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Trajectories of Triglyceride–Glucose Index and Incident Hypertension During Young Adulthood: A Longitudinal Cohort Study in China

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Abstract

Evidence regarding the influence of triglyceride–glucose (TyG) index trajectory patterns on incident hypertension remains limited. In this study, we aimed to explore the association between TyG index trajectories and hypertension risk among Chinese young adults. This cohort study included 2376 young adults, predominantly male, who attended at least three annual check-ups from 2014 to 2021, without hypertension at baseline. The latent class growth mixture model was used to identify various trajectory patterns of the TyG index during young adulthood. Cox proportional hazards models were used to estimate associations between TyG index trajectory group memberships and incident hypertension via the hazard ratio (HR) and 95% confidence interval (CI). The baseline mean age of these participants was 31.6 (6.5) years. During the average follow-up of 3.2 years, 13.7% were diagnosed with incident hypertension. Three distinct trajectories labeled as low-stable (36.9%), medium-rising (58.0%), and high-rising (5.1%) were identified. In comparison with the low-stable group, the high-rising and medium-rising groups were 2.83 times (95% CI: 1.63–4.93) and 2.25 times (95% CI: 1.45–3.50) more likely to develop hypertension. The Kaplan–Meier curves of incident hypertension likewise indicated that the findings were consistent. Rising TyG index trajectories during young adulthood were independently associated with an increased risk of hypertension. Monitoring longitudinal TyG index trajectory trends could be beneficial for the early prevention of hypertension; young adults in the high-rising and medium-rising trajectory groups, particularly young men, may warrant prioritization for primary hypertension prevention.

Keywords: triglyceride–glucose index; hypertension; trajectory; young adult; cohort study

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1. Introduction

As an emerging public health concern worldwide, hypertension is a leading cause of cardiovascular disease (CVD) and is associated with an elevated risk of all-cause mortality [1]. Over the past three decades, China has witnessed a striking increase in the

prevalence of hypertension, ranging from 11.3% in 1991 to 27.5% in 2020; compared with other age groups, adults younger than 45 years have experienced the most prominent rise owing to lifestyle changes [2,3]. Thus, identifying feasible and effective predictors to curb this alarming rise in hypertension, especially among Chinese young adults, is an urgent task.

Insulin resistance (IR) has been proven to make a critical contribution to the development of hypertension [4]. In terms of IR evaluation, the hyperinsulinemic–euglycemic clamp (HIEC) is regarded as the "gold standard" method, and the other approach presently popular in clinical trials is the homeostatic model assessment of insulin resistance (HOMA-IR) [5]. Nevertheless, because both tests are relatively expensive and complicated, their application remains limited in large epidemiological studies [6]. By contrast, as a reliable, low-cost, and easily accessible surrogate biochemical marker for IR, the triglyceride–glucose (TyG) index is widely selected for its excellent specificity and sensitivity in IR measurement [7]. One recent review paper reported that IR screening results obtained using the TyG index showed good correlation with findings measured using the HIEC technique and the HOMA-IR index, and suggested that the TyG index is suitable for IR diagnosis in essential hypertension, particularly in Asian countries [6].

Recently, a growing number of studies have explored the relationship between TyG index scores and new-onset hypertension, but have produced inconsistent results, with some studies reporting positive relationships [8–21] and others no association [22,23]. Moreover, the TyG index is reported to be susceptible to change for various reasons [24]. However, most cross-sectional or longitudinal studies that used the TyG index have relied on only one measurement and have ignored dynamic changes in the TyG index and consequent impacts on incident hypertension.

To solve this problem, trajectory modeling approaches can be applied in epidemiological research [25]. For instance, Yan et al. used latent class growth mixture modeling to identify the influence of TyG index trajectories on arterial stiffness [26]. The same trajectory modeling was conducted by Huang et al. to investigate the association between the trajectory of the TyG index and stroke risk among hypertensive patients [24]. However, evidence regarding the influence of TyG index trajectory patterns on incident hypertension remains limited. Furthermore, young adults as a specific population warrant greater attention as they have experienced the most prominent increase in the prevalence of hypertension. Therefore, to fill this significant knowledge gap, this study aimed to describe TyG index trajectories during young adulthood and to examine their associations with incident hypertension among Chinese young adults.

2. Materials and Methods

2.1. Research Design and Population

This retrospective cohort study was conducted at one hospital in Shenzhen City, China. Approximately 6330 adults who underwent an annual health examination at the Department of Health Management of Shenzhen People's Hospital between October 2014 and December 2021 were recruited. Inclusion criteria were (1) age 20–44 years; (2) attended at least three annual health examinations; and (3) non-hypertensive status at baseline. Exclusion criteria were (1) severe physical diseases (e.g., carcinoma; severe cardiac, renal, or hepatic dysfunction; or stroke); (2) severe mental diseases; or (3) incomplete demographic or clinical data. Finally, 2376 young adults were enrolled in our cohort.

Figure 1 presents the participant enrollment flowchart. The Shenzhen People's Hospital Ethics Committee approved this study (ethical approval number: LL-KY-202224) in line with the Helsinki declarations. A signed consent form was obtained from every subject prior to data collection.

