

Triglyceride to high-density lipoprotein cholesterol ratio is associated with incident diabetes in men: A retrospective study of Chinese individuals

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Keywords

Chinese male, Incident diabetes, Triglyceride : high-density lipoprotein cholesterol ratio

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J Diabetes Investig 2020; 11: 192–198

doi: 10.1111/jdi.13087

ABSTRACT

Aims/Introduction: Dyslipidemia is commonly present in type 2 diabetes mellitus patients. Recently, the triglyceride : high-density lipoprotein cholesterol (TG/HDL-C) ratio, a novel parameter of lipid abnormality, has been seen as an independent predictor for incident diabetes. However, the correlation of the TG/HDL-C ratio with incident diabetes in the Chinese population and how this relationship is impacted by sex have been rarely studied. In the present study, the correlation of the TG/HDL-C ratio with incident diabetes is investigated between different sexes of the Chinese population.

Materials and Methods: A total of 116,855 participants who were free of diabetes at baseline were enrolled in the study. The participants were grouped by the median value (0.82) of the TG/HDL-C ratio. Then, participants were further analyzed according to their sex. Cumulative incidence and person-years incidence were used to express the incidence rate. The predictive value of the TG/HDL-C ratio for incident diabetes was probed by the Cox regression proportional hazards model.

Results: The mean age of the participants was 44.1 ± 12.9 years, and 53% of participants ($n = 62,868$) were the men. A total of 2,685 incident diabetes cases occurred during the 3.1 years of the median follow-up period. The cumulative incidence in total incident diabetes patients, men and women was 2.30% (2.21–2.38%), 3.01% (2.87–3.14%) and 1.47% (1.37–1.57%), respectively. After the adjustment of multivariate factors, the multivariate Cox regression analysis results showed that a higher TG/HDL-C ratio was the independent predictive factor of incident diabetes in men (hazard ratio 1.30, 95% confidence interval 1.03–1.64), compared with women (hazard ratio 0.85, 95% confidence interval 0.53–1.38).

Conclusions: Among the Chinese population, the TG/HDL-C ratio is an independent predictor for incident diabetes in male patients.

INTRODUCTION

Owing to the aging and growth of the global population, and the changes in lifestyles and dietary patterns, the ratio of people with diabetes mellitus is rapidly increasing. Therefore, diabetes mellitus is seen as a major public health issue around the world¹. In 2017, there were 425 million of adults with diabetes worldwide, among which China had reached up to

111.4 million². It has been showed that diabetes is one of the major causes of mortality, especially in regard to cardiovascular disease^{3,4}. Therefore, the identification and management of the subgroups with high risks of diabetes would have cost-effective and significant benefits. To achieve better risk stratification, a novel, exact and readily measured indicator is required.

Dyslipidemia, the common risk factor of diabetes mellitus, is represented by higher triglycerides (TG) content, lower high-density lipoprotein cholesterol (HDL-C) levels, as well as the

Received 25 March 2019; revised 4 May 2019; accepted 25 May 2019

predominance of small dense low-density lipoprotein (LDL) particles^{5,6}. Compared with other individual lipids, the TG : HDL-C (TG/HDL-C) ratio is proven to be the better predictive index for insulin resistance and diabetes⁷⁻¹⁰. Furthermore, some evidence has shown that the TG/HDL-C ratio is applicable to predict cardiovascular events, hypertension, incident fatty liver, chronic kidney disease and all-cause mortality¹¹⁻¹⁷.

However, previous studies regarding the correlation of the TG/HDL-C ratio with incident diabetes between different the sexes have shown some conflicting results. Vega *et al.* reported that the TG/HDL-C ratio is used to predict the risks of diabetes mellitus in men¹⁸, whereas some studies showed that high a TG/HDL-C ratio is linked with diabetes only in the women¹⁹. To our knowledge, the effect of the TG/HDL-C ratio on incident diabetes among the Chinese population and how this correlation is impacted by sex have rarely been reported²⁰. The present study was designed to clarify the association of the TG/HDL-C ratio with diabetes between different the sexes among Chinese people.

