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Association Between Triglyceride-Glucose Index and Lung Function Parameters in the General Population Undergoing Health Examinations

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Purpose: To investigate the relationship between the triglyceride-glucose (TyG) index and pulmonary function metrics among the general population undergoing health examinations.

Materials and Methods: The enrollment totaled 696 participants. Fasting triglycerides and glucose levels were used to calculate the TyG index. Participants were divided into two categories according to their median TyG: one with high TyG and the other with low TyG. A portable spirometer was used to assess lung function. Fundamental clinical features and lung function indicators were compared between the two groups, and the relationship between the TyG index and lung function parameters was explored.

Results: Compared with the low TyG group, the high TyG group exhibited significantly reduced levels of FEV1/FVC, FVC% pred, FEV1% pred, FEV3% pred, FEV3/FVC, FEF75, FEF75% pred, FEF25-75% pred, and MVV% pred, suggesting poor pulmonary function. The TyG index was significantly inversely correlated with multiple pulmonary function metrics, including FVC% pred, FEV1% pred, FEV3% pred, FEV1/FVC, FEV3/FVC, FEF75, FEF75% pred and FEF25-75% pred, which persisted even after accounting for confounding variables.

Conclusion: In summary, the present study establishes a correlation between the TyG index and some lung function indicators, offering a new indicator of metabolic abnormalities related to lung functionality.

Keywords: triglyceride-glucose index, lung function, insulin resistance, FEV1, FVC

Introduction

A decline in lung capacity may negatively impact health results and the quality of life. Accumulating evidence has shown that reduced pulmonary capacity is associated with mortality rates.[1–3] Most individuals with reduced lung capacity, encompassing smokers and non-smokers, show no symptoms, indicating a greater risk of the disease's pre-clinical phase with population aging. A multitude of research have reported a connection between diabetes and hyperglycemia and the emergence of several lung diseases.[4,5] The deterioration of lung function is often seen as a significant complication associated with diabetes.[6,7] The body produces abundant insulin to maintain steady blood sugar levels, resulting in hyperinsulinemia, closely linked to insulin resistance (IR). IR is a crucial contributor to obesity, type 2 diabetes (T2DM), metabolic syndrome (MetS), and non-alcoholic fatty liver disease (NAFLD).[8,9] IR is strongly related to asthma, leading to reduced lung capacity, hastened deterioration of lung function, and less-than-ideal responses to bronchodilator and corticosteroid therapies.[10] IR is also a major factor in the reduced lung capacity in children with asthma.[11]

The triglyceride-glucose (TyG) index quantifies metabolic impairment by tracking triglyceride (TG) and glucose levels in fasting blood.[12] The TyG index is currently considered a more precise measure of IR. Earlier studies have confirmed a link between the TyG and various health issues, including NAFLD, diabetic nephropathy, cervical vascular dysfunction, coronary artery disease and non-small cell lung cancer.[13–18] The TyG index even outperforms the

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homeostatic model assessment for insulin resistance (HOMA-IR) in forecasting conditions such as NAFLD and arterial stiffness.[19,20]

The link between the TyG and pulmonary performance remains ambiguous in the general population undergoing health examinations. This study investigated the association between the TyG and pulmonary performance, possibly offering new perspectives for the early identification, diagnosis, and treatment of pulmonary injury in the general populace.

Materials and Methods

Study Population

A cross-sectional study was conducted based on outpatient data. From June 2023 to January 2024, 696 adults were enlisted from the Hebei Provincial Medical Examination Center. The Hebei General Hospital's Ethics Committee sanctioned this research methodology in alignment with the Declaration of Helsinki's tenets (No. 2024-LW-112). Individuals in the general populace who received a physical check-up were deemed prospective participants in the study. Exclusion criteria: (1) aged at most 18 years old; (2) individuals suffering from critical liver, lung, and kidney malfunctions, along with cancerous growths; (3) a history of lung-related illnesses; (4) those with various illnesses or drugs impacting pulmonary performance; (5) missing essential information; and (6) those utilizing of additional oxygen.

Data Collection and Laboratory Analysis

Patient baseline information was collected, including age, gender, smoking and drinking records, systolic blood pressure (SBP), diastolic blood pressure (DBP), height, and weight. Laboratory examinations included total cholesterol (TC), TG, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), fasting blood glucose (FBG), blood urea nitrogen (BUN), uric acid (UA), aspartate transaminase (AST), alanine transaminase (ALT), blood creatinine (Cr), γ-glutamyl transpeptidase (γ-GT), direct bilirubin (DBIL), indirect bilirubin (IBIL), and total bilirubin (TBIL). Blood routine indicators included neutrophil count (NEUT), hemoglobin (HGB), white blood count (WBC), red blood count (RBC), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV), platelet count (PLT), plateletcrit (PCT), basophils (BA), eosinophils (EO), lymphocytes (LY), monocytes (MO), platelet-larger cell ratio (P-LCR), red cell distribution width-standard deviation (RDW-SD), red cell distribution width-standard deviation coefficient variation (RDW-CV), hematocrit (HCT), mean platelet volume (MPV), and platelet volume distribution width (PDW).

Lung Function Measures

Trained technicians conducted all lung function tests utilizing a portable spirometer III (Spiro-lab MIR, co. Ltd., Roma, Italy) as previously described.[21] Participants were instructed to remain motionless, gripping the spirometer, before executing a compulsory exhalation. Each participant performed the procedure thrice and the peak reading was recorded. The examined lung functions included the forced expiratory volume in 1 second (FEV1), FEV1 to predicted value ratio (FEV1% pred), forced expiratory volume in 3 second (FEV3), FEV3 to predicted value ratio (FEV3% pred), forced vital capacity (FVC), FVC to predicted value ratio (FVC% pred), FEV1/FVC, peak expiratory flow (PEF), PEF to predicted value ratio (PEF% pred), maximal voluntary ventilation (MVV), MVV to predicted value ratio (MVV% pred), forced inspiratory vital capacity (FIVC), forced inspiratory volume in 1 second (FIV1), FIV1/FIVC, peak inspiratory flow (PIF), forced expiratory flow (FEF) at 25 and 75% of the pulmonary volume (FEF25-75), FEF25-75 to predicted value ratio (FEF25-75% pred), FEF25, FEF25 to predicted value ratio (FEF25% pred), FEF50, FEF50 to predicted value ratio (FEF50% pred), FEF75, FEF75 to predicted value ratio (FEF75% pred), and forced expiratory time (FET).

Calculation of Parameters

The TyG index was derived by multiplying TG and FBG levels using the following formula: Ln (fasting TG (mg/dl) × FBG (mg/dl)/2).[14,17]

Statistical Analysis

Every piece of data underwent analysis and visualization through the utilization of GraphPad Prism 10 and SPSS 27 software. Data following a normal distribution was presented as the average ± standard deviation and analyzed using the Student's *t*-test. Data that did not follow a normal distribution were represented as the median values (25th and 75th percentiles) and analyzed through the Mann–Whitney *U*-test. The connection among variables was examined using Spearman or Pearson correlation analyses. Multiple linear regression was employed to investigate the independent relationships among variables. A *P*-value below 0.05 was deemed to hold statistical significance.

