

Association Between Different Lipid Ratios and Diabetes in Chinese Adults With H-type Hypertension

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Research

Keywords: total cholesterol, atherogenic index of plasma, triglyceride, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, hypertension, diabetes

Posted Date: December 11th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-124308/v1>

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Abstract

Background: Previous studies have shown that lipid ratios [total cholesterol (TC)/high-density lipoprotein cholesterol (HDL-C), atherogenic index of plasma (AIP, lg [triglyceride (TG)/HDL-C]), low-density lipoprotein cholesterol (LDL-C)/HDL-C, non-HDL-C/HDL-C] were associated with the risk of diabetes in non-hypertension population. However, the relationship between different lipid ratios and diabetes is unclear in the H-type hypertension population. The purpose of this study is to investigate the relationship between lipid ratios and diabetes in Chinese adults with H-type hypertension.

Methods: The current study included 13,581 H-type hypertension participants from the China hypertension registry study. Logistic regression analysis and smooth curve fitting were used to assess the association between different lipid ratios and diabetes.

Results: Prevalence of diabetes was 17.8%. All lipid ratios (TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C) were positively and independently associated with diabetes. In the fully adjusted model, AIP manifested the largest ORs of diabetes (OR:2.84, 95%CI:2.37-3.41). However, the fully adjusted ORs (95%CI) of TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C ratio was only 1.34 (1.27, 1.43), 1.40 (1.29, 1.51), 1.42 (1.35, 1.50), respectively. Comparing the area under receiver-operating characteristic curve (AUC), we found that AIP had the stronger ability to identify diabetes.

Conclusions: all lipid ratios (TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C) were independently and positively correlated with the risk of diabetes in the Chinese population with H-type hypertension. Compared with other lipid ratios (TC/HDL-C, LDL-C/HDL-C, and non-HDL-C/HDL-C), AIP was superior in discriminating diabetes.

Introduction

Diabetes is one of the major global public health problems. The ninth edition of the International Diabetes Federation report showed that the number of people with diabetes worldwide will reach 770 million in 2019, and this number would increase to 950 million by 2045.[1] As a country with a large diabetic population, Chinese diabetics reached 116.4 million in 2019. Because diabetes significantly increases the risk of cardiovascular disease (CVD) and death, approximately 4.2 million adults died as a result of diabetes or its complications in 2019, accounting for 11.3% of all-cause deaths. It was worth noting that approximate half of diabetics worldwide was undiagnosed. [1]Therefore, it is urgent to identify the risk factors of diabetes, early diagnosis, and follow-up intervention to prevent this public health epidemic. [2, 3]

Hypertension is recognized as one of the leading causes of cardiovascular disease and death worldwide. [4] H-type hypertension is defined as hypertension accompanied by plasma homocysteine concentration $\geq 10\mu\text{mol/L}$. [5] China stroke primary prevention trial showed that H-type hypertension accounted for 80.3% of hypertensive population. [6] Previous studies have shown that H-type hypertension is an independent risk factor for carotid atherosclerosis and cardiovascular and

cerebrovascular events.[7-9] Several studies had suggested that people with insulin resistance had a higher plasma homocysteine levels.[10-12] Hence, there is an obvious clinical significance to detect the risk factors of diabetes in patients with H-type hypertension.

Previous studies have shown that dyslipidemia is one of the risk factors for diabetes.[13-15] Besides, study found that dyslipidemia was associated with poor blood glucose control in diabetic patients.[16] Recently, several studies have proposed that lipid ratios is a powerful predictor of cardio-cerebrovascular disease.[17-20] In addition, some studies also suggested that the lipid ratio had a better predictive value for the occurrence of diabetes than traditional lipid parameters.[21-23]. However, previous studies were mainly conducted in non-hypertensive people. Hence, the relationship between different lipid ratios and diabetes in patients with type H hypertension is still unclear. This study aims to investigate the relationship between different blood lipid ratios and diabetes in Chinese patients with H-type hypertension, and to compare the predictive significance of different lipid ratios.

Methods

Study population

The study population in this research was from the ongoing China Hypertension Registry Study (Registration number: ChiCTR1800017274). This study was a real-world, observational registration study regarding hypertension and aimed to get insight into the incidence and control of hypertension, and factors affecting the prognosis of hypertension. Detailed inclusion and exclusion criteria were documented in previous literature.[24] Current study strictly complied with the Declaration of Helsinki, and at the same time was approved by the Ethics Committee of the Institute of Biomedicine, Anhui Medical University. All participants signed an informed consent before being recruited in the study.

