Fasting and non-fasting lipid profile for cardiovascular risk assessments using China ASCVD risk estimator and Europe SCORE risk charts in Chinese participants

Shi-Lan Zhang
Second Xiangya Hospital
Xiao Du
Second Xiangya Hospital
Jin Xu
Second Xiangya Hospital
Qun-yan Xiang
Second Xiangya Hospital
Ling Liu (feliuling@csu.edu.cn)
Second Xiangya Hospital

Research article

Keywords: Non-fasting lipid profile; Cardiovascular disease; Risk estimation; China ASCVD risk estimator; SCORE risk charts; Chinese participants

Posted Date: August 25th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-60051/v1

Version of Record: A version of this preprint was published at Cardiovascular Diagnosis and Therapy on January 1st, 2021. See the published version at https://doi.org/10.21037/cdt-20-1012.

Abstract

Background Previous studies have shown that non-fasting lipids have similar values in cardiovascular risk estimation as fasting, but it is not clear whether this could also be applicable to Chinese participants.

Methods A total of 127 (76 men, 51 women) participants without atherosclerotic cardiovascular diseases (ASCVD) were enrolled in the study. Serum levels of blood lipids were monitored at 0 h, 2 h and 4 h after a daily breakfast. Ten-year cardiovascular disease (CVD) risk was estimated with China ASCVD risk estimator and Europe SCORE risk charts. Kappa statistic was used to determine agreement among estimators.

Results there was substantial agreement between China ASCVD risk estimator based on fasting and non-fasting lipid profiles (Kappa = 0.731 or 0.718, $P < 0.001$), but poorly agreement between China ASCVD risk estimator and SCORE low- or high-risk chart (Kappa = 0.339 or 0.300, $P < 0.001$).

Conclusions Promoting use of non-fasting blood lipids in diagnosis, evaluation, and prediction of CVD are feasible. Furthermore, non-fasting blood lipids could be used in China ASCVD risk estimator to evaluate assess 10-year risk of ASCVD among Chinese general participants.

1. Background

Cardiovascular disease (CVD) is the leading cause of death in worldwide [1] and accounts for more than 40% of deaths in China [2]. CVD is caused by multiple invariable and variable factors, the former includes age, gender, genetic heritage, and the latter includes smoking, physical inactivity, obesity, hypertension, hyperglycemia and hyperlipidemia, which can be modified [3]. Dyslipidemia is the strongest modifiable risk factor for CVD, and the measurement of blood lipids is an integral part of overall CVD risk assessment [4]. For decades, many guidelines recommended that blood lipids should be detected in the fasting state (usually at least 8 h or even overnight after the last meal), which actually poses obvious barriers and inconvenience to lipids detection, such as poor compliance, time-consuming, income reduction, losing visit and missed cases.

However, fasting is not routinely required for determination of a lipid profile [5]. Large population studies performed in Copenhagen and Calgary showed that maximal mean changes in lipid profiles as measured in non-fasting samples versus fasting ones were minor, with triglyceride (TG) level increased 26 mg/dl (0.3 mmol/l), remnant cholesterol (RC) level increased 8 mg/dl (0.2 mmol/l), total cholesterol (TC) level decreased 8 mg/dl (0.2 mmol/l), low density lipoprotein cholesterol (LDL-C) level decreased 8 mg/dl (0.2 mmol/l), non-high-density–lipoprotein cholesterol (non-HDL-C) level decreased 8 mg/dl (0.2 mmol/l), whereas high density lipoprotein cholesterol (HDL-C), lipoprotein(a), apolipoprotein B, and apolipoprotein A1 were largely unaffected [6, 7]. Recent evidence showed that non-fasting lipid profile had similar predictive strength as fasting in risk estimation, and thus it could be used for screening general risk assessment [8–12]. Moreover, non-fasting level of TG or RC as well as LDL-C has been demonstrated as

an independent risk factor for CVD and ischemic stroke [13–15]. Thus, non-fasting blood lipid testing has been supported by multiple societies, guidelines and statements [5, 16–20].

As we know that study about evaluating cardiovascular risk with non-fasting blood lipids for primary prevention in China is rare [21], especially about the comparison of fasting and non-fasting blood lipids in the same patients within a same day [22]. Furthermore, there was no study to compare the roles of two different risk assessment tools in risk stratification in Chinese general subjects via fasting or non-fasting blood lipids after a daily meal in a same day. The aim of this study was to use fasting and non-fasting lipid profiles to estimate CVD risk in Chinese participants through two established risk assessment tools: China atherosclerotic CVD (ASCVD) risk estimator and Europe Systemic Coronary Risk Estimation (SCORE) risk charts, and compare the consistency between two estimators.

2. Methods

2.1 Study participants

From March 2017 to September 2019, 127 participants (76 men, 51 women) without ASCVD were enrolled in the study at the Second Xiangya Hospital of Central South University. All participants were hospitalized due to supraventricular tachycardia without acute attacks waiting for radiofrequency ablation, and had no history of thyroid diseases, liver and kidney diseases, autoimmune disease, cancer or other severe medical illnesses, and no one took hypolipidemic agents. The study was approved by the Ethics Committee of the Second Xiangya Hospital of Central South University and informed consent was gained from all participants.

