

# Association of Triglyceride-Glucose Index and Liver Function Parameters Among Healthy Obese Civil Servants: A Center-Based Study

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**Purpose:** To investigate the correlation between Triglyceride-glucose (TyG) index and liver function parameters in healthy obese civil servants in Shijiazhuang, China.

**Materials and Methods:** This was an outpatient-based cross-sectional study in which 6452 participants were recruited. A total of 784 participants were analyzed according to inclusion and exclusion criteria. A TyG index was calculated based on fasting glucose and triglycerides. All patients were divided into a high TyG index group and a low TyG index group, using the median TyG index as a cut-off. Finally, patients were further divided into two subgroups: males and females.

**Results:** While AST/ALT and direct bilirubin levels were lower in the high TyG index group compared to the low TyG index group, ALT, AST, total protein, and albumin levels were greater. Particularly in male participants, TyG index was inversely connected with AST/ALT and direct bilirubin levels and favorably correlated with ALT, AST, total protein, and albumin levels. These connections persisted in the multilinear regression study even after adjusting for confounding variables.

**Conclusion:** This study describes the correlation between TyG index and liver function parameters in obese populations without comorbid diseases, providing a new idea for early interventional treatment in this group.

**Keywords:** TyG index, obesity, NAFLD, ALT, AST

## Introduction

Obesity is a global health problem, and of the approximately 1.5 billion overweight people worldwide, about 200 million men and 300 million women are obese.<sup>1</sup> One of the main causes of death worldwide is obesity and the diseases that it produces. Metabolic syndrome (MetS) and its associated comorbidities, such as type 2 diabetes mellitus (T2DM), nonalcoholic fatty liver disease (NAFLD), hypertension, hyperlipidemia, chronic renal disease, and cardiovascular disease (CVD), are brought on by obesity.<sup>2,3</sup> Nearly a quarter of the world's population now suffers with NAFLD, making it the most prevalent chronic liver disease. Obese people have a 25–30% greater prevalence of NAFLD than the overall population. NAFLD and obesity are well-known western illnesses. Changes in nutrition and lifestyle over the past three decades have paved the way for obesity and contributed to the rise of NAFLD in Asia. Despite having a lower BMI, Asians are more likely to have central fatty deposits, which suggests that the prevalence of NAFLD may be higher in this population. NAFLD, like other chronic liver illnesses, causes some individuals' fibrosis to worsen, which then causes cirrhosis and accompanying complications.<sup>4</sup> The majority of individuals can die from cardiovascular disease and metabolic syndrome since NAFLD and metabolic syndrome are closely related. In wealthy nations, obesity and NAFLD are widespread problems. There are many drugs on the pipeline that are reckoned as good candidates to cure NAFLD.<sup>5</sup> The primary goal of efforts should be to prevent or lessen the impacts of obesity and NAFLD.

There is a significant correlation between the prevalence of obesity and NAFLD, and these two conditions reinforce one another. NAFLD may also have an impact on obesity through a number of mechanisms, such as liver dysfunction, hepatic insulin resistance (IR), and oxidative stress.<sup>6</sup> Obesity promotes the development of NAFLD. Future hepatic steatosis and fibrosis progression is more apparent in those with higher IR. IR refers to the decrease in the efficiency of insulin to promote glucose uptake and utilization for various reasons, and the compensatory overproduction of insulin by the body to produce hyperinsulinemia, which predisposes to MetS and T2DM. Because it considers glucolipid metabolism, the triglyceride-glucose (TyG) index is currently thought to be a more accurate indicator for determining IR.<sup>7</sup> Studies have shown that the TyG index is associated with NAFLD and therefore has the potential to predict this disease, and TyG has also recently been proposed to be associated with extrahepatic cancer.<sup>8,9</sup> Additionally, since NAFLD's early stages are typically asymptomatic, the prevalence and subsequent incidence of NAFLD linked to obesity can be seen as one of the worst health disasters in the coming ten years. The prognosis of patients depends greatly on early detection and prevention of NAFLD. Imaging tests can help with the diagnosis of NAFLD, however in the early stages of the illness, there are typically no visible imaging alterations. Transaminases and bilirubin are two liver function indices that have the potential to detect liver cell damage early and appear to be more useful for NAFLD early detection.<sup>10</sup> It is unclear, though, how the TyG index and liver function metrics relate to an obese population. In order to better understand the relationship between TyG index and liver function parameters in the obese population, which is important for the early diagnosis of liver function impairment and the prevention of NAFLD in the obese population, this study included an obese population without comorbid diseases as the study population.

## Materials and Methods

### Study Population

This was an outpatient-based cross-sectional study. A total of 6452 adult participants were recruited from the Hebei Provincial Medical Examination Center from June 2022 to July 2022. Written informed consent was obtained from each subject. The study protocol was approved by the Ethics Committee of Hebei General Hospital in accordance with the principles of the Declaration of Helsinki (The number of ethics committee: No.202027). Inclusion criteria were obese people (BMI  $\geq 28$  kg/m<sup>2</sup>) aged  $\geq 18$  years and without coexisting diseases. Exclusion criteria: 1) non-obese population (BMI  $< 28$  kg/m<sup>2</sup>) 2) hypertension, coronary artery disease or diabetes mellitus; 3) liver function impairment.; 4) pregnancy or lactation; 5) malignancy; 6) other diseases or medications that affect liver function; 7) lack of necessary data.

