BioChemMed

*Technium BioChemMed Vol. 12, pp.62-70 (2025)*
*ISSN: 2734-7990*
*www.techniumscience.com*

# Insulin Resistance Indexes, Predictors of Diabetic Kidney Disease in Elderly Iraqis

**Lect. Dr. Mayyada Bassim Rasul Aldbagh**

Email Address: mayyadab.aldbagh@uokufa.edu.iq

Department of Pathological Analyses, Faculty of Science, University of Kufa, Iraq.

**Abstract**

This cross-sectional study aimed to evaluate the utility of three surrogate markers of insulin resistance, TyG, TG/HDL, and TyG-BMI in clinical practice by examining their association with diabetic kidney disease (DKD). **Results:** Of 476 patients with type 2 diabetes (T2DM), 42 (8.8%) had DKD. Patients with DKD showed significantly higher levels of BMI, fasting blood glucose, HbA1c, lipids, markers of renal dysfunction and three IR indices (TyG, TG/HDL and TyG-BMI) than those without DKD compared to those without DKD. Crosstabs/Risk analysis revealed that TyG index (OR = 1.39, 95% CI =1.218-1.587, p= 0.002), TG/HDL (OR =1.356, 1.189-1.545, p= 0.004), and TyG-BMI (OR =1.247, 1.073-1.450, p= 0.043). Based on the receiver operating characteristic curve, the areas under ROC with best cutoff values of TyG index, TG/HDL and TyG-BMI, were 0.762, 0.720 and 0.654, respectively and 9.5, 2.19 and 225, respectively. DKD patients >40 years had a significantly increased TyG index (p = 0.047) of 67.0% compared to patients <40 years of age of 50.0%. **Conclusion:** Among T2DM patients, the risk of DKD increases with the increase of TyG index, TG/HDL and TyG-BMI, with their respective cut-off values being 9.5, 2.19 and 225. The TyG performed best in predicting DKD, followed by TG/HDL and then TyG-BMI. Age was positively associated with TyG index, indicating a higher prevalence of DND in patients with T2DM.

**Keywords:** T2DM, Insulin resistance indexes, Diabetic kidney disease risk, Elderly.

## 1. Introduction

Diabetic kidney disease (DKD) is a major complication of diabetes and the leading cause of end-stage renal disease. Its hallmark is the presence of albumin in the urine, which increases the risk of kidney damage and cardiovascular events. Changes in renal circulation, oxidative stress, inflammation, increased activity of the renin-angiotensin-aldosterone system, and hypoxia are the causes of DKD, with renal fibrosis playing the major role [1]. Given the large number of diabetic patients in the Arab region, especially Iraq, the number of DKD patients constitutes a significant burden on the healthcare system. Insulin resistance is thought to be associated with the clinical manifestations of CKD and may be one of the underlying causes of the histological features of CKD [5]. An increasing number of studies have shown that insulin resistance plays an important role in the development and progression of CKD [6-8]. In addition, insulin resistance can be identified in the early stages of CKD, where its severity increases with deterioration of kidney function [9,10].

*Technium BioChemMed Vol. 12, pp.62-70 (2025)*
*ISSN: 2734-7990*
*www.techniumscience.com*

Given the high cost of treating diabetic kidney disease and insulin resistance and its negative impact on quality of life, early diagnosis and prompt therapeutic intervention can delay the progression of the disease and reduce the need for expensive and complex treatments. Recently, some surrogate markers of insulin resistance have been widely used, such as triglyceride-to-glucose (TyG) index, triglyceride-to-glucose body mass index (TyG-BMI), and triglyceride-to-high-density lipoprotein (TG/HDL) ratio. For TyG index, some studies have shown a significant association between it and CKD [11-16], but another study found no significant association between TyG index and CKD [17]. Given these different findings, we set out to explore the relationship between these surrogate markers of insulin resistance and DKD.

## 2. Method

### 2.1. Data with Participants

A cross-sectional study was performed on 476 participants with type 2 diabetes mellitus (T2DM) from Al-Sadr Hospital/Diabetes Center in Najaf, Iraq, which was conducted in 2023. Demographic and clinical data of patients were collected from electronic and medical records. Demographic information included: age and sex, clinical data included: fasting plasma glucose (FPG), glycated hemoglobin (HbA1c), and body mass index (BMI). Laboratory data: renal function parameters (creatinine, urea, and uric acid), and lipid profile [high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), very-low-density lipoprotein cholesterol (VLDL), total cholesterol (TC), and triglycerides (TG)].

