Postprint: Association of the Fasting C-Peptide to Diabetes Duration Ratio with Metabolic Dysfunction-Associated Fatty Liver Disease in Type 2 Diabetes Mellitus

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Date: 2025-04-11T09:09:39+00:00

Abstract

Background Type 2 diabetes mellitus (T2DM) is the most common form of diabetes. The incidence of metabolic dysfunction-associated fatty liver disease (MAFLD) is higher in T2DM patients than in non-diabetic individuals; therefore, identifying effective predictive indicators for MAFLD development in T2DM patients is of great significance.

Objective To investigate the predictive value of the fasting C-peptide to diabetes duration ratio (FCP/DD) for MAFLD development in T2DM patients, and to provide a predictive indicator for the early prevention and treatment of MAFLD.

Methods A total of 532 T2DM patients admitted to the Department of Endocrinology, Hebei General Hospital from September 2018 to December 2021 were selected. General patient data were collected, fasting blood samples were drawn to detect biochemical indicators, and FCP/DD was calculated according to the formula. Based on whether T2DM patients developed MAFLD, patients were divided into the MAFLD group (n=359) and the non-MAFLD group (n=173). According to the median FCP/DD ratio, study subjects were divided into the low FCP/DD group (n=266) and the high FCP/DD group (n=266). Spearman rank correlation and Logistic regression analysis were used to explore the association between the FCP/DD ratio and MAFLD development in T2DM patients, and receiver operating characteristic (ROC) curves were constructed and the area under the curve (AUC) was calculated to investigate the value of the FCP/DD ratio in predicting MAFLD development in T2DM patients.

Results The FCP/DD was higher in the MAFLD group than in the non-MAFLD group ($P<0.05$). The incidence of MAFLD was higher in the high FCP/DD group than in the low FCP/DD group ($P<0.05$). Spearman rank correlation analysis showed that in T2DM patients with MAFLD, FCP/DD

was negatively correlated with age and high-density lipoprotein cholesterol (HDL-C), and positively correlated with BMI, fasting blood glucose (FBG), glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), serum uric acid (SUA), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and triglyceride-glucose index (TyG) ($P<0.05$). Multivariate Logistic regression analysis showed that after adjusting for confounding factors, high-level FCP/DD was an independent risk factor for MAFLD development in T2DM patients ($P<0.05$). ROC curve results showed that the AUC of FCP/DD for predicting MAFLD development in T2DM patients was 0.829 (0.791~0.867), the AUC of FCP was 0.758 (95%CI=0.711~0.805), the AUC of HbA1c was 0.525 (0.471~0.578), and the AUC of TyG was 0.733 (95%CI=0.689~0.778).

Conclusion FCP/DD levels were elevated in the T2DM with MAFLD group. T2DM patients with high FCP/DD levels had a higher risk of developing MAFLD. FCP/DD demonstrated better predictive value for MAFLD in T2DM patients compared with FCP, HbA1c, and TyG.

Full Text

Correlation Between the Fasting C-Peptide to Diabetes Duration Ratio and Type 2 Diabetes Mellitus Complicated with Metabolic-Associated Fatty Liver Disease

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is the most common form of diabetes, and the incidence of metabolic-associated fatty liver disease (MAFLD) is significantly higher in T2DM patients than in non-diabetic individuals. Identifying effective predictive indicators for MAFLD development in T2DM patients is therefore of great clinical importance.

Objective: To investigate the predictive value of the fasting C-peptide to diabetes duration ratio (FCP/DD) for MAFLD occurrence in T2DM patients, and to provide a predictive indicator for the early prevention and management of MAFLD.

Methods: A total of 532 T2DM patients admitted to the Department of Endocrinology at Hebei Provincial People' s Hospital between September 2018 and December 2021 were enrolled. General patient data were collected, and fasting blood samples were obtained for biochemical analysis. The FCP/DD ratio was calculated using a standardized formula. Patients were divided into MAFLD (n=359) and non-MAFLD (n=173) groups based on MAFLD status, and further stratified into low FCP/DD (n=266) and high FCP/DD (n=266) groups according to the median FCP/DD value. Spearman rank correlation and logistic regression analyses were employed to examine the association between FCP/DD and MAFLD in T2DM patients. Receiver operating characteristic (ROC) curves were constructed, and the area under the curve (AUC) was calculated to evaluate the predictive efficacy of FCP/DD for MAFLD.