### Data Collection

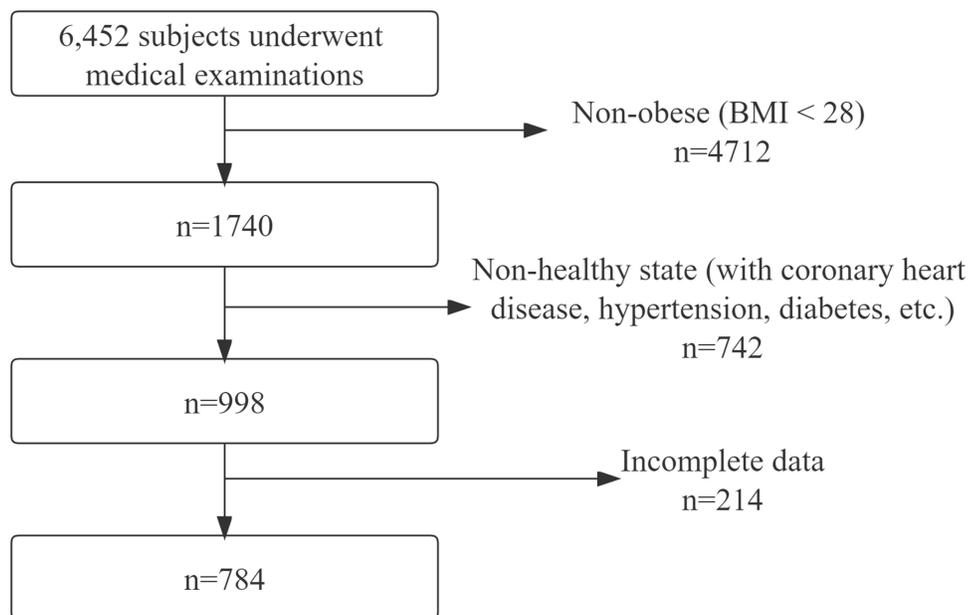
We collected demographic characteristics (age and sex), past medical history, anthropometric data (height, weight, waist and hip circumference), blood pressure, and personal habits (smoking and alcohol consumption). Blood parameters collected included fasting blood glucose (FBG), triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), total protein, albumin, globulin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, indirect bilirubin and direct bilirubin. All biochemical parameters were tested using venous blood samples following fasting for 8h. The same instrument was used for the measurement of all indicators.

### Calculation of Parameters

The formula for calculating BMI is the ratio of weight (kg) to height<sup>2</sup> (m<sup>2</sup>). The TyG index is calculated as  $\text{Ln}(\text{fasting TG (mg/dl)} \times \text{FBG (mg/dl)})/2$ .

### Statistical Analysis

All analyses were performed using GraphPad Prism 8.01 statistical software. Continuous variables were expressed as mean  $\pm$  standard deviation and compared using independent samples *t*-test. Data that did not conform to a normal distribution were



**Figure 1** Flow chart of the included subjects.

expressed as median (interquartile range: 25–75), and comparisons between groups were made using the Mann–Whitney *U*-test. Categorical variables were expressed as percentages and the chi-square test was used to compare differences between groups. Pearson’s correlation coefficient was used to assess the correlation between variables. Multiple linear regression was used to analyze independent influences.  $P < 0.05$  was considered statistically significant.

**Table 1** Clinical Baseline Characteristics of All Included Populations

	Low TyG Index (n=784)
Gender (male)	633 (80.74%)
Age (years)	49.01±13.08
BMI (kg/m <sup>2</sup> )	30.07±2.09
Hip circumference (cm)	105.5±5.92
Waist Circumference (cm)	97.94±7.64
Smoking	217 (27.68%)
Drinking	330 (42.09%)
SBP (mmHg)	126.5±15.67
DBP (mmHg)	82.63±11.05
FBG (mmol/L)	5.88±1.25
HDL-C (mmol/L)	1.19±0.23
LDL-C (mmol/L)	3.23±0.68
TG (mmol/L)	1.57 (1.12, 2.28)
TC (mmol/L)	5.03±0.96
Total Protein (g/L)	72.41±3.62
Albumin (g/L)	44.55±2.45
Globulin (g/L)	27.86±3.3
ALT (U/L)	22.7 (16.4, 32.3)
AST (U/L)	22.5 (19, 26.9)

(Continued)