### 2.2. Calculation of measurements

The TyG index, TG/HDL ratio, body mass index (BMI), and TyG-BMI were calculated. The TyG index was calculated as ln (fasting triglycerides [mg/dL] × fasting glucose [mg/dL]/2) [18]. The TyG-BMI index was calculated by multiplying the TyG index by BMI [19]. While the TG/HDL ratio was calculated by the dividing TG (mg/dL) by HDL-c (mg/dL).

Estimated glomerular filtration rate (eGFR) was calculated using MDRD equation based on serum creatinine with age, sex, and race as follows: MDRD eGFR= $186.3 \times (\text{serum Cr})^{-1.154} \times \text{age}^{-0.203} \times$ (0.742 if female) × (1.212 if African−American). DKD was considered as eGFR < 60 ml/min/1.73m2 [20]; otherwise, they were defined not to have DKD.

### 2.3. Statistical Analysis

SPSS version 26 was used to analyze the data. Descriptive statistics were used to summarize the characteristics of the participants with T2DM. Chi-square test was used to compare categorical variables between patients with and without DKD. Independent t-test was used to compare continuous variables between patients with and without DKD. ROC curve analysis was used for diagnostic accuracy. Crosstabs/Risk analysis tested the OR and 95% CIs for the association of insulin resistance risk with DKD ($p < 0.05$) especially in the context of age.

## 3. Results

### 3.1. Participants' baseline characteristics

A total of 476 participants (aged 18-89) with T2DM were enrolled in the study, including 311 women and 165 men. The total patients with DKD were 42 (8.8%). Their mean age was 59.74±12.224 years.

*Technium BioChemMed Vol. 12, pp.62-70 (2025)*
*ISSN: 2734-7990*
*www.techniumscience.com*

Among them, 26.2% had a lower BMI (<25), while 73.8% had a higher BMI (≥25). The results revealed that in the DKD group BMI, FPG, HbA1c, TG, TC, LDL, VLDL, HDL, urea, creatinine, uric acid, TyG index, TG/HDL ratio and TyG-BMI index all increased ($p < 0.05$), while eGFR decreased ($p < 0.01$). As for the age and gender of type 2 diabetes patients with or without DKD, no significant differences were detected ($p = 0.094$) between them **Table 1**.

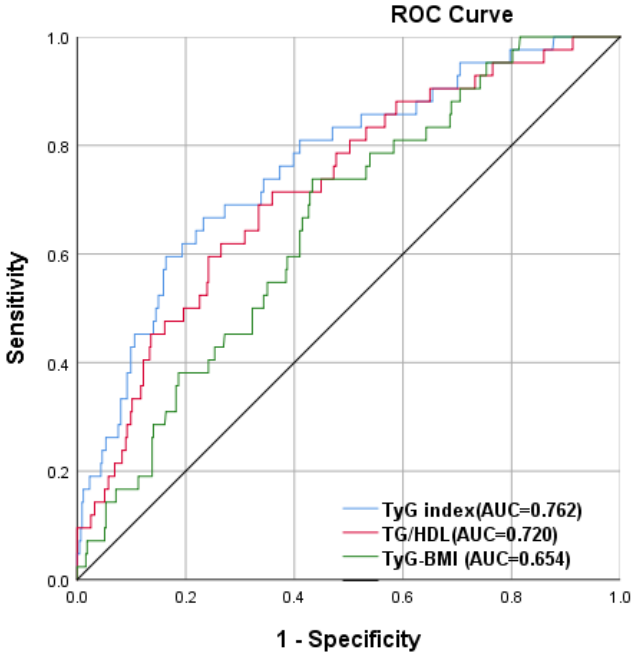
**Table 1: Demographic and clinical factors with T2DM with or without DKD.**

