Original Research Article

USING THE TRIGLYCERIDE-GLUCOSE INDEX TO MEASURE INSULIN RESISTANCE AND PREDICT DIABETIC NEPHROPATHY

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A B S T R A C T

Background: Diabetes mellitus (DM) is a collection of metabolic illnesses characterised by lipid and protein metabolism, hyperglycemia, progressive damages, irregularities in carbohydrate, and failures and malfunctions of different important organs. According to research, diabetes was expected to be prevalent at a rate of 10.5% in 2021 or more than 537M people. The prevalence of diabetes was projected to grow to 643% by 2030. After estimating spot UACR (UACR = Urinary Albumin-to-Creatinine Ratio) from serum creatinine, albumin, and urinary creatinine, screening should also assess estimated GFR (eGFR). In order to measure insulin resistance, the triglyceride-glucose (TyG) index is recommended. It is because it is a cost-effective method and it correlates with DIABETIC NEPHROPATHY prediction. The objective is to assess the relationship between the triglyceride-glucose (TyG) index and HOMA-IR (HOMA-IR = Homeostatic Model Assessment of Insulin Resistance) in patients having type 2 diabetes mellitus and also evaluating the association between TyG index and UACR (UACR = Urinary Albumin-to-Creatinine Ratio) in order to predict diabetic nephropathy. Study design is an observational, cross-sectional study. This study was conducted at Liaquat University of Medical and Health Sciences Jamshoro from October 2024 to October 2025.

Materials and Methods: All the patients who were having type 2 diabetes mellitus were a part of this research. A non-probability consecutive sampling method was used to determine the sample Along with Type 2 DM, patients having fasting plasma glucose ≥126mg/dl were included. Moreover, those who had this condition for about 1 to 5 years were included. Clinical as well as demographic data was gathered. Patients were instructed to fast for 10 to 12 hours. Later, their venous blood samples were collected (5 ml) and stored at -20°C. SPSS version 26 was used to analyze the data.

Results: There were a total of 200 patients involved in this study. The majority of the participants were females, representing 65% of the total participants. There were 130 females and 70 males in this study. 46 percent of the patients were overweight, 16% were obese and 38% had normal weight. The mean BMI for Q1 was 26.2±3.21. The mean fasting serum insulin was 3.46. The mean HOMA-IR and TyG index levels were 1.79 and 5.39. The higher mean age and BMI were found in Q4 which is the highest TyG quartile (Mean age = 52.1 yrs, BMI = 26.7). A positive correlation was seen between TyG index and total cholesterol and LDL-C while there was a negative relation seen between TyG index and HDL-C. TyG index showed significant

positive beta value for UACR. HOMA-IR was also significantly linked with UACR.

Conclusion: There is a strong association between HOMA-IR and TyG index and it surpassed it in predicting DN in type 2 DM patients.

Keywords: Diabetes mellitus (DM), lipid and protein metabolism, hyperglycemia, progressive damages.

INTRODUCTION

Diabetes mellitus (DM) is a collection of metabolic illnesses characterized by lipid and protein metabolism, hyperglycemia, progressive damages, irregularities in carbohydrate, and failures and malfunctions of different important organs.[1] These important organs include kidneys, eyes, heart, nerves, and blood vessels. According to research, diabetes was expected to be prevalent at a rate of 10.5% in 2021 or more than 537M people.[2] The prevalence of diabetes was projected to grow to 643% by 2030.[3] Moreover, it is projected to grow to 783% by 2045.[4] According to the International Diabetes Federation (2022), there is an increase in the prevalence of diabetes in adults of Pakistan.[5]

According to the World Health Organization (WHO), diabetes was the leading cause of mortality in 2019.[6] One of the countries which are vulnerable to diabetes-related deaths is Pakistan. The prevalence of diabetes is higher in middle and low-income countries.[7] Adopting an unhealthy lifestyle and genetics are the main reasons for the incidence of diabetes in adults. An unhealthy lifestyle includes having processed food with added sugar which leads to a sedentary lifestyle. All of this leads to obesity.[8] Patients should be tested for diabetic nephropathy (DN) upon diagnosis since type 2 diabetes mellitus (T2DM) progresses slowly.[9] After estimating spot urinary albumin-to-creatinine ratio (UACR) from serum creatinine, albumin, and urinary creatinine, screening should also assess estimated GFR (eGFR). Due to increased glomerular hydrostatic pressure, hyper-filtration is experienced by insulin-resistant kidneys.[10] If glomerular hyper-filtration is found in DN, it leads to the progression of the disease. Therefore, there are chances that the disease could become more advanced.