**Table 1** (Continued).

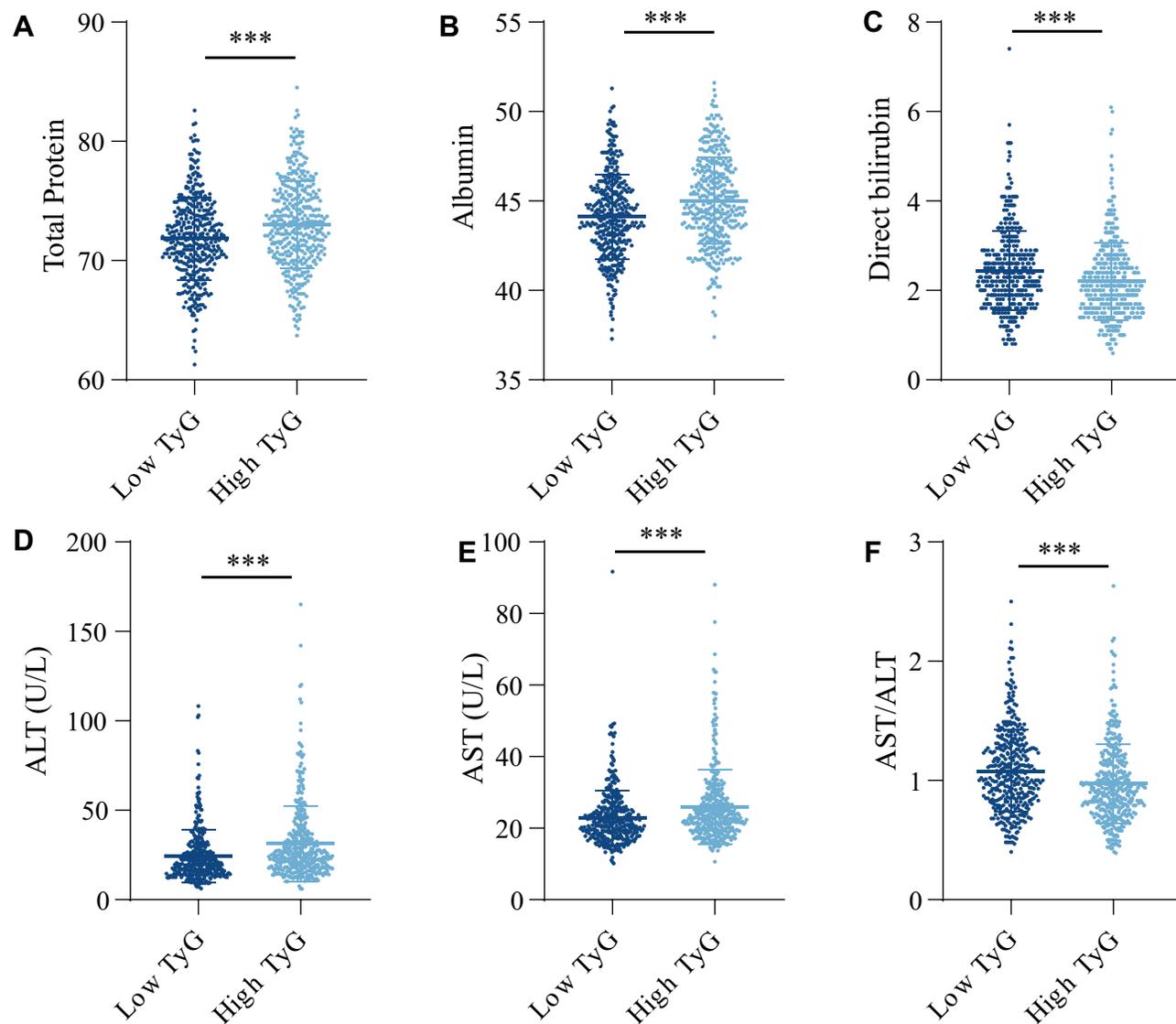
	Low TyG Index (n=784)
AST/ALT	1.03±0.34
Total bilirubin (g/L)	16.11±6
Direct bilirubin (g/L)	2.32±0.88
Indirect bilirubin (g/L)	13.79±5.27
TyG index	8.63±0.28

**Abbreviations:** BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index.

## Results

### Clinical Characteristics of All Participants

A total of 6452 participants were recruited, and 784 subjects underwent the next step of the study analysis based on inclusion and exclusion criteria. The screening flow chart of the study population can be seen in [Figure 1](#). The 784 obese



**Figure 2** Comparison of liver function parameters between the low TyG index and high TyG index groups. (A) Total Protein. (B) Albumin. (C) Direct bilirubin. (D) Alanine aminotransferase (ALT). (E) Aspartate aminotransferase (AST). (F) AST/ALT. \*\*\*P<0.001.

participants included 633 males and 151 females, with a mean age of 49.01 years and a mean BMI of 30.07 (kg/m<sup>2</sup>). The mean TyG index was 8.63. Detailed information on the clinical characteristics of the participants as well as liver function parameters are shown in [Table 1](#).

## Comparison of Basic Parameters Between the Low TyG Index Group and High TyG Index Group

All participants were divided into a high TyG group and a low TyG group based on the median of the TyG index, with 387 participants in each group. The high TyG index group had higher levels of ALT, AST, direct bilirubin, total protein and albumin ( $P<0.001$ ) ([Figure 2A-E](#)). However, AST/ALT was higher in the low TyG index group, suggesting that ALT was more elevated in the high TyG group than AST ( $P<0.001$ ) ([Figure 2F](#)). Compared to the low TyG group, the high TyG group had higher FBG, LDL-C, TC, TG levels and waist circumference, while having lower HDL-C ( $P<0.001$ ). Anthropometric and biochemical data in both the low TyG index group and the high TyG index group are presented in [Table 2](#).