From March 2018 to August 2018, we consecutively recruited 14,268 eligible adults in Wuyuan, Jiangxi Province. After excluding 34 non-hypertensive individuals, 506 individuals taking lipid-lowering drugs and 147 individuals with plasma homocysteine levels less than 10umol/L, a total of 13,581 H-type hypertension subjects were included in the final analysis.

Clinical characteristics

Demographic characteristics were obtained through questionnaire surveys, which were conducted by uniformly trained researchers. Questionnaire content included gender, age, physical activity, education, smoking history, drinking history, clinical diagnosis history, and current drug use. Anthropometric parameters comprised height, weight, waist circumference. The body mass index (BMI) was calculated by dividing the weight (kg) by the height (m²). All blood pressures (BP) were obtained by the same electronic sphygmomanometer (Omron; Dalian, China) with the subject in the sitting position, after resting for at least 5 minutes. The blood pressure of the right arm was measured 3 times for each subject, with an interval of 1 minute between each measurement. The average of the 3 blood pressures was used in the final analysis.

Laboratory assays

The fasting venous blood samples of all study subjects were collected by uniformly trained nurses, and were carried out strictly in accordance with the procedure of this study. They were used to detect fasting serum glucose, fasting lipid parameters (TC, TG, HDL-C, and LDL-C), Serum uric acid (UA), serum homocysteine and creatinine. The specific details of storage, transportation and laboratory measurement methods have been shown in previous studies.[25] Non-HDL-C concentration was determined by subtracting HDL-C from TC. The TC/HDL-C, LDL-C/HDL-C, non-HDL-C/HDL-C and TG/HDL-C, ratios were measured by dividing TC, LDL-C, non-HDL-C by HDL-C. The equation was used to calculate the estimated glomerular filtration rate(eGFR) from the Chronic Kidney Disease Epidemiological Collaboration.[26]

Definitions

Diabetes was defined as fasting glucose ≥ 7 mmol/L, or a history of self-reported diabetes, or ongoing hypoglycemic therapy.[27] Hypertension was determined by the following 3 points: 1. Mean systolic blood pressure ≥ 140 mmHg, or/and mean diastolic blood pressure ≥ 90 mmHg; or 2. Self-reported history of hypertension; or 3. Taking antihypertensive drugs.[28] Hypertension with serum homocysteine level ≥ 10 umol/L was considered as H-type hypertension. [29]The definition of AIP was based on the base-10 logarithm of the TG/HDL-C ratio.[18]

Statistical analysis

The baseline characteristics of this study were shown as continuous variables in the form of mean \pm standard deviation (SD), and categorical variables in the form of number (%). All continuous variables in present study basically conformed to the normal distribution. According to the stratification of diabetes, the student's t-test was used to compare the differences of continuous variables between the groups, while the chi-square test was used to compare the differences of categorical variables between the groups. According to continuous variables and tertile categorical variables. logistic regression analysis was adopted to estimate the relationship between different lipid ratios (TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C) and diabetes with adjusting the related covariates. The results were presented in the form of odds ratio (OR) and 95% confidence interval (CI). In addition, we treat the lipid ratios tertile categorical variables as continuous variables for trend test. The receiver-operating characteristic (ROC) curve was used to evaluate the predictive value of different lipid ratios for diabetes. By comparing the area under the ROC curve (AUC), we distinguished the ability of different lipid ratios to identify diabetes. Finally, after adjusting for multivariate, we used a smooth fitting curve to visually evaluate the association between different lipid ratios and diabetes.

All data were analyzed using R statistical package (<http://www.r-project.org>) and EmpowerStates (www.empowerstats.com; X&Y Solutions, Inc., Boston, MA). If the two-sided $P < 0.05$, we thought there was a statistical difference.

Results

According to the inclusion and exclusion criteria of this study, a total of 13,581 H-type hypertension participants (mean age:63.79±9.40) without lipid-lowering drugs were included in the final data analysis, with 2412 cases (17.8%) diagnosed diabetes. The clinical and demographic baseline characteristics of subjects recruited in this study, stratified according to whether they were diagnosed with diabetes, are presented in Table 1. Compared with the non-diabetic group, there was a smaller proportion of male in the diabetes group. People with diabetes showed lower exercise intensity, lower homocysteine levels, higher BMI, WC,UA and Systolic blood pressure (SBP) than those without ($p \leq 0.05$). People with diabetes were associated with higher TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C ratio ($p \leq 0.001$). In addition, participants with diabetes had a higher incidence of history stroke and the use of antihypertensive drugs ($p \leq 0.007$). Although there was no statistical difference ($p = 0.143$), the incidence of CVD in the diabetic population was higher than that in the non-diabetic population, which were 5.22% and 4.53%, respectively.