Results

Medical Traits of Every Participant

The study encompassed 696 participants, of who 534 (76.72%) were males. Of the 696 participants, 327 (46.98%) and 282 (40.52%) were alcohol drinkers and smokers, respectively. The average age was 45 years, with a body mass index (BMI) of 25.10 kg/m^2. The study participants were divided into groups according to their median TyG score (7.08), divided into the high TyG (n = 348) and low TyG (n = 348) clusters. The mean FBG, TC, TG, HDL-C, and LDL-C were 5.41, 4.97, 1.32, 1.29, and 3.14 mmol/L, respectively. The mean HGB, WBC, NEUT, PLT, and RBC were 152 g/L, 6.37 × 10^9/L, 3.73 × 10^9/L, 248 × 10^9/L, and 4.90 ± 0.47 × 10^{12}/L, respectively. Table 1 displays the fundamental clinical attributes of each participant.

Table 1 Medical Traits of Every Participant

	Subjects (n=696)
Male (%)	534(76.72%)
Smoking (%)	282(40.52%)
Drinking (%)	327(46.98%)
Age(years)	45(35, 51)
Height (cm)	172(166, 177)
Weight (kg)	75(66, 83)
BMI (kg/m^2)	25.1(23.1, 27.58)
SBP (mmHg)	120(110, 131)
DBP (mmHg)	79(71, 85.75)
TyG	7.08(6.65, 7.51)
FBG (mmol/L)	5.41(5.12, 5.92)
AST (U/L)	21.4(18.2, 26.08)
ALT (U/L)	21.15(15.3, 29.88)
AST/ALT	1.02(0.78, 1.29)
IBIL (μmol/L)	13.3(10.43, 16.4)
DBIL (μmol/L)	2.4(1.9, 2.9)
TBIL (μmol/L)	15.7(12.4, 19.4)
γ-GT (U/L)	24.4(17.7, 36.4)
TG (mmol/L)	1.32(0.9, 2.01)
TC (mmol/L)	4.97(4.45, 5.63)
HDL-C (mmol/L)	1.29(1.13, 1.48)
LDL- C (mmol/L)	3.14(2.75, 3.62)
Cr (μmol/L)	71.5(63.3, 80.2)
UA (μmol/L)	384.62±90.23
BUN (mmol/L)	4.92(4.2, 5.73)
RBC (10^{12}/L)	4.90±0.47
WBC (10^9/L)	6.37(5.49, 7.42)
NEUT (10^9/L)	3.73(3.09, 4.54)

(*Continued*)

Table 1 (Continued).

	Subjects (n=696)
LY (10^9/L)	2.09(1.71, 2.52)
PLT (10^9/L)	248(214, 291)
MO (10^9/L)	0.31(0.25, 0.38)
BASO (10^9/L)	0.03(0.01, 0.04)
EO (10^9/L)	0.1(0.06, 0.18)
PDW (fL)	11.4(10.3, 12.7)
PCT (%)	0.25(0.22, 0.29)
HGB (g/L)	152(142, 160)
MPV (fL)	10.1(9.5, 10.6)
MCV (fL)	90.7(88.3, 93.3)
MCH (pg)	30.7(29.7, 31.68)
MCHC (g/L)	337(331, 343.75)
HCT (L/L)	0.447(0.420, 0.472)
RDW-CV (%)	12.4(12.1, 12.9)
RDW-SD (fL)	41.3(39.7, 43.1)
P-LCR (%)	25.55(21.13, 30.25)

Lung Function Parameters of Participants

The average FVC, FEV1, FEV1% pred, FEV3, PEF, FEF25% pred, FIVC, and MVV were 3.85 ± 0.77 L, 3.13 ± 0.62 L, 0.98 ± 0.11, 3.74 ± 0.74, 7.44 ± 1.59 L/s, 0.84 ± 0.16, 3.51 ± 0.76 L, and 109.67 ± 21.87 L/min, respectively. The mean FEF25, FEF50, FEF75, FEF25-75, FET, FIV1, and PIF were 6.28 L/s, 3.62 L/s, 1.25 L/s, 3.09 L/s, 4.08 s, 2.89 L, and 3.17 L/s, respectively. The mean FVC% pred, FEV3% pred, PEF% pred, FEF50% pred, FEF75% pred, FEF25-75% pred, and MVV% pred were 0.98, 1, 0.91, 0.81, 0.71, 0.93, and 0.86 respectively. The lung function metrics of participants are displayed in Table 2.

Table 2 Lung Function Index of Participants

	Subjects (n=696)
FVC (L)	3.85±0.77
FVC% pred	0.98 (0.91, 1.06)
FEV1 (L)	3.13±0.62
FEV1% pred	0.98±0.11
FEV3 (L)	3.74±0.74
FEV3% pred	1 (0.93, 1.08)
FEV1/FVC	0.81 (0.78, 0.85)
FEV3/FVC	0.97 (0.96, 0.99)
PEF (L/s)	7.44±1.59
PEF% pred	0.91 (0.81, 1.02)
FEF25 (L/s)	6.28 (5.27, 7.36)
FEF25% pred	0.84±0.16
FEF50 (L/s)	3.62 (2.96, 4.38)
FEF50% pred	0.81 (0.69, 0.95)
FEF75 (L/s)	1.25 (0.99, 1.64)
FEF75% pred	0.71 (0.58, 0.86)
FEF25-75 (L/s)	3.09 (2.53, 3.75)

(*Continued*)

Table 2 (Continued).

	Subjects (n=696)
FEF25-75% pred	0.93 (0.81, 1.1)
FET (s)	4.08 (3.43, 4.64)
MVV (L/min)	109.67±21.87
MVV% pred	0.86 (0.8, 0.93)
FIV1 (L)	2.89 (2.28, 3.55)
FIVC (L)	3.51±0.76
FIV1/FIVC	0.87 (0.73, 0.97)
PIF (L/s)	3.17 (2.4, 4.07)

Comparison of Clinical Traits Between High and Low TyG Groups

Furthermore, the high TyG group exhibited a greater percentage of males, alcohol consumers, and smokers. Participants in the high TyG group were older, with elevated BMI, and blood pressure compared with their counterparts in the low TyG group (Table 3) (Figure 1).