## Comparison of Basic Parameters Between the Male Group and Female Group

The TyG index was higher in male participants compared to female participants ( $P<0.001$ ). Albumin, globulin, ALT, AST, total bilirubin, direct bilirubin, indirect bilirubin and waist circumference were significantly higher in the male group than in the female group, while AST/ALT and HDL-C were higher in the female group ( $P<0.001$ ).

**Table 2** Comparison of Indicators Between the Low-TyG and High-TyG Groups

	Low TyG Index (n=387)	High TyG Index (n=387)	P value
Gender (male)	293 (75.71%)	333 (86.05%)	<0.001*
Age	49.16±13.85	48.8±12.24	0.702
BMI	29.95±2.1	30.15±2.08	0.174
Hip circumference	104.7±6.04	105.4±5.77	0.096
Waist Circumference	96.7±7.82	99.15±7.31	<0.001*
Smoking	320 (82.69%)	125 (32.3%)	<0.001*
Drinking	157 (40.57%)	169 (43.67%)	0.423
SBP	125.7±16.37	127.3±14.89	0.161
DBP	81.97±11.36	83.28±10.76	0.1
FBG	5.55±0.61	6.2±1.6	<0.001*
HDL-C	1.24±0.23	1.14±0.22	<0.001*
LDL-C	3.06±0.65	3.39±0.66	<0.001*
TG	1.12 (0.89, 1.38)	2.28 (1.84, 2.95)	<0.001*
TC	4.74±0.85	5.3±0.97	<0.001*
Total Protein	71.86±3.47	73.02±3.69	<0.001*
Albumin	44.13±2.37	45.02±2.43	<0.001*
Globulin	27.73±3.27	28±3.34	0.253
ALT	20.1 (15, 28.9)	25.1 (18.2, 36.3)	<0.001*
AST	21.6 (18.3, 25.4)	23.1 (19.5, 28.4)	<0.001*
AST/ALT	1.08±0.34	0.97±0.33	<0.001*
Total bilirubin	16.02±5.77	16.21±6.26	0.672
Direct bilirubin	2.44±0.89	2.2±0.86	<0.001*
Indirect bilirubin	13.58±4.99	14±5.56	0.271
TyG index	8.47±0.3	9.4±0.51	<0.001*

**Note:** \* $P<0.05$ .

**Abbreviations:** BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index.

In addition, male participants had higher rates of smoking, alcohol consumption and SBP compared to female participants ( $P<0.001$ ), while age, BMI, hip circumference and DBP did not differ significantly between the two groups ( $P>0.05$ ). The comparative results of all basic information for the male and female groups are displayed in Table 3.

### Correlation of TyG Index with Liver Function Parameters in Obese Population

In all obese participants, TyG index was significantly positively correlated with total protein, albumin, ALT, and AST, and negatively correlated with AST/ALT, total bilirubin, and direct bilirubin (Figure 3 and Table 4).

In male participants, TyG index was positively correlated with total protein, albumin, ALT, and AST, and negatively correlated with AST/ALT, total bilirubin, direct bilirubin, and indirect bilirubin. However, in female participants, TyG index was only positively correlated with albumin (Figure 4 and Table 5).

### Multivariate Linear Correlation Analysis of TyG Index and Liver Function Parameters in Obese Population

In all participants, TyG index was positively correlated with total protein, albumin, ALT, and AST, while negatively correlated with AST/ALT, total bilirubin, and direct bilirubin in model 1 (unadjusted) and model 2 (adjusted for BMI, Hip circumference, Waist Circumference, SBP, and DBP) (Table 6).