2.2 Sample collection

All enrolled participants took breakfast according to their daily diet habits after at least 8 h or overnight fasting. Venous blood samples were collected before and at 2 h, 4 h after breakfast. During the 4 h period, participants were only allowed to drink water and prohibited to smoke, drink wine, eat any food or strenuous exercises.

2.3 Laboratory examinations

The concentrations of serum TC and TG were measured by enzyme method, HDL-C and LDL-C were measured by chemical masking method (Wako, Japan) based on Hitachi 7170A automatic biochemical analyzer [23, 24]. RC and non-HDL-C level were calculated by the two following formulas, RC = TC – (HDL–C) – (LDL-C), and non-HDL-C = TC – (HDL–C).

2.4 Risk estimator

China ASCVD risk estimator based on China's first risk prediction model with ASCVD as the endpoint event to validate the 10-year ASCVD risk in Chinese participants, which included age, BP, TC level, LDL-C level, HDL-C level, current smoking, and diabetes mellitus. [25, 26]. Europe SCORE system was based on large, representative European cohort datasets, and included age, gender, smoking, systolic blood pressure and total cholesterol level [27].

2.5 Statistical analyses

All data were analyzed using Social Sciences (SPSS) version 22.0 and Graph Pad prism7.0 software. Continuous variables and categorical parameters were compared with the Students *t*-test and chi-square test, respectively. Quantitative variables were expressed as mean ± standard deviation (SD) unless specifically explained, and qualitative variables were expressed as numbers and percentages. Reliability analysis was performed with the Kappa statistic to determine consistency among estimators. Two estimators were said to be in poor agreement if the Kappa statistic was < 0, in slight agreement if 0.0 to 0.20, fair agreement if 0.21 to 0.40, moderate agreement if 0.41 to 0.60, substantial agreement if 0.61 to 0.80, and in perfect agreement if it was 0.81 to 1.00 [28]. All tests were considered to be statistically significant at *P* value < 0.05.

3. Results

3.1 Basic characteristics of the study participants

The total number of participants in this study was 127, including 76 men (59.8%) and 51 (40.2%) women. There were no significant differences in age, systolic or diastolic blood pressure, TC level, LDL-C level, non-HDL-C level, the percentages of cases with hypertension and diabetes between male and female participants, except male participants had significantly higher body mass index (BMI), levels of TG and RC, while lower HDL-C level. Besides, the smokers incorporated in this study were all male (Table 1).

Table 1
Basic clinical features of study participants

	Total participants (n = 127)	Man (n = 76)	Female (51)	*P* value
Age, y	53.5 ± 8.9	52.9 ± 9.1	54.4 ± 8.5	0.363
BMI, kg/m^2	24.4 ± 3.3	24.9 ± 3.4	23.7 ± 2.9	0.029*
SBP, mm Hg	130.9 ± 16.8	129.0 ± 14.8	133.6 ± 19.2	0.16
DBP, mmHg	80.8 ± 11.6	79.1 ± 12.4	83.2 ± 10.0	0.053
TC, mmol/L	4.5 ± 0.8	4.4 ± 0.9	4.6 ± 0.8	0.215
HDL-C, mmol/L	1.1 ± 0.3	1.0 ± 0.2	1.2 ± 0.3	< 0.001*
LDL-C, mmol/L	2.9 ± 0.7	2.8 ± 0.7	2.9 ± 0.7	0.831
TG, mmol/L	1.5 (1.2–2.2)	1.7 (1.2–2.3)	1.4 (1.0–2.0)	0.041*
non-HDL, mmol/L	3.3 ± 0.8	3.3 ± 0.8	3.3 ± 0.8	0.747
RC, mmol/L	0.5 (0.4–0.5)	0.5 (0.4–0.6)	0.4 (0.3–0.5)	0.028*
Hypertension, n (%)	66 (52.0)	43 (56.6)	23 (45.1)	0.091
Diabetes, n (%)	11 (8.7)	8 (10.5)	3 (5.9)	0.362
Smoking, n (%)	40 (31.5)	40 (52.6)	0 (0.0)	< 0.001*
BMI, Body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure;				
Data expressed as mean with standard deviation, number (percentage) and quantile.				
* *P* values are statistically significant.				

3.2 Changes between fasting and non-fasting lipid levels after a daily breakfast

Taking all participants as a whole, the serum levels of TC and non-HDL-C mildly decreased at 2 h, but slightly recovered at 4 h. In the meantime, both TG and RC levels increased significantly and reached their peak at 4 h while LDL-C level reached the lowest value at 4 h ($P < 0.05$). Besides, postprandial change in HDL-C level was negligible (Fig. 1).

To be specific, in this study, TC level decreased from 4.5 mmol/l at baseline to 4.1 mmol/l at 2 h and increased to 4.2 mmol/l at 4 h, non-HDL-C level decreased from 3.3 mmol/l to 3.1 mmol/l at 2 h and increased to 3.2 mmol/l at 4 h, and LDL-C level decreased from 2.9 to 2.2 mmol/l at 4 h. Besides, TG and RC levels respectively varied from 1.5 mmol/l at baseline to 2.1 mmol/l, 0.5 mmol/l to 0.7 mmol/l at 4 h after a daily breakfast.