Table 2 revealed that with the increase of TC/HDL-C, AIP, LDL-C/HDL-C and non-HDL-C/HDL-C, ORs and 95%CI for the presence of diabetes showed a progressive increment in a dose-response fashion (all P for trend ≤ 0.001). When all lipid ratios were treated as continuous variables, in the fully adjusted model, the risk of diabetes will increase by 1.84 times for per 1 unit of AIP increase (OR:2.84, 95%CI:2.37-3.41). Nevertheless, per 1 unit increase of TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C ratio only increased the prevalence of diabetes by 1.34, 1.40, 1.42 times respectively, which was almost half of AIP. All lipid ratios were divided into three groups according to the tertile, and converted into categorical variables. In the fully adjusted model, the odds of prevalent diabetes in the upper tertile of AIP was 1.83 times than that in the lower tertile (OR:1.83,95%:1.59-2.10), while the ORs with regard to diabetes was similar in TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C, which were 1.64(95%CI:1.43-1.88), 1.62(95%CI:1.41-1.86) and 1.65(95%CI:1.44-1.86) respectively. Figure 1 illustrated that all lipid rates are positively correlated with the risk of diabetes after adjusting for multivariable.

Table 3 showed the relationship between different lipid ratios and AUCs(95%CI) of diabetes. AIP had the largest AUC scores, which meant it had the best accuracy in determining the occurrence of diabetes (AUC:0.619,95%CI:0.606-0.631). In contrast, LDL-C/HDL-C had the smallest AUC value (AUC:0.601,95%CI:0.589-0.613). When compared with TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C, AIP had a stronger capability to recognize the occurrence of diabetes and had statistical difference after comparisons of AUC, whereas we did not see a statistical difference between either two of TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C.

Discussion

Our study suggested that TC/HDL-C, AIP, LDL-C/HDL-C and non-HDL-C/HDL-C were positively correlated with the risk of diabetes in the Chinese population with H-type hypertension. In addition, this study for the first time revealed that AIP had relatively superior ability to assessing the risk of prevalent diabetes, compared to TC/HDL-C, LDL-C/HDL-C and non-HDL-C/HDL-C.

Previous studies on the relationship between AIP and diabetes are limited. A prospective study involving 2676 middle-aged Turkish people found that after adjusted for multivariate, AIP predicted diabetes significantly with RRs of 1.48 (95% CI:1.22-1.80) in men and 1.32 (95% CI:1.06-1.64) in women for per 1 SD increment. [30] Similarly, a meta-analysis indicated that the standard mean difference (SMD) in AIP for patients with or without diabetes was 1.78 (95%CI: 1.04–2.52).[31] In accordance with the above results, our study showed that the risk of diabetes increased by 1.84 times for per 1SD increment (OR=2.84, 95%CI:2.37-3.41; P=0.001).

In addition, our study found that TC/HDL-C and LDL-C/HDL were positively correlated for the risk of diabetes in the Chinese population with H-type hypertension, and there was no statistical difference in their ability of identifying diabetes. TC/HDL-C can indirectly estimate of LDL-C particle number and can be a strong predictor of the risk of atherosclerosis and coronary heart disease.[32] Similar to the findings of our study, A cross-sectional study involving 935 Chinese hypertensive patients showed that LDL-C/HDL-C was significantly associated with the onset of diabetes. Compared with the lower tertile, the risk of diabetes was 1.6 times in the upper tertile.[33] Ming Zhang et al. followed up 11929 non-diabetic patients for 6 years and found that TC/HDL-C was associated with diabetes risk (HR=1.66, 95%CI: 1.23-2.25). In addition, the study also revealed interactions between TC/HDL-C with age and BMI.[34] However, a prospective study conducted in Isfahan found that TC/HDL-C was not significantly correlated to risk of diabetes.[35] The above results are inconsistent with our study, which may be caused by the following reasons: 1) the race of the population included in the study is different; 2) the population of H-type hypertension was included in this study; 3) current study adjusted for more confounding factors.