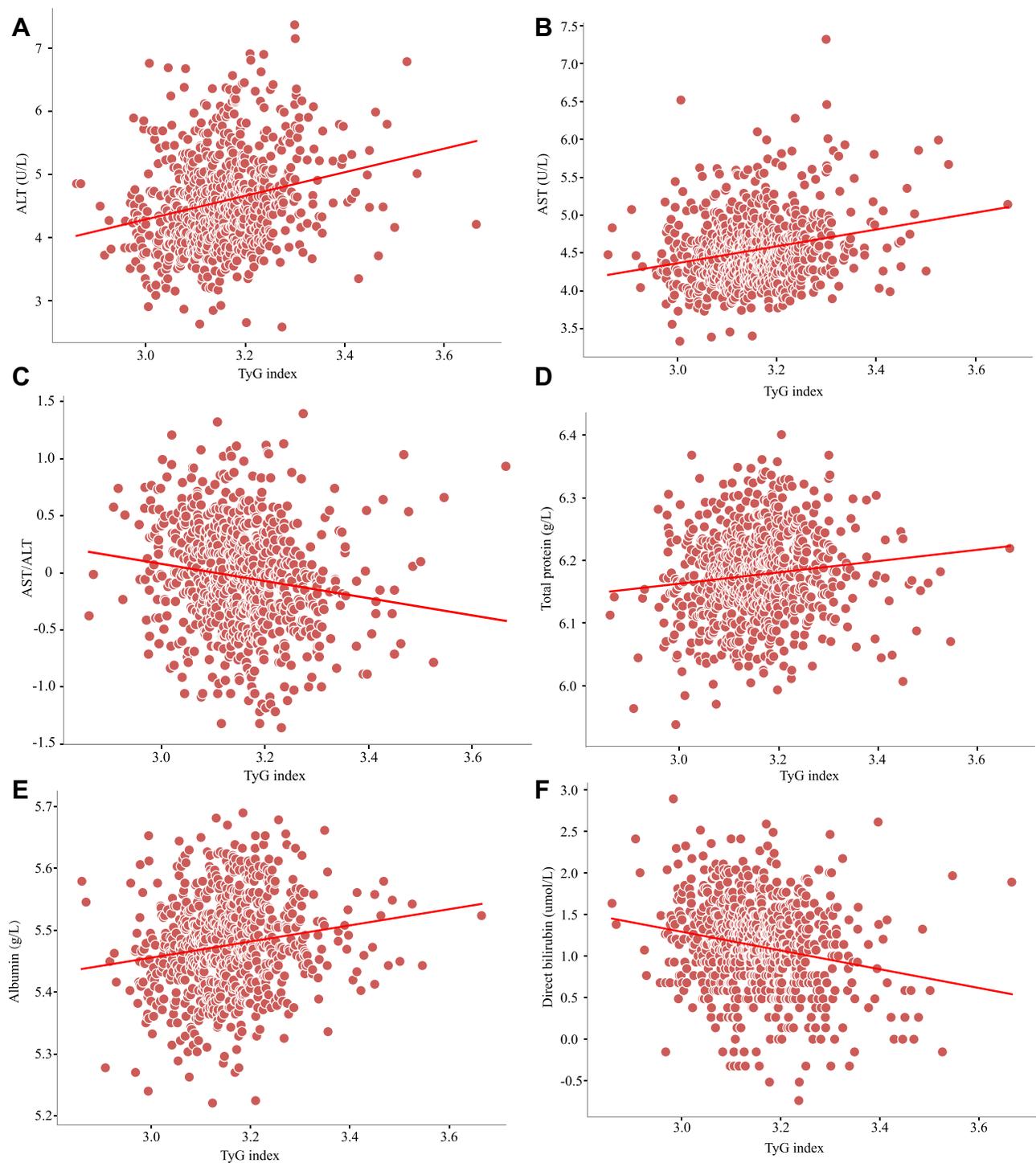
In male participants, TyG index was positively correlated with total protein, albumin, ALT, and AST, and negatively correlated with AST/ALT, total bilirubin, direct bilirubin, and indirect bilirubin, regardless of

**Table 3** Comparison of Indicators Between the Male and Female Groups

	Male (n=626)	Femal (n=148)	P value
Age	48.95±12.99	49.1±13.38	0.896
BMI	30.02±2.06	30.17±2.19	0.426
Hip circumference	105.1±5.9	104.5±5.98	0.253
Waist Circumference	99.55±6.89	91.18±7.03	<0.001*
Smoking	213 (34.03%)	0 (0%)	<0.001*
Drinking	320 (51.12%)	6 (4.05%)	<0.001*
SBP	127.6±15.52	122±15.47	<0.001*
DBP	82.85±11.29	81.68±10.11	0.249
FBG	5.9±1.23	5.77±1.32	0.238
HDL-C	1.16±0.21	1.32±0.25	<0.001*
LDL-C	3.23±0.69	3.2±0.61	0.559
TG	1.625 (1.15, 2.33)	1.37 (0.92, 1.94)	0.083
TC	5.01±0.97	5.06±0.89	0.557
Total Protein	72.38±3.64	72.69±3.55	0.345
Albumin	44.39±2.39	43.06±2.03	<0.001*
Globulin	27.45±3.16	29.64±3.33	<0.001*
ALT	23.4 (17.38, 3.88)	17.65 (13.53, 25.75)	<0.001*
AST	22.9 (19.5, 27.43)	19.6 (16.63, 24.83)	0.002*
AST/ALT	1±0.34	1.12±0.34	<0.001*
Total bilirubin	16.87±6.16	12.93±4.08	<0.001*
Direct bilirubin	2.44±0.9	1.85±0.62	<0.001*
Indirect bilirubin	14.43±5.42	11.09±3.61	<0.001*
TyG index	8.98±0.61	8.76±0.65	<0.001*

**Note:** \* $P<0.05$ .

**Abbreviations:** BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index.



**Figure 3** Correlation between TyG index and liver function parameters. **(A)** Alanine aminotransferase (ALT). **(B)** Aspartate aminotransferase (AST). **(C)** AST/ALT. **(D)** Total Protein. **(E)** Albumin. **(F)** Direct bilirubin.

adjustment models used or not used (Table 6). In female participants, there was no significant correlation between TyG index and albumin after adjustment for BMI, Hip circumference, Waist Circumference, SBP, and DBP (Table 6).