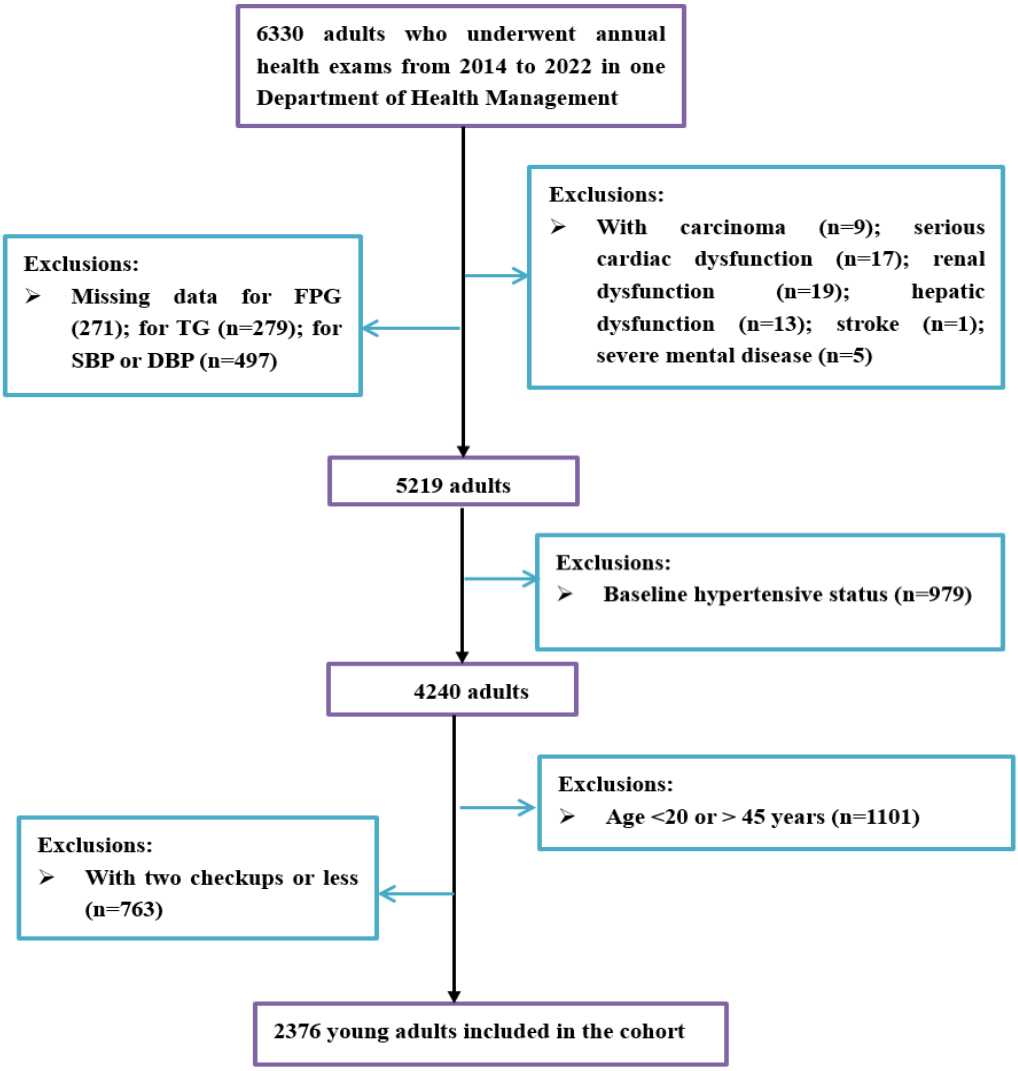


Figure 1. Participant enrollment flow chart. Note: TyG index, triglyceride–glucose index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting plasma glucose; TG, triglyceride.

2.2. Data Collection, Anthropometric Measurement, and Laboratory Assay

At each annual health check-up, the subjects' age, gender, and comorbidities were recorded, and their height, weight, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured by well-trained health professionals. Every subject underwent three blood pressure measurements using an electric sphygmomanometer (HBP-9020, Omron, Beijing, China) at the same point on the upper arm while seated, and the average reading was used for data analysis. Before measurement, participants were asked to rest for at least 5 min, and smoking or caffeine intake were prohibited for at least 30 min prior to the test [27]. Venous blood samples were collected from all participants in the morning after an overnight fast and analyzed for a range of biochemical parameters, including fasting plasma glucose (FPG), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), serum uric acid (SUA), and creatinine (Cr). The routine health examination database used in this study does not systematically collect information on smoking status, alcohol consumption, physical activity, dietary habits, and the use of lipid-lowering or glucose-lowering medication; therefore, these variables were not included in the multivariable models.

2.3. Outcome Definition

According to Chinese hypertension guidelines, the disease is defined as SBP over 140 mmHg and/or DBP over 90 mmHg, or the use of any antihypertensive medicine; meanwhile, normal blood pressure is defined as SBP < 120 mmHg and DBP < 80 mmHg, and elevated blood pressure is SBP 120–139 mmHg and DBP 80–89 mmHg, in patients not taking any antihypertensive medications [28]. The event of interest in the present study was a participant being newly diagnosed with hypertension. Death or loss to follow-up was considered censoring during the follow-up period. The follow-up period was calculated as the date of the new hypertension diagnosis minus the baseline physical examination date for participants with hypertension and as the last physical examination date minus the baseline physical examination date for those without hypertension. The TyG measurements used were limited to those obtained prior to the onset of hypertension. The formula for the TyG index in the present study was Ln [fasting TG (mg/dL) × fasting FPG (mg/dL)/2] [29]. Body mass index (BMI) was calculated as a subject's weight in kilograms divided by the square of their height in meters [30]. According to the Chinese dyslipidaemia management guidelines for adults, TC ≥ 6.22 mmol/L, LDL-C ≥ 4.14 mmol/L, HDL-C < 1.04 mmol/L, TG ≥ 2.26 mmol/L are defined as hypercholesterolemia (HTC), elevated LDL-C, low HDL-C, and hypertriglyceridemia (HTG), respectively. Dyslipidemia is defined as HTC, HTG, low HDL-C and/or elevated LDL-C, or currently undergoing pharmacological treatment [31].

In this study, estimated glomerular filtration rate (eGFR) was calculated using the modification of diet in renal disease (MDRD) formula: 186 × Scr-1.154 × age-0.203 × 0.742 [if female] [31]. Diabetes was defined by current history of diabetes mellitus and/or FPG ≥ 7.0 mmol/L [32].

2.4. Statistical Methods

The latent class growth mixture model (LCGMM) was performed to identify various trajectory patterns in the TyG index during young adulthood using the lcmm R package [33]. Given the statistical considerations involved in modeling repeated measures, three latent class modeling approaches, LCGMM, GBTM (Group-Based Trajectory Modelling), and LTA (Latent Transition Analysis), were considered [25]. Compared with GBTM and LTA, the main advantage of LCGMM is that it allows heterogeneity within the subgroups that usually exist in trajectories [25]. Thus, LCGMM was chosen in this study. The TyG index trajectories were modeled as a function of age, and gender was included as a covariate. Repeated analyses were conducted to determine the optimal number of latent classes (trajectory groups), testing models with two to five groups assigned different sets of random starting values based on a one-group model. The appropriate polynomial order (trajectory shape) was then determined as linear, quadratic, or cubic. The criteria for a best-fit model with the optimal trajectory number and shape were (1) a decrease in BIC (Bayesian information criterion) of at least 10 points; (2) at least 5% of participants in each group; and (3) a posterior probability >0.65 [34]. Based on the above criteria, the best fitting model identified in the present study comprised three quadratic trajectory groups. The trajectory curves were plotted across the actual observed follow-up age range (22–50 years) rather than the baseline eligibility range (20–45 years). Solid lines indicate age intervals with adequate data support, and dashed lines indicate extrapolated segments where data were sparse or unavailable. These trajectories represent estimated population-level patterns over age and do not depict the individual evolution of any single participant. Observed age-specific mean TyG values overlaying the model-predicted trajectories are provided in Figure S1.

In addition, Cox proportional hazards models were used to estimate the association between TyG index trajectory group memberships and incident hypertension, with results expressed as hazard ratios (HRs) and 95% confidence intervals (CIs). Model 1 was adjusted

for age and sex; Model 2 was adjusted for age, sex, and baseline BMI; Model 3 was adjusted for age, sex, baseline BMI, and baseline SBP; and, based on Model 3, Model 4 was additionally adjusted for diabetes and dyslipidemia. To further explore potential effect modification by sex, we also employed sex-stratified Cox proportional hazards models. In these stratified models, all covariates from Model 4 were included except for sex. Kaplan–Meier curves were plotted to present incidences of hypertension in different TyG index trajectories. Subgroup analysis and sensitivity analysis were conducted to test the robustness of the findings. To address potential informative truncation and clarify temporal ordering, we additionally performed a landmark sensitivity analysis. TyG trajectories were re-estimated using only measurements obtained within the first 2.5 years of follow-up among participants with ≥3 measurements in this window and free of hypertension at 2.5 years. Incident hypertension was analyzed from the landmark time onward. R software (version 4.3.1, Vienna, Austria) was used to perform all statistical analyzes, and a two-tailed p value less than 0.05 was considered a significant difference.