METHODS

Study population and design

The clinical data of the population we studied were obtained from a public database (<https://datadryad.org>), which was offered by Chen *et al.*^{21,22}. The research ethics approval was obtained in the previous study and was no longer required for the present study. The participants were aged at least 20 years, with at least two visits for a physical examination between 2010 and 2016. Follow up started from the completion of the health examination in 2006, and the end of follow up was either the occurrence of diabetes or 31 December 2016. In this retrospective cohort study, those who met the following criteria at baseline were excluded: (i) participants with incomplete clinical data; (ii) extreme body mass index (BMI) ($<15 \text{ kg/m}^2$ or $>55 \text{ kg/m}^2$); (iii) visit intervals <2 years; (iv) diabetes at baseline (diagnosed by self-report and fasting plasma glucose $\geq 7.0 \text{ mmol/L}$); and (v) undefined diabetes status at the follow-up visit. A total of 116,855 participants (62,868 men, 53.8%) took part in the research. The selection process of the participants was specifically explained previously²¹.

Data acquisition

Baseline examinations were carried out, as described previously. Briefly, the trained staff would use the standardized spreadsheet to obtain the participant's general data, such as sex, age, site, drinking status, family history of diabetes, smoking status, height, weight, systolic blood pressure (SBP) and diastolic blood pressure (DBP), were collected and measured by a physician. BMI was calculated as $\text{weight} / \text{height}^2$ with the unit of kg/m^2 . Smoking status was defined as: former smoker, current smoker and never smoker. Drinking status was defined as: former drinker, current drinker and never drinker. At each visit, the trained investigators would collect the laboratory parameters for

the participants under the fasting condition. Serum total cholesterol, TG, HDL-C, LDL cholesterol (LDL-C) and plasma glucose levels were measured on an autoanalyzer (AU5800; Beckman Coulter, Brea, CA, USA).

Definitions

Diagnosis criteria for incident diabetes were defined as fasting plasma glucose (FPG) of 7.00 mmol/L at least and/or application of insulin or oral hypoglycemic medication and/or a self-reported history of diabetes²³. The TG/HDL-C ratio was counted by serum TG (mmol/L) : HDL-C concentration (mmol/L) ratio.

Statistical analysis

According to normal and abnormal distribution, continuous variables are described as the mean \pm standard deviation or median (quartile), and then compared through one-way ANOVA and a non-parametric test for abnormal and normal distribution data, respectively. The categorical variables are expressed as absolute number and percentage, and then compared by the χ^2 -test. In order to make contrasts on the baseline features, the cohort was assigned to two groups by the median value (0.82) of the TG/HDL-C ratio, namely, high the TG/HDL-C ratio (≥ 0.82) group and low TG/HDL-C ratio (<0.82) group. At the same time, sex differences in baseline data were analyzed. The incidence rate of incident diabetes was counted as a whole and then compared by the log-rank test. The incidence rate was described by cumulative incidence and person-years incidence. The Cox proportional hazards regression model was applied to analyze the correlation of the TG/HDL-C ratio with incident diabetes by regulating the covariates that were found to be significantly different in the univariate analysis. The *P*-values and hazard ratios with 95% confidence intervals were recorded. For the potential effects of sex in TG/HDL-C ratio, using different cut-points of the TG/HDL-C ratio by sex (1.14 in men, 0.92 in women), the sex-stratified multivariate Cox regression proportional hazards model was carried out on the adjustment of the covariates. All of the models would be adjusted for none (model 1), age (model 2), age, BMI, FPG, TG, HDL-C, endogenous creatinine clearance rate (CCR), blood urea nitrogen (BUN), smoking status and family history of diabetes (model 3). Statistical analyses were made by SPSS Statistics version 23.0 (SPSS Inc., Chicago, IL, USA) and SAS System version 9.4 (SAS Institute, Cary, NC, USA). *P* < 0.05 (two tailed) was considered to show a statistically significant difference.