Non-HDL-C was introduced as a novel means to refine risk estimation beyond LDL-C from Friedewald's formula in the presence of elevated triglyceride levels (≥ 200 mg/dl), since associated changes of the VLDL-TG/VLDL-C ratio may lead to LDL-C undercalculation.[36] our study provided a novel insight that non-HDL-C/HDL-C was positively correlated to diabetes among H-type hypertension populations in China. In accordance with the results of current study, Minghui Han et al. conducted a 6-year follow-up of 11487 non-diabetic Chinese populations and found that the baseline non-HDL-C/HDL-C, an absolute gain in non-HDL-C/HDL-C and a relative gain in non-HDL-C/HDL-C was associated with the risk of diabetes. Compared with quartile1 group, the ORs of diabetes in the quartile4 group were 2.16 (95%CI: 1.62–2.88), 2.00 (95%CI: 1.52–2.61) and 1.97 (95%CI: 1.49-2.60), respectively.[37] Minghui Han et al. performed a retrospective study on 41,821 Korean adults who participated in routine health screening examinations and found that elevated non-HDL-C/HDL-C was significantly associated with odds of incident diabetes (OR=1.54, 95%CI: 1.48-1.60 in man ; OR=1.84,95%1.77-1.91 in women).[38]

The specific mechanism of the association between lipid ratios and diabetes is currently unclear. However, Previous studies had proposed some possible mechanisms regarding the relationship between blood lipids and diabetes. As we all knew, blood glucose homeostasis was maintained by the balanced interaction between insulin action and insulin secretion. When the feedback loop between the action of insulin and insulin secretion is not functioning properly, it would lead to abnormal blood glucose levels and even diabetes.[39] Some epidemiological studies have demonstrated that lipid ratios are independent

risk factor for insulin resistance. For example, a cross-sectional study from a Czech population revealed that AIP was significantly associated with insulin resistance (OR=1.32; 95%CI: 1.09-1.61).[40] In addition, Tingting Du et al. analyzed the data from the China Health Nutrition Survey 2009 and found that after adjusting for multivariate, TC/HDL-C, LDL-C/HDL and non-HDL/HDL-C were all correlated to insulin resistance. When treating quartile 1 group as reference group, the adjusted ORs of insulin resistance in quartile4 group were 2.31 (95%CI: 1.84-2.89), 1.71 (95%CI: 1.38-2.12) and 2.31 (95%CI: 1.84-2.89), respectively.[41] The association between lipid ratios and β cell function was also documented in previous literature. Recently, a prospective study involving 1246 Hispanics and African Americans indicated that a higher TG/HDL-C ratio was associated with impaired β -cell function.[42] Sabine Rutt et al. conducted an experiment in vitro and found that LDL-C/HDL-C can modulated the function and apoptosis of human and murine β cells.[43] Also, increased non-HDL-C/HDL-C ratio might be associated with β -cell dysfunction.[44] The underlying molecular mechanisms explaining the link between lipids and diabetes are not understood in depth. Currently, the most widely accepted view is lipotoxicity comprising endoplasmic reticulum pressure, mitochondrial dysfunction, oxidative stress and inflammation, which can induce insulin resistance and affect β -cell function.[45, 46] besides, Chie Ebato et al. found that dyslipidemia can inhibit β -cell insulin secretion and proliferation by affecting the autophagy ability of β -cells.[47] Low plasma level of HDL-C is an independent risk factor for atherosclerosis and may also contribute to the pathophysiology of diabetes. The possible mechanism is that low levels of HDL-C may inhibit insulin secretion, impair insulin sensitivity and impair glucose uptake of muscle via AMP-activated protein kinase.[48] Although current research has initially explored the molecular mechanisms of lipids and diabetes, there are still controversies. We need further basic research to clarify the relationship between blood lipids and diabetes.

Some limitations and strengths of the current study need to be mentioned when interpreting our findings. Our study evaluated the association between different lipid ratios (TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C) and the risk of diabetes among the Chinese population with H-type hypertension for the first time. Compared with other lipid ratios, AIP is superior in terms of assessing the relationship between lipid ratios and diabetes. nevertheless, several limitations of this study need to be pointed out. First, this study is a cross-sectional study that cannot explain the causal relationship between lipid ratio and diabetes. Second, our study used fasting plasma glucose as the criterion for diagnosing diabetes, and did not detect glycosylated hemoglobin and performed oral glucose tolerance tests. Therefore, some diabetic patients might miss the diagnosis. This may lead to underestimation of the relationship between blood lipid ratio and diabetes. However, the same method of diagnosing diabetes by measuring fasting blood glucose was used in the Framingham Heart Study. [49]Third, present study recruited H-type hypertension population in southern China, so it cannot be generalized to other groups.