| Variables | | Non- DKD group 434 (91.2%) | DKD group 42 (8.8%) | P-value |
|---|---|---|---|---|
| Age (year) | | 56.36±12.497 | 59.74±12.224 | 0.094 |
| Gender, n(%) | Male | 154(93.3%) | 11(6.7%) | 0.299 |
| | Female | 280(90.0%) | 31(10.0%) | |
| BMI (kg/m$^2$) | | 26.470±4.9756 | 28.067±4.0281 | 0.020* |
| BMI (kg/m$^2$) | <25 | 205(47.2%) | 11(26.2%) | 0.014* |
| | ≥25 | 229(52.8%) | 31(73.8%) | |
| Fasting glucose (mmol/L) | | 235.078±80.0325 | 298.631±92.2091 | 0.000* |
| HbA1c (%) | | 7.6035±1.95016 | 8.9821±2.15652 | 0.000* |
| Serum creatinine (µmol/L) | | 0.7373±0.18154 | 1.3235±.18251 | 0.000* |
| B. Urea (µmol/L) | | 29.4127±7.37485 | 44.3810±20.56858 | 0.000* |
| Serum uric acid (µmol/L) | | 4.6499±1.23355 | 5.3726±1.38518 | 0.000* |
| eGFR (ml/min/1.73 m2) | | 104.15±30.234 | 48.33±7.417 | 0.000* |
| Total cholesterol (mmol/l) | | 190.986±47.2038 | 234.512±57.6645 | 0.000* |
| T.G (mmol/l) | | 154.765±71.6542 | 231.214±185.6782 | 0.011* |
| LDL (mmol/l) | | 126.681±30.670 | 135.940±21.8803 | 0.015* |
| VLDL (mmol/l) | | 30.9533±14.3307 | 46.2429±37.1356 | 0.011* |
| HDL (mmol/l) | | 55.2169±20.74727 | 45.6274±12.61990 | 0.003* |
| TyG index | | 9.6643±0.5309 | 10.2158±0.56004 | 0.000* |
| TyG-BMI index | | 256.8050±54.40741 | 286.9884±45.70449 | 0.000* |
| TG/HDL | | 3.0883±1.63581 | 5.5663±5.2387 | 0.004* |

### 3.2. ROC curves of alternative IR indexes

To evaluate the performance of TyG Index, TG/HDL, and TyG-BMI Index in predicting DKD, the researcher plotted the areas under the receiver operating curve (AUC). The areas under ROC of TyG index were 0.762 with the sensitivity (88.1%) and specificity (62.4%) at the cut-point of ≥ 9.5. The areas under ROC of TG/HDL were 0.720 (sensitivity: 88.1%; specificity: 65%) with the cut-point of ≥ 2.19 and the areas under ROC of TyG-BMI were 0.654 (sensitivity: 83.3%; specificity: 66.8%) with the cutoff values of ≥ 225. Hence, ROC showed that TyG index was more accurate than TG/HDL following by TyG-BMI at predicting the risk of IR and DM-related complications (Figure 1).

**Figure 1. ROC curve analyses to predict TyG index, TG/HDL and TyG-BMI**




### 3.3. Correlation of the alternative IR indexes with DKD

To discover correlation of TyG Index and TyG-BMI Index and TG/HDL with DKD, we performed Crosstabs/Risk analysis of the cross-sectional data. TyG index greater than 9.5 was linked with a odds ratio (OR) for DKD (OR = 1.39, 95% CI =1.218-1.587, p =0.002), TG/HDL greater than 2.19 (OR =1.356, 1.189-1.545, p =0.004), and TyG-BMI greater than 225 (OR =1.247, 1.073-1.450, p =0.043) (Table 2).

**Table 2: Odds ratio of alternative IR indexes in predicting DKD risk**

| Variable | | Odds Ratio | 95% CI | P-value |
|---|---|---|---|---|
| TyG index | >9.5 | 1.390 | 1.218-1.587 | 0.002* |
| | <9.5 | 0.325 | 0.141-0.747 | |
| TG/HDL | >2.19 | 1.356 | 1.189-1.545 | 0.004* |
| | <2.19 | 0.340 | 0.148-0.782 | |
| TyG-BMI | >225 | 1.247 | 1.073-1.450 | 0.043* |
| | <225 | 0.502 | 0.252-1.001 | |

*Technium BioChemMed Vol. 12, pp.62-70 (2025)*
*ISSN: 2734-7990*
*www.techniumscience.com*

**3.4.** Relationship between age and insulin resistance indices:

Table 3 showed that there is a positive relationship between age and TyG index. This means that people over 40 years of age have 67.0% higher rates of TyG index compared to people under 40 years of age by 50.0%. This result is statistically significant (p = 0.047). In contrast, no statistically significant relationship was found between age and other indices TG/HDL and TyG-BMI.