3. Results

3.1. Cohort Profile

In total, 2376 participants were included in the cohort, their baseline mean age was 31.6 (6.5) years, and 1776 (74.8%) were male. During the follow-up period, which had an average duration of 3.2 years, 325 young adults (13.7%) were diagnosed with hypertension. Overall, the median number of TyG measurements was four (IQR 3–5). Participants who developed hypertension contributed fewer TyG measurements (a median of three vs. four) and had shorter follow-up (a median of 2.4 vs. 3.2 years) than those who remained free of hypertension, reflecting the exclusion of post-diagnosis measurements. This difference was of similar magnitude across the three trajectory classes. The baseline and follow-up characteristics of all participants, and their comparisons between the normotensive and hypertensive groups at follow-up, are summarized in Table S1. Apart from gender ($p < 0.001$), no significant differences in baseline characteristics were identified between the included subjects and those excluded due to missing data (all $p > 0.05$, Table S2).

3.2. Identification of TyG Index Trajectories for Young Adults

In the current study, approximately seven years of participant TyG index data were used to generate the trajectories. The LCGMM findings are described in Table S3. As illustrated in Figure 2, three distinct trajectories—labeled low-stable (Class A, $n = 877$, 36.9%), medium-rising (Class B, $n = 1379$, 58.0%), and high-rising (Class C, $n = 120$, 5.1%)—were identified based on TyG index change patterns across the observed follow-up age range (22–50 years). In the low-stable group, the TyG index remained stable at a low level of 8.0 to 8.1 during young adulthood; in the medium-rising group, the TyG index increased gradually from 8.1 at 20 years to 8.7 at 45 years; and in the high-rising group, the TyG index rose rapidly from 8.0 at 20 years to 9.8 at 35 years, and then slightly decreased to 9.3 at 45 years. Detailed parameter estimates of fixed and random effects for the best-fitting three-class quadratic model are shown in Table S4. Comparisons of baseline characteristics and incident hypertension at follow-up stratified by TyG index trajectory group are presented in Table 1. In comparison with the low-stable group, subjects in the medium-rising and high-rising groups were more likely to be male and overweight, with higher baseline levels of SBP, DBP, LDL-C, TG, TC, FPG, TyG index, and SUA, as well as a lower baseline level of HDL-C and a higher incidence of dyslipidemia and diabetes at baseline, and hypertension at follow-up (all $p < 0.001$).

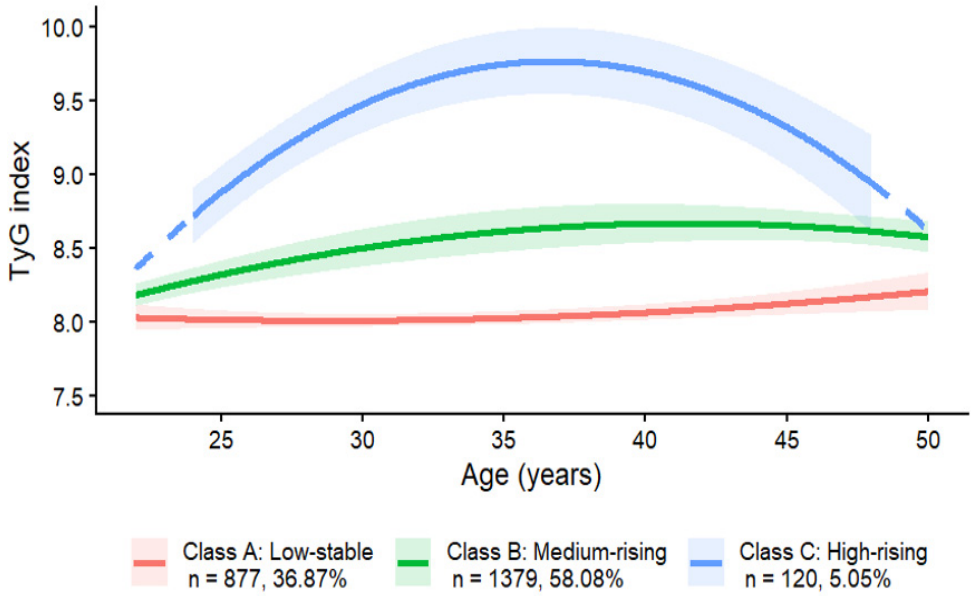


Figure 2. Trajectory patterns of TyG during young adulthood. Note: TyG index, triglyceride–glucose index. The x-axis shows the actual observed follow-up age range (22–50 years). Solid lines indicate trajectory segments supported by empirical data; dashed lines indicate extrapolated segments where data were sparse or unavailable. Shaded areas represent 95% confidence intervals.

Table 1. Comparisons of baseline characteristics and incident hypertension at follow-up stratified by TyG index trajectory groups.

Variable	Overall, n = 2376 [a]	Low-Stable, n = 877 [a]	Medium-Rising, n = 1379 [a]	High-Rising, n = 120 [a]	p Value
Baseline					
Gender/male, n (%)	1776 (74.75)	289 (32.95)	1375 (99.71)	112 (93.33)	<0.001
Age, years	31.61 ± 6.49	31.53 ± 6.02	31.57 ± 6.75	32.67 ± 6.73	0.183
BMI, Kg/m^2	23.01 ± 3.22	21.42 ± 2.78	23.79 ± 3.02	25.70 ± 3.41	<0.001
BMI group, n (%)					<0.001
Normal (18.5–23.9 Kg/m^2)	1533 (65.54)	732 (84.92)	766 (56.28)	35 (30.17)	
Overweight (≥24.0 Kg/m^2)	806 (34.46)	130 (15.08)	595 (43.72)	81 (69.83)	
SBP, mmHg	115.29 ± 10.99	111.97 ± 11.10	117.63 ± 10.10	120.08 ± 9.97	<0.001
DBP, mmHg	69.43 ± 8.26	66.79 ± 7.94	70.71 ± 8.00	74.13 ± 7.97	<0.001
BP states [b], n (%)					<0.001
Normal state	1501 (63.17)	671 (76.51)	776 (56.27)	54 (45.00)	
Elevated state	875 (36.83)	206 (23.49)	603 (43.73)	66 (55.00)	
LDL-C, mmol/L	2.99 ± 0.80	2.74 ± 0.72	3.14 ± 0.79	3.15 ± 1.05	<0.001
HDL-C, mmol/L	1.39 ± 0.36	1.62 ± 0.36	1.28 ± 0.27	1.00 ± 0.23	<0.001
TG, mmol/L	1.34 ± 1.09	0.86 ± 0.36	1.41 ± 0.63	4.11 ± 2.98	<0.001
TC, mmol/L	5.02 ± 0.94	4.84 ± 0.86	5.07 ± 0.93	5.73 ± 1.17	<0.001
Dyslipidemia	648 (27.27)	97 (11.06)	449 (32.56)	102 (85.00)	<0.001
FPG, mmol/L	5.09 ± 0.79	4.97 ± 0.44	5.08 ± 0.53	6.14 ± 2.57	<0.001
Diabetes	28 (1.18)	3 (0.34)	9 (0.65)	16 (13.33)	<0.001
TyG index	8.42 ± 0.58	8.05 ± 0.39	8.55 ± 0.45	9.63 ± 0.75	<0.001
Cr, mg/dL	0.94 ± 0.19	0.83 ± 0.19	1.02 ± 0.15	0.95 ± 0.18	<0.001
SUA, mg/dL	6.22 ± 1.50	5.25 ± 1.26	6.76 ± 1.29	7.09 ± 1.58	<0.001
eGFR, mL/min/1.73 m^2	95.89 ± 18.77	99.38 ± 20.37	93.34 ± 16.77	99.74 ± 23.28	<0.001
High LDL-C, n (%)	192 (8.08)	34 (3.88)	142 (10.30)	16 (13.33)	<0.001

