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Original Article

Cross-sectional associations between serum bilirubin and dyslipidemia in a population-based sample of Chinese

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Abstract: The associations between serum bilirubin (TB) and dyslipidemia were observed in some studies. However, these associations were controversial and such studies were few in China. Our study aimed to evaluate the cross-sectional relationships between TB and dyslipidemia in a representative general Chinese population. A total of 2464 participants aged 18-80 years were selected in Shanghai, using a randomized, stratified, multi-stage sampling method, and were asked to provide blood samples to test for TB and other indexes, quantiles were used to evaluate the distribution of TB and odds ratios (ORs) of prevalent dyslipidemia for TB were estimated by logistic model to reveal the association between TB levels and dyslipidemia. Median TB level was 11.3 μmol/L for all the participants (12.3 μmol/L for males and 10.6 μmol/L for females). In males, there were significant inverse associations between TB and both prevalent hypertriglyceridemia and hypo-HDL cholesterolemia in both models (all $P<0.05$). In females, such association was just observed in the prevalence of hypertriglyceridemia in both models (all $P<0.05$). The baseline TB levels were significantly correlated with total cholesterol, triglyceride, HDL cholesterol and LDL cholesterol in male. In females, the baseline TB levels were only significantly correlated with triglyceride and HDL cholesterol. The TB level of Chinese population is close to other Asian populations but much higher than the western populations. The increasing TB level was significantly associated with decreasing prevalent hypertriglyceridemia both in males and females, and with decreasing prevalent hypo-HDL cholesterolemia just in males.

Keywords: Total bilirubin, Chinese, dyslipidemia, oxidative stress

Introduction

Serum bilirubin which has antioxidant properties [1] is negatively associated with oxidative stress [2]. Individuals with congenital hyperbilirubinemia, such as individuals with Gilbert's syndrome (GS) and carriers with UGT1A1*28 allele, had low levels of oxidative stress and lower risk of cardiovascular diseases (CVD) [2-4]. In general population, epidemiological studies also found negative associations between high level of serum total bilirubin (TB) and decreased risk of CVD [5, 6]. There were similar associations between TB levels and CVD risk factors including blood pressure, triglycerides, hyper-density-lipoprotein (LDL) cholesterol, fasting glucose, hemoglobin A1c (HbA1c) [7, 8]. The prevalence of hypertriglyceridemia and high Hypo-density-lipoprotein (HDL) cholesterolemia is reported high to 24.9% and 4.7% in China [9, 10]. Previous studies based on other populations confirmed several factors were related dyslipidemia, including low level of TB [11-13]. However, studies on the association between the level of TB and the prevalence of dyslipidemia are few and the association is still unclear in China.

In this study, we aimed to evaluate the distribution of TB and the cross-sectional relationships between TB and dyslipidemia, including hypertriglyceridemia, hypercholesterolemia, hypo-HDL cholesterolemia and hyper-LDL cholesterolemia, in a representative Chinese population which included young, middle-aged and older adults. The protocol for this study was approved by the medical ethics of the Second Military Medical University (SMMU) and the study pro-

cedures were in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Subjects and methods

Study population and design

The methods have been described in detail elsewhere [14], and are briefly summarized here. A randomized, stratified, multi-stage sampling method was used to select a representative sample of the general population in Shanghai, China. Baoshan and Hongkou districts were selected at random in Shanghai. After passing through several hierarchical strata of sampling, several residential areas were sampled. Eventually, 3600 subjects were sampled at random in those areas. An informed written consent was obtained from every participant.

From April 2007 to February 2008, a total of 3153 participants (1402 males and 1751 females) completed the survey, and the overall response rate was 87.6%. We excluded participants with aspartate aminotransferase (AST) and/or alanine aminotransferase (ALT) of 60 U/L or higher [13], self-reported history of hepatobiliary disease, potential Gilbert syndrome (TB >34.2 μmol/L, aspartate aminotransferase [AST] <80 IU/L, alanine transaminase [ALT] <80 IU/L, gamma glutamyl transpeptidase [GGT] <80 IU/L and no self-reported history of hepatobiliary disease) [6], and with missing important information. At least, 2464 participants (1066 male and 1398 female) were enrolled in this cross-sectional study.