In conclusion, we found that all of lipid ratios (TC/HDL-C, AIP, LDL-C/HDL-C, and non-HDL-C/HDL-C) in the Chinese population with H-type hypertension were independently and positively correlated with the risk of prevalent diabetes. Also, AIP seemed to perform better in assessing the correlation between lipid ratios and diabetes. This suggests that early monitoring of AIP for Chinese patients with H-type hypertension and dyslipidemia, while early intervention may reduce the risk of diabetes.

Declarations

Acknowledgements All authors acknowledge the contribution the all staff who participated in this study as well as the study participants who shared their time with us.

Funding This study was supported by Science and Technology Innovation Platform Project of Jiangxi Province (Grant number: 20165BCD41005); the National Natural Science Foundation of China (Grant number: 81960074 and 81500233); the Project of Jiangxi Outstanding Person Foundation (Grant number: 20192BCBL23024); and the Projects of the Science and Technology Department, Jiangxi (Grant number: 20171BAB205008 and 20204237).

Author contributions All authors were responsible for drafting the manuscript and revising it critically for constructive intellectual content. All authors approved the version to be published.

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consents were obtained from all individual participants included in the study.

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Tables

Table 1 Baseline characteristics of H-type hypertension population with or without diabetes

Variables	Total=13581	Non-diatetes=1169	Diabetes=2412	P-value
Male, n (%)	6461(47.57%)	5461 (48.89%)	1000 (41.46%)	0.001
Age, years	63.79±9.40	63.88 ± 9.55	63.40 ± 8.67	0.025
BMI, kg/m ²	23.57±3.75	23.34 ± 3.76	24.64 ± 3.47	<0.001
WC, cm	83.74±9.86	83.00 ± 9.65	87.18 ± 10.09	<0.001
SBP, mmHg	148.51±17.82	148.34 ± 17.83	149.28 ± 17.74	0.018
DBP, mmHg	89.03±10.76	89.12 ± 10.81	88.56 ± 10.51	0.02
eGFR(ml/min per 1.73m ²)	88.34±20.18	88.68 ± 19.71	86.74 ± 22.17	<0.001
Serum homocysteine, μmol/L	17.96±11.03	18.07 ± 11.35	17.45 ± 9.39	0.012
Serum uric acid, μmol/L	419.13±120.71	417.79±119.96	432.70±121.84	0.001
TC, mmol/L	5.18±1.10	5.11 ± 1.05	5.50 ± 1.25	<0.001
TG, mmol/L	1.80±1.25	1.69 ± 1.12	2.28 ± 1.65	<0.001
LDL-C, mmol/L	3.00±0.80	2.95 ± 0.77	3.24 ± 0.87	<0.001
Non-HDL-C, mmol/L	3.61±0.99	3.53 ± 0.95	3.95 ± 1.09	<0.001
HDL-C, mmol/L	1.57±0.43	1.58 ± 0.42	1.54 ± 0.44	<0.001
TC/HDL-C	3.44±0.87	3.38 ± 0.85	3.71 ± 0.92	<0.001
AIP	0.01±0.30	-0.02 ± 0.29	0.11 ± 0.31	<0.001
LDL-C/HDL-C	2.01±0.65	1.97 ± 0.56	2.16 ± 0.57	<0.001
Non-HDL-C/HDL-C	2.44±0.87	2.38 ± 0.85	2.71 ± 0.92	<0.001
Education, n (%)				0.007
Low	12435(91.56%)	10270 (91.95%)	2165 (89.76%)	
Moderate	942(6.94%)	738 (6.61%)	204 (8.47%)	
High	204(1.50%)	161 (1.44%)	43 (1.77%)	
Physical activity, n (%)				<0.001
Low	7590(55.89%)	6152 (55.08%)	1438 (59.62%)	
Moderate	3166(23.31%)	2646 (23.69%)	520 (21.56%)	
high	2825(20.80%)	2371 (21.23%)	454 (18.82%)	

Current smoking, n (%)	3549 (26.13%)	3047 (27.29%)	502 (20.82%)	<0.001
Current drinking, n (%)	2993 (22.04%)	2560 (22.93%)	433 (17.96%)	<0.001
Self-reported stroke, n (%)	816 (6.01%)	643 (5.76%)	173 (7.17%)	0.007
Self-reported CVD, n (%)	632 (4.65%)	506 (4.53%)	126 (5.22%)	0.143
Antihypertensive drugs, n (%)	8689 (63.98%)	7016 (62.83%)	1673 (69.39%)	<0.001

Data are the mean \pm SD, or number (percentage)