RESULTS

Baseline features and population studied

In the present study, a total of 116,855 participants without diabetes at baseline were enrolled. The population we had studied was at a mean age of 44.08 years, and 53.8% of the subjects were men. The basic physical measurements, laboratory examinations and other parameters are shown in Table 1. Participants were stratified into two groups according to the median

Table 1 | Baseline characteristics of 116,855 participants

Characteristics	All participants	TG/HDL-C ratio		P-value
		Low, <0.8163	High, ≥0.8163	
<i>n</i> (%)	116,855	58,412 (50.0)	58,443 (50.0)	–
Age (years)	44.08 ± 12.93	41.67 ± 12.30	46.49 ± 13.09	<0.001
Male, <i>n</i> (%)	62,868 (53.8)	21,974 (37.6)	40,894 (70.0)	<0.001
Height (cm)	116.29 ± 8.31	164.66 ± 7.99	167.92 ± 8.31	<0.001
Weight (kg)	64.88 ± 12.11	59.82 ± 10.19	69.93 ± 11.76	<0.001
BMI (kg/m ²)	23.35 ± 3.30	21.99 ± 2.86	24.71 ± 3.14	<0.001
SBP (mmHg)	119.42 ± 16.68	115.44 ± 15.70	123.41 ± 16.68	<0.001
DBP (mmHg)	74.44 ± 10.98	71.71 ± 10.25	77.16 ± 11.00	<0.001
FPG (mmol/L)	4.95 ± 0.61	4.85 ± 0.56	5.04 ± 0.64	<0.001
TC (mmol/L)	4.79 ± 0.90	4.61 ± 0.83	4.97 ± 0.93	<0.001
TG (mmol/L)	1.10 (0.76–1.66)	0.77 (0.60–0.93)	1.66 (1.31–2.24)	<0.001
HDL-C (mmol/L)	1.37 ± 0.31	1.52 ± 0.29	1.23 ± 0.25	<0.001
LDL-C (mmol/L)	2.77 ± 0.68	2.64 ± 0.62	2.90 ± 0.71	<0.001
ALT (U/L)	23.84 ± 21.86	18.62 ± 18.00	29.04 ± 23.96	<0.001
AST (U/L)	24.08 ± 12.54	22.29 ± 11.55	25.86 ± 13.21	<0.001
BUN (mmol/L)	4.69 ± 1.18	4.61 ± 1.19	4.76 ± 1.166	<0.001
CCR (μmol/L)	70.34 ± 15.82	66.50 ± 15.15	74.16 ± 15.54	<0.001
Smoker, <i>n</i> (%)	6,672 (5.7)	1,762 (3.0)	4,910 (8.4)	<0.001
Drinker, <i>n</i> (%)	878 (0.8)	242 (0.4)	636 (1.1)	<0.001
Family history of diabetes, <i>n</i> (%)	2,640 (2.3)	1,298 (2.2)	1,342 (2.3)	NS

Continuous variables are presented as the mean ± standard deviation (normal distribution)/median (quartile) (abnormal distribution); categorical variables are presented by the number (percentage). ALT, alanine aminotransferase; AST, aspartate transaminase; BMI, body mass index; BUN, blood urea nitrogen; CCR, endogenous creatinine clearance rate; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride; TG/HDL-C, triglyceride : high-density lipoprotein cholesterol ratio.

