Association between Triglyceride/High-Density Lipoprotein Cholesterol Ratio and Metabolic Syndrome in Male Workers

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1. Introduction

Metabolic syndrome (MetS) comprised of abdominal obesity, high blood pressure (BP), high fasting plasma glucose (FPG), high triglyceride (TG) and low high-density lipoprotein cholesterol (HDL-C). It causes cardiovascular disease (CVD), type 2 diabetes mellitus (DM), cancers and leads to increased mortality. Therefore, prevention and early identification of MetS is absolutely important. For this, factors associated with MetS including homocysteine, testosterone, uric acid (UA) and hs-CRP have been investigated previously. Lipid disorders affect beta cell of pancreas, cause insulin resistance (IR) which is related to MetS and IR aggravates lipid disorders [1]. Instead of IR, TG/HDL-C ratio has been investigated targeting various populations as biomarker of MetS [2,3]. In this study, we investigated association between TG/HDL-C ratio and MetS in male nuclear power plant workers (NPW).

2. Methods and Results

2.1 Participants

From March 2022 to December 2022, 11,333 NPW underwent regular health check-up. Of those, 9,639 NPW were enrolled, excluding 58 who did not complete questionnaire, 13 who did not take physical measurement or blood test, and 1,623 women.

2.2 Measurements

Height (cm), weight (kg), waist circumference (WC), body mass index (BMI), systolic and diastolic blood pressure (SBP and DBP) were measured. Using blood samples, data including white blood cell count (WBC), aspartate aminotransferase (AST), alanine aminotransferase (ALT), γ-glutamyl transpeptidase (GGT), FPG, total cholesterol (T-Chol), HDL-C, low lipoprotein cholesterol (LDL-C), TG, serum creatinine (Cr), serum UA were collected.

We applied the criteria for MetS based on the 2009 harmonized definition. All participants completed questionnaire for smoking status, alcohol consumption and exercise.

2.3 Statistical analysis

For the comparison between workers with MetS and without MetS, the student-t test and Chi-square test were used for continuous and categorical variables, respectively. Correlation of TG/HDL-C ratio with other variables was analyzed using Pearson's correlation analysis. TG/HDL-C ratio was divided into quartiles (Q1: ≤1.38, Q2: 1.39-2.19, Q3: 2.20-3.56, Q4: ≥3.57) and analyzed the differences of variables among quartiles using analysis of variance (ANOVA) for continuous variables and Chi-square test for categorical variables. Multiple logistic regression analysis was performed to obtain the odds ratio (OR) of MetS according to quartiles of TG/HDL-C ratios. Six models were used to correct the confounding factors [Model 1; unadjustment, Model 2; age, Model 3; Model 2 + WBC, AST, ALT, GGT, Model 4; Model 3 + Cr, Model 5; Model 4 + alcohol consumption, smoking status, exercise, Model 6; Model 5 + BMI]. The optimum cut-off point for MetS diagnosis was determined using a receiver operating characteristic (ROC) curve of MetS versus TG/HDL-C ratio.

2.4 Characteristics of the participants

Workers with Mets showed significantly increased age, body mass index (BMI), BP, WBC, AST, ALT, GGT, FPG, HDL-C, TG, uric acid (UA), the number of metabolic components (MS) and TG/HDL-C ratio in comparison with workers without MetS (P<0.001). The number of current smoker and workers with below recommended physical activity (PA) was significantly higher in MetS group (P<0.001).