Abbreviations: BMI body mass index, WC waist circumference, SBP systolic blood pressure, DBP diastolic blood pressure, eGFR estimated glomerular filtration rate, TC Total cholesterol, TG Triglyceride, LDL-C Low-density lipoprotein cholesterol, non-HDL-C Non-high-density lipoprotein cholesterol, HDL-C High-density lipoprotein cholesterol, AIP atherogenic index of plasma, CVD cardiovascular disease

Table 2 Odd ratios (95% CI) for diabetes in H-type hypertensive participants according to continuous or tertiles of different lipid ratios

Variables	N	Events, n (%)	Crude Model		Model 1	
			OR (95%CI)	P value	OR (95%CI)	P value
TC/HDL-C ratio (per 1 SD increase)	13581	2412(17.76%)	1.52 (1.45, 1.59)	<0.001	1.34 (1.27, 1.43)	<0.001
Tertiles of TC/HDL-C ratio						
T1(\leq 2.75)	4487	557 (23.09%)	Reference		Reference	
T2(2.75-4.13)	4542	752 (31.18%)	1.41 (1.25, 1.58)	<0.001	1.13 (0.98, 1.31)	0.083
T3(\geq 4.13)	4552	1103 (45.73%)	2.26 (2.02, 2.53)	<0.001	1.64 (1.43, 1.88)	<0.001
P for trend			<0.001		<0.001	
AIP (per 1 SD increase)	13581	2412(17.76%)	3.95 (3.42, 4.56)	<0.001	2.84 (2.37, 3.41)	<0.001
Tertiles of AIP						
T1(\leq 0.24)	4516	526 (21.81%)	Reference		Reference	
T2(0.24-0.24)	4526	746 (30.93%)	1.48 (1.32, 1.67)	<0.001	1.18 (1.03, 1.36)	0.021
T3(\geq 0.24)	4539	1140 (47.26%)	2.53 (2.26, 2.83)	<0.001	1.83 (1.59, 2.10)	<0.001
P for trend			<0.001		<0.001	
LDL-C/HDL-C ratio (per 1 SD increase)	13581	2412(17.76%)	1.68 (1.58, 1.80)	<0.001	1.40 (1.29, 1.51)	<0.001
Tertiles of LDL-C/HDL-C ratio						
T1(\leq 1.50)	4511	556 (23.05%)	Reference		Reference	
T2(1.50-2.53)	4521	753 (31.22%)	1.43 (1.27, 1.61)	<0.001	1.14 (0.99, 1.32)	0.059
T3(\geq 2.53)	4549	1103 (45.73%)	2.27 (2.04, 2.54)	<0.001	1.62 (1.41, 1.86)	<0.001

P for trend			<0.001		<0.001	
Non-HDL-C/HDL-C ratio (per 1 SD increase)	13581	2412(17.76%)	1.52 (1.46, 1.59)	<0.001	1.42 (1.35, 1.50)	<0.001
Tertiles of Non-HDL-C/HDL-C ratio						
T1(\leq 1.75)	4506	560 (23.22%)	Reference			
T2(1.75-3.13)	4523	749 (31.05%)	1.41 (1.25, 1.58)	<0.001	1.14 (0.99, 1.31)	0.071
T3(\geq 3.13)	4552	1103 (45.73%)	2.26 (2.02, 2.52)	<0.001	1.65 (1.44, 1.89)	<0.001
P for trend			<0.001		<0.001	

Model 1 adjusted for age, sex, BMI, waist circumference, education, physical activity, SBP, DBP, eGFR, current smoking, current drinking, serum uric acid, serum homocysteine, antihypertensive drugs, self-reported stroke, and self-reported CVD

Abbreviations: OR Odd ratio, 95% CI 95% Confidence interval, TC Total cholesterol, HDL-C High-density lipoprotein Cholesterol, AIP atherogenic index of plasma, LDL-C Low-density lipoprotein cholesterol, non-HDL-C Non-high-density lipoprotein cholesterol

Table 3 The area under the curve (AUC) of different lipid ratios for the presence of diabetes in H-type hypertension population

Variables	AUC	(95%CI)	P value
AIP	0.619	(0.606-0.631) ^{a, b, c}	0.005
TC/HDL-C	0.606	(0.594-0.618) ^d	0.005
Non-HDL-C/HDL-C	0.606	(0.594-0.618) ^d	0.005
LDL-C/HDL-C	0.601	(0.589-0.613) ^d	0.005