**Table 3.** Relationship **between age in terms of insulin resistance**

| Variable | | Age < 40 | Age > 40 | P-value |
|---|---|---|---|---|
| TyG index | < 9.5 | 20(50.0%) | 144(33.0%) | 0.047* |
| | > 9.5 | 20(50.0%) | 292(67.0%) | |
| TG/HDL | < 2.19 | 16(40.0%) | 141(32.3%) | 0.418 |
| | > 2.19 | 24(60.0%) | 295(67.7%) | |
| TyG-BMI | < 225 | 17(42.5%) | 134(30.7%) | 0.176 |
| | > 225 | 23(57.5%) | 302(69.3%) | |

## 4. Discussion

Our results noted that DKD group had higher clinical parameters, including BMI, blood glucose, lipid profile, and kidney profile, compared with non-DKD group. Elevated levels of these parameters indicate more significant metabolic disturbances in DKD group. Importantly, this group showed more severe insulin resistance, as indicated by higher TyG index, TG/HDL, and TyG-BMI, compared to the non-DKD. While we did not find any interaction between sex and DKD, our study was consistent with [21].

The metabolic mechanisms and pathological changes that contribute to diabetic kidney disease are very complex, for example, glomerular hyperfiltration is one of the first signs of the disease. In addition, renal hemodynamics are worsened by downregulation of the natriuretic peptide system, oxidative stress, and sodium and water deficiency induced by insulin resistance [22]. Previous research has shown that insulin resistance causes serious metabolic diseases such as cardiovascular disease and diabetes due to its contribution to disturbances in inflammatory reactions, oxidative stress, and glucose metabolism [23]. Other researchers have demonstrated that high blood sugar, elevated free fatty acids, and insulin resistance can cause inflammation and renal fibrosis through metabolic imbalance, thus initiating the chronic stages of kidney disease and promoting kidney injury [24].

The study also revealed that 73.8% of diabetic patients had a BMI ≥ 25 kg/m2, and their BMI was significantly higher than that of those without diabetes. One researcher suggested that obesity is involved in insulin resistance or its development by causing changes in adipocyte function, macrophage infiltration, and chronic inflammation [25]. Another researcher suggested that BMI and end-stage renal disease are mediated through TyG [26]. In addition to TyG, high TyG significantly increases the risk of diabetes [27]. It is worth noting that combining TyG and BMI by TyG may improve the accuracy of predicting insulin resistance [28]; for this reason, we included and compared it with TyG and TG/HDL in our study.

To evaluate the diagnostic value of the three studied indices for type 2 diabetes patients, ROC curve analysis was used. The TyG index showed a higher area under the ROC curve for identifying DKD

patients than TG/HDL and TyG-BMI. While a previous study reported that the diagnostic accuracy of the TyG index was poor when using ROC analysis [21]. Other researchers reported that TyG-BMI had a better diagnostic performance than TG/HDL for diagnosing IR [28]. In contrast, another suggested that the TyG index is much more efficient than TG/HDL in predicting insulin resistance, because it is less affected by future fat distribution [29]. They also found that the TyG index and TG/HDL were better at predicting the risk of DKD than TyG-BMI [30]. The TyG index includes indices of both glucose and lipid metabolism, indicating that serum triglycerides and glucose play a serious role in the pathophysiology of DND. Therefore, we used the TyG index as an effective index for evaluating insulin resistance.

Our analysis showed a statistically significant association between high TyG index (<9.5) and older age (>40 years) in DKD patients. In other words, younger individuals are less likely to be insulin resistant than older individuals, based on TyG index measurement. Our study is consistent with others [12,31,32], which found that high TyG index served as a risk factor for DKD in patients aged 40 years or older. These results contrast with Cha et al., who suggested that insulin resistance may be more significant at early-onset DKD [33].