Table 3 Comparison of Clinical Features Between High and Low TyG Groups

	High TyG (n=348)	Low TyG (n=348)	*P*
Male (%)	305(87.64%)	229(65.80%)	<0.001
Smoker (%)	187(53.74%)	95(27.30%)	<0.001
Drinker (%)	188(54.02%)	139(39.94%)	<0.001
Age(y)	47.00(40.00, 52.00)	43.00(33.00, 49.00)	<0.001
Height (cm)	173.00(168.25, 176.75)	171.00(164.00, 177.00)	0.0079
Weight (kg)	79.00(71.00, 87.75)	70.00(62.00, 78.00)	<0.001
BMI (kg/m^2)	26.35(24.43, 28.70)	23.90(22.00, 25.90)	<0.001
SBP (mmHg)	123.00(114.25, 134.00)	115.00(107.00, 128.00)	<0.001
DBP (mmHg)	81.00(75.00, 88.00)	75.50(69.25, 83.00)	<0.001
TyG	7.51(7.30, 7.86)	6.65(6.41, 6.89)	<0.001
TG (mmol/L)	2.01(1.61, 2.54)	0.91(0.71, 1.12)	<0.001
TC (mmol/L)	5.27±0.98	4.80±0.82	<0.001
LDL-C (mmol/L)	3.36±0.72	2.99±0.62	<0.001
HDL-C (mmol/L)	1.19(1.07, 1.39)	1.35(1.21, 1.56)	<0.001
FBG (mmol/L)	5.60(5.25, 6.55)	5.27 (4.99, 5.59)	<0.001
Cr (μmol/L)	74.20(66.22, 81.78)	69.00(61.40, 77.97)	<0.001
BUN (mmol/L)	5.07±1.15	5.03±1.36	0.474
UA (μmol/L)	409.57±84.94	359.67±88.57	<0.001
TBIL (μmol/L)	16.20(12.43, 19.88)	15.45(12.13, 18.98)	0.154
IBIL (μmol/L)	13.90(10.70, 17.15)	12.85(10.03, 16.10)	0.019
DBIL (μmol/L)	2.40(1.90, 2.80)	2.40(1.90, 3.10)	0.059
ALT (U/L)	25.85(18.82, 36.70)	17.35(13.43, 24.00)	<0.001
AST (U/L)	22.30(19.20, 27.38)	20.50(17.30, 23.95)	<0.001
AST/ALT	0.89(0.70, 1.11)	1.16(0.90, 1.43)	<0.001
γ-GT (U/L)	30.50(22.70, 46.55)	19.65(14.60, 27.77)	<0.001
RBC (10^{12}/L)	5.02±0.43	4.78±0.47	<0.001
WBC (10^9/L)	6.79(5.86, 7.99)	5.94(5.12, 6.90)	<0.001
NEUT (10^9/L)	4.01(3.32, 4.86)	3.48(2.83, 4.14)	<0.001
LY (10^9/L)	2.18(1.83, 2.70)	1.99(1.59, 2.36)	<0.001

(*Continued*)

Table 3 (Continued).

	High TyG (n=348)	Low TyG (n=348)	*P*
PLT (10^9/L)	251.00(217.00, 289.00)	244.00(211.00, 295.75)	0.383
MO (10^9/L)	0.33(0.27, 0.39)	0.29(0.24, 0.35)	<0.001
BASO (10^9/L)	0.03(0.01, 0.05)	0.02(0.01, 0.04)	<0.001
EO (10^9/L)	0.12(0.07, 0.21)	0.09(0.06, 0.16)	<0.001
PDW (fL)	11.35(10.30, 12.60)	11.50(10.33, 12.70)	0.686
PCT (%)	0.25(0.22, 0.29)	0.25(0.22, 0.29)	0.78
HGB (g/L)	155.00(148.00, 164.00)	147.50(136.00, 157.00)	<0.001
MPV (fL)	10.00(9.50, 10.60)	10.10(9.60, 10.70)	0.165
MCV (fL)	90.65(88.40, 93.00)	91.05(88.30, 93.50)	0.565
MCH (pg)	30.90(29.82, 31.77)	30.50(29.60, 31.50)	0.009
MCHC (g/L)	339.00(333.00, 345.00)	336.00(329.00, 342.00)	<0.001
HCT (L/L)	0.456(0.4, 0.5)	0.436(0.4, 0.5)	<0.001
RDW-CV (%)	12.40(12.10, 12.80)	12.40(12.10, 12.90)	0.218
RDW-SD (fL)	41.20(39.40, 42.80)	41.60(39.90, 43.30)	0.027
P-LCR (%)	25.10(20.70, 29.80)	26.00(21.53, 31.05)	0.196

An analysis of the biochemical markers revealed that the high TyG group exhibited significantly elevated TG, TC, LDL-C, FBG, Cr, and UA, along with a decrease in HDL-C, in contrast to the low TyG group (Figure 2). Additionally, the high TyG group had higher AST, ALT, and γ-GT and a lower AST/ALT than the low TyG group. There were no notable disparities in the levels of BUN, TBIL, and DBIL between the two groups ($P > 0.05$) (Table 3).

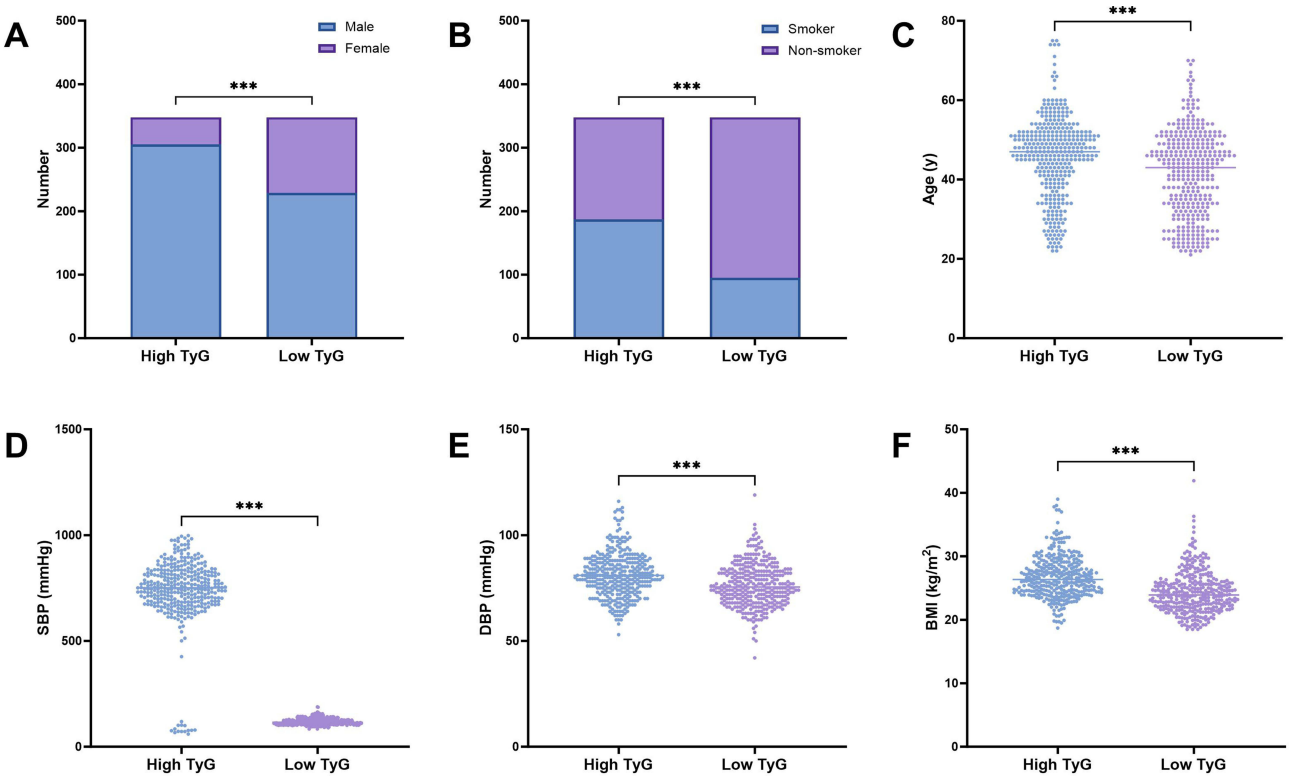

Figure 1 Baseline features of participants in high and low TyG groups. (**A**) Histogram of gender distribution. (**B**) Histogram of smokers and non-smokers in different groups. (**C**) Age. (**D**) SBP. (**E**) DBP. (**F**) BMI. ***P<0.001.

Abbreviations: TyG, triglyceride-glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index.