Results: The FCP/DD ratio was significantly higher in the MAFLD group compared to the non-MAFLD group ($P<0.05$). The incidence of MAFLD was also higher in the high FCP/DD group than in the low FCP/DD group ($P<0.05$). Spearman correlation analysis revealed that in T2DM patients with MAFLD, FCP/DD was negatively correlated with age and high-density lipoprotein cholesterol (HDL-C), and positively correlated with body mass index (BMI), fasting blood glucose (FBG), glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), serum uric acid (SUA), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and the triglyceride-glucose index (TyG) ($P<0.05$). Multivariate logistic regression analysis demonstrated that after adjusting for confounding factors, elevated FCP/DD remained an independent risk factor for MAFLD in T2DM patients ($P<0.05$). ROC curve analysis showed that the AUC for FCP/DD in predicting MAFLD was 0.829 (95% CI: 0.791–0.867), compared to 0.758 (95% CI: 0.711–0.805) for FCP alone, 0.525 (95% CI: 0.471–0.578) for HbA1c, and 0.733 (95% CI: 0.689–0.778) for TyG.

Conclusion: FCP/DD levels are significantly elevated in T2DM patients with MAFLD. Higher FCP/DD levels are associated with increased MAFLD risk. The FCP/DD ratio demonstrates superior predictive value compared to FCP, HbA1c, and TyG for identifying MAFLD in T2DM patients.

Keywords: Type 2 diabetes mellitus; Metabolic-associated fatty liver disease; Fasting C-peptide; Diabetes duration; Insulin resistance; Triglyceride-glucose index

Introduction

Type 2 diabetes mellitus (T2DM) accounts for 90–95% of all diabetes cases and is characterized by insulin resistance (IR) combined with inadequate or relative insulin secretion deficiency. Recent epidemiological surveys indicate that the prevalence of diabetes among Chinese adults has reached 11.2% and continues to rise annually. Metabolic-associated fatty liver disease (MAFLD) is the most

common cause of chronic liver disease, with research demonstrating that hepatic steatosis is associated with metabolic dysregulation caused by IR and represents the hepatic manifestation of metabolic syndrome. A recent meta-analysis revealed that the prevalence of MAFLD in T2DM patients, characterized by IR, is more than double that in non-diabetic individuals. Therefore, identifying effective predictive indicators for MAFLD development in T2DM patients is of significant clinical importance.

Current methods for assessing MAFLD risk in T2DM include the homeostatic model assessment of insulin resistance (HOMA-IR) and the triglyceride-glucose index (TyG). However, both indicators are influenced by fasting glucose levels, which can be affected by diet, medication, exercise, and other factors, potentially leading to clinical misinterpretation of IR. Previous studies have shown that fasting C-peptide (FCP) is associated with MAFLD development, and diabetes duration (DD) also correlates with MAFLD occurrence. We hypothesized that the ratio of FCP to DD (FCP/DD) might demonstrate a stronger correlation with MAFLD and offer greater predictive value than either FCP or DD alone. This study therefore established a novel model using the FCP/DD ratio to explore its relationship with MAFLD and compared its predictive value against indicators such as TyG.

Methods

1.1 Study Subjects

We enrolled 532 T2DM patients admitted to the Department of Endocrinology at Hebei Provincial People' s Hospital between September 2018 and December 2021. The cohort comprised 335 males (63.0%) and 197 females (37.0%), aged 20–88 years with a mean age of 55.1 $\pm$ 0.5 years and a median age of 55 years. Among these patients, 359 (67.5%) were diagnosed with MAFLD. All included T2DM patients met the 1999 WHO diagnostic criteria for T2DM: (1) classic diabetes symptoms (polydipsia, polyuria, polyphagia, unexplained weight loss) plus random plasma glucose $\geq$ 11.1 mmol/L; (2) fasting plasma glucose $\geq$ 7.0 mmol/L; or (3) 2-hour plasma glucose $\geq$ 11.1 mmol/L during an oral glucose tolerance test.

Exclusion criteria were: (1) non-T2DM diabetes (type 1 diabetes, specific types of diabetes, gestational diabetes); (2) age $<$ 18 years; (3) acute diabetic complications (diabetic ketoacidosis, hyperosmolar hyperglycemic state, hypoglycemic coma); (4) hepatitis, liver cirrhosis, hepatic encephalopathy, or history of liver surgery; (5) severe hepatic or renal insufficiency, acute cardiovascular or cerebrovascular disease, acute infection, stress status, or malignant tumors; and (6) pregnancy or lactation.