**Table 4** Correlation Between TyG Index and Liver Function Parameters

		TyG Index
Total Protein	r value	0.114 (0.044, 0.183)
	p value	0.002*
Albumin	r value	0.1577 (0.088, 0.226)
	p value	<0.001*
Globulin	r value	0.009 (-0.062, 0.079)
	p value	0.808
ALT	r value	0.216 (0.148, 0.286)
	p value	<0.001*
AST	r value	0.23 (0.162, 0.295)
	p value	<0.001*
AST/ALT	r value	-0.134 (-0.203, -0.064)
	p value	<0.001*
Total bilirubin	r value	-0.065 (-0.135, -0.005)
	p value	0.07
Direct bilirubin	r value	-0.179 (-0.246, -0.11)
	p value	<0.001*
Indirect bilirubin	r value	-0.044 (-0.115, 0.026)
	p value	0.217

**Abbreviations:** ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index. \*P<0.05.

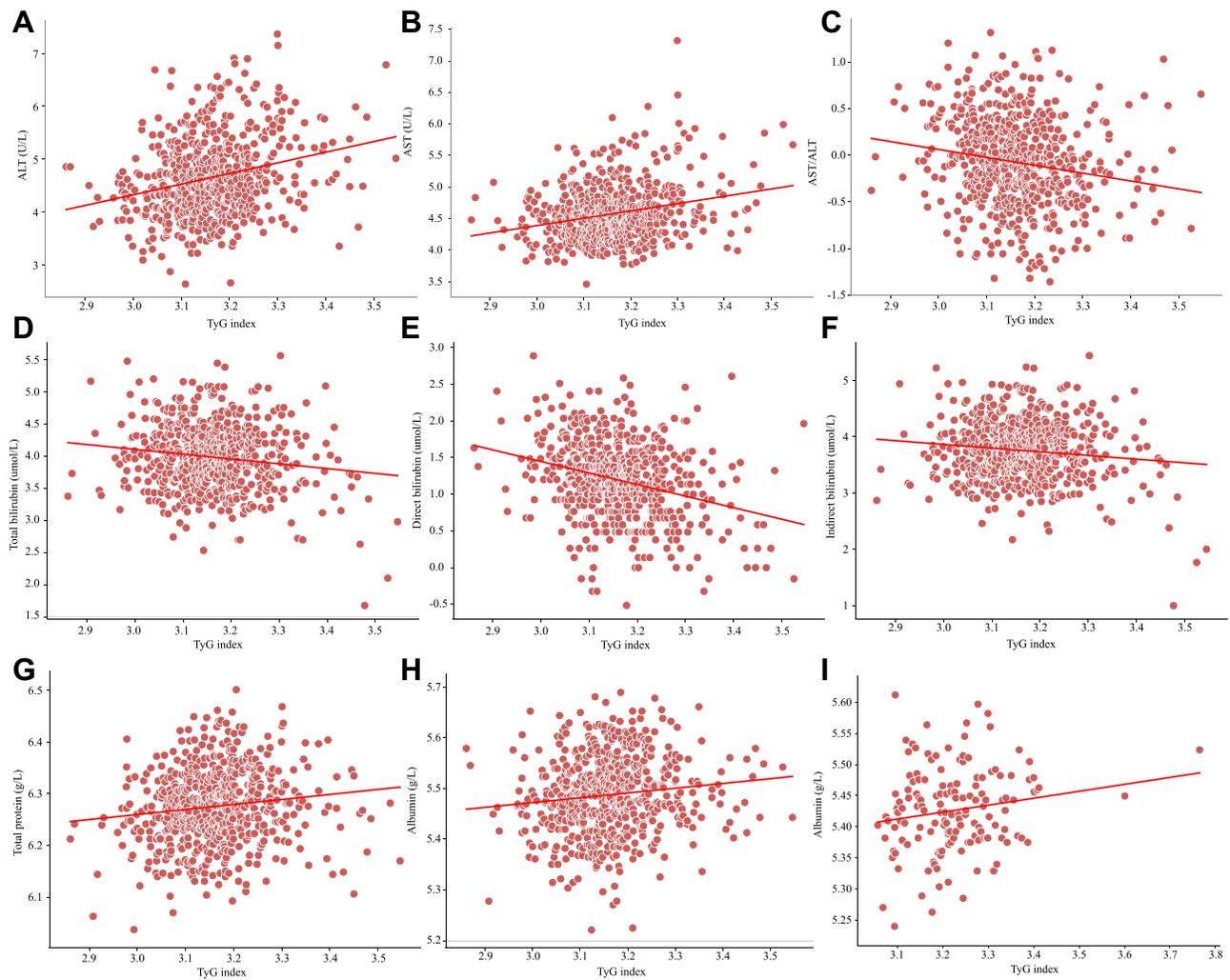
## Discussion

A risk factor for NAFLD is obesity, and NAFLD also encourages the growth of obesity, where insulin resistance is a key element.<sup>11</sup> TyG index, a measure of insulin resistance, and NAFLD had a favorable correlation.<sup>12</sup> However, changes in liver enzymes and bilirubin levels can be an early predictor of hepatocyte function impairment, and thus may be an early sensitivity indicator for obese patients with NAFLD.<sup>13</sup> Early on in the development of NAFLD, there are typically no clinical symptoms or even imaging changes. The relationship between TyG index and liver function indices in the obese population was investigated in this study, and we discovered various liver function parameters that varied between individuals with high and low TyG index.