In addition, by testing the risk model from cross-tables, we found a positive association between TyG, TG/HDL, and TyG-BMI with the risk of DKD. The results revealed that the risk of DKD was lower among participants with TyG <9.5, TG/HDL <2.19, and TyG-BMI <225, while the risk of DKD was higher among participants with TyG >9.5, TG/HDL >2.19, and TyG-BMI >225, respectively. This is explained by the fact that for each 1-unit increase in TyG, TG/HDL and TyG-BMI, the odds of DKD increased by 1.390, 1.356 and 1.247, respectively. Our result was somewhat similar to the study by Mu et al., who showed that TyG and TG/HDL performed best in predicting DKD, followed by TyG-BMI [30]. These findings emphasize the importance of regular screening of diabetic patients, with a focus on assessing lipid and glucose levels and BMI. Through early detection of the disease and appropriate preventive measures, patients can reduce the risk of progression to DKD.

## 5. Conclusion

We found that the studied IR indices act as risk factors for patients with diabetic kidney disease (DKD) in Iraq. Of the three studied indices, TyG index was the best predictor of DKD, followed by TG/HDL index and then TyG-BMI index. Age was positively associated with TyG index, indicating a higher prevalence of DND in older patients with T2DM.

## References

[1] Yi-Chih Lin, Yu-Hsing Chang, Shao-Yu Yang, Kwan-Dun Wu, Tzong-Shinn Chu, (2018). Update of pathophysiology and management of diabetic kidney disease,Journal of the Formosan Medical Association,Volume 117, Issue 8, 662-675,ISSN 0929-6646,https://doi.org/10.1016/j.jfma.2018.02.007. [PubMed]

[2] Chen L, Hu Y, Ma Y, Wang H (2023). Non-linear association of fasting C-peptide and uric acid levels with renal dysfunction based on restricted cubic spline in patients with type 2 diabetes: A real-world study. Front Endocrinol (Lausanne) 14:1157123. doi: 10.3389/fendo.2023.1157123 [DOI] [PMC free article] [PubMed] [Google Scholar]

[3] Li D, Hsu FC, Palmer ND, Liu L, Choi YA, Murea M, et al. (2024). Multi-omics analyses identify AKR1A1 as a biomarker for diabetic kidney disease. Diabetes, db230540. doi: 10.2337/db23-0540 [DOI] [PMC free article] [PubMed] [Google Scholar]

[4] Al Tuhaifi T, Zhong J, Yang HC, Fogo AB (2024). Effects of dipeptidyl peptidase-4 inhibitor and angiotensin-converting enzyme inhibitor on experimental diabetic kidney disease. Lab Invest 104(2):100305. doi: 10.1016/j.labinv.2023.100305 [DOI] [PMC free article] [PubMed] [Google Scholar]

[5] Adeva-Andany MM, Adeva-Contreras L, Fernández-Fernández C, Carneiro-Freire N, Domínguez-Montero A (2023). Histological manifestations of diabetic kidney disease and its relationship with insulin resistance. Curr Diabetes Rev. 19(1):e280322202705. doi: 10.2174/1573399818666220328145046 [DOI] [PubMed] [Google Scholar]

[6] Akhtar M, Taha NM, Nauman A, Mujeeb IB, Al-Nabet ADMH (2020). Diabetic kidney disease: past and present. Adv Anat Pathol. 27(2):87–97. doi: 10.1097/PAP.0000000000000257 [DOI] [PubMed] [Google Scholar]

[7] Artunc F, Schleicher E, Weigert C, Fritsche A, Stefan N, Häring HU (2016). The impact of insulin resistance on the kidney and vasculature. Nat Rev Nephrol. 12(12):721–37. doi: 10.1038/nrneph.2016.145 [DOI] [PubMed] [Google Scholar]

[8] De Cosmo S, Menzaghi C, Prudente S, Trischitta V (2013). Role of insulin resistance in kidney dysfunction: insights into the mechanism and epidemiological evidence. Nephrol Dial Transpl. 28(1):29–36. doi: 10.1093/ndt/gfs290 [DOI] [PubMed] [Google Scholar]

[9] Nabipoorashrafi SA, Adeli A, Seyedi SA, Rabizadeh S, Arabzadeh Bahri R, Mohammadi F, et al. (2023). Comparison of insulin resistance indices in predicting albuminuria among patients with type 2 diabetes. Eur J Med Res. 28(1):166. doi: 10.1186/s40001-023-01134-2 [DOI] [PMC free article] [PubMed] [Google Scholar]

[10] Leyking S and Fliser D (2014). Insulin resistance in CKD. Clin J Am Soc Nephrol 9(4):638–40. doi: 10.2215/CJN.01290214 [DOI] [PMC free article] [PubMed] [Google Scholar]

