ORIGINAL ARTICLE

Association of Altered Lipid Profile with Glycemic Status and Anthropometric Indices in Pre-Diabetic and Type 2 Diabetic Patients. A Biochemical Cross-Sectional Study

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is increasingly a worldwide health problem; it is frequently preceded by a pre-diabetic state with insidious metabolic changes. Among these, dyslipidemia is the most important factor in accelerating cardiovascular risk. Early risk stratification and intervention depend on understanding the association of lipid profile, glycemic control, and anthropometric indices.

Objective: The objective of this cross sectional study was to assess the relationship of altered lipid profile, glycemic status and anthropometric indices among pre diabetic and T2DM patients.

Methodology: Fifty pre diabetic and fifty type-2 DM patients aged 18 to 50 years attending a tertiary care hospital were enrolled for a total of 100 adult patients. Lipid profile (total cholesterol, triglycerides, LDL-C, HDL-C) and glycemic parameters (fasting plasma glucose, HbA1c) in fasting blood samples were analyzed. Body mass index (BMI) and waist-to-hip ratio (WHR) were recorded as anthropometric measures. Correlations between lipid parameters, glycemic indices, and anthropometric measures were assessed statistically.

Results: Total cholesterol, triglycerides, and LDL cholesterol were significantly ($p < 0.05$) higher and HDL cholesterol significantly ($p < 0.05$) lower in T2DM patients compared to pre diabetics. Total cholesterol, triglycerides, and LDL-C ($r = 0.34$–0.52, $p < 0.01$) were positively correlated with glycemic parameters (fasting glucose, HbA1c), and negatively correlated with HDL-C ($r = –0.28$, $p < 0.05$). Both groups were found to have a positive association of BMI and WHR with triglyceride levels and an inverse association with HDL-C.

Conclusion: We find that there is a clear association between altered lipid profiles, poor glycemic control, and adverse anthropometric indices in pre-diabetic and T2DM patients. Dyslipidemia in these groups may be identified early and managed to reduce cardiovascular risk and slow diabetes progression.

Keywords: pre-diabetes, type 2 diabetes, lipid profile, glycemic control, anthropometric indices, dyslipidemia

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is an important global health challenge which is rapidly increasing in prevalence, especially in low- and middle-income countries [1]. The International Diabetes Federation says 537 million adults worldwide suffered from diabetes in 2021, and that number is projected to soar over the coming decades [2]. One feature of the diabetes epidemic is the large and growing pool of people with pre-diabetes, impaired fasting glucose, or impaired glucose tolerance, and this pool of people has a high risk for developing overt diabetes and its complications if left untreated. It is well established that abnormal lipid metabolism (dyslipidemia) is a common metabolic abnormality that is usually accompanied by T2DM and pre-diabetes. In these patients, the typical lipid abnormalities are hypertriglyceridemia, hypercholesterolemia (elevated LDL-C), and low HDL-C [4]. These changes are closely associated with insulin resistance, poor glycemic control, and obesity and are thus important contributors to the markedly increased cardiovascular morbidity and mortality observed in diabetic populations [3].

Body mass index (BMI) and waist to hip ratio (WHR) are simple yet powerful anthropometric indices of general and central obesity [5]. These markers of insulin resistance have been shown to correlate strongly with insulin resistance and are key risk markers for both metabolic syndrome and cardiovascular disease [6]. It is important to understand how these anthropometric measures correlate with lipid and glycemic profiles to identify pre-diabetic and diabetic patients who are at increased risk of cardiovascular

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disease [7]. Despite the significant research on diabetes and cardiovascular risk, few studies have examined simultaneously the relationships between lipoprotein profiles, glycemic status, and BMI in the pre-diabetic and diabetic stages [8]. The gap is especially pronounced in South Asian populations, where the genetic and environmental factors may modify metabolic risk patterns [9]. Early detection of dyslipidemia in individuals with abnormal glucose metabolism and assessment of anthropometric measures allow for early lifestyle and pharmacologic interventions to prevent or delay the onset of cardiovascular disease [10].

Given the need to identify metabolic disorders early, the present cross-sectional study was done to find out an association between altered lipid profile, glycemic control, and anthropometric indices in pre diabetic as well as T2DM patients. The study aimed to evaluate these relationships in a cohort of 100 patients to make important contributions to targeted screening and management strategies to reduce cardiovascular risk in this high-risk population.

