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# Age-related and gender-stratified differences in the association between high triglyceride and risk of hyperuricemia

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## Abstract

**Background:** Elevated serum uric acid is commonly associated with high triglyceride. However, the relation of triglyceride and hyperuricemia in different gender and age groups is currently not well understood. This study aimed to evaluate age- and gender-related association of high triglyceride with hyperuricemia in a subgroup of Chinese population.

**Methods:** We retrospectively analyzed physical examination data of 24,438 subjects (12,557 men and 11,881 women) in Kaifeng, China. The alanine aminotransferase,  $\gamma$ -glutamyl transpeptidase, serum creatinine, blood urea nitrogen, total cholesterol, high-density lipoprotein cholesterol, triglyceride and serum uric acid were measured in all subjects. The triglyceride was categorized into < 1.21, 1.21 ~, 1.7 ~, 2.83 ~ and > 5.6 mmol/L subgroups, and odds ratio (OR) and 95% confidence interval (CI) of hyperuricemia were calculated by logistic regression analysis.

**Results:** Univariate and age-adjusted analyses showed that high triglyceride was positively associated with hyperuricemia ( $p < 0.01$ ). Further age-stratified analysis showed that the positive association was significant in the 20 ~, 30 ~, 40 ~, 50 ~, 60 ~ and 80 ~ age groups in men. In women, no statistically significant was found in 60 ~ and 70 ~ age groups.

**Conclusion:** High triglyceride is positively associated with hyperuricemia in both men and women, and this association is age-related, especially in women.

**Keywords:** Hyperuricemia, Triglyceride, Risk, Age-related

## Background

Hyperuricemia is widely considered as a key risk factor for metabolic syndrome, including dyslipidemia, in which hypertriglyceridemia is the most common lipid abnormality [1–6]. High uric acid (UA) levels were associated with increased triglyceridemia, independently of metabolic syndrome [7]. A survey of the prevalence of obesity in China during 2004 to 2008 showed that all rural areas had a low prevalence of obesity except in Henan, probably because of differences in diet [8]. Furthermore, a recent

meta-analysis evaluating 302,430 individuals free of known vascular disease at baseline in 68 prospective studies showed that high triglyceride had a strong association with both cardiovascular disease and ischemic stroke [9]. In addition, the secondary prevention of those diseases and antihyperuricemic therapy involve long term and high costs [10–12]. Therefore, if we can identify the link of triglycerides with hyperuricemia in different age groups, more people will benefit.

Liou et al. reported that uric acid aggregated with log value of triglycerides but concluded that metabolic syndrome was not associated with hyperuricemia [13]. However, an Indian study enrolling 121 healthy men suggested that serum uric acid level was a good indicator of the level of triglyceride [14]. At present, little is known whether serum uric acid level and high triglyceride has the similar relationship in Chinese in different

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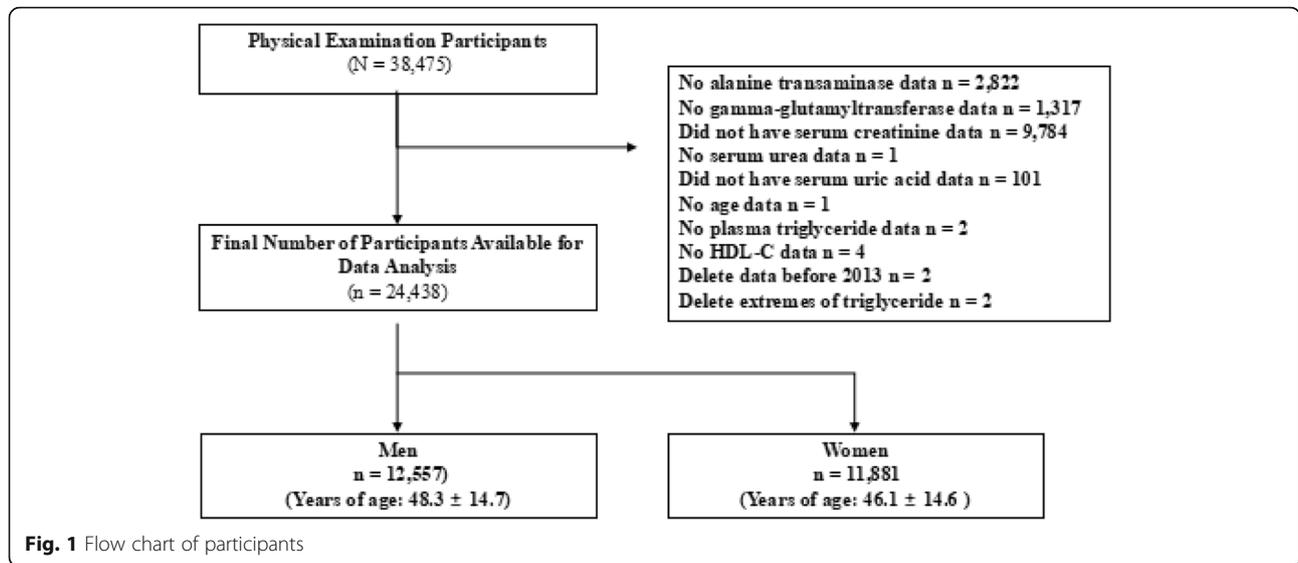
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age-groups. Therefore, this study aimed to investigate the association of high triglyceride with the risk of hyperuricemia in different genders and age-groups using physical examination data from a hospital-based physical examination center in Kaifeng, China.