Data collection

Every participant was asked to complete a comprehensive general information questionnaire and to provide a collection of fasting blood samples.

The general information questionnaire was used to collect general demographic characteristics, including age, gender, smoking status, alcohol consumption, height, weight and frequency of activities.

The fasting blood samples were analyzed to get the physical and chemical properties and components of the blood. The main information included AST, ALT, TB, total cholesterol, triglyceride, LDL cholesterol, HDL cholesterol, fasting blood glucose, HbA1c and C reactive protein (CRP).

Derived variables

We used cut-off values from the third National Health and Nutrition Examination Survey for defining normal, borderline, or abnormal states [15, 16]. We focused on these following values: triglyceride levels (non-hypertriglyceridemia <1.70 mmol/L; hypertriglyceridemia ≥1.70 mmol/L); total cholesterol levels (non-hypercholesterolemia <6.22 mmol/L, hypercholesterolemia ≥6.22 mmol/L); HDL cholesterol levels (non-hypo-HDL cholesterolemia, ≥1.04 mmol/L in males and ≥1.30 mmol/L in females; hypo-HDL cholesterolemia <1.04 mmol/L in males and <1.30 mmol/L in females); LDL cholesterol levels (non-hyper-LDL cholesterolemia <4.14 mmol/L, hyper-LDL cholesterolemia ≥4.14 mmol/L). Body mass index (BMI) was calculated from height and weight, and the Chinese criterion was defined according to the Chinese criterion (normal, <24 kg/m^2; overweight, 24 to 28 kg/m^2; and obese, ≥28 kg/m^2) [17]. Smoking status was classified as not (including never and former) and current. Alcohol consumption was grouped into not frequent drinking (include never and <4 times/month) and frequent drinking (include at least one time/week and daily). Physical activity was graded according to frequency into 2 categories as not frequent activity (less than 4 times per month) and frequent activity (at least 1 time per week). A history of CVD was defined as diagnosis with hypertension, coronary heart disease, myocardial infarction, angina pectoris, cerebrovascular disorder by physicians. The state of high blood pressure was grouped into normal (having no hypertension history) and hypertension (having hypertension diagnosed by physicians).

Statistical analysis

Data were double entered by two independent professional data processors using software Epidata 3.1. All analyses were performed separately by gender. Data management and statistical analysis were performed with the SAS statistical package version 9.4 (SAS Institute, Cary, North Carolina). Statistical tests were 2-sided, and a p value <0.05 was considered statistically significant.

Table 1. Characteristics of the participants by gender[a]

	Total (N=2518)	Male (N=1106)	Female (N=1412)	*P*[b]
Mean age (years)	47.2 (14.2)	48.0 (14.4)	46.6 (14.1)	0.573
BMI (kg/m^2)	22.97 (3.22)	23.46 (3.16)	22.61 (3.22)	0.489
Total bilirubin (μmol/L)	12.2 (5.0)	13.3 (5.5)	11.4 (4.5)	<0.001
Total cholesterol (mmol/L)	4.90 (1.28)	4.87 (1.61)	4.92 (0.96)	<0.001
Triglycerides (mmol/L)	1.39 (1.11)	1.58 (1.33)	1.25 (0.88)	<0.001
LDL cholesterol (mmol/L)	3.14 (0.84)	3.14 (0.83)	3.14 (0.84)	0.859
HDL cholesterol (mmol/L)	1.40 (0.33)	1.31 (0.29)	1.57 (0.33)	<0.001
Fasting blood glucose (mmol/L)	5.24 (1.32)	5.26 (1.48)	5.23 (1.19)	<0.001
CVD history (%)				
Yes	506 (20.54)	241 (22.61)	265 (18.96)	0.026
No	1958 (79.46)	825 (77.39)	1133 (81.04)	
Smoking status (%)				
Not	1753 (71.14)	385 (36.12)	1368 (97.85)	<0.001
Current	711 (28.86)	681 (63.88)	30 (2.15)	
Alcohol consumption (%)				
Not frequent	2073 (84.13)	698 (65.48)	1375 (98.35)	<0.001
Frequent	391 (15.87)	368 (34.52)	23 (1.65)	
Physical activity (%)				
Not frequent	554 (22.48)	236 (22.14)	318 (22.75)	0.720
Frequent	1910 (77.52)	830 (77.86)	1080 (77.25)	