1.2 Data Collection

1.2.1 General Data and Physical Measurements A dedicated endocrinology medical team collected comprehensive patient information, including age,

sex, diabetes duration, smoking and alcohol consumption habits, and medical history. Height and body weight were measured using professional equipment.

1.2.2 Laboratory Measurements Fasting blood samples (3 tubes, 4–5 mL each) were collected by trained professionals on the morning following admission. All biochemical parameters, including total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), fasting C-peptide (FCP), fasting blood glucose (FBG), aspartate aminotransferase (AST), alanine aminotransferase (ALT), serum uric acid (SUA), serum creatinine (SCr), and albumin (ALB), were measured using the hospital' s automated biochemical analyzer. Glycated hemoglobin (HbA1c) was determined by high-performance liquid chromatography with cation exchange at the hospital' s endocrinology laboratory. The following indices were calculated: FCP/DD = FCP (ng/mL) / DD (years), BMI = weight (kg) / height^2 (m^2), and TyG = ln[TG (mg/dL) × FBG (mg/dL) / 2].

1.2.3 Grouping Methods For cases diagnosed before 2020, MAFLD was identified based on imaging evidence of hepatic steatosis (ultrasound, CT, or MRI) combined with T2DM diagnosis. For cases from 2020 onward, MAFLD diagnosis followed the 2020 International Expert Consensus on metabolic dysfunction-associated fatty liver disease, requiring evidence of hepatic steatosis from histology, non-invasive biomarkers, or imaging, plus at least one of three criteria: overweight/obesity, T2DM, or metabolic dysregulation. Patients were stratified into MAFLD and non-MAFLD groups, and further divided into low FCP/DD and high FCP/DD groups based on the median FCP/DD value.

1.3 Statistical Analysis

Data were compiled using Excel and analyzed with SPSS version 25.0. Normally distributed continuous variables were expressed as mean ± standard deviation and compared using independent samples t-test or one-way ANOVA. Non-normally distributed variables were presented as median (P25, P75) and compared using Mann-Whitney U test. Categorical data were analyzed using ^{2} test. Correlations were assessed with Pearson or Spearman rank correlation analysis. Univariate and multivariate logistic regression analyses were performed to explore the relationship between FCP/DD and MAFLD risk. ROC curves were constructed to evaluate the predictive value of FCP/DD for MAFLD in T2DM patients. Statistical significance was defined as $P < 0.05$.

Results

2.1 Comparison of Clinical Characteristics Between MAFLD and Non-MAFLD Groups

No significant differences were observed between groups in alcohol consumption, HbA1c, or SCr levels ($P > 0.05$). However, the MAFLD group was significantly

younger, had shorter diabetes duration, and exhibited higher proportions of males and smokers, along with elevated BMI, FCP, FBG, SUA, TC, TG, LDL-C, ALT, AST, ALB, FCP/DD, and TyG levels compared to the non-MAFLD group. HDL-C levels were significantly lower in the MAFLD group ($P < 0.05$ for all comparisons) .

2.2 Comparison Based on FCP/DD Levels

The FCP/DD ratio among all 532 patients ranged from 0.0004 to 332.3077, with a median value of 0.3325. Using this median cutoff, patients were divided into low FCP/DD (n = 266) and high FCP/DD (n = 266) groups. No significant differences were found between these groups in sex distribution, smoking status, alcohol consumption, or SCr levels ($P > 0.05$). The high FCP/DD group was significantly younger, had shorter diabetes duration, and showed higher BMI, FCP, FBG, HbA1c, SUA, TC, TG, LDL-C, ALT, AST, ALB, TyG, and MAFLD prevalence compared to the low FCP/DD group. HDL-C levels were significantly lower in the high FCP/DD group ($P < 0.05$ for all comparisons) .