(0.82) value of the TG/HDL-C ratio. Compared with the low TG/HDL-C ratio group, the high TG/HDL-C ratio group had dramatically lower HDL-C levels. In addition, the levels of TG, total cholesterol, FPG, DBP, SBP, BMI, alanine aminotransferase, LDL-C, aspartate transaminase, BUN and CCR, and the percentage of men, current smokers and current drinkers in those with an increased TG/HDL-C ratio were statistically higher than those with a decreased TG/HDL-C ratio ($P < 0.001$; Table 1). As shown in Table 2, compared with women, male participants were older, had a higher TG/HDL-C ratio, lower HDL levels, and higher values of DBP, SBP, BMI, total cholesterol, TG, FPG, LDL, alanine aminotransferase, aspartate transaminase, BUN and CCR. Other covariates, such as smoking, drinking status and family history of diabetes, were also found to be significantly different between the sexes.

Incidence rate of incident diabetes

During the 3.10 years of the mean follow-up period, 2,685 patients developed incident diabetes (Table 3). The incidence rates of total incident diabetes of men and women were 741.20, 969.77 and 475.02 per 100,000 person-years, respectively. In comparison with those with a low TG/HDL-C ratio, participants with an increased TG/HDL-C ratio had a higher cumulative incidence; in addition, the cumulative incidence of total incident diabetes patients, men and women was 1.78 (1.70–

1.85), 2.46 (2.34–2.58) and 0.99 (0.90–1.07), respectively. Furthermore, men had a higher incidence rate than women (Table 3).

Association of clinical characteristics, lipid profiles, TG/HDL-C ratio and incident diabetes among the whole population

Except for drinking status, the univariate Cox analysis results showed that the age, sex, BMI, SBP, DBP, TG/HDL-C ratio, total cholesterol, TG, LDL, HDL-C, alanine aminotransferase, aspartate transaminase, BUN, CCR, family history of diabetes and smoking status were found to have an obvious correlation with diabetes ($P < 0.001$). To identify the independent predictors, significant influencing factors screened by univariate analysis were covered in the multivariate analysis, showing that age ($P < 0.001$), being male ($P = 0.041$), BMI ($P < 0.001$), TG ($P < 0.001$), HDL-C ($P = 0.001$), BUN ($P = 0.006$), CCR ($P = 0.002$), family history of diabetes ($P = 0.01$) and smoking status ($P = 0.029$) might be considered as the independent predictive markers of diabetes mellitus (Table 4).

Stratification analysis about the relationship between the TG/HDL-C ratio and incident diabetes by sex

Table 4 shows the results of multivariate Cox proportional hazards regression analysis. In model 1 and model 2 (adjust for age), a higher TG/HDL-C ratio had a significant association

Table 2 | Baseline characteristics of participants stratified by sex

Characteristics	Male	Female	P-value
n (%)	62,868 (53.8)	53,987 (46.2)	–
Age (year)	44.42 ± 13.19	43.68 ± 12.61	<0.001
Height (cm)	171.65 ± 6.24	160.06 ± 5.65	<0.001
Weight (kg)	71.75 ± 10.62	56.87 ± 8.19	<0.001
BMI (kg/m ²)	24.33 ± 3.17	22.21 ± 3.67	<0.001
SBP (mmHg)	122.99 ± 15.74	115.27 ± 16.78	<0.001
DBP (mmHg)	76.94 ± 10.76	71.52 ± 10.50	<0.001
FPG (mmol/L)	5.00 ± 0.63	4.88 ± 0.57	<0.001
TC (mmol/L)	4.81 ± 0.88	4.77 ± 0.92	<0.001
TG (mmol/L)	1.32 (0.92–1.96)	0.90 (0.65–1.30)	<0.001
HDL-C (mmol/L)	1.29 ± 0.82	1.47 ± 0.31	<0.001
LDL-C (mmol/L)	2.79 ± 0.67	2.74 ± 0.69	<0.001
TG/HDL-C	1.37 ± 1.14	0.80 ± 0.69	<0.001
ALT (U/L)	29.37 ± 23.69	17.37 ± 17.31	<0.001
AST (U/L)	25.85 ± 13.27	21.86 ± 11.17	<0.001
BUN (mmol/L)	4.94 ± 1.16	4.39 ± 1.13	<0.001
CCR (μmol/L)	80.55 ± 11.99	58.32 ± 10.42	<0.001
Smoker, n (%)	6,655 (10.6)	17 (0)	<0.001
Drinker, n (%)	861 (1.4)	17 (0)	<0.001
Family history of diabetes, n (%)	1,031 (1.6)	1,690 (3.0)	<0.001