3.3 Cardiovascular risk classifications based on fasting and non-fasting lipid profiles using different risk estimators

All participants were undergone cardiovascular risk assessment according to China ASCVD risk estimator and Europe SCORE risk charts respectively.[25, 26, 29, 30]. China ASCVD risk estimator respectively classified approximately half of the participants as low-risk (0 h, 2 h, 4h: 49.6%, 55.1%, 55.1%), less than one-fifth of them as moderate-risk (0 h, 2 h, 4h: 18.9%, 17.3%, 15.7%), about one-fifth of them as high-risk (0 h, 2 h, 4h: 22.8%, 18.9%, 20.5%) in fasting and non-fasting state after a daily breakfast (Fig. 2A). However, Europe SCORE system (low-and high-risk charts) showed a different result which classified less than one-third them as low risk (low risk chart: 0 h, 2 h, 4h: 25.2%, 25.2%, 24.4%; high risk chart: 0 h, 2 h, 4h: 15.0%, 15.0%, 15.0%), more than half of the participants as moderate risk (low risk chart: 0 h, 2 h, 4h: 55.9%, 55.9%, 56.7%; high risk chart: 0 h, 2 h, 4h: 53.5%, 55.9%, 55.1%), less one-fourth of them as high-risk (low risk chart: 0 h, 2 h, 4h: 10.2%, 10.2%, 10.2%; high risk chart: 0 h, 2 h, 4h: 22.8%, 20.4%, 21.2%) in both fasting and non-fasting states. Apart from this, the percentages of very high-risk in both two risk estimators are the same (8.7%) (Fig. 2B-C). From these results, the big difference is that China ASCVD risk estimator assessed half of the participants as low risk, while the European risk charts assessed half of the participants as moderate risk in the same participants (Fig. 2A-C).

There was substantial agreement between China ASCVD risk estimator based on fasting and non-fasting lipid profiles (Kappa = 0.731 or 0.718, $P < 0.001$) (Table 2). In addition, the agreement between SCORE system based on fasting and non-fasting lipid profiles in both low- and -high risk charts were high respectively, (Kappa = 0.922 or 0.935, $P < 0.001$, Table 3) (Kappa = 0.886 or 0.874, $P < 0.001$, Table 4). However, agreement between China ASCVD risk estimator and SCORE low- or high-risk chart was relatively poorly no matter in fasting (Kappa = 0.339 or 0.300, $P < 0.001$) (Table 5) or non-fasting state. (Kappa = 0.364 or 0.286, $P < 0.001$) (Table 6), which indicated China ASCVD risk estimator and SCORE risk charts are inconsistent in risk stratification in the same Chinese general participants.

Table 2
Agreement in China ASCVD risk estimator based on fasting and non-fasting lipid profiles.

	Fasting risk category						
Postprandial blood lipid	Low-risk	Moderate-risk	High-risk	Very high-risk	**Total, n (%)**	**Kappa**	P **value**
Postprandial 2 h risk category						0.731	0.001
Low risk	60	8	2	0	70(55.1)		
Moderate-risk	3	13	6	0	22 (17.3)		
High-risk	0	3	21	0	24 (18.9)		
Very high-risk	0	0	0	11	11 (8.7)		
Postprandial 4 h risk category						0.718	0.001
Low risk	59	10	1	0	70 (55.1)		
Moderate-risk	4	11	5	0	20(15.7)		
High-risk	0	3	23	0	26(20.5)		
Very high-risk	0	0	0	11	11 (8.7)		
Total, n (%)	63 (49.6)	24(18.9)	29(22.8)	11 (8.7)	127 (100.0)		

Table 3
Agreement in SCORE low- risk chart based on fasting and non-fasting lipid profiles.

	Fasting risk category						
Postprandial blood lipid	Low-risk	Moderate-risk	High-risk	Very high-risk	**Total, n (%)**	**Kappa**	P **value**
Postprandial 2 h risk category						0.922	0.001
Low risk	29	3	0	0	32(25.2)		
Moderate-risk	3	68	0	0	71 (55.9)		
High-risk	0	0	13	0	13 (10.2)		
Very high-risk	0	0	0	11	11 (8.7)		
Postprandial 4 h risk category						0.935	0.001
Low risk	29	2	0	0	31 (24.4)		
Moderate-risk	3	69	0	0	72(56.7)		
High-risk	0	0	13	0	13(10.2)		
Very high-risk	0	0	0	11	11 (8.7)		
Total, n (%)	32 (25.2)	71(55.9)	13(10.2)	11 (8.7)	127 (100.0)		

Table 4
Agreement in SCORE high- risk chart based on fasting and non-fasting lipid profiles.

	Fasting risk category						
Postprandial blood lipid	Low-risk	Moderate-risk	High-risk	Very high-risk	**Total, n (%)**	**Kappa**	P **value**
Postprandial 2 h risk category						0.886	0.001
Low risk	16	3	0	0	19 (15.0)		
Moderate-risk	3	65	3	0	71 (55.9)		
High-risk	0	0	26	0	26 (20.5)		
Very high-risk	0	0	0	11	11 (8.7)		
Postprandial 4 h risk category						0.874	0.001
Low risk	16	3	0	0	19 (15.0)		
Moderate-risk	3	64	3	0	70 (55.1)		
High-risk	0	1	26	0	27 (21.3)		
Very high-risk	0	0	0	11	11 (8.7)		
Total, n (%)	19 (15.0)	68 (53.5)	29 (22.8)	11 (8.7)	127 (100.0)		

Table 5
Agreement between China ASCVD risk estimator and SCORE risk charts based on fasting lipid profiles.