MATERIALS AND METHODS

Study Design: This was a month-long cross-sectional biochemical study conducted at the outpatient department of Sughra Shafi Medical Complex, Narowal, Pakistan from September 2022 till September 2023. The study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the institutional ethical review board, and written informed consent was obtained from all participants before enrollment.

Study Population and Sample Size: The study included 100 adult patients, two groups: 50 pre-diabetic patients and 50 patients diagnosed with type 2 diabetes mellitus (T2DM). Purposive

sampling was used to recruit the participants from patients attending the hospital for routine checkups and diabetes management.

Inclusion Criteria:
➢ Age between 30 and 65 years
➢ For pre diabetic group: FPG 100– 125 mg/dL or HbA1c 5.7 – 6.4 %
➢ Previously diagnosed with diabetes, FPG ≥126 mg/dL or HbA1c ≥6.5%, for T2DM group
➢ Both males and females

Exclusion Criteria:
➢ Known history of cardiovascular disease, renal disease, liver disease, or thyroid disorders
➢ Patients on lipid-lowering therapy or insulin therapy
➢ Pregnant women

Anthropometric Measurements: The height and body weight were measured to the nearest 0.1 kg using a calibrated weighing scale and a stadiometer, respectively. Body mass index (BMI) was defined as weight in kilograms divided by the square of height in meters (kg/m²). Waist and hip circumferences were measured from a non-stretchable measuring tape, and WHR was calculated.

Biochemical Analysis: All of the participants provided venous blood samples after overnight fasting (8–12 hours). The glucose oxidase-peroxidase method was used for measuring blood glucose levels. High-performance liquid chromatography was used to measure glycated hemoglobin (HbA1c). After standard protocols, it was measured lipoprotein parameters, including total cholesterol, triglycerides, low-density lipoprotein cholesterol, and high-density lipoprotein cholesterol using enzymatic colorimetric methods on an automated analyzer.

Statistical Analysis: The data were then entered and analyzed using SPSS version 25.0. The continuous variables are expressed as (Mean ± Standard Deviation), and categorical variables by frequency and percentage. Means between the pre-diabetic and T2DM groups were compared with the independent samples t-test. The relationship between lipid parameters, glycemic indices, and anthropometric measures was assessed with Pearson's correlation coefficient. Statistical significance was considered if the p-value <0.05.

Ethical Considerations: This study was carried out according to the Declaration of Helsinki. All participants gave informed written consent, and ethical approval had been obtained from the institutional ethics committee. The study involved 100 total participants; 50 of whom had pre-diabetes and 50 had type 2 diabetes (T2DM). The pre-diabetic group had a mean age of 48.2 ± 8.5 years, and the T2DM group 51.6 ± 7.9 years. There was no difference in gender distribution between the two groups (pre-diabetics 52% female, 48% male; T2DM 50% female, 50% male).

RESULTS

The study involved 100 total participants; 50 of whom had pre-diabetes and 50 had type 2 diabetes (T2DM). The pre-diabetic group had a mean age of 48.2 ± 8.5 years, and the T2DM group 51.6 ± 7.9 years. There was no difference in gender distribution between the two groups (pre-diabetics 52% female, 48% male; T2DM 50% female, 50% male).

Body mass index (BMI) and waist to hip ratio (WHR) were significantly (p < 0.05) greater in the T2DM group compared to the pre diabetic group. Plasma glucose fasting (FPG) and HbA1c levels were significantly increased in T2DM patients compared to pre diabetics (p < 0.001). In comparison with the pre-diabetic group, total cholesterol, triglycerides, and LDL-C levels were significantly higher and HDL-C levels were significantly lower in the T2DM group (p < 0.05). FPG, HbA1c, and lipid parameters (TC, TG, and LDL-C) have positive and HDL-C has a negative correlation with glycemic indices (p < 0.01). Both groups showed a positive correlation of BMI and WHR with triglycerides and an inverse correlation with HDL-C.

The results showed that the patients in the T2DM group had significantly higher age, body mass index (BMI), waist to hip ratio,

fasting plasma glucose, HbA1c, total cholesterol, triglycerides, and LDL-C compared to pre diabetic group and all differences were significant (p < 0.05 or p < 0.01). In addition, HDL-C levels were significantly lower in the T2DM group compared to pre diabetics. These findings demonstrate that type 2 diabetic patients have poorer glycemic control, more pronounced lipid abnormalities, and more central obesity and point to the close interrelationship between dysglycemia, dyslipidemia, and adverse anthropometric indices.