a: Values are arithmetic means (SD) unless indicated otherwise; b: *P* value was calculated by comparing males with females.

Descriptive statistics were summarized using mean (standard deviation, SD) or median (quartile range) if necessary for each numerical variables and counts and percentages for categorical variables. Comparisons were made across the two gender groups using the unpaired two-sample *t* test (for normal distributed data) or nonparametric test (for non-normal distributed data) for continuous variables such as age, BMI, etc. and using Chi-square test for categorical variables, such as smoking status, alcohol consumption, etc. Armitage trend test (for binary variables) and Spearman rank correlation test (for continuous variables) were used to test for a trend over quartiles.

We employed logistic regression models with the states of triglyceridemia, Hypercholesterolemia, HDL cholesterolemia and LDL cholesterolemia as the dependent variables. Odds ratios (ORs) of hypertriglyceridemia, hypercholesterolemia, hypo-HDL cholesterolemia and hyper-LDL cholesterolemia for each quartile of TB was calculated adjusted for age, current smoking, daily alcohol consumption, physical activity, history of CVD (Model 1), plus fasting glucose, HbA1c, AST, ALT, alkaline phosphatase (ALP), glutamyl transpeptidase (GGT), CRP and BMI (Model 2). The lowest quartile of TB was used as a reference group in the calculations of the ORs for the higher TB quartiles.

Results

Characteristics of the 2464 participants (1066 males and 1398 females) are shown in **Table 1**. The mean age was 47.2 years (48.0 for males and 46.6 for females). The mean (SD) of total cholesterol, triglycerides, HDL cholesterol and LDL cholesterol were 4.90 (1.61) mmol/L, 1.58 (1.33) mmol/L, 1.31 (0.29) mmol/L and 3.14 (0.83) mmol/L in male and 4.92 (0.96) mmol/L, 1.25 (0.88) mmol/L, 1.57 (0.33) mmol/L and 3.14 (0.84) mmol/L in females. Compared with the females, the males had higher level of BMI, TB and triglycerides and lower level of HDL cholesterol (all $P<0.05$). More males smoked and drunk than females. A total of 506 (20.54%) of the participants reported having history of CVD.

The distribution of TB for both males and females were slightly skewed toward a lower level. A total of 2367 (96.1%) participants (95.4% in males and 96.6% in females) had the

Table 2. Baseline data of blood samples stratified by the quartiles of total bilirubin