ALT, alanine aminotransferase; AST, aspartate transaminase; BMI, body mass index; BUN, blood urea nitrogen; CCR, endogenous creatinine clearance rate; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride; TG/HDL-C, triglyceride : high-density lipoprotein cholesterol ratio.

with incident diabetes in either male or female patients. After further adjusting the significant independent predictors, such as BMI, FPG, TG, HDL-C, BUN, CCR, family history of diabetes

and smoking status in the whole population, the TG/HDL-C ratio had no significant relationship with incident diabetes in female cases (hazard ratio 0.85, 95% confidence interval 0.53–1.38), but still in male cases (hazard ratio 1.30, 95% confidence interval 1.03–1.64; Table 5).

DISCUSSION

In the present retrospective cohort study, we investigated the relationship of the TG/HDL-C ratio with incident diabetes among Chinese adults, showing that a high TG/HDL-C ratio has a positive and independent correlation with the increased risks of incident diabetes in men. In addition, we found that the incidence rate of diabetes in men was higher than that of women.

The TG/HDL-C ratio is a reproducible and inexpensive indicator, which can be readily collected during physical examination and routine clinical management. Therefore, the survey enriches the recent evidence that it can serve as a critical predictive value for diabetes. In Chinese, only a cross-sectional study including 687 adults with a 15-year follow-up period reported that increased an TG/HDL ratio increased the risk of type 2 diabetes, and another a cohort study based on rural adults analyzed a dose–response relationship between TG/HDL ratio and type 2 diabetes risk^{20,24}. A case–control study in a Singapore Chinese population also found that the TG/HDL ratio is the independent risk factor for incident diabetes²⁵. However, former studies paid more attention to the general population, and fewer studies examined gender specificity and multiple regions. To our knowledge, the present study is the first large cohort study to analyze the sex-related difference between the TG/HDL-C ratio and incident diabetes across 32 sites and 11 cities in China.

To our knowledge, men and women have different HDL-C and TG metabolism, as women are prone to have reduced TG

Table 3 | Incidence rate of incident diabetes

Group	Participants (n)	DM events (n)	Cumulative incidence (95% CI)	Per 100,000 person-years
Total DM events				
Total	116,855	2,685	2.30 (2.21–2.38)	741.20
High TG/HDL-C	58,443	2,079	1.78 (1.70–1.85)	1,140.16
Low TG/HDL-C	58,412	606	0.52 (0.48–0.56)	336.84
P-value for log–rank test	–	–	<0.001	–
DM events in men				
Total	62,868	1,890	3.01 (2.87–3.14)	969.77
High TG/HDL-C	40,894	1,545	2.46 (2.34–2.58)	1,210.92
Low TG/HDL-C	21,974	345	0.55 (0.49–0.61)	511.41
P-value for log–rank test	–	–	<0.001	–
DM events in women				
Total	53,987	795	1.47 (1.37–1.57)	475.02
High TG/HDL-C	17,549	534	0.99 (0.90–1.07)	978.43
Low TG/HDL-C	36,438	261	0.48 (0.42–0.54)	231.81
P-value for log–rank test	–	–	<0.001	–

CI, confidence interval; DM, diabetes mellitus; TG/HDL-C, triglyceride : high-density lipoprotein cholesterol ratio.