Table 1. *Cont.*

Variable	Overall, n = 2376 [a]	Low-Stable, n = 877 [a]	Medium-Rising, n = 1379 [a]	High-Rising, n = 120 [a]	p Value
Low HDL-C, n (%)	339 (14.27)	29 (3.31)	238 (17.26)	72 (60.00)	<0.001
HTG, n (%)	235 (9.89)	8 (0.91)	143 (10.37)	84 (70.00)	<0.001
HTC, n (%)	236 (9.93)	58 (6.61)	144 (10.44)	34 (28.33)	<0.001
Follow-up time Follow-up	3.18 (2.87, 5.71)	3.20 (2.95, 5.88)	3.18 (2.83, 5.63)	3.07 (2.75, 4.91)	0.002
Cumulative incidence of hypertension, n (%)	325 (13.68)	52 (5.93)	239 (17.33)	34 (28.33)	<0.001
Incidence rate of hypertension, per 100 person-years	3.48	1.45	4.48	7.80	<0.001

Abbreviations: Body mass index (BMI), creatinine (Cr), diastolic blood pressure (DBP), estimated glomerular filtration rate (eGFR), fasting plasma glucose (FPG), high-density lipoprotein cholesterol (HDL-C), hypercholesterolemia (HTC), hypertriglyceridemia (HTG), low-density lipoprotein cholesterol (LDL-C), systolic blood pressure (SBP), serum uric acid (SUA), total cholesterol (TC), triglyceride (TG), triglyceride–glucose index (TyG index). (*a*) Mean (SD), n/N (%). (*b*) Normal blood pressure is defined as SBP < 120 mmHg, DBP < 80 mmHg; elevated blood pressure is defined as SBP 120–139 mmHg, DBP 80–89 mmHg.

3.3. Association of TyG Index Trajectory and Incident Hypertension

Table 2 describes the HR and 95% CI for the relationship between TyG index trajectory and hypertension risk during young adulthood. In comparison with the low-stable (reference) group, the medium-rising group was 3.12 times (95% CI: 2.31–4.21) more likely to develop hypertension, and the high-rising group was 5.61 times (95% CI: 3.64–8.64) more likely to develop hypertension in the unadjusted model. After adjusting for potential covariates, the HRs of the medium-rising and high-rising groups were 2.25 (95% CI: 1.45–3.50) and 2.83 (95% CI: 1.63–4.93), respectively. The Kaplan–Meier curves of incident hypertension shown in Figure 3 likewise illustrate that subjects in the high-rising group had the highest risk of hypertension compared with those in the medium-rising and low-stable groups (log-rank test, $p < 0.001$).

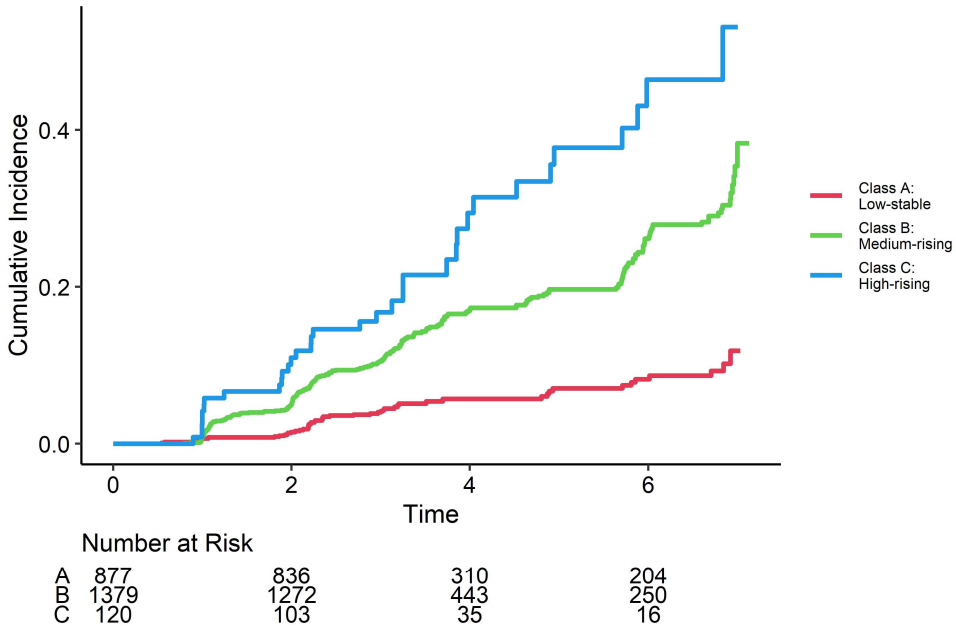


Figure 3. Kaplan–Meier curves of the incidences of hypertension among different TyG index trajectory classes.

Table 2. Hazard ratio and 95% CI for the relationship between TyG index trajectory and hypertension risk.

	Event/N	Non-Adjusted	Model 1	Model 2	Model 3	Model 4
		HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Trajectory groups						
Class A (Ref): Low-stable	52/877	1	1	1	1	1
Class B: Medium-rising	239/1379	3.12 (2.31–4.21)	3.19 (2.01–5.05)	2.86 (1.79–4.59)	2.23 (1.44–3.44)	2.25 (1.45–3.50)
Class C: High-rising	34/120	5.61 (3.64–8.64)	5.66 (3.33–9.64)	3.90 (2.25–6.76)	2.69 (1.61–4.48)	2.83 (1.63–4.93)
Covariates						
Age			1.03 (1.02–1.05)	1.02 (1.01–1.04)	1.03 (1.01–1.04)	1.03 (1.01–1.05)
Sex			0.97 (0.58–1.62)	0.76 (0.45–1.27)	0.69 (0.43–1.10)	0.68 (0.42–1.10)
BMI				1.14 (1.10–1.18)	1.07 (1.03–1.11)	1.07 (1.03–1.11)
SBP					1.09 (1.07–1.10)	1.09 (1.07–1.10)
Diabetes						0.75 (0.30–1.86)
Dyslipidemia						0.98 (0.76–1.26)

Abbreviations: BMI, body mass index; CI, confidence interval; HR, hazard ratio; Ref, reference; SBP, systolic blood pressure.