	China ASCVD risk estimator						
Risk estimators	Low-risk	Moderate-risk	High-risk	Very high-risk	**Total, n (%)**	**Kappa**	P **value**
SCORE low risk chart						0.339	0.001
Low risk	24	3	5	0	32 (22.2)		
Moderate-risk	35	21	15	0	71 (55.9)		
High-risk	4	0	9	0	13 (10.2)		
Very high-risk	0	0	0	11	11 (8.7)		
SCORE high risk chart						0.300	0.001
Low risk	16	2	1	0	19 (15.0)		
Moderate-risk	38	17	13	0	68 (53.5)		
High-risk	9	5	15	0	29 (22.8)		
Very high-risk	0	0	0	11	11 (8.7)		
Total, n (%)	63 (49.6)	24 (18.9)	29 (22.8)	11 (8.7)	127 (100.0)		

Table 6
Agreement between China ASCVD risk estimator and SCORE risk charts based on non-fasting lipid profiles.

	China ASCVD risk estimator						
Risk estimators	Low-risk	Moderate-risk	High-risk	Very high-risk	**Total, n (%)**	**Kappa**	P **value**
SCORE low risk chart						0.364	0.001
Low risk	55	3	5	0	63 (24.8)		
Moderate-risk	77	39	27	0	143 (56.3)		
High-risk	8	0	18	0	26 (10.2)		
Very high-risk	0	0	0	22	22 (8.7)		
SCORE high risk chart						0.286	0.001
Low risk	35	3	0	0	38 (15.0)		
Moderate-risk	85	31	25	0	141 (55.5)		
High-risk	20	8	25	0	53 (20.9)		
Very high-risk	0	0	0	11	22 (8.7)		
Total, n (%)	140 (55.1)	42 (16.5)	50 (19.7)	22 (8.7)	254 (100.0)		

4. Discussion

In this study, we using fasting and non-fasting lipid profiles to assess 10-year risk of ASCVD in the same Chinese general patients through both China ASCVD risk estimator and Europe SCORE risk charts respectively. It is showed that China ASCVD risk estimator assessed half of the participants as low risk, while the European risk charts assessed half of the participants as moderate risk in the same participants. And the agreement between China ASCVD risk estimator and SCORE system was relatively poorly. Interestingly, there was substantial agreement on China ASCVD risk estimator between fasting and non-fasting lipid profiles, which indicated that non-fasting lipid profiles could also be considered to evaluate 10-year CVD risk via China ASCVD risk estimator in clinical practice.

Non-fasting changes in lipid profiles, especially LDL-C and TG, in Chinese participants in this study were relatively different from those in other studies with large population in Denmark, which showed that changes in lipid profiles were insignificant after a daily meal [6, 31–33]. The maximal mean changes between non-fasting versus fasting blood samples as measured in random are + 0.3 mmol/l for TG level

and − 0.2 mmol/l for TC or LDL-C level [33]. However, TC and LDL-C levels decreased by 0.3 and 0.7 mmol/l, respectively, while TG level increased by 0.6 mmol/l at 4 h after a daily breakfast in this study. The potential causes for non-fasting reduction in LDL-C and increment in TG were complicated and controversial. We previously found that postprandial reduction in direct measured LDL-C level was more prominent than that in calculated LDL-C level by Friedewald formula at both 2 h and 4 h after a daily breakfast in Chinese subjects [34], and LDL-C level was detected by the direct method in the present study. Additionally, some scholars believed that mildly reduction in LDL-C level after a daily meal was due to fluid intake, but changes could be corrected by adjustment for albumin levels [6, 12]. Compared with the western breakfast, the traditional Chinese breakfast could have a higher carbohydrate content and fluid intake, such as porridge, noodles, vermicelli, soy milk and so on, but not breakfast rich in protein and/or fat and solid food such as cheese, sausage, ham and bacon [35, 36]. Unfortunately, changes in albumin levels were not included in this study. Moreover, the potential role of difference in commercial lipid test kits and race between different studies could also be considered.

China ASCVD risk estimator is primarily based on the results of the China-PAR (i.e. Prediction for ASCVD Risk in China) project which was the first study to develop and validate the 10-year ASCVD risk in four large, contemporary Chinese populations, which fasting lipid profiles but not non-fasting lipids were used in that project [25]. The equations directly included age, BP, TC level, LDL-C level, HDL-C level current smoking, and diabetes mellitus. It was demonstrated that the China-PAR project had excellent performance in ASCVD risk prediction with good internal consistency and external validation compared with western estimators [37, 38].

SCORE system, which estimates 10-year cumulative risk of first fatal atherosclerotic events, has been recommended for risk stratification in European countries, and the corresponding risk estimator has been produced as charts for low-and high-risk regions [27]. SCORE system is based on large, representative European cohort datasets, and includes several risk factors, such as age, gender, smoking, systolic blood pressure and total cholesterol level in risk charts. Agreement between fasting and non-fasting in risk stratification is high in both low-and high-risk charts, and it is TC level that used in the SCORE system.