Table 4 | Univariate and multivariate Cox regression analysis for incident diabetes

Characteristics	Univariate analysis		Multivariate analysis	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Age	1.064 (1.062–1.067)	<0.001	1.070 (1.058–1.083)	<0.001
Sex	0.496 (0.456–0.539)	<0.001	0.640 (0.417–0.982)	0.041
BMI	1.222 (1.212–1.233)	<0.001	1.166 (1.119–1.216)	<0.001
SBP	1.037 (1.035–1.039)	<0.001	1.003 (0.993–1.014)	NS
DBP	1.042 (1.039–1.045)	<0.001	1.013 (0.997–1.029)	NS
TG/HDL-C	3.393 (3.099–3.714)	<0.001	1.342 (0.926–1.945)	NS
TC	1.338 (1.289–1.390)	<0.001	0.910 (0.672–1.233)	NS
TG	1.260 (1.245–1.275)	<0.001	1.168 (1.072–1.272)	<0.001
HDL-C	0.575 (0.506–0.654)	<0.001	1.897 (1.287–2.796)	0.001
LDL-C	1.348 (1.281–1.419)	<0.001	0.966 (0.672–1.388)	NS
ALT	1.004 (1.004–1.004)	<0.001	1.008 (0.998–1.017)	NS
AST	1.006 (1.005–1.007)	<0.001	0.998 (0.978–1.019)	NS
BUN	1.213 (1.182–1.244)	<0.001	1.148 (1.040–1.267)	0.006
CCR	1.007 (1.006–1.008)	<0.001	0.983 (0.972–0.994)	0.002
Smoking status	0.647 (0.599–0.700)	<0.001	0.851 (0.736–0.984)	0.029
Drinking status	0.883 (0.761–1.026)	NS		
Family history of diabetes	1.403 (1.148–1.715)	<0.001	1.952 (1.303–2.925)	0.01

ALT, alanine aminotransferase; AST, aspartate transaminase; BMI, body mass index; BUN, blood urea nitrogen; CCR, endogenous creatinine clearance rate; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride; TG/HDL-C, triglyceride : high-density lipoprotein cholesterol ratio.

Table 5 | Cox regression analysis for the association between triglyceride : high-density lipoprotein cholesterol ratio and incident diabetes by sex

Group	Model 1	Model 2	Model 3
Men			
TC/HDL-C <1.14	1	1	1
TC/HDL-C ≥1.14	2.29 (2.08–2.52)	2.16 (1.96–2.38)	1.30 (1.03–1.64)
Women			
TC/HDL-C <0.92	1	1	1
TC/HDL-C ≥0.92	4.79 (4.15–5.53)	2.56 (2.20–2.97)	0.85 (0.53–1.38)

Model 1 was stratified for triglyceride : high-density lipoprotein cholesterol (TC/HDL-C) ratio; model 2 was further adjusted for age; model 3 was further adjusted for body mass index, fasting plasma glucose, triglyceride, HDL-C, BUN, creatinine clearance rate, family history of diabetes and smoking status.

levels and elevated HDL-C levels among the general population²⁶. As shown in Table 1, 70% of men are included in those with a high TG/HDL-C ratio, which is far higher than women. Although women have a lower TG/HDL-C ratio by comparison to men²⁷, whether the ratio has a sex-related difference in regard to incident diabetes is unclear. Several studies showed that an elevated TG/HDL-C ratio can predict the development of diabetes in either male or female patients^{20,28}. According to Song *et al.*²⁹, a cross-sectional study showed that the TG/HDL-C ratio has an association with higher risks of type 2 diabetes, and this association appears to be stronger among older or postmenopausal women in Korea. Previous investigations in