^a means a significant difference as compared to TC/HDL-C

^b means a significant difference as compared to LDL-C/HDL-C

^c means a significant difference as compared to non-HDL-C

^d means a significant difference as compared to AIP

Abbreviations: 95%CI 95% confidence interval, AIP atherogenic index of plasma, TC total cholesterol, HDL-C high-density lipoprotein cholesterol, non-HDL-C non-high-density lipoprotein cholesterol, LDL-C low-density lipoprotein cholesterol

Figures

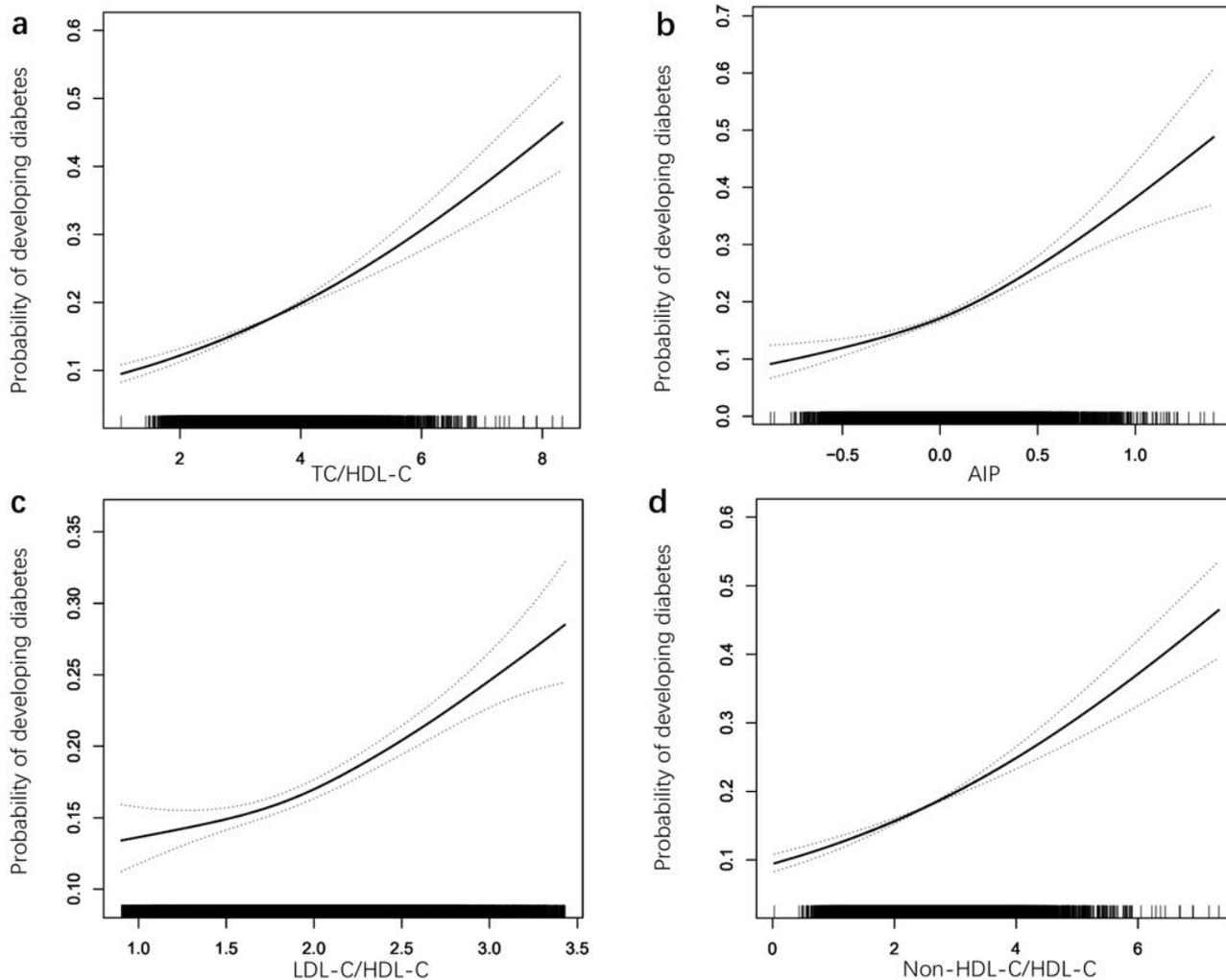


Figure 1

The relationship between TC/HDL-C(a), AIP(b), LDL-C/HDL-C(c) and non-HDL-C/HDL-C(d) and the risk of diabetes in Chinese people with H-type hypertension Adjusted for age, sex, BMI, waist circumference,

education, physical activity, SBP, DBP, eGFR, current smoking, current drinking, serum uric acid, serum homocysteine, antihypertensive drugs, self-reported stroke, and self-reported CVD

