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Research Article

METABOLIC AND CARDIOVASCULAR RISK FACTORS IN YOUNG ADULTS WITH TYPE 2 DIABETES: THE ROLE OF LIPID ABNORMALITIES AND FAMILY HISTORY

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ABSTRACT

Objective: Cardiovascular diseases (CVDs) are a major cause of illness and death worldwide, with dyslipidemia and insulin resistance contributing significantly to their development. Although these metabolic conditions were once considered prevalent mainly in older adults, these conditions are increasingly seen in younger populations due to lifestyle changes, obesity, and genetics. Early identification of high-risk individuals is crucial, yet research on these conditions in young adults is limited.

This study aimed to investigate the relationship between lipid profiles, insulin resistance, and cardiovascular risk factors in young adults, especially those with a family history of diabetes.

Methods: A cross-sectional case–control study involved 200 participants (aged 25–35 years), including 70 diabetic patients with a family history, 70 without, and 60 healthy controls. Cardiovascular and metabolic parameters, including waist circumference, body mass index, blood pressure, triglycerides (TG), high-density lipoprotein (HDL), total cholesterol, fasting blood sugar (FBS), hemoglobin A1c (HbA1c), and TG/HDL ratio, were measured. Insulin resistance was assessed using the homeostatic model assessment of insulin resistance (HOMA-IR).

Results: Significant differences in metabolic and cardiovascular parameters were observed between diabetic patients and controls, especially in those with a family history. Diabetic patients with a family history had systolic blood pressure (131.5±12.90 vs. 121±16.9), TG (183.4±114.9 vs. 114±54.3), FBS (128.9±31.14 vs. 97.4±21.6), HbA1c (6.06±0.8 vs. 5.39±0.44), and TG/HDL ratio (4.22±2.42 vs. 1.04±0.28). A positive correlation was found between HOMA-IR and FBS, HbA1c, insulin levels, and TG, indicating a strong link between insulin resistance and these metabolic disturbances.

Conclusion: The findings highlight the importance of early metabolic health assessments and interventions, particularly for young adults with a family history of diabetes, to reduce CVD risk. Further research is needed to explore the long-term cardiovascular impacts of early metabolic dysfunction.

Keywords: Diabetes, Lipid abnormalities, Cardiovascular risk, Family history.

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INTRODUCTION

Cardiovascular diseases (CVDs) are among the leading causes of morbidity and mortality globally, posing a significant burden on public health systems. Dyslipidemia and insulin resistance are well-established contributors to the development of CVDs, primarily by promoting atherosclerosis and metabolic disturbances [1,2]. Conventionally regarded as conditions affecting older adults, these metabolic abnormalities are now alarmingly prevalent among younger populations, driven by lifestyle changes, increased prevalence of obesity, and genetic predisposition.

The rising incidence of lipid dysregulation and insulin resistance in young adults is concerning, as these conditions often remain undiagnosed until significant complications arise. Early identification of high-risk individuals is crucial for implementing preventive measures to reduce long-term cardiovascular risks. Despite their critical importance, there is limited research focusing on the prevalence and impact of these metabolic abnormalities in young adults, particularly those with a family history of diabetes or other risk factors [3,4].

Lipid abnormalities, characterized by elevated levels of total cholesterol (TC), low-density lipoprotein (LDL), triglycerides (TG), and reduced levels of high-density lipoprotein (HDL), play a significant role in the onset of atherosclerosis and related cardiovascular events [5,6]. Insulin resistance, a condition in which the body's cells exhibit diminished responsiveness to insulin, is strongly associated with dyslipidemia and serves as a precursor to type 2 diabetes mellitus [7,8]. These conditions often coexist and are shaped by a combination of factors, including genetic predisposition, lifestyle habits, and environmental influences.

There is a growing trend among young adults, particularly those in their late teens and twenties, of adopting sedentary behaviors and unhealthy eating habits, leading to the early development of metabolic disorders [9,10]. The rising rates of obesity in this group further increase the risk of insulin resistance and lipid imbalances. Despite this, research into the prevalence and impact of these conditions in young adults is scarce, revealing a critical gap in understanding early metabolic dysfunction and its potential long-term effects.

This study aims to bridge this knowledge gap by examining lipid profiles, insulin resistance markers, and associated cardiovascular risk factors in young adults. By analyzing key metrics such as the TG/HDL ratio, homeostatic model assessment of insulin resistance (HOMA-IR), and anthropometric data, the study seeks to provide insights into the metabolic and cardiovascular risks faced by this demographic. The findings emphasize the importance of early detection and targeted interventions to mitigate the progression of CVDs in younger populations. It highlights the critical need for early metabolic health assessments and preventive measures in younger populations.