the USA showed the association of the TG/HDL-C ratio with β -cell function and insulin sensitivity is the same for men and women, but the correlation with type 2 diabetes only occurred in women¹⁹. Our current sex-specific analysis is inconsistent with former studies after adjusting the confounding factors, showing a high TG/HDL-C ratio is a risk factor for diabetes development among male participants, but not in female participants. Vega *et al.*¹⁸ reported similar results. There are two possible explanations. First, the levels of triglyceride in women are dramatically influenced by the endogenous hormonal environment and exogenously administered reproductive hormones¹². Menopause caused by an insufficiency of estrogen and elevated circulating follicle-stimulating hormone levels has an association with dyslipidemia that is taken as an increased risk of metabolic syndrome and cardio-cerebrovascular disease^{30,31}. In addition, the incidence rate of hypercholesterolemia in peri-menopausal women is statistically higher than that in pre-menopausal women³². In the present study, the population we studied was widely distributed in age, 20–70 years, with an average age of 44 years in women, and the ratio of men : women was close to 1:1. However, previous reports mainly focus on women aged >50 years, whereas the proportion of men to women in the study populations was uneven^{20,25,28,29}. Second, the different population bases, follow-up time and dietary patterns will produce diversified results. Therefore, further investigations in a larger population with longer follow-up periods are required.

In the present study, higher participants with higher TG/HDL-C were inclined to be men, and we further studied the differences between baseline data for men and women. Our

results showed that other metabolic risks, such as elevated BMI, FPG and BP, were grouped in men, whose TG/HDL-C ratio were significantly higher than women. At the same time, poor living habits, such as the proportion of smoking and drinking, were much higher for men than for women. To some extent, all of the aforementioned factors might lead to the excess risk of diabetes among individuals with a higher TG/HDL-C ratio. Multivariate Cox regression results showed that most of traditional diabetes risk factors for incident diabetes are statistically significant, such as age, BMI, TG, BUN, CCR, family history of diabetes, smoking status and so on. However, traditional protective factors, such as HDL-C, have become risk factors for diabetes. He *et al*²⁴ also showed similar results. However, the specific mechanism is still unclear, but different lifestyles, dietary patterns and races regarding lipid profiles might be possible causes.

Related studies showed that the TG/HDL-C ratio might have an obvious correlation with the estimates of insulin resistance, impaired β -cell function, small dense LDL particles and higher LDL particle number that might lead to the accelerated development of type 2 diabetes^{19,33}. Because of the reliable relationship with insulin resistance, the TG/HDL-C ratio should be associated with incident diabetes. This is the reason that the TG/HDL-C ratio has a positive association with the development of incident diabetes. In other words, this elevated ratio can be taken as a target on the prevention of incident diabetes. A large-scale observational study showed that the application of fibrates drugs might lead to obviously increased HDL-C levels, and decreased TG levels and hazard ratio of diabetes mellitus³⁴.

There are still potential limitations regarding the present study. First, we missed some type 2 diabetes patients because they did not carry out an oral glucose tolerance test. Evidence showed that just 55% of new patients with diabetes are detected through fasting glucose alone in Asia³⁵. However, carrying out the oral glucose tolerance test for a large cohort is not feasible because of its operation complexity. Second, type 1 diabetes and type 2 diabetes are not distinguished in the present study. However, type 2 diabetes is the most common kind of diabetes, accounting for approximately 95% of diabetes patients. The research findings are approximately representative of type 2 diabetes³⁶. Third, we examined the lipid and other parameters only once at the baseline per participant. Because the present study was a retrospective cohort study, all variables were collected before. Therefore, other related factors, including fat distribution, weight changes, dietary patterns and physical activity, were not collected.

In summary, the present study suggests that an elevated TG/HDL ratio has an independent and positive association with the increased risks of incident diabetes in the Chinese male population. Additionally, there is a higher incidence rate in men. To search for and identify the independent risk factors in the general population is necessary for us to adopt the various prevention measures. Future studies should review whether a

decreased TG/HDL-C ratio can prevent diabetes among a large population, and detect the other risk factors.

ACKNOWLEDGMENT

We appreciate Dr Ying Chen and Professor Xiaoying Li *et al.* for sharing their scientific knowledge.

DISCLOSURE

The authors declare no conflict of interest.

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