Of course, we noticed that agreement between SCORE low-and high-risk charts was high, whereas relatively poorly with China ASCVD risk estimator as the former classified half of the participants as moderate risk, while China ASCVD risk estimator assessed half of the participants as low risk in the same participants. That is to say that SCORE system could be not appropriate for Chinese individuals to evaluate CVD risk. Substantial differences in prediction capability between China ASCVD risk estimator and SCORE risk charts may be due to ethnic heterogeneities, distinctive risk characteristics of CVD, as well as different treatment and control rates for risk factors (e.g. hyperlipidemia) [29, 39–42]. Since the two established risk assessment systems above were based on per se research results or databases of the respective populations, so it is more suitable for individuals to use specific and regional assessment tools when conducting cardiovascular risk assessments.

There were several limitations in this study. Firstly, the number of participants in this study was relatively small. Secondly, this is a cross-sectional study, and thus it was impossible to verify the occurrence of cardiovascular events. A prospective study with large sample size could be needed to further explore the application of non-fasting blood lipids in CVD risk assessments.

5. Conclusions

Our study suggested that non-fasting lipids could also be applied in evaluation of 10-year CVD risk via ASCVD risk estimator in Chinese, which make the application of non-fasting lipids in CVD more widely.

Abbreviations

ASCVD: Atherosclerotic cardiovascular diseases

CVD: Cardiovascular disease

TG: Triglyceride

RC: Remnant cholesterol

TC: Total cholesterol

LDL-C: Low density lipoprotein cholesterol

non-HDL-C: non-high-density–lipoprotein cholesterol

HDL-C: High density lipoprotein cholesterol

SCORE: Europe Systemic Coronary Risk Estimation

BMI: Body mass index

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Second Xiangya Hospital of Central South University and informed consent was gained from all participants by verbal. All information collected from the participants was kept confidential.

Consent for publication

Not applicable.

Competing Interests:

The authors declare no conflicts of interest.

Funding

This work was supported by National Natural Science Foundation of China (No. 81902512 and 81470577) and Fundamental Research Funds for the Central Universities of Central South University (No. 2018zzts047, 2020zzts280).

Acknowledgments

Not Applicable

References

1. Sacco RL, Roth GA, Reddy KS, Arnett DK, Bonita R, Gaziano TA, Heidenreich PA, Huffman MD, Mayosi BM, Mendis S *et al*: **The Heart of 25 by 25: Achieving the Goal of Reducing Global and Regional Premature Deaths From Cardiovascular Diseases and Stroke: A Modeling Study From the American Heart Association and World Heart Federation**. *Circulation* 2016, **133**(23):e674-690.
2. Zhou M, Wang H, Zhu J, Chen W, Wang L, Liu S, Li Y, Wang L, Liu Y, Yin P *et al*: **Cause-specific mortality for 240 causes in China during 1990-2013: a systematic subnational analysis for the Global Burden of Disease Study 2013**. *Lancet (London, England)* 2016, **387**(10015):251-272.
3. Reiner Z, Catapano AL, De Backer G, Graham I, Taskinen MR, Wiklund O, Agewall S, Alegria E, Chapman MJ, Durrington P *et al*: **ESC/EAS Guidelines for the management of dyslipidaemias: the Task Force for the management of dyslipidaemias of the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS)**. *European heart journal* 2011, **32**(14):1769-1818.
4. Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J *et al*: **Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study**. *Lancet (London, England)* 2004, **364**(9438):937-952.
5. Nordestgaard BG, Langsted A, Mora S, Kolovou G, Baum H, Bruckert E, Watts GF, Sypniewska G, Wiklund O, Boren J *et al*: **Fasting is not routinely required for determination of a lipid profile: clinical and laboratory implications including flagging at desirable concentration cut-points-a joint consensus statement from the European Atherosclerosis Society and European Federation of Clinical Chemistry and Laboratory Medicine**. *European heart journal* 2016, **37**(25):1944-1958.
6. Langsted A, Freiberg JJ, Nordestgaard BG: **Fasting and nonfasting lipid levels: influence of normal food intake on lipids, lipoproteins, apolipoproteins, and cardiovascular risk prediction**. *Circulation* 2008, **118**(20):2047-2056.