METHODS

The study was a cross-sectional observational case–control investigation conducted at Parul Sevashram Hospital, Waghodia, Vadodara. Approval for the study was granted by the Institutional Ethics Committee for Human Research, Parul University, Vadodara (Approval Number: PUIECHR/PIMSR/00/081734/6719), and as per the Declaration of Helsinki on Ethical Principles for Medical Research. A total of 200 individuals aged 25–35 years were enrolled, all of whom were screened for diabetes according to the American Diabetes Association (ADA) criteria from February 2024 to September 2024 [11]. Data on participants' sociodemographic profiles, clinical and family histories, as well as medication adherence, were collected from those who provided informed consent to participate in the study.

The study participants were categorized into three groups: Group 1 consisted of 70 diabetic patients with a family history of diabetes, group 2 included 70 diabetic patients without a family history, and group 3 consisted of 60 healthy volunteers serving as the control group.

This study will include 200 participants with diabetes, balancing the need for meaningful results with available resources. While a larger sample could enhance statistical power, this size is feasible and cost-effective given current budgetary constraints.

Inclusion criteria

- Participants between the ages of 25 and 35 years, with both males and females eligible
- All participants met the ADA criteria for diabetes and were willing to participate in the study.

Exclusion criteria

- A history of lipid abnormalities or insulin resistance within the past 2 years
- Pregnancy or breastfeeding
- Any chronic diseases (such as renal failure or cancer), smoking, alcoholism
- Any medical conditions that could interfere with the study.

The ADA criteria for diagnosing diabetes include several tests. A fasting plasma glucose level of 126 mg/dL (7.0 mmol/L) or higher indicates diabetes, while levels between 100 and 125 mg/dL (5.6–6.9 mmol/L) suggest pre-diabetes. For the oral glucose tolerance test, a 2-h plasma glucose level of 200 mg/dL (11.1 mmol/L) or more confirms diabetes, with levels between 140 and 199 mg/dL (7.8–11.0 mmol/L) indicating pre-diabetes. A hemoglobin A1c (HbA1c) of 6.5% or greater is diagnostic for diabetes, while 5.7–6.4% signals pre-diabetes. In addition, a random plasma glucose level of 200 mg/dL (11.1 mmol/L) or higher, along with symptoms of hyperglycemia, can also confirm diabetes [11].

For the study method, family history, current complications, and prescription history were recorded using a standardized pro forma after obtaining written consent. Anthropometric measurements, including weight and height, were taken to calculate the body mass index (BMI=weight in kg/[height in (m)]^2). A fasting blood sample of approximately 5 mL was collected after 10–12 h of fasting for biochemical analysis. The sample was centrifuged at 3000 rpm for 10 min, and the serum was separated and stored at −20°C in a deep freezer until further analysis. Biochemical tests included fasting blood sugar (FBS), lipid profile (using the EM360 Auto Analyzer), HbA1c (measured by the Affinion HbA1c Analyzer), and insulin (via Fine test ELISA kit). Insulin resistance (HOMA-IR) and the TG/HDL ratio were calculated based on the results. HOMA-IR was calculated using the following formula: HOMA-IR=(FBG in mg/dL × Fasting Insulin in mIU/L) ÷ 405 [12].

Statistical analysis

To determine the comparison and significance correlation between the two groups – diabetic with family history and diabetic without family history,along with controls, *post hoc* Bonferroni analysis will be applied. All of the various variables were examined for relationship using Pearson's correlation. $p<0.05$ were regarded as statistically significant.

RESULTS

Table 1 presents the distribution of study participants by age and sex. Out of 200 individuals, 130 were male and 70 were female. This distribution shows a higher number of male participants, particularly in the 33–35 years category.

Table 2 highlights significant differences in cardiovascular and metabolic parameters among healthy individuals and diabetic patients.