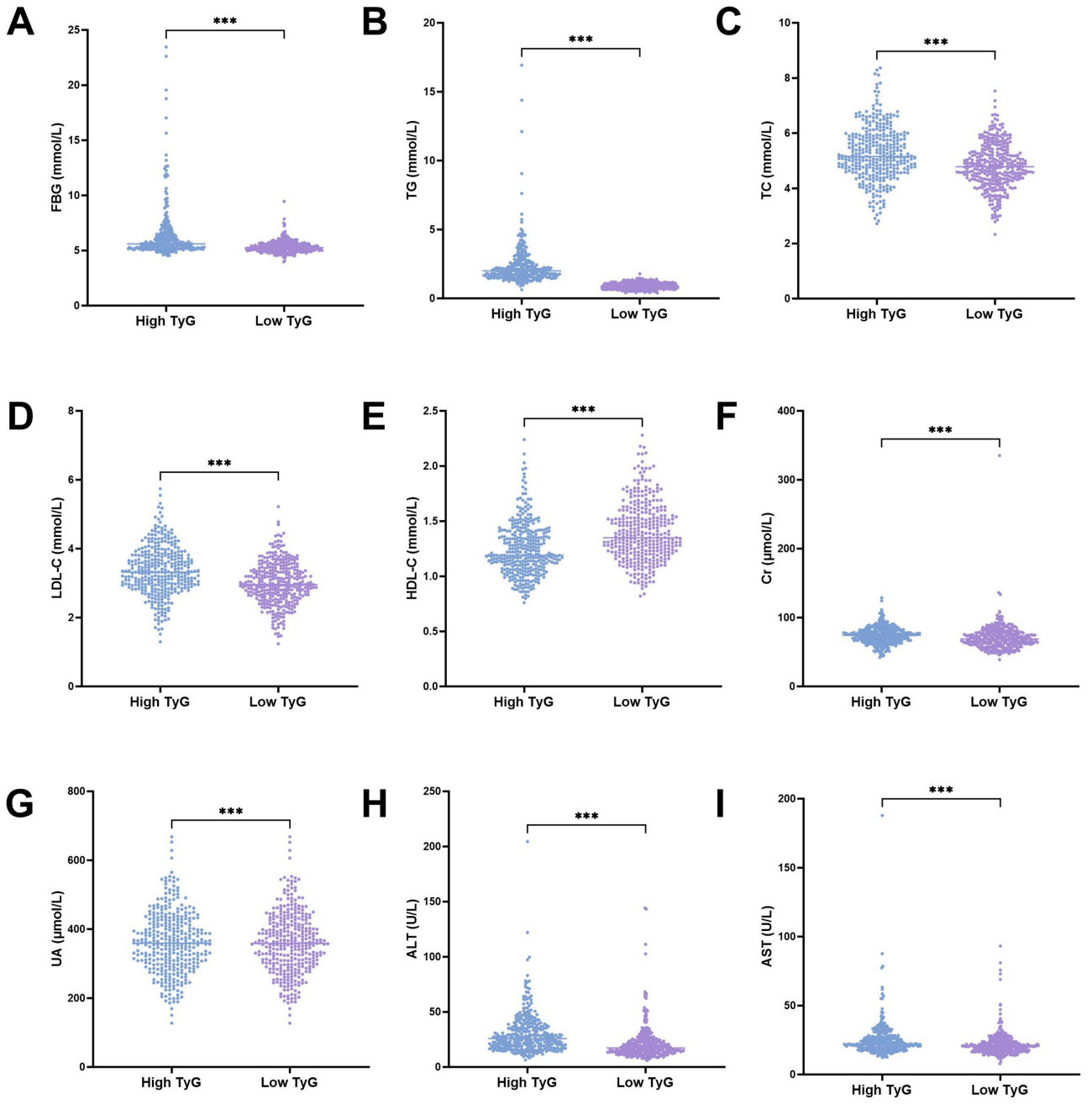

Figure 2 Comparison of biochemical markers indices between high and low TyG groups. (**A**) FBG. (**B**) TG. (**C**) TC. (**D**) LDL-C. (**E**) HDL-C. (**F**) Cr. (**G**) UA. (**H**) ALT. (**I**) AST. ***P<0.001.

Abbreviations: FBG, fasting blood glucose; TG, triglyceride; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; Cr, creatinine; UA, uric acid; ALT, alanine transaminase; AST, aspartate transaminase.

Regarding the blood routine index, individuals with elevated TyG indices exhibited increased levels of RBC, WBC, NEUT, LY, MO, BASO, EO, HGB, MCH, MCHC, and HCT and reduced RDW-SD compared with those with lower TyG indices. There were no notable disparities between the two groups regarding RDW-CV, MPV, PLT, PCT, MCV, and P-LCR (Figure 3) (Table 3).