7. Sidhu D, Naugler C: **Fasting time and lipid levels in a community-based population: a cross-sectional study**. *Archives of internal medicine* 2012, **172**(22):1707-1710.
8. Kolovou GD, Mikhailidis DP, Kovar J, Lairon D, Nordestgaard BG, Ooi TC, Perez-Martinez P, Bilianou H, Anagnostopoulou K, Panotopoulos G: **Assessment and clinical relevance of non-fasting and postprandial triglycerides: an expert panel statement**. *Current vascular pharmacology* 2011, **9**(3):258-270.
9. Mihas C, Kolovou GD, Mikhailidis DP, Kovar J, Lairon D, Nordestgaard BG, Ooi TC, Perez-Martinez P, Bilianou H, Anagnostopoulou K *et al*: **Diagnostic value of postprandial triglyceride testing in healthy subjects: a meta-analysis**. *Current vascular pharmacology* 2011, **9**(3):271-280.
10. Nordestgaard BG, Varbo A: **Triglycerides and cardiovascular disease**. *Lancet (London, England)* 2014, **384**(9943):626-635.
11. Jorgensen AB, Frikke-Schmidt R, West AS, Grande P, Nordestgaard BG, Tybjaerg-Hansen A: **Genetically elevated non-fasting triglycerides and calculated remnant cholesterol as causal risk factors for myocardial infarction**. *European heart journal* 2013, **34**(24):1826-1833.
12. Langsted A, Nordestgaard BG: **Nonfasting lipids, lipoproteins, and apolipoproteins in individuals with and without diabetes: 58 434 individuals from the Copenhagen General Population Study**. *Clinical chemistry* 2011, **57**(3):482-489.
13. Bansal S, Buring JE, Rifai N, Mora S, Sacks FM, Ridker PM: **Fasting compared with nonfasting triglycerides and risk of cardiovascular events in women**. *Jama* 2007, **298**(3):309-316.
14. Freiberg JJ, Tybjaerg-Hansen A, Jensen JS, Nordestgaard BG: **Nonfasting triglycerides and risk of ischemic stroke in the general population**. *Jama* 2008, **300**(18):2142-2152.
15. Doran B, Guo Y, Xu J, Weintraub H, Mora S, Maron DJ, Bangalore S: **Prognostic value of fasting versus nonfasting low-density lipoprotein cholesterol levels on long-term mortality: insight from the National Health and Nutrition Examination Survey III (NHANES-III)**. *Circulation* 2014, **130**(7):546-553.
16. Catapano AL, Graham I, De Backer G, Wiklund O, Chapman MJ, Drexel H, Hoes AW, Jennings CS, Landmesser U, Pedersen TR *et al*: **2016 ESC/EAS Guidelines for the Management of Dyslipidaemias**. *European heart journal* 2016, **37**(39):2999-3058.
17. Anderson TJ, Gregoire J, Pearson GJ, Barry AR, Couture P, Dawes M, Francis GA, Genest J, Jr., Grover S, Gupta M *et al*: **2016 Canadian Cardiovascular Society Guidelines for the Management of Dyslipidemia for the Prevention of Cardiovascular Disease in the Adult**. *The Canadian journal of cardiology* 2016, **32**(11):1263-1282.
18. Scartezini M, Ferreira C, Izar MCO, Bertoluci M, Vencio S, Campana GA, Sumita NM, Barcelos LF, Faludi AA, Santos RD *et al*: **Positioning about the Flexibility of Fasting for Lipid Profiling**. *Arquivos brasileiros de cardiologia* 2017, **108**(3):195-197.
19. Miller M, Stone NJ, Ballantyne C, Bittner V, Criqui MH, Ginsberg HN, Goldberg AC, Howard WJ, Jacobson MS, Kris-Etherton PM *et al*: **Triglycerides and cardiovascular disease: a scientific statement from the American Heart Association**. *Circulation* 2011, **123**(20):2292-2333.

20. Downs JR, O'Malley PG: **Management of dyslipidemia for cardiovascular disease risk reduction: synopsis of the 2014 U.S. Department of Veterans Affairs and U.S. Department of Defense clinical practice guideline**. *Annals of internal medicine* 2015, **163**(4):291-297.
21. Hong LF, Yan XN, Lu ZH, Fan Y, Ye F, Wu Q, Luo SH, Yang B, Li JJ: **Predictive value of non-fasting remnant cholesterol for short-term outcome of diabetics with new-onset stable coronary artery disease**. *Lipids in health and disease* 2017, **16**(1):7.
22. Tian F, Xiang QY, Zhang MY, Chen YQ, Lin QZ, Wen T, Liu L: **Changes in non-fasting concentrations of blood lipids after a daily Chinese breakfast in overweight subjects without fasting hypertriglyceridemia**. *Clinica chimica acta; international journal of clinical chemistry* 2019, **490**:147-153.
23. Zhao Y, Peng R, Zhao W, Liu Q, Guo Y, Zhao S, Xu D: **Zhibitai and low-dose atorvastatin reduce blood lipids and inflammation in patients with coronary artery disease**. *Medicine* 2017, **96**(7):e6104.
24. Tian F, Wu CL, Yu BL, Liu L, Hu JR: **Apolipoprotein O expression in mouse liver enhances hepatic lipid accumulation by impairing mitochondrial function**. *Biochemical and biophysical research communications* 2017, **491**(1):8-14.
25. Yang X, Li J, Hu D, Chen J, Li Y, Huang J, Liu X, Liu F, Cao J, Shen C *et al*: **Predicting the 10-Year Risks of Atherosclerotic Cardiovascular Disease in Chinese Population: The China-PAR Project (Prediction for ASCVD Risk in China)**. *Circulation* 2016, **134**(19):1430-1440.
26. Hu DY: **[New guidelines and evidence for the prevention and treatment of dyslipidemia and atherosclerotic cardiovascular disease in China]**. *Zhonghua xin xue guan bing za zhi* 2016, **44**(10):826-827.
27. Perk J, De Backer G, Gohlke H, Graham I, Reiner Z, Verschuren M, Albus C, Benlian P, Boysen G, Cifkova R *et al*: **European Guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts)**. *European heart journal* 2012, **33**(13):1635-1701.
28. Landis JR, Koch GG: **The measurement of observer agreement for categorical data**. *Biometrics* 1977, **33**(1):159-174.
29. Conroy RM, Pyorala K, Fitzgerald AP, Sans S, Menotti A, De Backer G, De Bacquer D, Ducimetiere P, Jousilahti P, Keil U *et al*: **Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project**. *European heart journal* 2003, **24**(11):987-1003.
30. Catapano AL, Graham I, De Backer G, Wiklund O, Chapman MJ, Drexel H, Hoes AW, Jennings CS, Landmesser U, Pedersen TR *et al*: **2016 ESC/EAS Guidelines for the Management of Dyslipidaemias**. *Revista espanola de cardiologia (English ed)* 2017, **70**(2):115.
31. Nordestgaard BG, Benn M: **Fasting and nonfasting LDL cholesterol: to measure or calculate?** *Clinical chemistry* 2009, **55**(5):845-847.
32. Nordestgaard BG, Langsted A, Mora S, Kolovou G, Baum H, Bruckert E, Watts GF, Sypniewska G, Wiklund O, Boren J *et al*: **Fasting Is Not Routinely Required for Determination of a Lipid Profile:**