**Methods**

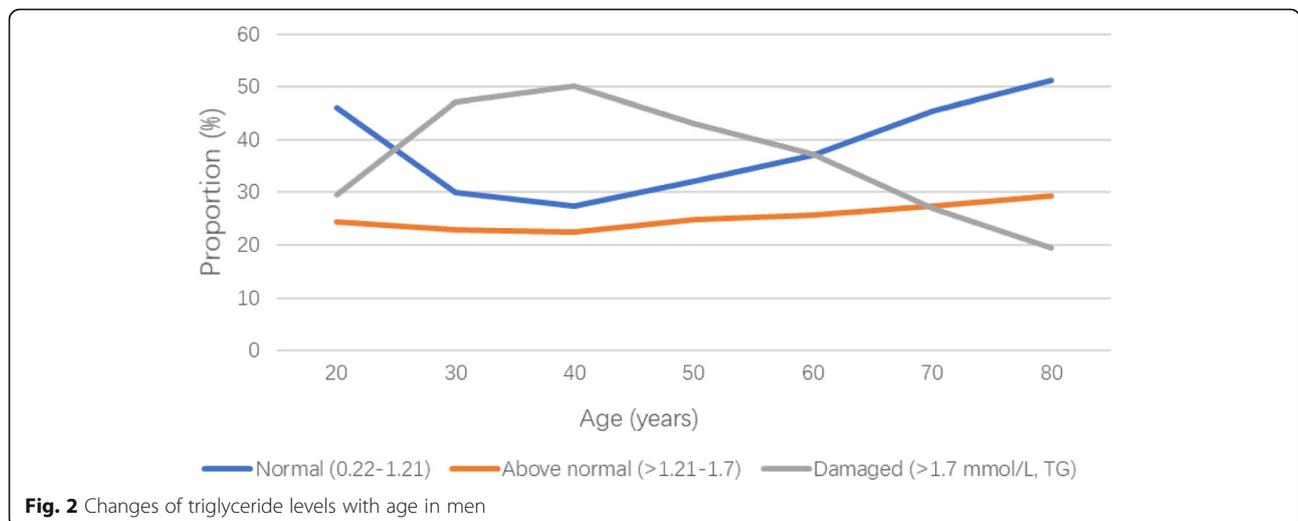
**Subjects**

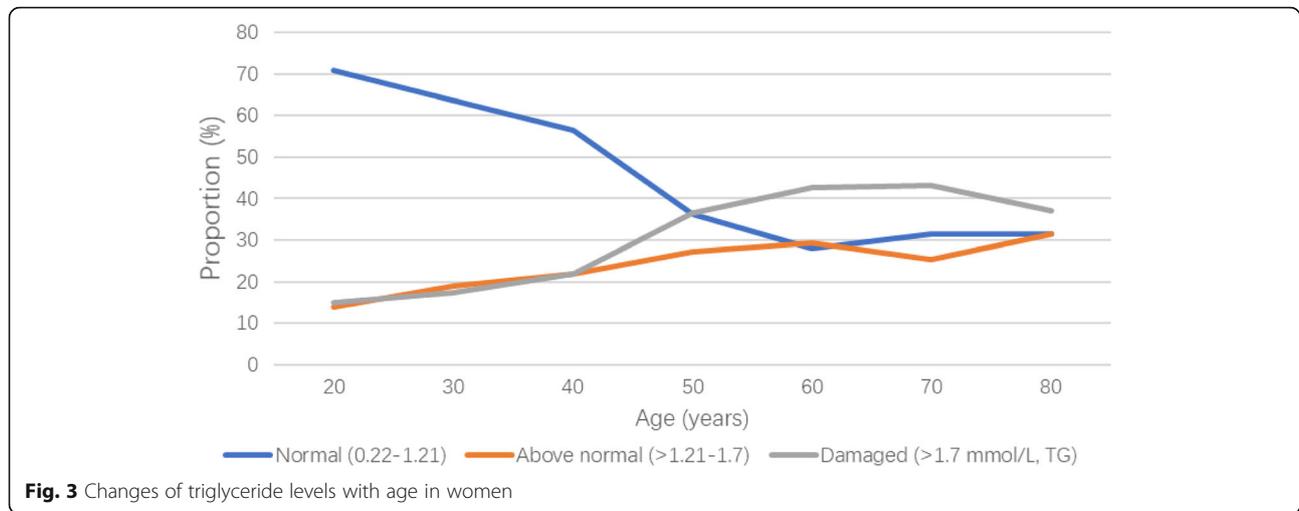
This study was approved by Ethics Committee of Huaihe Hospital of Henan University and all subjected provided written consent. The subjects were participants of physical examination at the Physical Examination Center of Huaihe Hospital of Henan University. Total number of the subjects were 38,475 consecutive participants from 2003 to 2017. After excluding subjects without available data on age, gender, total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C),

alanine aminotransferase (ALT),  $\gamma$ -glutamyl transpeptidase ( $\gamma$ -GT), blood urea nitrogen (BUN) and serum creatinine (SCr), a total of 24,438 eligible subjects (12,557 men and 11,881 women) were included in the final analysis (Fig. 1).