	Q1	Q2	Q3	Q4	*P*[a]
Male					
Total bilirubin range (μmol/L)	≤9.7	≤12.3	≤15.6	>15.6	
n	268	273	269	256	
Age (year)	47.1 (13.1)	48.3 (15.0)	48.5 (14.5)	48.0 (14.6)	0.330
AST (U/L)	22.4 (6.7)	23.0 (6.2)	23.5 (6.6)	23.7 (7.9)	0.011
ALT (U/L)	23.6 (11.6)	24.0 (11.3)	25.0 (11.9)	23.9 (11.7)	0.448
ALP (U/L)	70.3 (17.0)	67.1 (16.9)	68.0 (17.6)	67.0 (25.5)	0.001
GGT (U/L)[b]	30.0 (21.0, 41.0)	29.0 (20.0, 41.0)	28.0 (19.0, 41.0)	26.5 (19.0, 43.0)	0.066
S-Creatinine (μmol/L)	77.0 (12.7)	79.7 (15.2)	78.5 (11.0)	78.2 (11.5)	0.116
Total Cholesterol (mmol/L)	4.98 (1.12)	5.03 (2.71)	4.82 (0.86)	4.63 (0.90)	<0.001
Triglyceride (mmol/L)	2.05 (2.09)	1.49 (0.89)	1.46 (0.99)	1.29 (0.78)	<0.001
HDL (mmol/L)	1.25 (0.28)	1.32 (0.31)	1.31 (0.28)	1.34 (0.29)	<0.001
LDL (mmol/L)	3.22 (0.82)	3.20 (0.84)	3.15 (0.8)	2.99 (0.83)	<0.001
Fasting blood glucose (mmol/L)	5.30 (1.5)	5.14 (1.2)	5.26 (1.6)	5.32 (1.6)	0.670
Hemoglobin A1c (nmol/mg)	5.97 (1.7)	5.82 (1.3)	5.86 (1.5)	5.76 (1.2)	<0.001
CRP (mg/L)[b]	0.91 (0.37, 1.91)	0.57 (0.28, 1.34)	0.61 (0.29, 1.29)	0.47 (0.23, 0.96)	<0.001
Hypertriglyceridemia (%)	108 (40.3%)	77 (28.2%)	69 (26.7%)	56 (21.9%)	<0.001
Hypercholesterolemia (%)	19 (7.1%)	25 (9.2%)	13 (4.8%)	14 (5.5%)	0.089
Hypo-HDL cholesterolemia (%)	58 (21.6%)	42 (15.4%)	36 (13.4%)	35 (13.7%)	0.005
Hyper-LDL cholesterolemia (%)	36 (13.4%)	33 (12.1%)	29 (10.8%)	19 (7.4%)	0.013
Current smoking (%)	186 (69.4%)	171 (62.6%)	167 (62.1%)	157 (61.3%)	0.030
Frequent alcohol consumption (%)	81 (30.2%)	92 (33.7%)	98 (36.4%)	97 (37.9%)	0.025
Frequent physical activity (%)	205 (76.5%)	219 (80.2%)	209 (77.7%)	197 (77.0%)	0.462
History of CVD (%)	56 (20.9%)	63 (23.1%)	60 (22.3%)	62 (24.2%)	0.215
Female					
Total bilirubin range (μmol/L)	≤8.4	≤10.6	≤13.3	>13.3	
n	365	342	337	354	
Age (year)	43.8 (13.1)	47.0 (14.7)	47.3 (13.8)	48.3 (14.5)	<0.001
AST (U/L)	20.5 (6.4)	20.9 (6.5)	21.2 (6.4)	22.3 (6.9)	<0.001
ALT (U/L)	16.8 (9.0)	17.5 (9.8)	18.5 (10.8)	19.5 (10.6)	<0.001
ALP (U/L)	63.4 (40.2)	61.4 (19.6)	59.4 (17.6)	60.2 (18.7)	0.195
GGT (U/L)[b]	16.0 (13.0, 22.0)	16.0 (13.0, 22.0)	17.0 (13.0, 22.0)	17.0 (13.0, 24.0)	0.355
S-Creatinine (μmol/L)	58.7 (11.8)	57.9 (8.4)	58.9 (8.4)	60.2 (9.3)	<0.001
Total Cholesterol (mmol/L)	4.84 (0.95)	4.96 (0.97)	4.97 (0.91)	4.90 (0.99)	0.319
Triglyceride (mmol/L)	1.37 (1.11)	1.24 (0.79)	1.22 (0.77)	1.15 (0.78)	0.001
HDL (mmol/L)	1.44 (0.33)	1.45 (0.31)	1.48 (0.35)	1.50 (0.34)	0.005
LDL (mmol/L)	3.08 (0.80)	3.22 (0.86)	3.16 (0.81)	3.10 (0.88)	0.831
Fasting blood glucose (mmol/L)	5.15 (1.04)	5.34 (1.45)	5.23 (1.15)	5.19 (1.10)	0.393
Hemoglobin A1c (nmol/mg)	5.78 (0.83)	5.98 (1.68)	5.82 (1.5)	5.78 (1.62)	0.003
CRP (mg/L)[b]	0.69 (0.28, 1.61)	0.49 (0.23, 1.35)	0.43 (0.20, 0.93)	0.43 (0.19, 0.90)	<0.001
Hypertriglyceridemia (%)	79 (21.6%)	57 (16.7%)	57 (16.9%)	54 (15.3%)	0.017
Hypercholesterolemia (%)	25 (6.9%)	38 (11.1%)	30 (8.9%)	34 (9.6%)	0.178
Hypo-HDL cholesterolemia (%)	133 (36.4%)	119 (34.8%)	111 (32.9%)	117 (33.1%)	0.142
Hyper-LDL cholesterolemia (%)	27 (7.4%)	51 (14.9%)	33 (9.8%)	43 (12.2%)	0.098
Current smoking (%)	16 (4.4%)	3 (0.9%)	6 (1.8%)	5 (1.4%)	0.009
Frequent alcohol consumption (%)	5 (1.4%)	8 (2.3%)	4 (1.2%)	6 (1.7%)	0.486
Frequent physical activity (%)	270 (74.0%)	278 (81.3%)	264 (78.3%)	268 (75.7%)	0.396
History of CVD (%)	60 (16.4%)	67 (19.6%)	66 (19.6%)	72 (20.3%)	0.101