3.4. Subgroup Analysis and Sensitivity Analysis

Subgroup analysis was conducted to further reveal the relationship between the different TyG index trajectory groups and the development of hypertension among different subgroups. As presented in Table 3, no significant interactions were observed for BMI group (<24 vs. ≥24 kg/m^2), HTC (no vs. yes), HTG (no vs. yes), and blood pressure states (normal state vs. elevated state) (p-value for interaction > 0.05), suggesting that these factors did not substantially modify the association. A significant sex interaction was observed ($p = 0.039$). In the sex-stratified analysis (Tables S9 and S10), the association remained highly significant in males after full adjustment (Model 4: HR 2.98, 95% CI 1.72–5.16 for medium-rising; HR 4.39, 95% CI 2.23–8.66 for high-rising). However, the female subgroup had extremely small sample sizes in the rising groups (only four participants in the medium-rising and eight in the high-rising groups), with only one and two incident events, respectively. This data sparsity resulted in extremely wide confidence intervals (Table S10: HR 2.24, 95% CI 0.29–17.52; HR 0.60, 95% CI 0.08–4.41), rendering the female-specific estimates statistically unreliable. Therefore, female-specific estimates should be regarded as exploratory, and the findings are most applicable to young men; results for the other subgroups were consistent.

In the sensitivity analysis, the results remained consistent with the main research findings after additionally adjusting for baseline TyG index (Table S5), excluding participants with diabetes (Table S6), individuals with dyslipidemia (Table S7), or using DBP instead of SBP as a covariate in the Cox proportional hazards models (Table S8), further supporting the robustness of our results. In the landmark analysis (2.5-year window; $n = 1552$; 114 events), the fully adjusted HR for medium-rising vs. low-stable was 1.95 (95% CI: 1.15–3.31), closely matching the primary analysis. The high-rising class was not modeled separately due to sparse events ($n = 25$, 1 event). Agreement between the primary and landmark classifications was 83.6% ($\kappa = 0.69$), with discordance occurring only between adjacent classes (Table S11).

Table 3. Subgroup analysis of the association between TyG index trajectory groups and incident hypertension.

	HR (95% CI)			*p* for Interaction
	Low-Stable (Class A)	Medium-Rising (Class B)	High-Rising (Class C)	
Gender				0.039
Male	reference	2.98 (1.72–5.16)	4.39 (2.23–8.66)	
Female	reference	2.24 (0.29–17.50)	0.60 (0.08–4.41)	
BMI				0.337
BMI < 24	reference	3.00 (1.62–5.58)	3.39 (1.09–10.60)	
BMI ≥ 24	reference	1.73(0.87–3.44)	2.40(1.13–5.13)	
HTC				0.880
No	reference	2.71 (1.62–4.52)	3.74 (1.90–7.35)	
Yes	reference	1.18 (0.27–5.24)	1.49 (0.32–6.93)	
HTG				0.463
No	reference	2.74 (1.64–4.57)	4.03 (1.73–9.41)	
Yes	reference	0.32 (0.02–4.07)	0.37 (0.03–4.60)	
BP States [a]				0.708
Normal	reference	2.19 (1.00–4.80)	2.78 (0.82–9.45)	
Elevated	reference	2.47 (1.42–4.28)	3.13 (1.61–6.09)	

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; HTC, hypercholesterolemia; HTG, hypertriglyceridemia; SBP, systolic blood pressure. (*a*) Normal blood pressure is defined as SBP < 120 mmHg, DBP < 80 mmHg; elevated state as SBP 120–139 mmHg, DBP 80–89 mmHg. Note: The female subgroup had few events; HR estimates are unstable and should be interpreted as exploratory. HRs and 95% CIs were derived from the fully adjusted model (Model 4).

4. Discussion

In the present cohort study, three distinct TyG index trajectory patterns were identified in Chinese young adults, and an important association was found between TyG index trajectory and incident hypertension. Previous work by Xin et al. examined TyG trajectories and incident hypertension in a general adult cohort from northeast China and reported that rising TyG trajectories were associated with a higher risk of hypertension [35]. Our findings are consistent in direction, and the main difference is that our study focuses on a younger population (mean baseline age 31.6 vs. median 38 years), extending the previous findings to a younger Chinese adult population. We verified that a higher rising TyG index trajectory pattern over the long term had a significant impact on hypertension risk. These findings imply that monitoring longitudinally changing patterns in the TyG index could be beneficial for early prevention of hypertension, and that young adults in the high-rising and medium-rising trajectory groups should be prioritized for primary prevention of hypertension, which is of great clinical significance in terms of decreasing the alarming rise in hypertension among Chinese young adults.

Some significant findings are worth noting. First, three distinct trajectory groups—labeled as low-stable, medium-rising, and high-rising—were initially identified based on patterns of TyG index change among Chinese adults younger than 45 years. Notably, most previous studies exploring the role of the TyG index in various clinical outcomes focused only on a single measure of TyG level and ignored its dynamic change over time [36–39]. To date, evidence supporting exploration of longitudinal TyG index trajectory patterns has been limited. One survey enrolled 180 subjects (mean age of 28.7 years) to investigate the association between TyG index trajectories and arterial stiffness [26]. They found that, over a 12-year follow-up, three TyG index trajectories including low-stable, moderate, and high-increasing were verified, which aligns with our results. Another cohort study included 19,924 hypertensive participants (mean age of 56.8 years) between 2006 and 2010 to explore the relationship between TyG index trajectory and stroke risk; five TyG index trajectories were identified: low-stable, moderate low-stable, moderate high-stable, elevated-stable, and elevated-increasing [24]. The heterogeneity of the selected sample in terms of age,

health status, and numbers may account for the findings being inconsistent with our results. Thus, more research monitoring longitudinal TyG index trajectory trends are strongly recommended in the future.

Moreover, the present study identified that rising TyG index trajectories during young adulthood are independently associated with an increased risk of hypertension, a finding worthy of further investigation and validation. In this study, the significant relationship between the TyG index trajectory and incident hypertension was concordant across different subgroup analyses and sensitivity analyses. In addition, our Kaplan–Meier curves for incident hypertension also emphasize that young adults with a high-rising trajectory pattern faced the highest risk of hypertension compared with those with medium-rising and low-stable trajectory patterns. Previous research has reported that a higher baseline TyG index level is significantly associated with an increased risk of new-onset hypertension among the general population [9,11,14], middle-aged, and elderly people (aged ≥ 45 years) in China [8,12], and implied that a high baseline TyG index level may serve as an important predictor for hypertension. One international study likewise reported that TyG index score at baseline is associated with hypertension incidence in Mexican adults [40]. Another study enrolled a Romanian population sample aged 18–80 years and found that the TyG index was independently associated with the presence of hypertension [15]. Yet another study also suggested that baseline TyG index was independently associated with an increased risk of incident hypertension in a Spanish cohort [13]. By contrast, Lee et al. analyzed data from 5414 Korean participants aged 40 to 69 years and found that baseline TyG index was significantly associated with new-onset hypertension only in women [41].