Clinical and Laboratory Implications Including Flagging at Desirable Concentration Cutpoints-A Joint Consensus Statement from the European Atherosclerosis Society and European Federation of Clinical Chemistry and Laboratory Medicine. *Clinical chemistry* 2016, **62**(7):930-946.

33. Nordestgaard BG: **A Test in Context: Lipid Profile, Fasting Versus Nonfasting**. *Journal of the American College of Cardiology* 2017, **70**(13):1637-1646.
34. Lin QZ, Chen YQ, Guo LL, Xiang QY, Tian F, Wen T, Liu L: **Comparison of non-fasting LDL-C levels calculated by Friedewald formula with those directly measured in Chinese patients with coronary heart disease after a daily breakfast**. *Clinica chimica acta; international journal of clinical chemistry* 2019, **495**:399-405.
35. Lee MM, Wu-Williams A, Whittemore AS, Zheng S, Gallagher R, Teh CZ, Zhou L, Wang X, Chen K, Ling C *et al*: **Comparison of dietary habits, physical activity and body size among Chinese in North America and China**. *International journal of epidemiology* 1994, **23**(5):984-990.
36. Chen Z, Shu XO, Yang G, Li H, Li Q, Gao YT, Zheng W: **Nutrient intake among Chinese women living in Shanghai, China**. *The British journal of nutrition* 2006, **96**(2):393-399.
37. D'Agostino RB, Sr., Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, Kannel WB: **General cardiovascular risk profile for use in primary care: the Framingham Heart Study**. *Circulation* 2008, **117**(6):743-753.
38. Goff DC, Jr., Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB, Gibbons R, Greenland P, Lackland DT, Levy D, O'Donnell CJ *et al*: **2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines**. *Circulation* 2014, **129**(25 Suppl 2):S49-73.
39. De Backer G, Ambrosioni E, Borch-Johnsen K, Brotons C, Cifkova R, Dallongeville J, Ebrahim S, Faergeman O, Graham I, Mancia G *et al*: **European guidelines on cardiovascular disease and prevention in clinical practice**. *Atherosclerosis* 2003, **171**(1):145-155.
40. Yang W, Xiao J, Yang Z, Ji L, Jia W, Weng J, Lu J, Shan Z, Liu J, Tian H *et al*: **Serum lipids and lipoproteins in Chinese men and women**. *Circulation* 2012, **125**(18):2212-2221.
41. Chan F, Adamo S, Coxson P, Goldman L, Gu D, Zhao D, Chen CS, He J, Mara V, Moran A: **Projected impact of urbanization on cardiovascular disease in China**. *International journal of public health* 2012, **57**(5):849-854.
42. Xu Y, Wang L, He J, Bi Y, Li M, Wang T, Wang L, Jiang Y, Dai M, Lu J *et al*: **Prevalence and control of diabetes in Chinese adults**. *Jama* 2013, **310**(9):948-959.