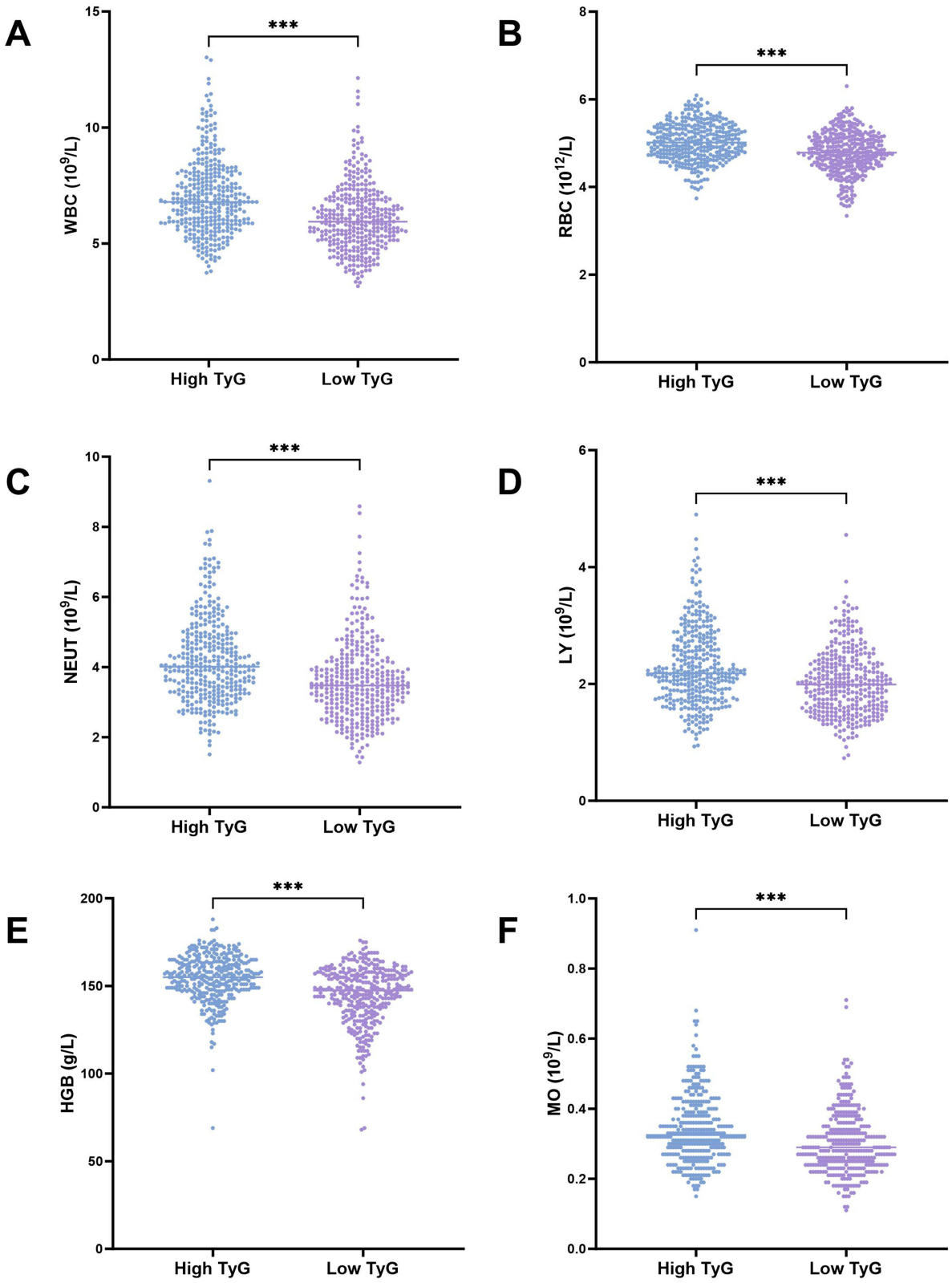

Figure 3 Comparison of blood routine indices between high and low TyG groups. (**A**) WBC. (**B**) RBC. (**C**) NEUT. (**D**) LY. (**E**) HGB. (**F**) MO. ***$P<0.001$.
Abbreviations: WBC, white blood count; RBC, red blood count; NEUT, neutrophil count; LY, lymphocytes; HGB, hemoglobin; MO, monocytes.

Comparison of Functional Characteristics of Lungs Between High and Low TyG Groups

Compared with the low TyG group, the high TyG group exhibited significantly reduced levels of FVC% pred, FEV1% pred, FEV3% pred, FEV1/FVC, FEV3/FVC, FEF75, FEF75% pred, FEF25-75% pred, and MVV% pred, suggesting poor pulmonary function. The high TyG group exhibited markedly elevated levels of PEF, FEF25, and FET compared with the low TyG group. However, the TyG index had no significant impact on FIV1, FVC, FEV1, FEV3, PEF% pred, FEF25-75%, FEF25% pred, FEF50, FEF50% pred, FIVC, FIV1/FIVC, MVV, and PIF (Table 4) (Figure 4).

Relationship Between the TyG Index and Pulmonary Functional Indicators

The TyG index was significantly inversely correlated with various pulmonary function metrics, including FEV1/FVC, FEV3/FVC, FVC% pred, FEV1% pred, FEF75, FEF75% pred, FEF25-75% pred, FEV3% pred, and MVV% pred. Additionally, a positive link exists between TyG and variables like PEF, FET, and FEF25. There was no notable link found between TyG and factors like FVC, FEV1, FEV3, PEF% pred, FEF25% pred, FEF50, FEF50% pred, FIV1, FIVC, FIV1/FIVC, PIF and MVV (Table 5) (Figure 5).

Multivariate Linear Analysis of the Association Between the TyG Index and Lung Function Metrics

There was a positive correlation observed between the TyG index and PEF, FEF25, FET, FIV1, and FIVC across all subjects but negatively correlated with FVC% pred, FEV1% pred, FEV3% pred, FEV1/FVC, FEV3/FVC, FEF75,

Table 4 Comparison of Functional Characteristics of Lungs Between High and Low TyG Groups

	High TyG (n=348)	Low TyG (n=348)	*P*
FVC (L)	3.88(3.43, 4.35)	3.84(3.25, 4.42)	0.575
FVC% pred	0.97±0.10	1.00±0.11	<0.001
FEV1 (L)	3.15(2.75, 3.51)	3.08(2.66, 3.59)	0.963
FEV1% pred	0.96(0.90, 1.03)	1.00(0.93, 1.07)	<0.001
FEV3 (L)	3.74(3.34, 4.17)	3.71(3.20, 4.27)	0.914
FEV3% pred	0.98±0.11	1.03±0.11	<0.001
FEV1/FVC	0.81(0.78, 0.85)	0.82(0.79, 0.86)	0.012
FEV3/FVC	0.97(0.96, 0.98)	0.98(0.96, 0.99)	<0.001
PEF (L/s)	7.77(6.61, 8.75)	7.18(6.04, 8.34)	<0.001
PEF% pred	0.92(0.80, 1.03)	0.90(0.81, 1.00)	0.371
FEF25 (L/s)	6.54(5.47, 7.44)	6.04(5.09, 7.19)	0.002
FEF25% pred	0.84±0.17	0.84±0.15	0.74
FEF50 (L/s)	3.62(2.96, 4.41)	3.63(2.95, 4.34)	0.967
FEF50% pred	0.80(0.68, 0.94)	0.83(0.70, 0.96)	0.229
FEF75 (L/s)	1.22(0.97, 1.55)	1.29(1.01, 1.71)	0.005
FEF75% pred	0.68(0.57, 0.82)	0.73(0.59, 0.89)	0.004
FEF25-75 (L/s)	3.06(2.50, 3.72)	3.14(2.56, 3.81)	0.342
FEF25-75% pred	0.91(0.80, 1.07)	0.96(0.81, 1.12)	0.040
FET (s)	4.29(3.73, 4.84)	3.84(3.22, 4.43)	<0.001
MVV (L/min)	110.08(96.34, 122.85)	107.97(93.10, 125.56)	0.963
MVV% pred	0.85(0.80, 0.91)	0.87(0.81, 0.95)	<0.001
FIV1 (L)	2.92(2.37, 3.58)	2.85(2.24, 3.51)	0.234
FIVC (L)	3.54±0.69	3.48±0.82	0.351
FIV1/FIVC	0.87(0.73, 0.98)	0.86(0.73, 0.96)	0.164
PIF (L/s)	3.22(2.44, 4.09)	3.17(2.35, 4.05)	0.542