Table 1: Comparison of Anthropometric, Glycemic, and Lipid Parameters between Pre-Diabetic and T2DM Groups

Parameter	Pre-Diabetic Group (n=50)	T2DM Group (n=50)	p-value
Age (years)	48.2 ± 8.5	51.6 ± 7.9	0.041*
BMI (kg/m²)	26.8 ± 3.2	29.5 ± 3.8	0.001**
Waist-to-Hip Ratio	0.89 ± 0.06	0.95 ± 0.07	0.002**
Fasting Plasma Glucose (mg/dL)	112.5 ± 8.9	154.7 ± 22.3	<0.001**
HbA1c (%)	6.0 ± 0.2	8.2 ± 1.1	<0.001**
Total Cholesterol (mg/dL)	192.4 ± 28.5	218.6 ± 34.7	0.003**
Triglycerides (mg/dL)	158.3 ± 42.1	201.2 ± 49.5	0.001**
LDL-C (mg/dL)	116.7 ± 24.6	142.5 ± 29.1	0.002**
HDL-C (mg/dL)	44.5 ± 6.8	38.1 ± 5.9	0.001**

* Significant at p < 0.05; ** Significant at p < 0.01

In terms of glycemic control and thermogenic lipid profile, the T2DM group had poorer control than the pre-diabetic group. Diabetics had significantly higher BMI and WHR (indicating a greater degree of obesity and central fat accumulation). Since there are strong correlations between lipid abnormalities, poor glycemic control, and anthropometric measures, comprehensive metabolic assessment in these populations is important.

DISCUSSION

The present cross-sectional study was undertaken to assess the correlation between disturbed lipid profiles, glycemic status, and anthropometric indices in pre diabetic and T2 DM patients. We found that patients with T2DM had significantly worse metabolic and anthropometric profiles compared to pre-diabetic individuals, showing that metabolic derangements are progressive across the diabetes spectrum [11]. For example, fasting plasma glucose and HbA1c levels were significantly greater in T2DM patients, which are in agreement with established diagnostic criteria and indicate poor glycemic control. More importantly, there were accompanying marked dyslipidemia characterized by elevated total cholesterol, triglycerides, LDL-C, and reduced HDL-C [12]. This is well known to increase the risk of atherosclerosis and cardiovascular disease in diabetic populations and is known to be patterned diabetic dyslipidemia in the literature [13].

It was also found that anthropometric indices were strongly associated with lipid abnormalities. Pre-diabetics had a significantly higher BMI and waist-to-hip ratios than T2DM patients, indicating greater general and central obesity [14]. In particular, central adiposity is a key driver of insulin resistance, which is the basis of both hyperglycemia and dyslipidemia. In addition, the positive correlations of BMI, waist-to-hip ratio, triglycerides, and the inverse correlation of HDL C further support the interconnection of obesity, lipid metabolism, and glucose regulation [15].

Our findings agree with previous studies showing that, even at the pre-diabetic stage, patients have demonstrated early lipid abnormalities and increased cardiovascular risk. Prevention of transition from pre-diabetes to overt diabetes and the burden of cardiovascular complications is based on early detection and management of these metabolic disturbances [16]. Both pre-diabetic and diabetic populations should emphasize lifestyle interventions consisting of weight reduction, dietary modification, and exercise that improve both glycemic control and lipid profile. Pharmacological interventions aiming at both glycemic and lipid

control may be necessary in some cases to optimize patient outcomes [17].

The main strength of this study lies in its comprehensive evaluation of glycemic, lipid, and anthropometric parameters in a single cohort and in the ability to demonstrate metabolic interactions [18]. However, the study also has some limitations. Because of its cross-sectional design, causal inference is not possible, and a small sample size diminishes the generalizability of the findings [19]. The confounding factors, such as dietary patterns, physical activity level, and socioeconomic status, were also not assessed [20].

CONCLUSION

This study demonstrated that type 2 diabetic patients have worse lipid profiles, higher obesity measures, and poorer glycemic control than pre diabetic patients. The strong association between dyslipidemia and glucose level, and obesity emphasize on early screening and lifestyle intervention to facilitate the prevention of diabetes progression and reduce cardiovascular risk.

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