Figures

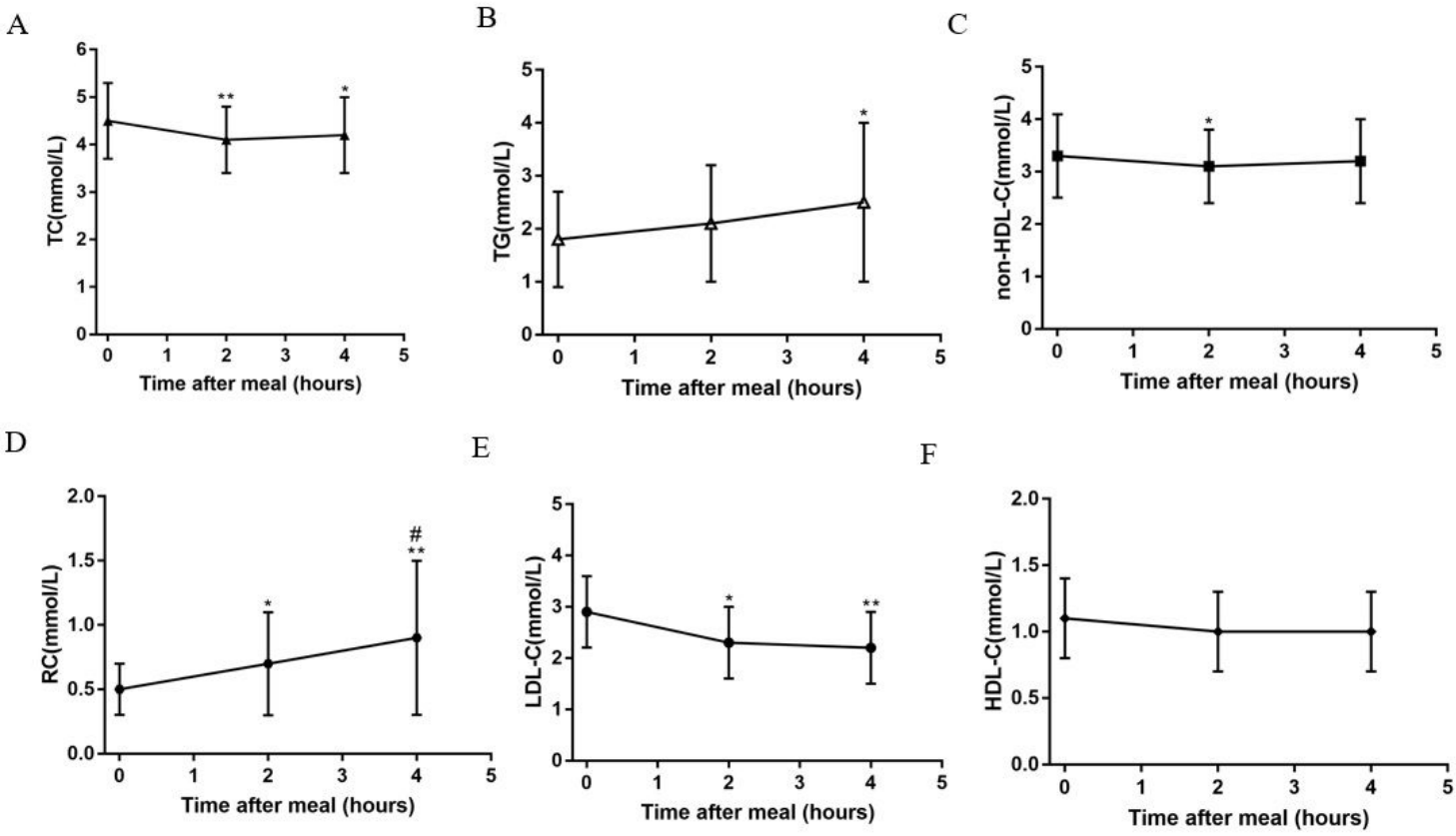

Figure 1

Changes between fasting and non-fasting lipid levels after a daily breakfast. The changes in serum concentrations of TC, TG, LDL-C, and HDL-C measured by direct method in laboratory (A, B, E, F). The changes in serum concentrations of non-HDL-C and RC determined by calculated methods (C, D). *p < 0.05 and **p < 0.01 when non-fasting state (2 h, 4 h after breakfast) compared with fasting state. #p < 0.05 when compared between 2 h and 4 h non-fasting state after breakfast.

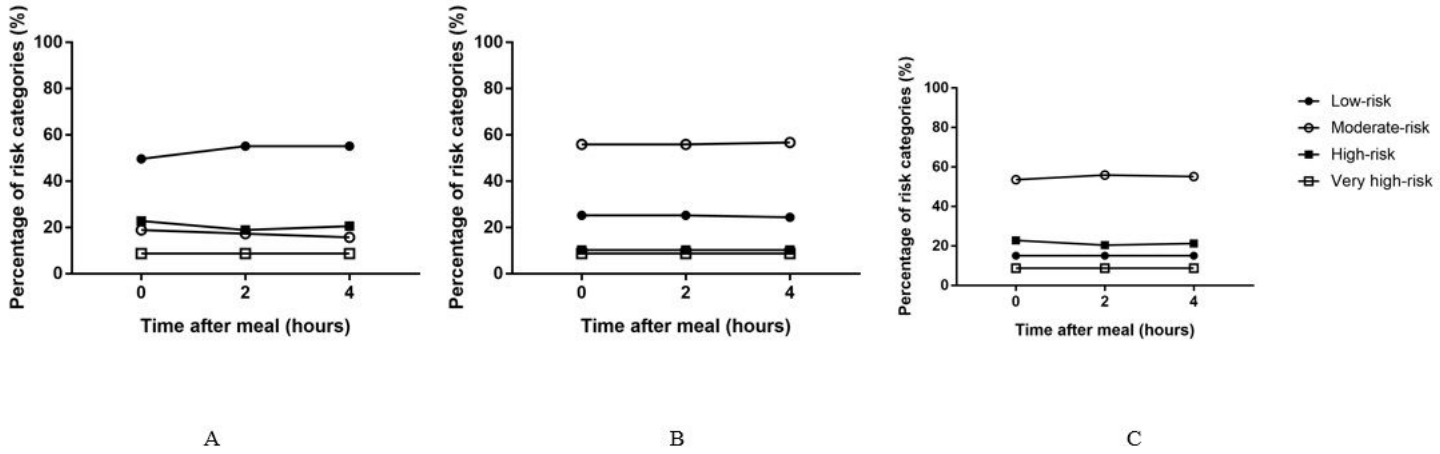

Figure 2

Cardiovascular risk classifications based on fasting and non-fasting lipid profiles using different risk estimators. The percentages of risk categories according to China ASCVD risk estimator at 0 h, 2 h, 4 h after breakfast (A). The percentages of risk categories based on SCORE low-and high-risk charts at 0 h, 2 h, 4 h after breakfast, respectively (B, C).