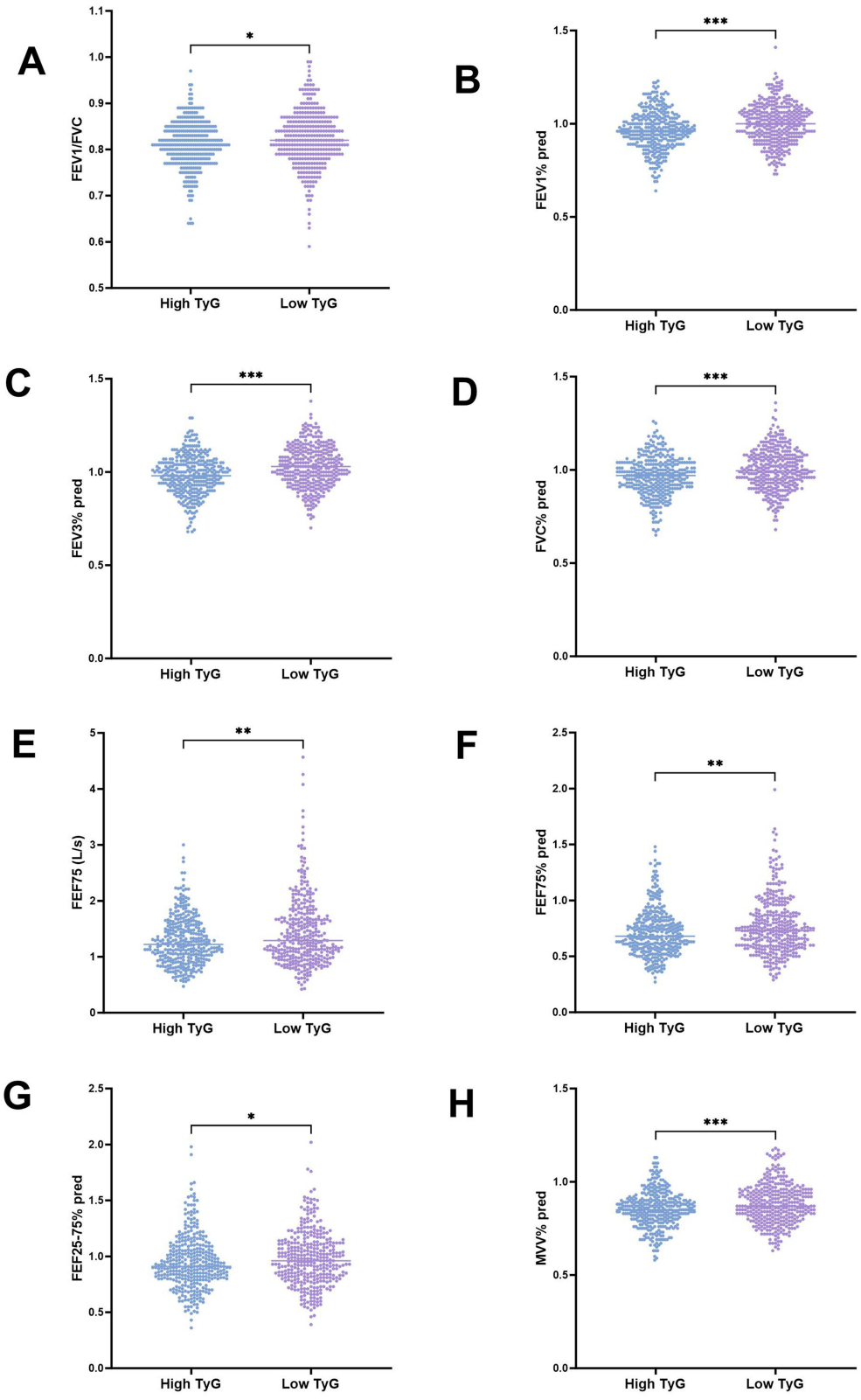

Figure 4 Comparison of lung function parameters between high and low TyG groups. (**A**) FEV1/FVC. (**B**) FEV1% pred. (**C**) FEV3% pred. (**D**) FVC% pred. (**E**) FEF75. (**F**) FEF75% pred. (**G**) FEF25-75% pred. (**H**) MVV% pred. **P*<0.05, ***P*<0.01, ****P*<0.001.

Abbreviations: FEV1/FVC, forced expiratory volume in 1 second/forced vital capacity; FEV1% pred, FEV1 to predicted value ratio; FEV3% pred, forced expiratory volume in 3 second to predicted value ratio; FVC% pred, FVC to predicted value ratio; FEF75, forced expiratory flow at 75% of the pulmonary volume; FEF75% pred, FEF75 to predicted value ratio; FEF25-75% pred, forced expiratory flow at 25%-75% of the pulmonary volume to predicted value ratio; MVV% pred, maximal voluntary ventilation to predicted value ratio.

Table 5 Relationship Between TyG and Pulmonary Functional Indicators

		TyG Index
FVC	r- value *P*-value	0.0155 0.6830
FVC% pred	r - value *P*-value	−0.1562 <0.0001
FEV1	r- value *P*-value	−0.0271 0.4760
FEV1% pred	r- value *P*-value	−0.1891 <0.0001
FEV3	r- value *P*-value	−0.0091 0.8112
FEV3% pred	r- value *P*-value	−0.2077 <0.0001
FEV1/FVC	r- value *P*-value	−0.1482 <0.0001
FEV3/FVC	r- value *P*-value	−0.2642 <0.0001
PEF	r- value *P*-value	0.1347 0.0004
PEF% pred	r- value *P*-value	0.0187 0.6217
FEF25	r- value *P*-value	0.0906 0.0169
FEF25% pred	r- value *P*-value	−0.0274 0.4708
FEF50	r- value *P*-value	−0.0280 0.4601
FEF50% pred	r- value *P*-value	−0.0614 0.1058
FEF75	r- value *P*-value	−0.1674 <0.0001
FEF75% pred	r- value *P*-value	−0.1521 <0.0001
FEF25-75	r- value *P*-value	−0.0824 0.0297
FEF25-75% pred	r- value *P*-value	−0.1069 0.0047
FET	r- value *P*-value	0.2721 <0.0001

(*Continued*)

Table 5 (Continued).

		TyG Index
MVV(cal)	r- value *P*-value	−0.0271 0.4760
MVV%pred	r- value *P*-value	−0.1601 <0.0001
FIV1	r- value *P*-value	0.0569 0.1334
FIVC	r- value *P*-value	0.0403 0.2886
FIV1/FIVC	r- value *P*-value	0.0656 0.0837
PIF	r- value *P*-value	0.0375 0.3232

FEF75% pred and FEF25-75% pred in model 1 (unadjusted), model 2 (adjusted for age, DBP and SBP), and model 3 (adjusted for age, DBP, SBP, WBC, NEUT and LY) (Table 6).

Discussion

An increase in smokers in developing countries, along with the growing number of seniors in advanced economies, is leading to reduced pulmonary capacity. The functionality of the lungs is a key factor in preventing and diagnosing respiratory illnesses.[22] Numerous studies have reported a link between reduced lung capacity and subsequent risks of death, respiratory issues, and heart-related problems. Therefore, exploring other modifiable risk factors for lung function harm is of utmost importance. IR is closely linked to a heightened likelihood of obesity, MetS, NAFLD, and T2DM. Acknowledged for its comprehensive and invasive nature, the hyperinsulinemic-euglycemic clamp is the premier method for evaluating IR.[23] Alternative laboratory methods, such as HOMA-IR, necessitate the direct measurement of insulin and thus are frequently unfeasible in epidemiological contexts. In addition, given that plasma insulin levels are typically gauged in diabetic individuals, these assessments are not appropriate for the general population. Given its focus on glucolipid metabolism, TyG is presently considered a more precise and reliable substitute indicator for IR.[24,25] Despite established links between TyG and conditions such as NAFLD, diabetic nephropathy, cervical vascular dysfunction and coronary artery disease, the relationship between TyG and lung function remains largely unexplored. Thus, the present study explored the potential relationship between the TyG index and pulmonary function. As a result, this study explored the potential link between TyG and lung function in the general populace undergoing health examinations.

It was found that subjects in the high TyG group exhibited elevated blood pressure and BMI compared with those in the low TyG group. Moreover, individuals in the high TyG group were generally older and had a greater percentage of males, smokers, and drinkers. Given that the TyG index relies on TG and glucose levels, individuals with a high TyG index exhibited elevated FBG, TG, TC, and LDL-C and reduced HDL-C. A comparison of liver functionality revealed significantly higher AST and ALT levels and lower AST/ALT ratios in individuals with elevated TyG indices than in those with lower indices, consistent with findings from reports.[14] An analysis comparing kidney performance revealed that subjects with a higher TyG index exhibited elevated Cr and UA.