In order to measure insulin resistance, the triglyceride-glucose (TyG) index is recommended. It is because it is a cost-effective method and it correlates with DN prediction. According to a research study in Taiwan, there is a strong association between TyG score and type 2 DM macro-angiopathies and micro-angiopathies.[11] However, there is still scarcity of relevant data in Pakistan. Therefore, this study was conducted to assess the relationship between the triglyceride-glucose (TyG) index and HOMA-IR in patients having type 2 diabetes mellitus and also evaluating the association between TyG index and UACR in order to predict diabetic nephropathy.

MATERIALS AND METHODS

This research is an observational, cross-sectional study. A non-probability consecutive sampling method was used to determine the sample.

Inclusion Criteria

All the patients who were having type 2 diabetes mellitus were a part of this research. Along with Type 2 DM, patients having fasting plasma glucose ≥126mg/dl were included. Moreover, those who had this condition for about 1 to 5 years were included. Patients were informed about this study and their consent was obtained. The Ethical Review Committee of the institute approved this study.

Exclusion criteria

Patients who had type 1 diabetes mellitus were not a part of this study. Moreover, those having pregnancy, chronic illnesses, and systemic illnesses were also excluded. Furthermore, those who smoked and were on dialysis were also not a part of this study.

Clinical as well as demographic data was gathered which include diabetes duration, height, age, gender, weight, blood pressure, waist circumference (WC), and BMI. Patients were instructed to fast for 10 to 12 hours. Later, their venous blood samples were collected (5 ml) and stored at -20°C. For the HOMA-IR assessment, insulin concentrations and FPG were measured. For ACR determination, a spot urine sample was taken. UACR was also measured.

All the people were divided into 4 quartiles based on the TyG index scores. We used SPSS version 26 to analyse the data. To analyse the link between HOMA-IR, TyG index, eGFR, UACR, biochemical parameters, and anthropometric indices, Pearson correlation was used. A p-value of less than 0.05 was considered significant.

RESULTS

There were a total of 200 patients involved in this study. The majority of the participants were females, representing 65% of the total participants. There were 130 females and 70 males in this study. 46% of the patients were overweight, 16% were obese and 38% had normal weight. The mean fasting serum insulin was 3.46 ±1.48 µIU/mL. The mean HOMA-IR and TyG index levels were 1.79 and 5.39. The higher mean age and BMI were found in Q4 which is the highest TyG quartile [Table 1]. The mean age in Q4 was 52.1 years while it was slightly lower than this in other quartiles. Similarly, the BMI was 26.7 in Q4 while it was 26.2, 26.1, and 26.2 in Q1, Q2, and Q3. Similarly, diastolic blood pressure was

90 mmHg in Q4 which was also the highest among all quartiles. Table number 1 shows the demographic parameters according to TyG index quartiles.

*The Triglyceride-Glucose (TyG) index is a sensitive, low-cost blood marker used to assess insulin resistance, metabolic syndrome, and cardiovascular risk. It is calculated using fasting triglycerides (mg/dL) and fasting plasma glucose (mg/dL) with the formula:

There was a positive correlation seen between fasting plasma glucose and TyG index (r=0.76, p<0.001). Similarly, a positive correlation was seen between TyG index and total cholesterol and LDL cholesterol (r=0.39, r=0.55). A negative correlation was seen between TyG index and HDL-C (r=-0.35). [Table 2] shows the correlation of biochemical parameters with UACR, HOMA-IR, and TyG index.

Table 1

Demographics	Q1 TyG *	Q2 TyG*	Q3 TyG*	Q4 TyG*
	(4.5 to 5)	(5.1 to 5.5)	(5.6 to 6)	(>6)
Age (yrs)	51.6	46.7	48.9	52.1
Waist circumference (inches)	30.6	30.4	30.0	30.7
Diastolic blood pressure (mmHg)	85.9	84.9	83.9	90.0
BMI	26.2	26.1	26.2	26.7
Duration of T2DM (yrs)	3.8	3.6	3.9	4.1
Systolic blood pressure (mmHg)	128.9	124.4	127.1	125.0

Table 2

Parameters	Fasting serum insulin		UACR		HOMA-IR		TyG index	
	r-value	p-value	r-value	p-value	r-value	p-value	r-value	p-value
LDL-C	-0.01	0.93	0.16	0.05	0.34	<0.001	0.55	<0.001
HDL-C	0.13	0.01	0.11	0.10	-0.22	0.11	-0.35	0.01
Fasting plasma glucose	-0.14	0.05	0.10	0.05	0.48	<0.001	0.76	<0.001
TyG Index	-0.13	0.05	0.28	0.05	0.32	<0.001	1	-
Total Cholesterol	-0.01	0.05	0.08	0.05	0.11	0.05	0.39	<0.001
eGFR	0.05	0.05	-0.02	0.8	-0.01	0.86	-0.35	0.01
Glycated Haemoglobin	-0.12	0.07	0.15	0.05	0.05	0.38	0.35	<0.001

[Table 3] shows regression analysis of TyG index and HOMA-IR predicting UACR and eGFR. TyG index showed significant positive beta value for UACR. HOMA-IR was also significantly linked with UACR.