ALT and AST are two of the most common indicators used to test liver function. ALT is mainly distributed in hepatocyte plasma, while AST is mainly distributed in hepatocyte plasma and mitochondria. Elevation of the former mainly reflects damage to the hepatocyte membrane, while elevation of the latter indicates gender damage to the level of organelles.<sup>14,15</sup> Another popular measure of liver function is the ratio of AST to ALT, with levels below one denoting modest hepatocyte injury. In this study, it was discovered that AST and ALT levels were considerably greater in individuals with high TyG indices compared to those with low ones, which may indicate hepatocyte injury to some extent. The results of AST/ALT, on the other hand, were contrary, indicating a minor hepatocyte damage at the time and maybe the very early stages of NAFLD. The TyG index is an indicator of insulin resistance, and ALT and AST levels increase as the TyG index increases, suggesting that the TyG index may serve as a potential predictor and diagnostic indicator of early NAFLD.

In addition, this study indicated that male participants had higher levels of hepatocellular damage than female participants, which may be related to a higher TyG index in the male population. Male participants also had lower AST to ALT ratios and higher ALT and AST levels than female participants. Men may have a greater TyG index than women because of their larger waist circumference, higher rates of smoking, and higher rates of alcohol use. The higher TyG index also represents higher levels of insulin resistance.

The central nervous system has long been thought to be harmed by bilirubin, a hemoglobin breakdown product that includes direct and indirect bilirubin.<sup>16</sup> An defective liver function is indicated by elevated bilirubin.<sup>17</sup> Direct bilirubin



**Figure 4** Correlation between TyG index and liver function parameters in different genders. (A) Alanine aminotransferase (ALT). (B) Aspartate aminotransferase (AST). (C) AST/ALT. (D) Total bilirubin. (E) Direct bilirubin. (F) Indirect bilirubin. (G) Total Protein. (H) Albumin. (I) Albumin. A-H indicates the correlation between TyG index and liver function parameters in males, while I indicates females.

stands out among them as a more precise gauge of hepatocyte activity, and an increase in it denotes hepatocellular injury. However, numerous studies have discovered an inverse relationship between moderately elevated serum bilirubin levels and some diseases, including obesity, diabetes, and coronary heart disease.<sup>18–20</sup> The current study discovered a significant

**Table 5** Correlation Between TyG Index and Liver Function Parameters in Different Genders

Male		TyG Index
Total Protein	r value	0.12 (0.042, 0.196)
	p value	0.003*
Albumin	r value	0.115 (0.037, 0.192)
	p value	0.004*
Globulin	r value	0.051 (–0.027, 0.129)
	p value	0.2
ALT	r value	0.249 (0.175, 0.322)
	p value	<0.001*

(Continued)

**Table 5** (Continued).

Male		TyG Index
AST	r value	0.26 (0.186, 0.332)
	p value	<0.001*
AST/ALT	r value	-0.155 (-0.231, -0.078)
	p value	<0.001*
Total bilirubin	r value	-0.112 (-0.188, -0.033)
	p value	0.006*
Direct bilirubin	r value	-0.258 (-0.33, -0.184)
	p value	<0.001*
Indirect bilirubin	r value	-0.083 (-0.161, 0.005)
	p value	0.038*
Female		TyG index
Total Protein	r value	0.12 (-0.042, 0.276)
	p value	0.146
Albumin	r value	0.165 (0.004, 0.318)
	p value	0.045*
Globulin	r value	0.027 (-0.135, 0.188)
	p value	0.743
ALT	r value	-0.031 (-0.191, 0.131)
	p value	0.712
AST	r value	0.042 (-0.121, 0.202)
	p value	0.617
AST/ALT	r value	0.037 (-0.125, 0.197)
	p value	0.655
Total bilirubin	r value	-0.078 (-0.237, 0.084)
	p value	0.345
Direct bilirubin	r value	-0.044 (-0.204, 0.118)
	p value	0.591
Indirect bilirubin	r value	-0.081 (-0.239, 0.082)
	p value	0.328

**Abbreviations:** ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index. \*P<0.05.

inverse link between reduced direct bilirubin levels and high TyG index, indicating that having a high TyG index may reduce the body's antioxidant capacity and increase the risk of developing obesity and associated comorbidities. However, this study also discovered that men had greater bilirubin levels than women, which may be related to more

**Table 6** Multivariate Linear Correlation Analysis of TyG Index and Liver Function Parameters in Obese Population

	ALT		AST		AST/ALT	
	B (95% CI)	P	B (95% CI)	P	B (95% CI)	P
<b>All patients</b>						
Model 1	0.007 (0.005, 0.01)	<0.001*	0.014 (0.01, 0.018)	<0.001*	-0.246 (-0.374, -0.117)	<0.001*
Model 2	0.006 (0.004, 0.009)	<0.001*	0.012 (0.008, 0.016)	<0.001*	-0.211 (-0.343, -0.079)	0.002*
<b>Male</b>						
Model 1	0.008 (0.006, 0.011)	<0.001*	0.015 (0.011, 0.02)	<0.001*	-0.281 (-0.422, -0.141)	<0.001*
Model 2	0.008 (0.005, 0.011)	<0.001*	0.015 (0.01, 0.019)	<0.001*	-0.268 (-0.416, -0.121)	<0.001*
<b>Female</b>						
Model 1	-0.001 (-0.008, 0.006)	0.712	0.003 (-0.008, 0.013)	0.616	0.071 (-0.243, 0.386)	0.655
Model 2	-0.002 (-0.009, 0.004)	0.46	0.001 (-0.01, 0.01)	0.945	0.116 (-0.188, 0.42)	0.453

(Continued)

Table 6 (Continued).