Values are means (SD) unless indicated otherwise. a: Spearman rank correlation for continuous variables and Chi-square trend test for categorical variables. b: Median and quartile range were used because of its highly skewed distribution.

TB level between 5 to 25 μmol/L, which is the adult recommended reference limits of TB [18].

Baseline data of blood sample stratified by the quartiles of TB are presented in **Table 2**. The

Table 3. Odds ratios of prevalent dyslipidemia for TB (adjustment for confounders using propensity score)

	Hypertriglyceridemia		Hypercholesterolemia		Hypo-HDL cholesterolemia		Hyper-LDL cholesterolemia	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	P	OR (95% CI)	*P*
Male								
Model 1[a]								
The second quartile[c]	0.57 (0.39, 0.81)	0.002	1.23 (0.66, 2.31)	0.520	0.68 (0.44, 1.06)	0.089	0.84 (0.50, 1.41)	0.516
The third quartile[c]	0.49 (0.34, 0.72)	0.002	0.60 (0.29, 1.25)	0.170	0.59 (0.37, 0.93)	0.025	0.75 (0.44, 1.27)	0.282
The forth quartile[c]	0.39 (0.27, 0.58)	<0.001	0.67 (0.33, 1.38)	0.279	0.61 (0.38, 0.97)	0.035	0.49 (0.27, 0.88)	0.018
Model 2[b]								
The second quartile[c]	0.53 (0.36, 0.79)	0.002	1.29 (0.67, 2.47)	0.449	0.68 (0.43, 1.07)	0.097	0.87 (0.51, 1.47)	0.600
The third quartile[c]	0.43 (0.29, 0.65)	<0.001	0.58 (0.27, 1.23)	0.156	0.55 (0.34, 0.98)	0.013	0.72 (0.42, 1.25)	0.247
The forth quartile[c]	0.35 (0.22, 0.54)	<0.001	0.64 (0.30, 1.36)	0.246	0.61 (0.38, 1.00)	0.048	0.50 (0.27, 0.92)	0.027
Female								
Model 1[a]								
The second quartile[c]	0.64 (0.43, 0.95)	0.026	1.42 (0.82, 2.46)	0.210	0.93 (0.68, 1.27)	0.630	1.89 (1.14, 3.14)	0.005
The third quartile[c]	0.65 (0.44, 0.96)	0.031	1.10 (0.62, 1.96)	0.737	0.84 (0.62, 1.15)	0.285	1.13 (0.66, 1.95)	0.477
The forth quartile[c]	0.55 (0.37, 0.82)	0.035	1.13 (0.65, 1.98)	0.665	0.84 (0.62, 1.15)	0.285	1.53 (0.90, 2.56)	0.116
Model 2[b]								
The second quartile[c]	0.60 (0.39, 0.91)	0.017	1.42 (0.81, 2.48)	0.222	0.94 (0.68, 1.29)	0.683	1.93 (1.15, 3.25)	0.013
The third quartile[c]	0.63 (0.41, 0.96)	0.041	1.04 (0.58, 1.88)	0.887	0.87 (0.63, 1.20)	0.395	1.08 (0.61, 1.90)	0.791
The forth quartile[c]	0.52 (0.34, 0.81)	0.004	1.03 (0.57, 1.85)	0.921	0.90 (0.65, 1.24)	0.513	1.30 (0.75, 2.24)	0.345