- Blood pressure: Both systolic blood pressure (SBP) and diastolic blood pressure (DBP) were significantly higher in diabetic patients compared to the control group. SBP was 131.5±12.90 mmHg (family history) and 128.6±10.66 mmHg (no family history), compared to 121±16.9 mmHg in controls (r=−0.338). DBP showed a similar trend (family history: 82.94±9.41 mmHg; no family history: 80.6±9.27 mmHg; controls: 74.2±7.6 mmHg; r=−0.285)
- TG: Diabetic patients had significantly higher TG levels (family history: 183.4±114.9 mg/dL; no family history: 171.2±102.8 mg/dL) compared to controls (114±54.3 mg/dL; r=−0.385)
- FBS: FBS was significantly elevated in diabetic groups (family history: 128.9±31.14 mg/dL; no family history: 136.5±38.4 mg/dL) compared to controls (97.4±21.6 mg/dL; r=−0.393)
- HbA1c: Diabetic patients had higher HbA1c levels (family history: 6.06±0.8; no family history: 6.25±1.06) compared to the control group (5.39±0.44; r=−0.346)

Table 1: Distribution of study participants by age and sex

Age	Sex		Total
	Male	Female	
25–27	26	12	38
28–30	20	8	28
31–32	34	28	62
33–35	50	22	72
Total	130	70	200

Table 2: Comparison of cardiovascular and metabolic parameters between healthy individuals and diabetic patients with and without family history of diabetes

Parameters	Diabetic with family history (DWFH)	Diabetic without family history (DWoFH)	Control	p-value
WC (cm)	89.7±6.86	88.39±6.03	87.8±6.07	0.430
BMI	23.89±4.44	23.16±3.27	22.59±3.46	0.445
SBP	131.5±12.90	128.6±10.66	121±16.9	0.004*
DBP	82.94±9.41	80.6±9.27	74.2±7.6	0.004*
TG (mg/dL)	183.4±114.9	171.2±102.8	114±54.3	0.010*
HDL (mg/dL)	45.17±9.51	45.87±9.288	44.12±9.16	0.710
Total cholesterol (mg/dL)	187.8±44.39	175.2±49.85	160.5±41.2	0.044*
Low-density lipoprotein (mg/dL)	104.1±39.35	98.43±37.24	93.5±33.2	0.612
Fasting blood sugar (mg/dL)	128.9±31.14	136.5±38.4	97.4±21.6	<0.001*
Hemoglobin A1c (%)	6.06±0.8	6.25±1.06	5.39±0.44	<0.001*
TG/HDL	4.22±2.42	3.81±2.023	1.04±0.28	<0.001*

Values are given as mean±standard deviation from 140 subjects in the test and 60 control group (*$p<0.001$ is considered highly statistically significant, while $p<0.005$ is considered significant). Here WC: Waist circumference (cm), SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TG: Triglycerides, HDL: High-density lipoprotein

- TG/HDL ratio: This cardiovascular risk marker was significantly elevated in diabetic groups (family history: 4.22±2.42; no family history: 3.81±2.023) compared to controls (1.04±0.28; r=−0.842).

These findings highlight significant cardiovascular and metabolic risks in diabetic patients, particularly in those with a family history of diabetes.

In the *post hoc* Bonferroni analysis comparing diabetic patients with a family history of diabetes to healthy individuals, the following significant differences were observed (Tables 3 and 4):

Significant differences were found for metabolic parameters (i.e., HbA1c) and cardiovascular risk factors such as blood pressure, TG, and most importantly TG/HDL ratio.

No significant difference was found for waist circumference (WC) (mean difference: 1.78, p=0.795).

In the *post hoc* Bonferroni analysis comparing diabetic patients without a family history of diabetes to healthy individuals, the following significant differences were observed:

Significant differences were found for metabolic parameters (i.e., HbA1c) and cardiovascular risk factors such as blood pressure, TG compared to individuals with a family history of diabetes.

No significant differences were noted for WC (mean difference: 0.39 cm, p=1.000) or TG/HDL ratio (mean difference: 0.28, p=1.000).

Table 5 presents the correlation coefficients between HOMA-IR and various cardiovascular and metabolic parameters.

- Significant positive correlations:
  - FBS: r=0.884, p<0.001
  - HbA1c: r=0.818, p<0.001
  - Insulin Levels: r=0.800, p<0.001
  - TG: r=0.300, p=0.002.

These findings indicate that higher HOMA-IR values are strongly associated with elevated levels of these parameters.

- Weak or non-significant correlations:
  - WC: r=0.081, p=0.426
  - BMI: r=0.116, p=0.252
  - TC: r=0.100, p=0.322
  - HDL: r=0.018, p=0.858
  - LDL: r=−0.041, p=0.684

These parameters appear less directly associated with HOMA-IR in this dataset.