2.3 Correlation Analysis

Spearman rank correlation analysis revealed that in T2DM patients with MAFLD, FCP/DD was negatively correlated with age ($r = -0.336$, $P < 0.001$) and HDL-C ($r = -0.107$, $P = 0.043$), and positively correlated with BMI ($r = 0.178$, $P < 0.001$), FBG ($r = 0.194$, $P < 0.001$), HbA1c ($r = 0.227$, $P < 0.001$), TC ($r = 0.115$, $P = 0.029$), TG ($r = 0.130$, $P = 0.014$), LDL-C ($r = 0.137$, $P = 0.009$), SUA ($r = 0.105$, $P = 0.048$), AST ($r = 0.281$, $P < 0.001$), ALT ($r = 0.339$, $P < 0.001$), and TyG ($r = 0.187$, $P < 0.001$). No significant correlations were observed with ALB ($r = 0.608$, $P = 0.200$) or SCr ($r = -0.088$, $P = 0.095$). In T2DM patients without MAFLD, FCP/DD was negatively correlated with HDL-C ($r = -0.158$, $P = 0.037$) and positively correlated with TC ($r = 0.159$, $P = 0.037$), TG ($r = 0.217$, $P = 0.004$), LDL-C ($r = 0.206$, $P = 0.007$), ALB ($r = 0.201$, $P = 0.008$), and TyG ($r = 0.209$, $P = 0.006$). No significant correlations were found with other variables.

2.4 Univariate Logistic Regression Analysis

Using MAFLD status (yes = 1, no = 0) as the dependent variable and age, sex (male = 1, female = 2), diabetes duration, smoking status (yes = 1, no = 0), alcohol consumption status (yes = 1, no = 0), FBG, HbA1c, FCP, TC, TG, LDL-C, HDL-C, SUA, SCr, AST, ALT, ALB, TyG, and FCP/DD as independent variables, univariate logistic regression analysis identified age, sex, diabetes duration, smoking status, FBG, FCP, TC, TG, LDL-C, HDL-C, SUA, SCr, AST, ALT, ALB, TyG, and FCP/DD as influencing factors for MAFLD in T2DM patients ($P < 0.05$) .

2.5 Multivariate Logistic Regression Analysis

Four models were constructed to assess the impact of FCP/DD on MAFLD risk in T2DM patients. Model 1 (crude model) showed FCP/DD was a significant influencing factor ($P < 0.001$). Model 2, adjusted for age, sex, BMI, smoking, and alcohol consumption, confirmed FCP/DD as an independent predictor ($P < 0.001$). Model 3 further adjusted for TC, TG, HDL-C, LDL-C, AST, ALT, SUA, and ALB, with FCP/DD remaining significant ($P < 0.001$). Model 4 additionally adjusted for FBG, HbA1c, and TyG, and demonstrated that elevated FCP/DD was still an independent risk factor for MAFLD in T2DM patients ($P < 0.001$) .

2.6 Predictive Value of FCP/DD

ROC curve analysis showed that FCP/DD predicted MAFLD in T2DM patients with an AUC of 0.829 (95% CI: 0.791–0.867), an optimal cutoff value of 0.205, sensitivity of 0.825, and specificity of 0.663. In comparison, FCP alone yielded an AUC of 0.758 (95% CI: 0.711–0.805), TyG achieved an AUC of 0.733 (95% CI: 0.689–0.778), while HbA1c showed no predictive value (AUC = 0.525, 95% CI: 0.471–0.578) , [Figure 1: see original paper].

Discussion

With rapid economic development, lifestyle changes, and the obesity epidemic, MAFLD has become the most prevalent liver disease and a leading cause of chronic liver disease worldwide. MAFLD is a chronic liver condition associated with metabolic abnormalities, affecting approximately 25% of the general population and over 50% of individuals with metabolic disorders. Characterized by hepatic steatosis, MAFLD can progress to metabolic-associated steatohepatitis, fibrosis, cirrhosis, and even hepatocellular carcinoma. Oxidative stress and insulin resistance appear to be central mechanisms in its pathogenesis. Studies have reported that T2DM patients face an elevated risk of developing MAFLD, with an even higher risk of progressing to steatohepatitis and fibrosis. As the incidence of both T2DM and MAFLD continues to rise rapidly, these metabolic diseases represent a major public health concern requiring urgent attention.

Liver biopsy remains the gold standard for diagnosing MAFLD, but its invasive nature, poor patient acceptance, and high cost limit its clinical utility. Consequently, developing non-invasive diagnostic methods is imperative. Serum biomarkers, particularly when combined with other clinical indicators, offer a convenient, cost-effective, and accurate approach for disease screening and risk stratification.