a: Adjusted for age, current smoking, daily drinking, physical activity, history of cardiovascular diseases and the state of high blood pressure; b: Adjusted for the covariates in Model 1 plus fasting glucose, HbA1c, ALP, GGT, AST, ALT, CRP, BMI; c: Compared with the lowest quintile of total bilirubin.

prevalence of hypertriglyceridemia, hypo-HDL cholesterolemia and hyper-LDL cholesterolemia is decreased with the increasing level of TB in males (all $P<0.05$), while in females, the increasing level of TB just associated with the decreased prevalence of hypertriglyceridemia ($P<0.05$).

The relationship between the prevalence of dyslipidemia (hypertriglyceridemia, hypercholesterolemia, hypo-HDL cholesterolemia and hyper-LDL cholesterolemia) and the quartiles of TB adjusted for possible confounders in males and females are presented in **Table 3**. In males, there were significant inverse associations between TB and both prevalent hypertriglyceridemia and hypo-HDL cholesterolemia in both models. In females, such association was just observed in the prevalence of hypertriglyceridemia. However, the associations between the prevalence of hypercholesterolemia, hyper-LDL cholesterolemia and quartile of TB were not observed neither in males nor in females.

Discussion

The association between TB and prevalence of dyslipidemia is controversial. Recently, a cross-sectional study comprising 1583 males and 883 females in Japan reported that low level of TB was significantly associated with prevalent hypertriglyceridemia and low HDL cholesterolemia [13]. The association between TB level and incident hyper-LDL cholesterolemia was significant in another cross-sectional study in Japan [12]. The prevalence of dyslipidemia is high in Chinese, especially in Shanghai [10] but lower than that in England [19], Finland [20], and the United States [21]. Whether the high level of TB is associated with the prevalence of dyslipidemia in Chinese is not clear. In this cross-sectional study, we used logistic regression to adjust the confounders and to find the association between the level of TB and dyslipidemia. After adjusted for confounders, the TB levels were significantly associated with prevalent hypertriglyceridemia and low HDL cholesterolemia in males. The participants who had higher level of TB had higher HDL cholesterol and lower triglycerides than those with lower level of TB.

Several studies also found the same associations between hyperbilirubinemia and increased HDL cholesterol and decreased triglycerides in general populations [22-24] and subjects with type 2 diabetes mellitus (T2DM) [25], while other studies just found the association with increased HDL cholesterol [26] or decreased triglycerides [27]. Besides, the gen-

der differences of TB biological effect were also observed in several studies [28]. However, there were few studies focused on the association between hyperbilirubinemia and dyslipidemia in general population in China and our study provided the latest evidence of this association.

Dyslipidemia is a risk factor of CVD and oxidative stress play a crucial role in cardiovascular diseases [29]. Several studies had found higher TB levels are associated with decreased risk for coronary-artery diseases [30, 31]. Besides, the increase in bilirubin level was associated with the reduction in the odds of peripheral arterial disease (PAD) [32]. This may be due to the antioxidant activity of bilirubin. Protection from oxidation represents the most probable mechanism of beneficial effects of TB.