The presence of total white blood cells, neutrophils, and lymphocytes is widespread, cost-effective, and widely used as indicators of inflammation. Multiple research have revealed a substantial link between MetS and a rise in total white blood cells, neutrophils, and lymphocytes.[26–29] Further blood routine analysis revealed that individuals with a high TyG index had elevated levels of red and white blood cells, neutrophils, and lymphocytes in contrast to those exhibiting lower TyG.

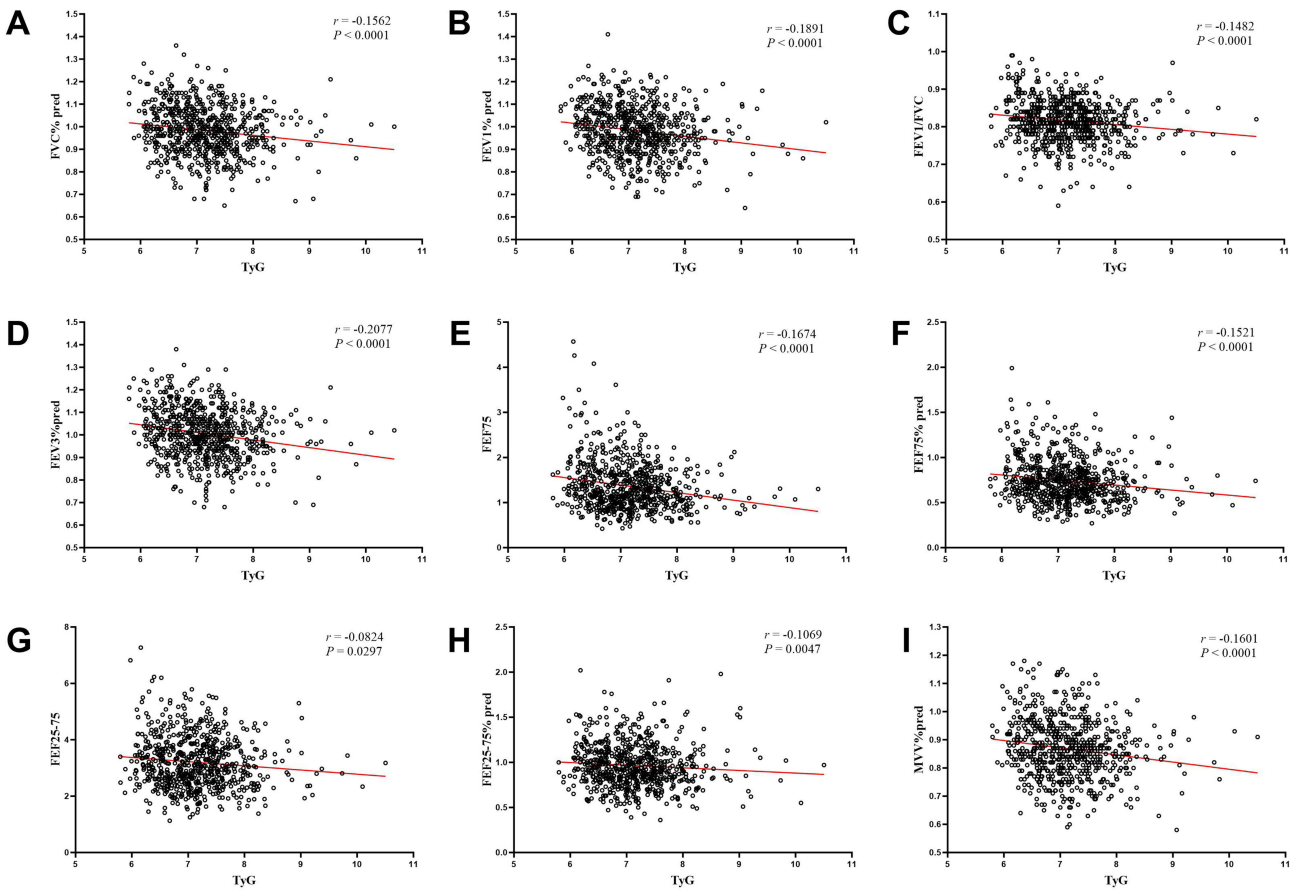

Figure 5 Correlation between TyG index and lung functional parameters. (**A**) FVC% pred. (**B**) FEV1% pred. (**C**) FEV1/FVC. (**D**) FEV3% pred. (**E**) FEF75. (**F**) FEF75% pred. (**G**) FEF25-75. (**H**) FEF25-75% pred. (**I**) MVV% pred.

Abbreviations: FEV1/FVC, forced expiratory volume in 1 second/forced vital capacity; FVC% pred, FVC to predicted value ratio; FEV1% pred, FEV1 to predicted value ratio; FEV3% pred, forced expiratory volume in 3 second to predicted value ratio; FEF75, forced expiratory flow at 75% of the pulmonary volume; FEF75% pred, FEF75 to predicted value ratio; FEF25-75, forced expiratory flow at 25%-75% of the pulmonary volume; FEF25-75% pred, FEF25-75 to predicted value ratio; MVV% pred, maximal voluntary ventilation to predicted value ratio.

Normal spirometry is characterized by an FEV1% forecast exceeding 80% and a FEV1/FVC ratio of 0.70 or more, whereas obstructive spirometry is identified by an FEV1/FVC ratio below 0.70.[30] Diagnosing COPD hinges on the clinical signs and whether the post-bronchodilator FEV1/FVC ratio falls below 0.70.[31] Preserved Ratio Impaired Spirometry, is characterized by an FEV1 less than 80% of the forecasted value and an FEV1/FVC ratio of 0.70 or more, indicative of a preclinical COPD condition.[32,33] A correlation between FEV1 and FVC and death rates was reported in individuals without lung conditions from the general population.[34] IR correlated with reduced FEV1% predicted, especially among the elderly.[35] The current study found that levels of FVC% pred, FEV1% pred, FEV3% pred, FEV1/FVC, FEF75, FEF75% pred, FEF25-75% pred and MVV% pred were significantly reduced in subjects with elevated TyG indices compared with those with lower indices, suggesting potential pulmonary damage to a certain degree. After adjustment for possible interfering variables, the TyG index was associated with reduced FEV1/FVC, FVC % pred, FEV1% pred, FEV3% pred, FEF75, FEF75% pred, and FEF25-75% pred. These data imply that the TyG index could act as an epidemiological instrument to measure the impact of metabolic dysfunction, potentially offering predictive and diagnostic significance as an indicator of pulmonary health. In our study, some indicators appeared to be higher in the high TyG group compared to the low TyG group, such as FVC, FEV1, FET and PEF. The reason for this outcome, we consider, is that the BMI of the high TyG group is higher than that of the low TyG group, which means that the population in the high TyG group is more prone to obesity and being overweight. Research indicates elevated lung function metrics (FVC and FEV1) and a reduced FEV1/FVC ratio in obese adolescents compared to non-obese ones,

Table 6 Multivariate Linear Analysis of the Association Between TyG and Lung Function Metrics