T2DM and MAFLD are clinically intertwined, with insulin resistance serving as a common pathophysiological feature. In the setting of IR, reduced HDL-C is an early manifestation of T2DM pathogenesis and is also associated with MAFLD development, potentially acting as a bridge between the two conditions. Both diseases share similar pathogenic mechanisms, including impaired

hepatic and peripheral insulin action, reduced lipoprotein lipase activity, and increased inflammatory responses in various tissues, along with gut-derived endotoxemia, enhanced oxidative stress, and mitochondrial dysfunction. Insulin resistance plays a pivotal role in the interplay between these conditions, representing the most important driver of liver inflammation and fibrosis in MAFLD and interacting with abnormal glucose and lipid metabolism to promote disease progression.

Recent studies have highlighted that non-alcoholic fatty liver disease (NAFLD), now termed MAFLD, is common in T2DM patients due to the frequent coexistence of IR and obesity. The reported prevalence of MAFLD in T2DM patients ranges from 21% to 78%, with our study finding a prevalence of 67.5%, consistent with previous reports. Beyond hyperglycemia, T2DM patients typically exhibit severe disruption of lipid homeostasis, manifested by elevated circulating free fatty acid (FFA) levels. Hepatic fat deposition can induce IR and increase blood glucose, leading to T2DM, while IR promotes excessive hepatic fat accumulation, oxidative damage, and inflammation, ultimately progressing to cirrhosis and hepatocellular carcinoma.

The relationship between IR, MAFLD development, and serum glucose concentration is bidirectional. Increased circulating glucose and insulin stimulate sterol regulatory element-binding protein 1c-induced lipogenic enzymes, enhancing de novo lipogenesis and increasing endogenous triglyceride production. Additionally, impaired suppression of adipose tissue lipolysis in IR states elevates hepatic fatty acid influx, further increasing TG accumulation and promoting MAFLD development and progression. Consistent with this mechanism, our study found significantly higher TG levels in T2DM patients with MAFLD compared to those without.

Researchers have utilized simple, readily available indicators to assess IR. Fasting C-peptide has gained clinical attention as it can be used in HOMA models to estimate IR, with elevated FCP levels often indicating IR in hyperglycemic states. Previous studies have demonstrated that FCP serves as a convenient predictor of IR. Li et al. found that increasing FCP levels were associated with higher total fat mass, fat mass percentage, and fat-to-lean mass ratio, along with decreased lean body mass percentage. Ren et al. reported that T2DM patients with NAFLD had significantly higher FCP and HOMA-IR values than those without NAFLD, suggesting greater IR in T2DM-NAFLD patients. Our findings align with these results, showing significantly elevated FCP in MAFLD patients. Additionally, previous research has indicated that T2DM patients with MAFLD have shorter diabetes duration than those without MAFLD, suggesting that more pronounced IR in the early stages of T2DM may predispose to MAFLD development.

Given the high risk of MAFLD in T2DM patients, identifying simple and rapid predictive methods is crucial for early prevention. This study is the first to combine FCP with diabetes duration to create a more specific indicator (FCP/DD) for T2DM-MAFLD association. Our results demonstrate that FCP/DD is sig-

nificantly higher in MAFLD patients, and that higher FCP/DD ratios correlate with increased MAFLD incidence. After adjusting for potential confounders, elevated FCP/DD remained an independent risk factor for MAFLD, with higher ratios demonstrating greater predictive value. This reinforces the notion that IR is a key factor in MAFLD pathogenesis.

The finding that T2DM patients with shorter diabetes duration had higher MAFLD risk may reflect that patients with recently diagnosed diabetes have had less time to implement lifestyle modifications and optimal medical management. Once diagnosed with T2DM and aware of its complications, patients may adopt healthier behaviors, regular medication use, and improved dietary and exercise habits, which over time may ameliorate or even reverse hepatic steatosis.

Our study also found a higher proportion of males in the MAFLD group, consistent with previous reports of increased MAFLD risk in men, possibly related to differences in lifestyle habits or the protective effects of estrogen on hepatic fat. Additionally, MAFLD patients had higher FBG levels, and the high FCP/DD group showed elevated FBG compared to the low FCP/DD group, confirming that intensive glycemic control can delay MAFLD onset and progression, further underscoring the close relationship between T2DM and MAFLD.