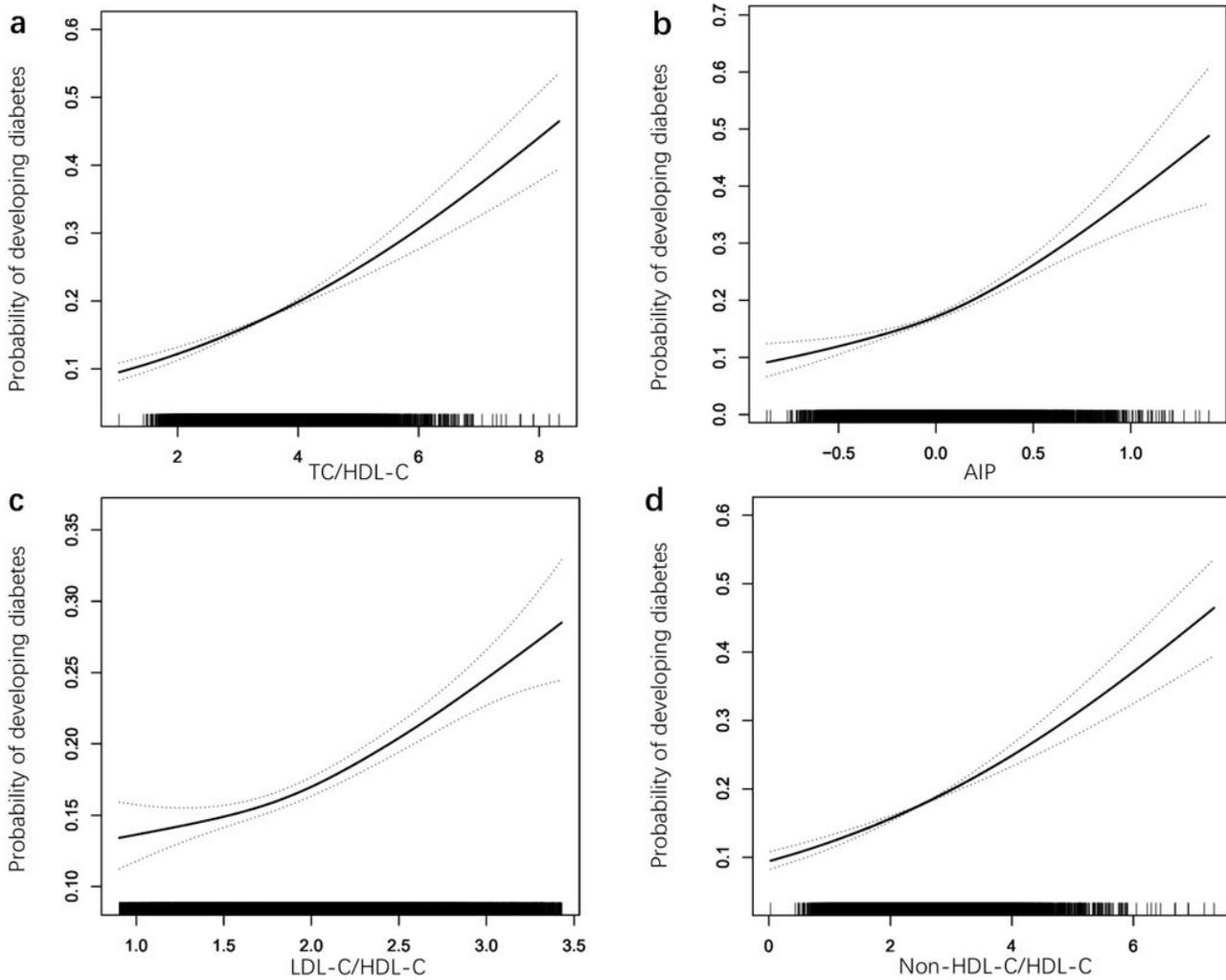


Figure 1

The relationship between TC/HDL-C(a), AIP(b), LDL-C/HDL-C(c) and non-HDL-C/HDL-C(d) and the risk of diabetes in Chinese people with H-type hypertension Adjusted for age, sex, BMI, waist circumference, education, physical activity, SBP, DBP, eGFR, current smoking, current drinking, serum uric acid, serum homocysteine, antihypertensive drugs, self-reported stroke, and self-reported CVD