Table 1. Clinical characteristics of the workers

Variables	Workers		*P* value
	without MetS (n = 7,510)	with MetS (n = 2,129)	
Age (year)	41.5 ± 9.9	46.6 ± 8.8	< 0.001
BMI (kg/m^2)	24.3 ± 2.7	27.5 ± 3.4	< 0.001
WC (cm)	82.4 ± 6.9	91.8 ± 8.1	< 0.001
SBP (mmHg)	120.3 ± 10.8	129.9 ± 11.1	< 0.001
DBP (mmHg)	75.0 ± 8.9	82.1 ± 8.9	< 0.001
WBC (n/μL)	5,872 ± 1431	6,568 ± 1618	< 0.001
AST (U/L)	25.6 ± 17.0	30.9 ± 17.5	< 0.001
ALT (U/L)	26.4 ± 17.6	40.2 ± 28.6	< 0.001
GGT (U/L)	31.5± 30.1	54.1 ± 53.5	< 0.001
FPG (mg/dL)	95.4 ± 12.1	109.9 ± 24.3	< 0.001
T-Chol (mg/dL)	201.7 ± 35.3	203.2 ± 42.1	0.123
HDL-C (mg/dL)	55.5 ± 12.1	45.9 ± 10.4	< 0.001
LDL-C (mg/dL)	126.4 ± 32.9	121.9 ± 39.3	< 0.001
TG (mg/dL)	116.6 ± 73.9	216.6 ± 133.0	< 0.001
UA (mg/dL)	6.2 ± 1.3	6.6 ± 1.4	< 0.001
Cr (mg/dL)	0.96 ± 0.14	0.97 ± 0.33	0.043
MS (number)	0.9 ± 0.8	3.4 ± 0.6	< 0.001
TG/HDL-C ratio	2.31 ± 1.87	5.16 ± 4.12	<0.001
Alcohol consumption			0.129
≥Twice a week (%)	4,615 (61.5)	1,347 (63.3)	
≤Once a week (%)	2,895 (38.5)	782 (36.7)	
Smoking status			< 0.001
Non-smoker (%)	3,555 (47.3)	710 (33.3)	
Former smoker (%)	2,288 (30.5)	762 (35.8)	
Current smoker (%)	1,667 (22.2)	657 (30.9)	
Exercise			< 0.001
Above recommended PA (%)	2,289 (30.5)	539 (25.3)	
Below recommended PA (%)	5,221 (69.5)	1,590 (74.7)	

2.5 Relationships between TG/HDL-C ratio and clinical variables

Continuous variables except for Cr showed significant correlation with TG/HDL-C ratio. Depending on TG/HDL-C ratio quartiles, mean values of age, BMI, WC, BP, WBC, AST, ALT, GGT, FPG, TG, UA and the number of current smokers increased among higher quartiles (P<0.001). HDL-C and the number of workers with above recommended PA showed inverse relationship with quartiles (P<0.001). The prevalence of MetS and MS showed positive relationship with quartiles (P<0.001).

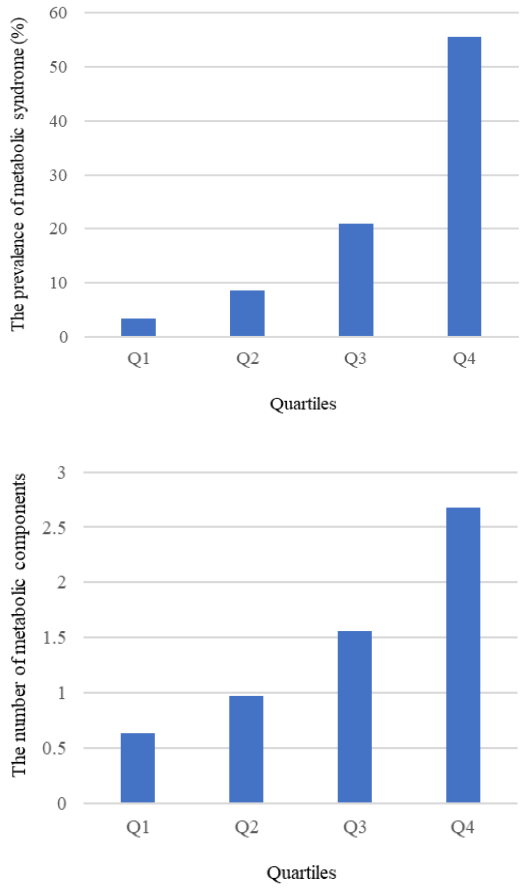

Fig. 1. Prevalence of metabolic syndrome and the number of metabolic components according to TG/HDL-C quartiles

2.6 Association of MetS according to TG/HDL-C ratio quartiles

Table 2 shows ORs with 95% confidence interval (CI) for prevalence of MetS depending on quartiles of TG/HDL-C ratio. The unadjustment OR in the Q4 is 36.91 (95% CI, 29.09 to 46.84) compared with Q1 which is reference group (P<0.001). Prevalence of MetS also significantly increased in Q3 and Q2 (P<0.001). The ORs after adjustment for confounding factors were decreased and finally the OR in Q4 after adjusting for BMI was 12.74 (95%CI, 9.87 to 16.44) (P<0.001). Even the ORs in Q3 and Q2 were 3.09 (95%CI, 2.38 to 4.01) and 1.44 (95%CI, 1.09 to 1.91), respectively (P<0.001).