The potential mechanisms responsible for the association of bilirubin with triglycerides and HDL-C have not been fully clarified. It is reported that serum amyloid A (SAA) proteins, a family of apolipoproteins associated with HDL, which are produced by the liver during the acute phase of inflammation [33] and are implicated in several chronic inflammatory diseases [34]. Higher SAA levels weaken HDL antioxidative functionality [35]. Bilirubin was correlated inversely with SAA levels in subjects without metabolic syndrome. These provide evidence for relationship between bilirubin and SAA [33] and this relationship reveal the potential mechanism underpinning the influence of bilirubin on HDL cholesterol.

Very low density lipoprotein (VLDL) secretion is the major route by which the liver can systemically (re) distribute triacylglycerol in the body [36]. In addition to reduced triacylglycerol levels in male individuals with GS, significantly reduced VLDL, intermediate density lipoprotein(IDL) and LDL 3-7 sub-fraction concentrations were also been described [37]. Besides, in subjects with T2DM and lower bilirubin, hepatic production of large VLDL increased, as a result, triglyceride-rich lipoproteins are increased [25]. These studies support a hypothesis of reduced hepatic VLDL assembly in higher bilirubin subjects by a currently unknown mechanism. The observation that circulating IDL, LDL and particularly LDL 3-7 subfraction concentrations are lower in these subjects suggests that decreased VLDL concentrations lead to reduced levels of progressively triacylglycerol poor, cholesterol sub-fractions [36].

Potential effects of bilirubin concentrations on lipoprotein metabolism and excretion had been revealed and the most likely target organs would include the liver, intestine and fat pads [36]. However, the exact mechanisms between bilirubin level and dyslipidemia remain to be discovered.

Decrease in TB was associated with incident hyper-LDL cholesterolemia [12], but neither with incident hypertriglyceridemia nor with incident low HDL cholesterolemia [13] in Japanese populations. Our study confirmed the association between TB and dyslipidemia is also exited in Chinese population and provided a basis for further studies.

It is noteworthy that the distribution of TB in adult Chinese was comparable with that of many other Asian populations but different from that of Western populations. Median TB level was 14.7 μmol/L (0.86 mg/dL) for males and 12.3 μmol/L (0.72 mg/dL) in Japanese (average age is 51.6 years old in males and 50.2 in females) [13]. In Koreans, the level is 16.4 μmol/L for males and 13.2 μmol/L for females aged 16-64 years (average age is 42.3 years old in males and 40.9 in females) [24]. These levels of TB were much higher than the levels in European (7 μmol/L, average age is 48 years old) [38]. The reason why most Asians have significantly high TB levels than Western populations is unclear.

We have to admit that this study didn't investigate the use of antihyperlipidemic drugs. However, the percentage of older people who with higher risk of dyslipidemia was quite low in our study (19.8%) and the rate of patients with dyslipidemia not treated using antihyperlipidemic drugs was high in China [39], so we thought the influence of using antihyperlipidemic drugs was little and didn't affect the final result.

Limitations

There are some inevitable limitations in this study. It was a cross-sectional study and the subjects were just from one major city in China. Detailed information about demographic back-

grounds and dietary habits was not available. Moreover, the causal connection between hyperbilirubine and dyslipidemia cannot be confirmed in this study.

Conclusions

The TB level of Chinese population is close to other Asian populations but much higher than the western populations. The increasing TB level was significantly associated with decreasing prevalent hypertriglyceridemia both in males and females, while the associations with decreasing prevalent hypo-HDL cholesterolemia in females were not significant. The findings of our study can be generalized to the general population of Chinese adults. This present retrospective cross-sectional study confirmed that the increase in TB level was significantly associated with the decrease prevalent hypertriglyceridemia and hypo-HDL cholesterolemia in males while the association in females was not significant. As dyslipidemia is an important risk factor of atherosclerosis and CVD, these findings suggest that TB level should be interpreted in conjunction with lipid profile and increasing TB level, to some extent, can prevent dyslipidemia and further reduce the risk of atherosclerosis and CVD. Future studies are needed to confirm the associations of CVD risk factors with the level of TB in China.

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Disclosure of conflict of interest

None.

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