Table 3

Parameters	Beta value	Std. Error	p-value
UACR			
TyG index	12.84	9.33	0.001
HOMA-IR	1.82	4.22	0.01
eGFR			
TyG index	-4.42	16.66	0.02
HOMA-IR	-1.90	7.54	0.05

HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) is a blood test calculating the relationship between fasting glucose and insulin, used to measure how sensitive body cells are to insulin and identify risk for type 2 diabetes.

DISCUSSION

Our study assessed the relationship between HOMA-IR and TyG index among patients having type 2 diabetes mellitus. Moreover, it also focused on assessing the relationship between UACR and TyG index in predicting diabetic nephropathy (DN). As an indicator for metabolic problems, diabetes, and heart conditions, TyG index is widely studied.[12] However, there is still scarcity of relevant data in Pakistan on it as compared to other methods of evaluating insulin resistance.

In our study, all the participants were divided into 4 quartiles which were based on TyG index values.

Through this, we were able to assess the metabolic trends across increasing levels of insulin resistance. According to [Table 1], the higher mean age and BMI were found in Q4 which is the highest TyG quartile (Mean age = 52.1 yrs, BMI = 26.7). These higher values suggest an association between higher TyG levels and adiposity. Waist circumference was also similar in all quartiles but still slightly higher in Q4. This reflects greater central obesity in the highest TyG quartile. Similarly, diastolic blood pressure was 90 mmHg in Q4 which was also the highest among all quartiles. This indicates clustering of metabolic risk factors in people with higher TyG levels. The study of Chiu et al. showed similar results where they found that higher TyG values were significantly linked with metabolic syndrome components and obesity in patients with T2DM.[13] Similarly, Liu et al. conducted a Chinese cross-sectional study which also found that higher TyG

index levels were significantly related with central obesity and higher BMI.[14]

To estimate the insulin action to judge insulin resistance, lipid levels were assessed as an important parameter. It is defined as reduced sensitivity to insulin in tissues.[15] It increases the risk of hypertension, hyperglycaemia, and dyslipidaemia. People who are overweight and obese commonly have higher levels of triglyceride-rich lipoprotein remnants, increased insulin resistance, apolipoprotein B, and remnant-like particle cholesterol.[16] Our study also focused on the correlation analysis (table number 2) which shows the significant relationship of several renal and metabolic parameters with the TyG index. The positive correlation between fasting plasma glucose and TyG index shows that TyG effectively reflects glycemic burden. A positive correlation was seen between TyG index and total cholesterol and LDL-C while there was a negative relation seen between TyG index and HDL-C. Similar results were found in the study of Jabeen et al. who found that TyG index was significantly correlated with LDL-C.[17]

Regression analysis is shown in [Table 3] where the TyG index showed significant positive beta value for UACR was demonstrated. This shows that increased albuminuria is independently predicted by TyG levels. Moreover, HOMA-IR was also significantly linked with UACR. Our study found that there is a significant negative correlation of eGFR with HOMA-IR, UACR, and TyG index. According to a study in China, there was no significant relationship seen between eGFR and TyG index and the p-value was 0.786.[18] However, another study found a strong association between type 2 DM and higher TyG index.[19] A study was conducted in India in 2020 which showed similar results to our study.[20] The study focused on exploring the relationship of TyG index with diabetic retinopathy and diabetic neuropathy.

There are a few limitations of our study. The limitation is that it is a cross-sectional and observational study which has inherent design constraints. In order to assess the relationship of TyG index with progression of DN in patients with type 2 diabetes mellitus, it is essential to perform prospective studies. Another limitation was that it was a single-centre study. For this type of topic, it is recommended to perform multicentre epidemiological studies.

Recommendations: By using the findings of this study, we recommend that the TyG index should be incorporated into routine clinical assessments of T2DM patients. It should particularly be incorporated into settings where there are limited resources and the advanced insulin essays may not be readily available. Moreover, for this type of topic, it is recommended to perform multicentre epidemiological studies.

CONCLUSION

There is a strong association between HOMA-IR (Homeostatic Model Assessment of Insulin Resistance) and TyG index and it surpassed it in predicting DN in type 2 DM patients.

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