Table 2. Odds ratios of metabolic syndrome depending on TG/HDL-C ratio quartiles

	TG/HDL-C ratio			
	Q1	Q2	Q3	Q4
Ratio	**≤1.38**	**1.39-2.19**	**2.20-3.56**	**≥3.57**
Number	2,408	2,415	2,404	2,412
Model 1	1.000			
Exp(B)		2.735	7.820	36.913
Lower		2.096	6.122	29.090
Upper		3.568	9.989	46.840
P value		<0.001	<0.001	<0.001
Model 2	1.000			
Exp(B)		2.484	6.909	32.882
Lower		1.901	5.400	25.875
Upper		3.246	8.838	41.786
P value		<0.001	<0.001	<0.001
Model 3	1.000			
Exp(B)		1.874	4.470	18.748
Lower		1.427	3.470	14.636
Upper		2.461	5.760	24.014
P value		<0.001	<0.001	<0.001
Model 4	1.000			
Exp(B)		1.887	4.486	18.897
Lower		1.436	3.480	14.745
Upper		2.480	5.783	24.216
P value		<0.001	<0.001	<0.001
Model 5	1.000			
Exp(B)		1.890	4.504	18.966
Lower		1.438	3.494	14.794
Upper		2.484	5.808	24.314
P value		<0.001	<0.001	<0.001
Model 6	1.000			
Exp(B)		1.441	3.093	12.736
Lower		1.091	2.383	9.870
Upper		1.905	4.014	16.435
P value		0.010	<0.001	<0.001

2.7 *ROC analysis*

We found that the best cut-off value (2.885) of TG/HDL-C ratio for diagnosis of MetS. The area under the curve (AUC) was 0.831 (95%CI, 0.821 to 0.840) (*P*<0.001). The Jordan index was 0.536 and the sensitivity and specificity were 76.9% and 76.7%, respectively.

3. Discussion

In this study, we found a TG/HDL-C ratio of 2.885 for optimal sensitivity and specificity. In the third quartile of TG/HDL-C ratio (2.20-3.56), the prevalence of MetS increased by more than three times compared to the reference, and in the highest quartile, it increased by more than twelve times even after adjustment by multiple potential confounding factors including age, liver function markers, WBC reflecting inflammation, creatinine as kidney function factor, life style factors and BMI. Among confounding factors, Cr showed no significant difference between workers with MetS and without MetS, and was not correlated with TG/HDL-C ratio quartiles. Although it is known that TG/HDL-C ratio is associated with chronic kidney disease, our study included most of the relatively healthy workers. We did not obtain HOMA-IR because we did not measure insulin. Therefore, we could not determine whether the TG/HDL-C ratio can be used as an indicator of IR.

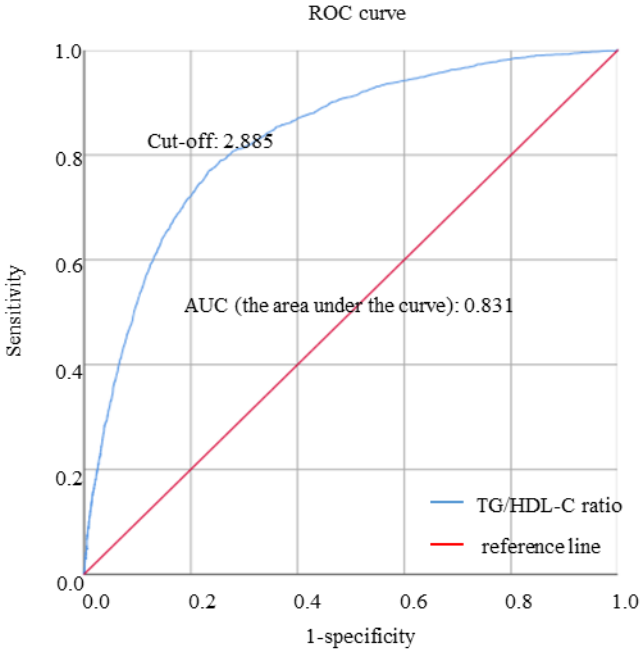

Fig. 2. Receiver operating characteristic (ROC) curve of the TG/HDL-C ratio as a predictor of metabolic syndrome

4. Conclusions

Nevertheless, TG/HDL-C ratio is considered as an independent risk factor of MetS in our study. In the future, studies including HOMA-IR, and studies comparing with serum UA levels we studied previously are needed.

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