DISCUSSION

Early-onset diabetes, coupled with a family history of the condition, has been associated with an elevated risk of metabolic and cardiovascular complications. Understanding the interplay between lipid profiles, insulin resistance, and cardiovascular risk factors is crucial, particularly in younger populations where these abnormalities may remain underdiagnosed. This study investigates these associations to shed light on the metabolic challenges faced by diabetic individuals with and without a familial predisposition, providing insights for early interventions and preventive strategies.

Diabetic patients with a family history had slightly higher WC (89.7±6.86 cm) and BMI (23.89±4.44) compared to those without a family history (WC: 88.39±6.03 cm, BMI: 23.16±3.27) and the control group (WC: 87.8±6.07 cm, BMI: 22.59±3.46). However, these differences were not statistically significant. These results align with prior studies suggesting a trend of increased obesity in diabetic patients (Espinoza *et al*., 2009; Pannacciulli *et al*., 2003) [11,12].

Table 3: *Post-hoc* Bonferroni analysis for diabetic patients with a family history of diabetes and healthy individuals

Dependent variable	Mean difference	Standard error	Significance (p-value)	95% confidence interval
Waist circumference	1.78	1.59	0.795	2.09–5.68
Systolic blood pressure	11.06	3.38	0.004*	2.84–19.28
Diastolic blood pressure	8.72	2.22	<0.001*	3.32–14.12
TG	69.35	23.96	0.014*	10.96–127.73
Hemoglobin A1c	0.65	0.21	0.006*	0.15–1.16
TG/ high-density lipoprotein	2.59	0.39	<0.001*	1.63–3.56

TG: Triglycerides (*p <0.001 is considered highly statistically significant, while p <0.005 is considered significant)

Table 4: *Post hoc* Bonferroni analysis for diabetic patients without a family history of diabetes and healthy individuals

Dependent variable	Mean difference	Standard error	Significance (p-value)	95% confidence interval
Waist circumference	0.39	1.601	1	3.51–4.28
Systolic blood pressure	8.72	3.398	0.035*	0.45–17.00
Diastolic blood pressure	6.51	2.231	0.013*	1.07–11.95
TG	59.29	24.130	0.047*	0.51–118.08
Hemoglobin A1c	0.87	0.208	<0.001*	0.37–1.38
TG/ high-density lipoprotein	0.28	1.601	1	1.24–0.69

TG: Triglycerides(*p <0.001 is considered highly statistically significant, while p <0.005 is considered significant)

Table 5: Comparison of cardiovascular and metabolic parameters with HOMA-IR

Variables	HOMA-IR (r-values)	HOMA-IR (p-values)
Waist circumference	0.081	0.426
Body mass index	0.116	0.252
Fasting blood sugar	0.884	0.000**
Hemoglobin A1c	0.818	0.000**
Insulin	0.800	0.000**
Total cholesterol	0.100	0.322
Triglycerides	0.300	0.002**
High-density lipoprotein	0.018	0.858
Low-density lipoprotein	−0.041	0.684

**:<0.001-Difference is significant, HOMA-IR: Homeostatic model assessment of insulin resistance

Our findings align with existing literature, which suggests that while obesity is common in diabetic patients, the influence of family history on WC and BMI may be less pronounced (Espinoza *et al*., 2009; Bethelli and Oroszi, 2023) [11,13]. Although diabetic patients showed higher WC and BMI, the impact of family history on these measures was minimal.

Both SBP and DBP were significantly higher in diabetic patients compared to healthy controls. Patients with a family history had the

highest SBP (131.5±12.90 mmHg) and DBP (82.94±9.41 mmHg), followed by those without a family history (SBP: 128.6±10.66 mmHg; DBP: 80.6±9.27 mmHg) and controls (SBP: 121±16.9 mmHg; DBP: 74.2±7.6 mmHg). These findings corroborate previous studies demonstrating elevated blood pressure in diabetic patients, with family history potentially exacerbating this risk (Espinoza *et al*., 2009; Yadav *et al*., 2018) [11,14]. The *post hoc* Bonferroni analysis further highlights significant differences in SBP and DBP, emphasizing the combined impact of diabetes and family history on blood pressure.

TG levels were significantly higher in both diabetic groups, with patients having a family history showing the highest levels (183.4±114.9 mg/dL). HDL-C levels were similar across all groups, aligning with studies suggesting that HDL-C is less influenced by family history (Espinoza *et al*., 2009) [11].

The TG/HDL ratio, a key cardiovascular risk marker, was significantly elevated in both diabetic groups, indicating a more atherogenic profile (Pannacciulli *et al*., 2003) [12]. TC levels were slightly higher in diabetic patients with a family history, but not statistically significant.