[11] Xu X, Tang X, Che H, et al. (2021). [Triglyceride-glucose product is an independent risk factor for predicting chronic kidney disease in middle-aged and elderly population: a prospective cohort study] *Nan Fang Yi Ke Da Xue Xue Bao.* 41(11):1600-1608. PubMed Google Scholar

[12] Li X, Wang L, Zhou H, Xu H (2024). Association between triglyceride-glucose index and chronic kidney disease: results from NHANES 1999-2020. Int Urol Nephrol. 56(11):3605-3616. doi: 10.1007/s11255-024-04103-8. Epub 2024 Jun 10. PMID: 38856937; PMCID: PMC11464617. PubMed

[13] Low S, Pek S, Moh A, et al. (2022). Triglyceride-glucose index is prospectively associated with chronic kidney disease progression in Type 2 diabetes - mediation by pigment epithelium-derived factor. *Diabetes Vasc Dis Res.* 19(4):14791641221113784. doi: 10.1177/14791641221113784. Crossref Scopus (14) PubMed Google Scholar

[14] Zhu Q, Chen Y, Cai X, et al. (2022). The non-linear relationship between triglyceride-glucose index and risk of chronic kidney disease in hypertensive patients with abnormal glucose metabolism: a cohort study. *Front Med* (Lausanne). 20;9:1018083. doi: 10.3389/fmed.2022.1018083. Crossref Scopus (26) Google Scholar

[15] Amouzegar A, Honarvar M, Masoumi S, et al. (2023). Sex-specific Trajectories of Insulin Resistance Markers and Reduced Renal Function During 18 Years of Follow-up: TLGS. J Clin Endocrinol Metab. 17;108(6):e230-e239. doi: 10.1210/clinem/dgac735. Crossref Scopus (7) PubMed Google Scholar

[16] Chen T, Wang X, Wang X, et al. (2020). Comparison of Novel Metabolic Indices in Estimation of Chronic Kidney Diseases in a Southern Chinese Population. *Diabetes Metab Syndr Obes*. 13:4919-4927. doi: 10.2147/DMSO.S286565. Crossref Scopus (15) PubMed Google Scholar

[17] Pan Y, Zhong S, Zhou K, Tian Z, Chen F, et al. (2021). Association between Diabetes Complications and the Triglyceride-Glucose Index in Hospitalized Patients with Type 2 Diabetes. *J Diabetes Res*. 2021, 8757996. doi: 10.1155/2021/8757996. Crossref Scopus (41) Google Scholar

[18] Guerrero-Romero F, Simental-Mendía LE, González-Ortiz M, Martínez-Abundis E, Ramos-Zavala MG, et al. (2010). The product of triglycerides and glucose, a simple measure of insulin sensitivity. Comparison with the euglycemic-hyperinsulinemic clamp. *J Clin Endocrinol Metab*. 95(7):3347–51. doi: 10.1210/jc.2010-0288. PubMed Abstract | CrossRef Full Text | Google Scholar

[19] Li HF, Miao X, Li Y (2023). The Triglyceride Glucose (TyG) Index as a Sensible Marker for Identifying Insulin Resistance and Predicting Diabetic Kidney Disease. *Med Sci Monit*. 29:e939482. doi: 10.12659/MSM.939482. PubMed Abstract | CrossRef Full Text | Google Scholar

[20] Chinese Diabetes Society; National Offic for Primary Diabetes Care. [National guidelines for the prevention and control of diabetes in primary care (2018)]. Zhonghua Nei Ke Za Zhi. 2018 Dec 1;57(12):885-893. Chinese. doi: 10.3760/cma.j.issn.0578-1426.2018.12.003. PMID: 30486556. PubMed Abstract | CrossRef Full Text | Google Scholar

[21] Jiang Y and Lai X (2024). Association between the triglyceride glucose index, triglyceride glucose body mass index and diabetic kidney disease in adults with newly diagnosed type 2 diabetes. Front Med (Lausanne) 11:1328601. doi: 10.3389/fmed.2024. 1328601. PubMed

[22] Spoto B, Pisano A, Zoccali C (2016). Insulin resistance in chronic kidney disease: a systematic review. Am J Physiol Renal Physiol. 311(6):F1087–f1108. doi: 10.1152/ ajprenal.00340.2016. Epub 2016 Oct 5. PMID: 27707707. PubMed

