetic control subjects.[33] Sultania et al found significant correlation of HbA1c with TC and LDL.[23] Yan et al conducted a study on 128 T2DM patients in Sichuan, China.[34] They found significant correlation of HbA1c with LDL.[24] A significant correlation between HbA1c level and lipid abnormalities were also noted and suggested importance of control of diabetes and control of lipids in Chinese study.[35] In the present study, HbA1c showed significant positive correlation with TGL, TC, VLDL and LDL, and significant negative correlation with HDL, these findings were in accordance with previous studies. Senthilkumar et al, conducted a perspective study on 162 T2DM patients in Tamil Nadu.[36] They found no significant correlation of HbA1cwith TC, LDL, HDL and TGL. The reduction in HbA1c is associated with reduction in diabetes related risk complication.[37]

T2DM patients are at a much higher risk of cardiovascular complications than the non-diabetics. Thus, the risk of cardiovascular events in diabetics can be reduced by improving the glycemic control.[38] Hence it is important to focus on HbA1c control and targeting lipids to avoid morbidity and mortality in diabetic patients. HbA1c measurement helps to control DM and helps identify dyslipidemias.[39]

Singh et al in their study on pre-diabetes found that there was significant increase TC, TGL, LDL and VLDL as compared to normal controls.[15] And significant decrease in HDL in pre-diabetics compared to normal controls. In the current study also, there was significant increase in TC and LDL, but TGL and VLDL did not show significant rise in IGT than controls. HDL was significantly decreased in IGT than controls. A study done in Saifai by Kumar et al on pre-diabetics showed TC, TGL, LDL were significantly more than normal controls and HDL was significantly decreased in pre-diabetics compared to controls.[16] Dyslipidemia in IGT patients indicated high risk category for cardiovascular diseases.[15]

Regarding correlation of glycemic control markers and lipid parameters between IGT and control group, we could not find any references to the best of our literature search. FBG showed significant positive correlation with TC (p=0.000) and LDL (p=0.004), significant negative correlation with HDL (p=0.000). PPBG showed significant positive correlation with TGL, TC and VLDL and significant negative correlation with HDL. HbA1c did not show significant correlation with any of the lipid profile parameters.

Limitations of the present study was small sample size; further large sample size prospective studies are required in this direction.

## CONCLUSION

In conclusion, proper screening of T2DM, IGT and associated dyslipidema is necessary as life style modification and pharmacotherapy can control these situations and thereby reduce the cardiovascular risk.

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