Our findings reveal that in the high-rising group the TyG index increased rapidly from 8.0 at age 20 to 9.8 by age 35, followed by a slight decline to 9.3 at age 45. The modest decrease in young adults may be attributed to various factors, including physiological changes, lifestyle adjustments, or medical interventions [24,42]. However, this minor reduction in TyG levels does not indicate a significant recovery or improvement in metabolic health, as these participants' TyG values remained elevated. Previous research has defined metabolically healthy TyG index thresholds as <8.73 for women and <8.82 for men [43]. Additionally, a TyG index > 8.5 has been significantly associated with an increased risk of new-onset hypertension in Chinese adults [11]. Consequently, young individuals in the high-rising group should remain a key focus for primary prevention strategies targeting hypertension.

Interestingly, our study provided new indications that a rising TyG index pattern could be a new easy-to-use monitoring indicator for the development of incident hypertension during young adulthood. Therefore, in order to reverse the rise in hypertension among Chinese young adults [2], regular identification of TyG index trajectory would be of substantial significance for the early detection of high-risk individuals and the primary prevention of new-onset hypertension.

Although the possible mechanisms accounting for the relationship between the TyG index trajectory and hypertension risk have been indistinct, IR could be part of the explanation. To be more specific, IR can cause hyperinsulinemia that excites the sympathetic nerves, eventually resulting in hypertension [44]. Furthermore, IR may improve the activity of the renin–angiotensin–aldosterone system (RAAS), leading to high blood pressure [45]. Moreover, IR-related factors can enhance the vascular endothelium's capability to affect the elasticity of blood vessels, causing hypertension [6]. Lastly, IR has been reported to be related to chronic inflammation, contributing to the development of hypertension [24].

The strengths of the current research include the retrospective cohort design with a large study size and repeated measures of research variables over a seven-year period, and the appropriate use of LCGMM to explore the association between TyG index trajectories and hypertension risk among young adults. However, some limitations still need to be

discussed. Primarily, our study participants were recruited in Shenzhen City, limiting the study population to Chinese young adults. Thus, multi-center studies in other regions of China and in other countries worldwide are strongly recommended to validate our findings. Second, information on smoking, alcohol consumption, physical activity, diet, workplace, environment, occupation, and use of lipid- or glucose-lowering medications was not systematically collected or was substantially incomplete; weight change was not modeled separately, and BMI was adjusted for instead. These factors may cause residual confounding and warrant further investigation. Third, although hypertension was diagnosed using the average of three consecutive measurements to improve accuracy, these were obtained during a single annual visit and were not confirmed through subsequent visits or 24 h ambulatory blood pressure monitoring (ABPM). The white-coat effect may have caused non-differential misclassification, which would likely attenuate the observed associations. Additionally, the lack of 24 h ABPM data precluded the analysis of different hypertension subtypes. Fourth, the proportion of female participants was low, particularly in the medium-rising and high-rising groups. The female subgroup had few events and wide confidence intervals; female-specific estimates should be regarded as exploratory, and the absence of a significant association in women should not be interpreted as evidence of no association. Fifth, in the 2.5-year landmark sensitivity analysis, 43 of the 67 participants originally classified in the high-rising group were reclassified into the medium-rising group. Consequently, the high-rising class in the landmark cohort was too small to be modeled separately, limiting our ability to evaluate this specific subgroup in the landmark analysis.

5. Conclusions

In the present study, we identified three distinct TyG index trajectories and a significant association between TyG index trajectories and incident hypertension among Chinese young adults. These findings suggest that monitoring longitudinal TyG index trajectory trends could be beneficial for the early prevention of hypertension among Chinese adults, particularly young men. Additionally, young adults in the high-rising and medium-rising trajectory groups should be the priority for primary hypertension prevention. Such a strategy could be of great significance in terms of decreasing the alarming rise in hypertension among Chinese young adults.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jcdd13110591/s1, Table S1. The baseline and follow-up characteristics of all participants by incident hypertension at follow-up; Table S2. Baseline characteristics between included subjects and exclude subjects with missing data; Table S3. LCGMM (Latent Class Growth Mixture models) findings of the model fitting process; Table S4. Parameter estimates for the best fitting 3-class quadratic LCGMM (Latent Class Growth Mixture models); Table S5. Sensitivity analysis of additional adjusting baseline TyG index; Table S6. Sensitivity analysis of excluding participants with diabetes; Table S7. Sensitivity analysis of excluding participants with dyslipidemia; Table S8. Sensitivity analysis of using DBP instead of SBP for the relationship between TyG index trajectory and hypertension risk. Table S9. Hazard ratio and 95% CI for the relationship between TyG index trajectory and hypertension risk in male participants. Table S10. Hazard ratio and 95% CI for the relationship between TyG index trajectory and hypertension risk in female participants. Table S11. Cross-tabulation of the primary and 2.5-year landmark trajectory classifications. Figure S1. Comparison of model-predicted trajectories and observed age-specific TyG means.

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Data Availability Statement: The data presented in this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy restrictions.

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Abbreviations

The following abbreviations are used in this manuscript:

BMI	Body mass index
BP	Blood pressure
CVD	Cardiovascular disease
Cr	Creatinine
DBP	Diastolic blood pressure
eGFR	Estimated glomerular filtration rate
FPG	Fasting plasma glucose
HDL-C	High-density lipoprotein cholesterol
HIEC	Hyperinsulinemic–euglycemic clamp
HOMA-IR	Homeostatic model assessment of insulin resistance
HTC	Hypercholesterolemia
HTG	Hypertriglyceridemia
IR	Insulin resistance
LCGMM	Latent class growth mixture model
LDL-C	Low-density lipoprotein cholesterol
SBP	Systolic blood pressure
SUA	Serum uric acid
TC	Total cholesterol
TG	Triglyceride
TyG	Triglyceride–glucose index