	Total bilirubin		Direct bilirubin		Indirect bilirubin	
	B (95% CI)	P	B (95% CI)	P	B (95% CI)	P
<b>All patients</b>						
Model 1	-0.007 (-0.014, 0.001)	0.07	-0.127 (-0.176, -0.077)	<0.001*	-0.005 (-0.014, 0.003)	0.217
Model 2	-0.011 (-0.019, -0.004)	0.004*	-0.016 (-0.209, -0.11)	<0.001*	-0.01 (-0.018, -0.001)	0.025*
<b>Male</b>						
Model 1	-0.011 (-0.019, -0.003)	0.005*	-0.176 (-0.228, -0.124)	<0.001*	-0.009 (-0.018, -0.001)	0.037*
Model 2	-0.013 (-0.021, -0.005)	0.002*	-0.184 (-0.236, -0.131)	<0.001*	-0.011 (-0.02, -0.002)	0.018*
<b>Female</b>						
Model 1	-0.012 (-0.038, 0.013)	0.345	-0.047 (-0.218, 0.125)	0.591	-0.015 (-0.044, 0.015)	0.328
Model 2	-0.008 (-0.032, 0.017)	0.534	-0.046 (-0.208, 0.116)	0.575	-0.009 (-0.036, 0.019)	0.543
	Total Protein		Albumin		Globulin	
	B (95% CI)	P	B (95% CI)	P	B (95% CI)	P
<b>All patients</b>						
Model 1	0.02 (0.008, 0.032)	0.001*	0.041 (0.023, 0.058)	<0.001*	0.002 (-0.012, 0.015)	0.808
Model 2	0.017 (0.005, 0.03)	0.005*	0.034 (0.016, 0.052)	<0.001*	0.002 (-0.011, 0.016)	0.743
<b>Male</b>						
Model 1	0.02 (0.007, 0.033)	0.003*	0.03 (0.009, 0.05)	0.004*	0.01 (-0.005, 0.025)	0.2
Model 2	0.018 (0.004, 0.031)	0.01*	0.03 (0.01, 0.05)	0.004*	0.006 (-0.01, 0.022)	0.443
<b>Female</b>						
Model 1	0.022 (-0.008, 0.052)	0.146	0.053 (0.001, 0.104)	0.045*	0.005 (-0.027, 0.037)	0.743
Model 2	0.011 (-0.018, 0.039)	0.452	0.043 (-0.007, 0.092)	0.09	-0.004 (-0.034, 0.027)	0.82

Notes: Model 1: unadjusted; Model 2: adjusted for Body mass index, Hip circumference, Waist Circumference, Systolic blood pressure, and Diastolic blood pressure. \*P<0.05.

Abbreviations: ALT, alanine aminotransferase; AST, aspartate aminotransferase; TyG index, triglyceride-glucose index.

severe hepatocellular damage brought on by the TyG index in men. Intriguingly, the TyG index and bilirubin levels in the male participants had a strong negative connection, indicating that the paradox may be brought on by the co-existence of diminished antioxidant capacity and hepatocyte injury.

The primary protein in plasma, albumin is primarily produced by hepatic parenchymal cells and serves as the clotting factor, substance binding, and colloid osmotic pressure regulator.<sup>21</sup> Albumin contains a sulfhydryl group that can control how inflammatory cells signal, limiting the release of inflammatory chemicals and functioning inadvertently as an anti-inflammatory agent. This study discovered comparatively high albumin levels in persons with high TyG indices, which may be linked to increased synthesis as a result of higher TyG indices being associated with bigger waist circumference. However, whether increasing albumin boosts anti-inflammatory capacity in vivo is unknown and has to be confirmed by additional clinical and fundamental research. In addition, since this study is a cross-sectional study thus no causal relationship between TyG index and liver function parameters can be drawn, which needs to be clarified by further clinical observational trials.

This study has several limitations. First, it was a cross-sectional study and causality could not be determined. Secondly, this study did not measure fasting insulin levels and thus the Homeostasis model assessment index could not be calculated. This should be considered in future studies. Finally, a larger sample as well as a multicenter population study is needed to validate the findings of this study and make the results more reliable.

## Conclusion

In this study, it was discovered that in the obese population, TyG index had a negative correlation with direct bilirubin and a positive correlation with ALT and AST. This implies that obesity, particularly in males, is an independent risk

factor for liver damage and impaired antioxidant capacity. In the obese population, the elevated TyG index may be a possible predictor and early diagnostic sign of NAFLD.

## Data Sharing Statement

Data supporting the results of this study are available upon reasonable request from the first author.

## Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Hebei General Hospital (Date May 8, 2020/No. 202027).

## Consent

Written informed consent was obtained from all participants.

## Disclosure

The authors declare that they have no conflicts of interest in this work.

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