Regarding lipid metabolism, MAFLD patients exhibited higher TC, LDL-C, and VLDL levels with lower HDL-C compared to non-MAFLD patients. After stratification by FCP/DD median, the high FCP/DD group showed more pronounced dyslipidemia. Impaired apolipoprotein B-100 synthesis in fatty liver may be related to elevated FFA levels, redox imbalance, hyperinsulinemia, and reduced expression, which hinder VLDL assembly and promote hepatic lipid accumulation. High HDL-C indicates efficient cholesterol utilization and represents a healthy metabolic state, while reduced HDL-C may contribute to MAFLD development and progression. Therefore, intensive lipid management in T2DM patients may help prevent MAFLD complications.

We also observed significantly higher SUA levels in MAFLD patients, with the high FCP/DD group showing greater SUA elevation. Hyperuricemia is an independent risk factor for MAFLD in Chinese adults. Elevated SUA promotes IR-mediated visceral fat accumulation and directly upregulates lipogenic proteins while downregulating lipolytic proteins in adipocytes, inducing TG accumulation. Additionally, uric acid promotes conversion of citrate to acetyl-CoA for de novo lipogenesis, increasing circulating FFAs that further convert to TG and exacerbate visceral obesity. Hyperuricemia also triggers inflammatory responses, endothelial dysfunction, and activates the renin-angiotensin system, contributing to cardiovascular and renal complications. Since MAFLD patients have higher future risks of cardiovascular disease and chronic kidney disease, SUA management in T2DM patients may prevent not only MAFLD but also other complications.

The TyG index, representing elevated TG and/or FBG levels, has been associated with increased MAFLD risk in Iranian populations. Our results align with

these findings, showing higher TyG indices in MAFLD patients and in the high FCP/DD group. From a mechanistic perspective, IR explains the link between TyG and MAFLD, as reduced glucose uptake in adipose and muscle tissues increases hepatic fat accumulation. Thus, identifying IR markers is crucial for early MAFLD prevention.

ALT and AST are indicators of hepatocellular injury, with ALT being the most sensitive. Studies have identified ALT as an independent risk factor for MAFLD in both obese and non-obese populations. Data from the Third National Health and Nutrition Examination Survey demonstrated significant associations between elevated ALT, IR, and T2DM. Kim et al. found a significant positive correlation between ALT and IR even after adjusting for confounders. Our study found significantly elevated ALT and AST in MAFLD patients, likely resulting from fatty acid infiltration and inflammatory stimulation. Notably, while MAFLD patients had higher transaminase levels, both groups' averages remained below conventional upper limits, suggesting that current reference ranges may need revision, as they were established approximately 25 years ago when some "healthy" individuals may have had undiagnosed MAFLD.

ROC curve analysis demonstrated that FCP/DD had the highest predictive value for MAFLD in T2DM patients (AUC = 0.829), outperforming FCP (AUC = 0.758), TyG (AUC = 0.733), and HbA1c (no predictive value). With an optimal cutoff of 0.205, FCP/DD achieved 82.5% sensitivity and 66.3% specificity. These findings indicate that FCP/DD, derived from routine biochemical parameters without requiring specialized or expensive tests, provides a simple, feasible method for early MAFLD risk identification in clinical practice.

However, this study has several limitations. First, its cross-sectional design precludes establishing causality. Second, the focus on Chinese adult T2DM patients may limit generalizability, as MAFLD diagnostic criteria based on BMI and waist circumference vary across populations. Third, as with all observational studies, unmeasured or unknown confounding factors may exist.

Conclusion

In summary, FCP/DD levels are significantly elevated in T2DM patients with MAFLD compared to those without. Higher FCP/DD ratios are associated with increased MAFLD incidence, and elevated FCP/DD represents an independent risk factor for MAFLD in T2DM patients. The FCP/DD ratio demonstrates superior predictive value compared to FCP, HbA1c, and TyG for identifying MAFLD in T2DM patients. Therefore, FCP/DD can serve as a simple and effective predictive indicator to facilitate early identification and prevention of MAFLD development.

Author Contributions: LIU Yueying conceived the study, designed the research protocol, and drafted the manuscript. WANG Xueli managed references, formatted the document, and performed data analysis. LIU Yuqiu collected and

analyzed data. WEI Limin revised the final manuscript and takes responsibility for the overall work.

Conflict of Interest Statement: The authors declare no conflicts of interest.

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Received: August 13, 2024; Revised: February 20, 2025
Edited by: JIA Mengmeng

Note: Figure translations are in progress. See original paper for figures.