[23] Laakso M and Kuusisto J (2014). Insulin resistance and hyperglycemia in cardiovascular disease development. Nat Rev Endocrinol. 10(5):293–302. doi: 10.1038/ nrendo.2014.29. Epub 2014 Mar 25. PMID: 24663222. PubMed

[24] Pérez-Morales RE, Del Pino MD, Valdivielso JM, Ortiz A, Mora-Fernández C, Navarro-González JF (2019). Inflammation in diabetic kidney disease. Nephron. 143(1):12–6. doi: 10.1159/000493278. Epub 2018 Oct 1. PMID: 30273931. PubMed

[25] Kojta I, Chacińska M, Błachnio-Zabielska A (2020). Obesity, bioactive lipids, and adipose tissue inflammation in insulin resistance. Nutrients. 12(5):1305. doi: 10.3390/ nu12051305. PMID: 32375231; PMCID: PMC7284998. PubMed

[26] Fritz J, Brozek W, Concin H, Nagel G, Kerschbaum J, Lhotta K, et al. (2021). The Triglyceride-Glucose Index and Obesity-Related Risk of End-Stage Kidney Disease in Austrian Adults. JAMA Netw Open. 4(3):e212612. doi: 10.1001/ jamanetworkopen.2021.2612. PMID: 33787913; PMCID: PMC8013829. PubMed

[27] Wang X, Liu J, Cheng Z, Zhong Y, Chen X, Song W (2021). Triglyceride glucose-body mass index and the risk of diabetes: a general population-based cohort study. Lipids Health Dis. 2021 Sep 6;20(1):99. doi: 10.1186/s12944-021-01532-7. PMID: 34488806; PMCID: PMC8420033. PubMed

[28] Er LK, Wu S, Chou HH, Hsu LA, Teng MS, Sun YC (2016). Triglyceride Glucose-Body Mass Index Is a Simple and Clinically Useful Surrogate Marker for Insulin Resistance in Nondiabetic Individuals. PLoS One. 2016 Mar 1;11(3):e0149731. doi: 10.1371/journal.pone.0149731. PMID: 26930652; PMCID: PMC4773118. PubMed

[29] Locateli JC, Lopes WA, Simões CF, de Oliveira GH, et al. (2019) Triglyceride/glucose index is a reliable alternative marker for insulin resistance in South American overweight and obese children and adolescents. J Pediatr Endocrinol Metab. 32(10):1163-1170. doi: 10.1515/jpem-2019-0037. PMID: 31472061. [DOI] [PubMed] [Google Scholar]

[30] Mu X, Wu A, Hu H, Yang M, Zhou H (2023). Correlation between alternative insulin resistance indexes and diabetic kidney disease: a retrospective study. Endocrine.84(1):136-147. doi: 10.1007/s12020-023-03574-6. Epub 2023 Oct 31. PMID: 37906402. [PubMed]

[31] Xu X, Tang X, Che H, Guan C, Zhao N, Fu S, Liu L, et al. (2021). [Triglyceride-glucose product is an independent risk factor for predicting chronic kidney disease in middle-aged and elderly population: a prospective cohort study]. Nan Fang Yi Ke Da Xue Xue Bao. 41(11):1600-1608. Chinese. doi: 10.12122/j.issn.1673-4254.2021.11.02. PMID: 34916184; PMCID: PMC8685706. [PubMed]

[32] Cha E, Pasquel FJ, Yan F, Jacobs DR Jr, Dunbar SB, Umpierrez G, et al. (2021). Characteristics associated with early- vs. later-onset adult diabetes: the CARDIA study. Diabetes Res Clin Pract. 182:109144. doi: 10.1016/j.diabres.2021.109144. Epub 2021 Nov 11. PMID: 34774915; PMCID: PMC8688278. [PubMed]

[33] Jiang W, Wang J, Shen X, Lu W, Wang Y, Li W, et al. (2020). Establishment and Validation of a Risk Prediction Model for Early Diabetic Kidney Disease Based on a Systematic Review and Meta-Analysis of 20 Cohorts. Diabetes Care. 43(4):925–933. doi: 10.2337/ dc19-1897. PMID: 32198286. [PubMed]