FBS and HbA1c levels were significantly higher in both diabetic groups compared to controls. Elevated HbA1c levels indicate poorer long-term glycemic control, irrespective of family history, suggesting that other factors may play a larger role in glycemic regulation (Rashad *et al*., 2019; Birendra *et al*., 2023) [15,16].

Our study found significant positive correlations between HOMA-IR and key metabolic parameters, including FBS ($r=0.884$, $p<0.001$), HbA1c ($r=0.818$, $p<0.001$), insulin levels ($r=0.800$, $p<0.001$), and TG ($r=0.300$, $p=0.002$). These results indicate that higher HOMA-IR values, reflecting insulin resistance, are closely associated with glycemic and lipid dysregulation typical of diabetes.

In contrast, WC, BMI, TC, HDL, and LDL showed weak or non-significant correlations with HOMA-IR, suggesting a less direct relationship with these anthropometric and lipid measures in this dataset. These findings align with studies like Pannacciulli *et al*. (2003; Emmanuel *et al*., 2022) [12,17], which reported higher fasting glucose, insulin, and TG levels in individuals with a family history of type 2 diabetes. However, studies (Iqbal *et al*. 2023) emphasize the role of family history in influencing BMI and WC, highlighting nuanced relationships between insulin resistance, family history, and metabolic risk factors [18].

Our results differ from Telles *et al*. [19], who found a significant negative correlation between TG and BMI in healthy obese individuals, while our study and Pannacciulli *et al*. observed a positive association between TG and BMI. This discrepancy highlights the complex, context-dependent relationship between TG and body fat [12].

In addition, studies by Rashad *et al*. and Hassani *et al*. suggest that interventions such as fenugreek intake and stevioside supplementation can significantly affect BMI, WC, and other metabolic parameters [15,20]. These findings indicate that lifestyle and dietary changes may influence metabolic parameters in diabetic patients, potentially altering the relationship between HOMA-IR and other health indicators (Domenico *et al*., 2025) [21].

The literature suggests that WC may be a more relevant indicator of metabolic risk than BMI. Hsieh *et al*. highlighted WC as a better measure for assessing the risk of abnormal liver function in diabetic patients by Nevill *et al*. [22,23]. In addition, Amini *et al*. found lower BMI and WC in depressive older adults, indicating that metabolic profiles can vary across different health conditions [24].

Despite extensive research on metabolic and cardiovascular risk factors in type 2 diabetes, significant gaps remain, particularly concerning young adults aged 18–35. Most studies focus on older populations, overlooking the unique challenges and risk profiles of early-onset diabetes. The role of family history as a modulator of metabolic and cardiovascular risk in young adults remains underexplored, with limited differentiation between individuals with and without a familial predisposition. In addition, the interaction between lipid abnormalities and other risk factors in this demographic is poorly understood, leaving a critical gap in understanding the comprehensive risk profile. Existing research often isolates individual parameters, such as glucose control or lipid levels, rather than examining their combined effects. Furthermore, there is a lack of tailored strategies for early identification and prevention of cardiovascular risks in young adults, emphasizing the need for studies addressing these gaps to inform effective interventions and improve long-term outcomes.

Limitations of the study

This study has several limitations. The cross-sectional design prevents establishing causality between metabolic parameters and cardiovascular risk. The exclusion of participants with pre-existing lipid abnormalities or insulin resistance may underestimate the true prevalence of metabolic disorders. Being a single-center study with a sample size of 200, the findings may not be generalizable to diverse populations. In addition, unmeasured factors such as diet, physical activity, and stress were not considered, and longitudinal data on disease progression were unavailable.

CONCLUSION

Our study underscores the significant cardiovascular and metabolic risks associated with diabetes, particularly in individuals with a family history of the disease. Elevated blood pressure, TG, and TG/HDL ratios emerge as key markers of increased risk, highlighting the importance of early detection and intervention. The strong association between HOMA-IR and metabolic markers such as FBS, HbA1c, insulin levels, and TG reinforces the critical role of addressing insulin resistance in diabetes care. While WC and BMI showed limited impact, the concerning risk profile in diabetics with a family history calls for comprehensive management strategies that integrate metabolic monitoring and lifestyle interventions. These findings emphasize the need for a tailored, proactive approach to reduce long-term cardiovascular and metabolic complications.

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AUTHOR CONTRIBUTIONS

All the authors have contributed equally.

CONFLICTS OF INTEREST

Declares no conflicts of interest.

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