References

1. Aune, D.; Huang, W.; Nie, J.; Wang, Y. Hypertension and the Risk of All-Cause and Cause-Specific Mortality: An Outcome-Wide Association Study of 67 Causes of Death in the National Health Interview Survey. *Biomed. Res. Int.* **2021**, *2021*, 9376134. [CrossRef] [PubMed]
2. Wang, J.G.; Zhang, W.; Li, Y.; Liu, L. Hypertension in China: Epidemiology and treatment initiatives. *Nat. Rev. Cardiol.* **2023**, *20*, 531–545. [CrossRef] [PubMed]
3. Chinese National Health Commission. Report on Nutrition and Chronic Diseases in China. 2020. Available online: http://cdcp.gd.gov.cn/attachment/0/519/519606/4176648.pdf (accessed on 12 January 2026). (In Chinese)
4. Wang, R.; Bai, Z.; Zhang, D.; Zhang, R.; Yang, J.; Yin, C.; Huang, W.; Huang, P.; Wang, Y.; Liu, N.; et al. Mediating effects of insulin resistance on the development of hypertension associated with elevated serum uric acid: A prospective cohort study. *J. Hum. Hypertens.* **2022**, *36*, 760–766. [CrossRef] [PubMed]
5. Guerrero-Romero, F.; Simental-Mendía, L.E.; González-Ortiz, M.; Martínez-Abundis, E.; Ramos-Zavala, M.G.; Hernández-González, S.O.; Jacques-Camarena, O.; Rodríguez-Morán, M. The product of triglycerides and glucose, a simple measure of insulin sensitivity. Comparison with the euglycemic-hyperinsulinemic clamp. *J. Clin. Endocrinol. Metab.* **2010**, *95*, 3347–3351. [CrossRef] [PubMed]
6. Minh, H.V.; Tien, H.A.; Sinh, C.T.; Thang, D.C.; Chen, C.H.; Tay, J.C.; Siddique, S.; Wang, T.D.; Sogunuru, G.P.; Chia, Y.C.; et al. Assessment of preferred methods to measure insulin resistance in Asian patients with hypertension. *J. Clin. Hypertens.* **2021**, *23*, 529–537. [CrossRef] [PubMed]
7. Huang, R.; Wang, Z.; Chen, J.; Bao, X.; Xu, N.; Guo, S.; Gu, R.; Wang, W.; Wei, Z.; Wang, L. Prognostic value of triglyceride glucose (TyG) index in patients with acute decompensated heart failure. *Cardiovasc. Diabetol.* **2022**, *21*, 88. [CrossRef] [PubMed]

8. Li, Y.; You, A.; Tomlinson, B.; Yue, L.; Zhao, K.; Fan, H.; Zheng, L. Insulin resistance surrogates predict hypertension plus hyperuricemia. *J. Diabetes Investig.* **2021**, *12*, 2046–2053. [CrossRef] [PubMed]
9. Cai, Q.; Xing, C.Y.; Zhu, J.; Wang, Y.; Lu, F.; Peng, J. Associations between triglyceride-glucose index and different hypertension subtypes: A population-based study in China. *Front. Cardiovasc. Med.* **2022**, *9*, 901180. [CrossRef] [PubMed]
10. Zhao, Y.; Yang, X.; Wu, Y.; Huang, H.; Hu, F.; Zhang, M.; Sun, L.; Hu, D. Association of triglyceride-glucose index and its 6-year change with risk of hypertension: A prospective cohort study. *Nutr. Metab. Cardiovasc. Dis.* **2023**, *33*, 568–576. [CrossRef] [PubMed]
11. Gao, Q.; Lin, Y.; Xu, R.; Luo, F.; Chen, R.; Li, P.; Zhang, Y.; Liu, J.; Deng, Z.; Li, Y.; et al. Positive association of triglyceride-glucose index with new-onset hypertension among adults: A national cohort study in China. *Cardiovasc. Diabetol.* **2023**, *22*, 58. [CrossRef] [PubMed]
12. Shan, S.; Li, S.; Lu, K.; Cao, J.; Sun, W.; Zhou, J.; Ren, Z.; Zhu, S.; Hou, L.; Chen, D.; et al. Associations of the Triglyceride and Glucose Index with Hypertension Stages, Phenotypes, and Their Progressions Among Middle-Aged and Older Chinese. *Int. J. Public Health* **2023**, *68*, 1605648. [CrossRef] [PubMed]
13. Sanchez-Inigo, L.; Navarro-Gonzalez, D.; Pastrana-Delgado, J.; Fernandez-Montero, A.; Martinez, J.A. Association of triglycerides and new lipid markers with the incidence of hypertension in a Spanish cohort. *J. Hypertens.* **2016**, *34*, 1257–1265. [CrossRef] [PubMed]
14. Zheng, R.; Mao, Y. Triglyceride and glucose (TyG) index as a predictor of incident hypertension: A 9-year longitudinal population-based study. *Lipids Health Dis.* **2017**, *16*, 175. [CrossRef] [PubMed]
15. Bala, C.; Gheorghe-Fronea, O.; Pop, D.; Pop, C.; Caloian, B.; Comsa, H.; Bozan, C.; Matei, C.; Dorobantu, M. The association between six surrogate insulin resistance indexes and hypertension: A population-based study. *Metab. Syndr. Relat. Disord.* **2019**, *17*, 328–333. [CrossRef] [PubMed]
16. Wang, K.; He, G.; Zhang, Y.; Yin, J.; Yan, Y.; Zhang, Y.; Wang, K. Association of triglyceride-glucose index and its interaction with obesity on hypertension risk in Chinese: A population-based study. *J. Hum. Hypertens.* **2021**, *35*, 232–239. [CrossRef] [PubMed]
17. Zhu, B.; Wang, J.; Chen, K.; Yan, W.; Wang, A.; Wang, W.; Gao, Z.; Tang, X.; Yan, L.; Wan, Q.; et al. A high triglyceride glucose index is more closely associated with hypertension than lipid or glycemic parameters in elderly individuals: A cross-sectional survey from the reaction study. *Cardiovasc. Diabetol.* **2020**, *19*, 112. [CrossRef] [PubMed]
18. Lee, D.H.; Park, J.E.; Kim, S.Y.; Jeon, H.J.; Park, J.H. Association between the triglyceride-glucose (TyG) index and increased blood pressure in normotensive subjects: A population-based study. *Diabetol. Metab. Syndr.* **2022**, *14*, 161. [CrossRef] [PubMed]
19. Jian, S.; Su-Mei, N.; Xue, C.; Jie, Z.; Xue-Sen, W. Association and interaction between triglyceride-glucose index and obesity on risk of hypertension in middle-aged and elderly adults. *Clin. Exp. Hypertens.* **2017**, *39*, 732–739. [CrossRef] [PubMed]
20. Zhang, F.; Zhang, Y.; Guo, Z.; Yang, H.; Ren, M.; Xing, X.; Cong, H. The association of triglyceride and glucose index, and triglyceride to high-density lipoprotein cholesterol ratio with prehypertension and hypertension in normoglycemic subjects: A large cross-sectional population study. *J. Clin. Hypertens.* **2021**, *23*, 1405–1412. [CrossRef] [PubMed]
21. Liu, T.; Xuan, H.; Yin, J.; Wang, L.; Wang, C.; Xu, X.; Chen, J.; Li, D.; Xu, T. Triglyceride glucose index increases significantly risk of hypertension development in Chinese individuals aged >/=45 years old: Analysis from the China health and retirement longitudinal study. *J. Multidiscip. Healthc.* **2023**, *16*, 63–73. [CrossRef] [PubMed]
22. Liu, X.Z.; Fan, J.; Pan, S.J. METS-IR, a novel simple insulin resistance indexes, is associated with hypertension in normal-weight Chinese adults. *J. Clin. Hypertens.* **2019**, *21*, 1075–1081. [CrossRef] [PubMed]
23. Morales-Gurrola, G.; Simental-Mendía, L.E.; Castellanos-Juárez, F.X.; Salas-Pacheco, J.M.; Guerrero-Romero, F. The triglycerides and glucose index is associated with cardiovascular risk factors in metabolically obese normal-weight subjects. *J. Endocrinol. Invest.* **2020**, *43*, 995–1000. [CrossRef] [PubMed]
24. Huang, Z.; Ding, X.; Yue, Q.; Wang, X.; Chen, Z.; Cai, Z.; Li, W.; Cai, Z.; Chen, G.; Lan, Y.; et al. Triglyceride-glucose index trajectory and stroke incidence in patients with hypertension: A prospective cohort study. *Cardiovasc. Diabetol.* **2022**, *21*, 141. [CrossRef] [PubMed]
25. Nguena Nguefack, H.L.; Pagé, M.G.; Katz, J.; Choinière, M.; Vanasse, A.; Dorais, M.; Samb, O.M.; Lacasse, A. Trajectory Modelling Techniques Useful to Epidemiological Research: A Comparative Narrative Review of Approaches. *Clin. Epidemiol.* **2020**, *12*, 1205–1222. [CrossRef] [PubMed]
26. Yan, Y.; Wang, D.; Sun, Y.; Ma, Q.; Wang, K.; Liao, Y.; Chen, C.; Jia, H.; Chu, C.; Zheng, W.; et al. Triglyceride-glucose index trajectory and arterial stiffness: Results from Hanzhong Adolescent Hypertension Cohort Study. *Cardiovasc. Diabetol.* **2022**, *21*, 33. [CrossRef] [PubMed]
27. CDC. Measure Your Blood Pressure. 2021. Available online: https://www.cdc.gov/bloodpressure/measure.htm (accessed on 4 March 2022).
28. Wu, Y.; Wu, W.; Lin, Y.; Xiong, J.; Zheng, X. Blood pressure states transitions among bus drivers: The application of multi-state Markov model. *Int. Arch. Occup. Environ. Health* **2022**, *95*, 1995–2003. [CrossRef] [PubMed]