	Model 1					Model 2					Model 3				
	B	**Std. Error**	**Beta**	**t**	***P***	**B**	**Std. Error**	**Beta**	**t**	***P***	**B**	**Std. Error**	**Beta**	**t**	***P***
FVC (L)	−0.025	0.044	−0.022	−0.576	0.565	0.07	0.041	0.061	1.721	0.86	0.078	0.043	0.068	1.828	0.068
FVC% pred	−0.025	0.006	−0.155	−4.147	<0.001	−0.019	0.006	−0.117	−3.006	0.003	−0.014	0.007	−0.088	−2.145	0.032
FEV1 (L)	−0.066	0.036	−0.07	−1.858	0.064	0.032	0.032	0.034	1.007	0.314	0.037	0.033	0.039	1.107	0.269
FEV1% pred	−0.029	0.006	−0.179	−4.801	<0.001	−0.027	0.006	−0.166	−4.235	<0.001	−0.023	0.007	−0.139	−3.375	<0.001
FEV3 (L)	−0.053	0.043	−0.048	−1.253	0.211	0.050	0.039	0.045	1.298	0.195	0.059	0.041	0.052	1.445	0.149
FEV3% pred	−0.034	0.006	−0.203	−5.459	<0.001	−0.025	0.006	−0.149	−3.891	<0.001	−0.020	0.007	−0.119	−2.939	0.003
FEV1/FVC	−0.013	0.003	−0.151	−4.031	<0.001	−0.008	0.003	−0.093	−2.398	0.017	−0.008	0.003	−0.094	−2.304	0.021
FEV3/FVC	−0.008	0.001	−0.226	−6.118	<0.001	−0.005	0.001	−0.154	−4.083	<0.001	−0.005	0.001	−0.147	−3.675	<0.001
PEF (L/s)	0.266	0.09	0.111	2.945	0.003	0.304	0.093	0.127	3.272	0.001	0.313	0.098	0.131	3.196	0.001
PEF% pred	0.005	0.009	0.022	0.591	0.555	−0.002	0.009	−0.008	−0.203	0.839	0.002	0.009	0.011	0.260	0.795
FEF25 (L/s)	0.13	0.084	0.059	1.557	0.12	0.220	0.086	0.099	2.566	0.011	0.219	0.091	0.099	2.416	0.016
FEF25% pred	−0.005	0.009	−0.020	−0.517	0.605	−0.005	0.01	−0.021	−0.519	0.604	−0.003	0.01	−0.011	−0.251	0.802
FEF50 (L/s)	−0.071	0.059	−0.045	−1.195	0.232	0.044	0.058	0.028	0.750	0.453	0.050	0.062	0.032	0.809	0.419
FEF50% pred	−0.009	0.012	−0.029	−0.767	0.443	−0.011	0.012	−0.036	−0.898	0.369	−0.008	0.013	−0.027	−0.636	0.525
FEF75 (L/s)	−0.167	0.03	−0.205	−5.516	<0.001	−0.067	0.027	−0.083	−2.522	0.012	−0.065	0.028	−0.080	−2.317	0.021
FEF75% pred	−0.056	0.013	−0.157	−4.178	<0.001	−0.046	0.014	−0.131	−3.330	<0.001	−0.044	0.015	−0.125	−3.013	0.003
FEF25-75 (L/s)	−0.149	0.052	−0.107	−2.836	0.005	−0.017	0.049	−0.012	−0.337	0.736	−0.012	0.052	−0.008	−0.224	0.823
FEF25-75% pred	−0.029	0.014	−0.08	−2.114	0.035	−0.039	0.014	−0.107	−2.739	0.006	−0.035	0.015	−0.097	−2.338	0.020
FET (s)	0.377	0.057	0.244	6.63	<0.001	0.298	0.059	0.193	5.043	<0.001	0.267	0.062	0.173	4.270	<0.001
MVV (L/min)	−2.324	1.251	−0.07	−1.858	0.064	1.112	1.104	0.034	1.007	0.314	1.286	1.162	0.039	1.107	0.269
MVV% pred	−0.026	0.006	−0.166	−4.444	<0.001	−0.015	0.006	−0.093	−2.462	0.014	−0.011	0.006	−0.072	−1.810	0.071
FIV1 (L)	0.055	0.05	0.042	1.098	0.272	0.138	0.050	0.104	2.765	0.006	0.129	0.053	0.098	2.453	0.014
FIVC (L)	0.016	0.043	0.014	0.357	0.721	0.095	0.041	0.083	2.297	0.022	0.102	0.044	0.089	2.340	0.020
PIF (L/s)	0.056	0.08	0.027	0.71	0.478	0.126	0.082	0.060	1.536	0.125	0.102	0.087	0.049	1.175	0.240

aligning with our findings.[36] Additionally, there is a greater male ratio in the high TyG group compared to the low TyG group, coupled with male participants exhibiting higher PEF and FET values than females.[37,38]

Diabetes, dyslipidemia, and MetS, a group of concurrent conditions supported by IR, are linked in various ways to the heightened occurrence, frequency, or intensity of COPD, asthma, and pulmonary fibrosis, sparking theories of their direct impact on the lungs.[39–44] Diabetes and hyperglycemia heighten the risk and intensity of lung infections due to weakened immune responses in the host and increased virulence of infectious agents.[45] Elevated insulin levels and resistance, often considered the root causes of dyslipidemia and diabetes, may trigger increased bronchial activity due to changes in parasympathetic signals and potentially lead to subepithelial fibrosis.[46,47] IR plays a crucial role in pulmonary function. Presently, the TyG index is recognized for its greater precision in assessing IR, given its focus on glucolipid metabolism. As far as we are aware, this is a pioneering study to demonstrate the link between TyG and pulmonary performance in the general population undergoing health assessments. The TyG index may act as a dependable tool for assessing lung function damage. An elevated initial TyG index correlates with a reduction in pulmonary capacity among the healthy populace. Increased levels in the TyG are indicative of dyslipidemia and hyperglycemia, disorders impacting lung structure and functionality. TyG correlated with symptoms of breathing, persistent bronchitis, and a pattern of constricted spirometry.[48] C-reactive protein and TyG index can mediate lung function and cognitive function in a widespread, mild inflammatory condition.[49] Collectively, these results underscore the significant yet often overlooked importance of the TyG index in hastening the deterioration of lung function. While the precise mechanism by which the TyG index influences lung function remains unclear, it might be connected to IR. Insulin plays a direct role in airway malfunction by stimulating immune cells and structural cells in the airways, leading to inflammation and constriction.[50,51] The current study has pinpointed TyG as a contributing factor to compromised pulmonary health. Therefore, determining measures to motivate the general public to maintain their TyG index within normal ranges may aid in lowering the occurrence of lung function damage.

Nonetheless, this research presents certain constraints. Initially, a direct cause-and-effect link between TyG and pulmonary function indicators was not established. Secondly, the association between TyG and pulmonary performance in individuals suffering from widespread chronic lung conditions warrants further investigation in the future. Third, the exclusion criteria do not mention whether the individual has had Corona Virus Disease 2019 (COVID-19).

Conclusion

In summary, the present study establishes a correlation between the TyG index and some lung function indicators, offering a new indicator of metabolic abnormalities related to lung functionality.

Ethics Approval and Informed Consent

The study protocol was approved by the Ethics Committee of Hebei General Hospital in accordance with the principles of the Declaration of Helsinki (No. 2024-LW-112). Since this was a cross-sectional, retrospective, non-interventional study, and the patient's information was anonymous and confidential, signed informed consent was waived.

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Disclosure

The authors declare no competing conflicts of interest in this work.

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