29. Simões, C.F.; Locatelli, J.C.; de Oliveira, G.H.; Lopes, W.A. It is time to standardize the TyG index. *Endocrine* **2021**, *71*, 522–523. [CrossRef] [PubMed]
30. World Health Organization. *The WHO STEPwise Approach to Noncommunicable Disease Risk Factor Surveillance*; World Health Organization: Geneva, Switzerland, 2017; Volume 36, pp. 1–474.
31. Tao, M.; Pi, X.; Ma, X.; Shi, Y.; Zhang, Y.; Gu, H.; Chi, Y.; Zhuang, S.; Liu, N. Relationship between serum uric acid and clustering of cardiovascular disease risk factors and renal disorders among Shanghai population: A multicentre and crosssectional study. *BMJ Open* **2019**, *9*, e025453. [CrossRef] [PubMed]
32. Alberti, K.G.; Zimmet, P.Z. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: Diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet. Med.* **1998**, *15*, 539–553. [CrossRef]
33. Proust-Lima, C.; Philipps, V.; Liquet, B. Estimation of extended mixed models using latent classes and latent processes: The R Package lcmm. *J. Stat. Softw.* **2017**, *78*, 1–56. [CrossRef]
34. Li, Z.; Li, C.; Pu, H.; Pang, X.; Wang, Y.; Zhang, D.; Lei, M.; Cheng, X.; Zhao, Y.; Lu, G.; et al. Trajectories of perioperative serum carcinoembryonic antigen and colorectal cancer outcome: A retrospective, multicenter longitudinal cohort study. *Clin. Transl. Med.* **2021**, *11*, e293. [CrossRef] [PubMed]
35. Xin, F.; He, S.; Zhou, Y.; Jia, X.; Zhao, Y.; Zhao, H. The triglyceride glucose index trajectory is associated with hypertension: A retrospective longitudinal cohort study. *Cardiovasc. Diabetol.* **2023**, *22*, 347. [CrossRef] [PubMed]
36. Yu, C.; Wang, T.; Zhou, W.; Zhu, L.; Huang, X.; Bao, H.; Cheng, X. Positive Association between the Triglyceride-Glucose Index and Hyperuricemia in Chinese Adults with Hypertension: An Insight from the China H-Type Hypertension Registry Study. *Int. J. Endocrinol.* **2022**, *2022*, 4272715. [CrossRef] [PubMed]
37. Wang, Y.; Yang, W.; Jiang, X. Association Between Triglyceride-Glucose Index and Hypertension: A Meta-Analysis. *Front. Cardiovasc. Med.* **2021**, *8*, 644035. [CrossRef] [PubMed]
38. Wang, L.; Cong, H.L.; Zhang, J.X.; Hu, Y.C.; Wei, A.; Zhang, Y.Y.; Yang, H.; Ren, L.B.; Qi, W.; Li, W.Y.; et al. Triglyceride-glucose index predicts adverse cardiovascular events in patients with diabetes and acute coronary syndrome. *Cardiovasc. Diabetol.* **2020**, *19*, 80. [CrossRef] [PubMed]
39. Shi, W.; Xing, L.; Jing, L.; Tian, Y.; Yan, H.; Sun, Q.; Dai, D.; Shi, L.; Liu, S. Value of triglyceride-glucose index for the estimation of ischemic stroke risk: Insights from a general population. *Nutr. Metab. Cardiovasc. Dis.* **2020**, *30*, 245–253. [CrossRef] [PubMed]
40. Argoty-Pantoja, A.D.; Velázquez-Cruz, R.; Meneses-León, J.; Salmerón, J.; Rivera-Paredez, B. Triglyceride-glucose index is associated with hypertension incidence up to 13 years of followup in mexican adults. *Lipids Health Dis.* **2023**, *22*, 162. [CrossRef] [PubMed]
41. Lee, J.H.; Heo, S.J.; Kwon, Y.J. Sex-Specific Comparison Between Triglyceride Glucose Index and Modified Triglyceride Glucose Indices to Predict New-Onset Hypertension in Middle-Aged and Older Adults. *JAHA* **2023**, *12*, e030022. [CrossRef] [PubMed]
42. Nikbakht, H.R.; Najafi, F.; Shakiba, E.; Darbandi, M.; Navabi, J.; Pasdar, Y. Triglyceride glucose-body mass index and hypertension risk in iranian adults: A population-based study. *BMC Endocr. Disord.* **2023**, *23*, 156. [CrossRef] [PubMed]
43. Avagimyan, A.; Pogosova, N.; Fogacci, F.; Aghajanova, E.; Djndoyan, Z.; Patoulias, D.; Sasso, L.L.; Bernardi, M.; Faggiano, A.; Mohammadifard, N.; et al. Triglyceride-glucose index (TyG) as a novel biomarker in the era of cardiometabolic medicine. *Int. J. Cardiol.* **2025**, *418*, 132663. [CrossRef] [PubMed]
44. Fan, J.; Liu, L.Y.; Liu, X.Z. Hyperinsulinemia Negatively Affects the Association between Insulin Resistance and Blood Pressure. *Nutr. Metab. Cardiovasc. Dis.* **2021**, *31*, 3359–3366. [CrossRef] [PubMed]
45. Fonseca, V.A. Insulin Resistance, Diabetes, Hypertension, and Renin-Angiotensin System Inhibition: Reducing Risk for Cardiovascular Disease. *J. Clin. Hypertens.* **2006**, *8*, 713–720; quiz 721–722. [CrossRef] [PubMed]

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