**Serum uric acid and lipids measurements**

Blood samples from participants undergoing an overnight fasting were collected in the morning and analyzed within an hour in hospital. Blood sample was tested using an autoanalyzer (Model 7600, HITACHI, Japan). Hyperuricemia was defined by the following criteria: men: serum uric acid  $\geq 440 \mu\text{mol/L}$ , women: serum uric acid  $\geq 360 \mu\text{mol/L}$  and categorized all the variables as follows: the plasma triglyceride were categorized into  $< 1.21$  (normal),  $1.21 \sim$  (above normal),  $1.7 \sim$  (slightly damaged),  $2.83 \sim$  (moderately damaged) and  $> 5.6 \text{ mmol/L}$  (severely damaged) subgroups, and we combined the slightly, moderately, and





severely damaged TG into a Damaged TG group; age was categorized into <20, 20 ~, 30 ~, 40 ~, 50 ~, 60 ~, 70 ~, and 80 ~ years age subgroups; ALT was dichotomized into normal ( $\leq 40$  U/L) and abnormal ( $> 40$  U/L) subgroups;  $\gamma$ -GT was categorized into low ( $< 16$  U/L), normal (16 ~ 73 U/L) and high ( $> 73$  U/L) subgroups; SCr was categorized into low (men:  $< 54$  mmol/L, women:  $< 44$  mmol/L), normal (men: 54 ~ 106 mmol/L, women: 44 ~ 97 mmol/L) and high (men:  $> 106$  mmol/L, women:  $> 97$  mmol/L) subgroups; BUN was categorized into low ( $< 2.86$   $\mu$ mol/L), normal (2.86 ~ 7.14  $\mu$ mol/L) and high ( $> 7.14$   $\mu$ mol/L) subgroups; TC was categorized into low ( $< 2.8$  mmol/L), normal (2.8 ~ 5.17 mmol/L) and high subgroups ( $> 5.17$  mmol/L); plasma glucose was categorized into low FPG ( $< 3.9$  mmol/L), normal FPG (3.9 ~ mmol/L), impaired FPG (6.1 ~ mmol/L) and diabetic FPG ( $> 7.0$  mmol/L) subgroups; and HDL-C was categorized into low ( $< 0.9$  mmol/L), normal (0.9 ~ 2.19 mmol/L) and high ( $> 2.19$  mmol/L) subgroups.

### Statistical analysis

Statistical analysis was performed using Stata version 13 (StataCorp LLC, TX, USA). The chi-squared test was used to analyze the differences in the distribution of TG categories. Three models with progressive degrees of adjustment were used to evaluate the relationship between hyperuricemia with TG for men and women, separately. Model 1 was a univariate logistic regression model; Model 2 was an age-adjusted logistic regression model, and Model 3 was a multivariate logistic regression model (adjusted for age, ALT,  $\gamma$ -GT, SCr, BUN, TC, FPG, and HDL-C). Multivariable logistic regression analysis were used to calculate age-stratified association of TG and hyperuricemia for both men and women. Odds ratio (OR) and 95% confidence intervals (CI) were estimated in the logistical regression analysis.  $p < 0.05$  was considered significant.

### Results

We observed an increasing trend in the proportion of the Damaged TG group when the age increased from 20 to 40 years; thereafter, the proportion of the Damaged TG group started to decrease with age in men (Fig. 2). There was a growing trend of the proportion of the Damaged TG group among women with a flat plateau from 60 years of age (Fig. 3).

In Table 1, the Damaged TG group (1.7 ~, 2.83 ~ and  $> 5.6$  mmol/L subgroups) had a higher proportion to have high levels of serum ALT,  $\gamma$ -GT, TC and hyperuricemia (all  $p < 0.05$ ), but had a lower proportion to have high level of serum HDL-C ( $p < 0.001$ ) in both genders.

Univariate logistical regression analysis (Model 1) in men showed that the above normal, slightly damaged, moderately damaged and severely damaged TG subgroups had an OR of 1.61 (95% CI: 1.34–1.94), 2.37 (95% CI: 2.00–2.82), 4.35 (95% CI: 3.62–5.23), and 6.53 (95% CI: 4.96–8.59), respectively; age-adjusted logistical regression analysis (Model 2) and multivariate logistical regression model (Model 3) showed a similar trend (Table 2). In all three models, the OR of hyperuricemia was positively associated with an increase in TG ( $p < 0.001$ ). In women, age-adjusted logistic regression analysis showed a similar trend to that of univariate logistic regression model, in accordance with the results in men. Moderately damaged and severely damaged TG subgroups in Model 3 showed an OR of 5.42 (95% CI: 4.03–7.28) and 4.01 (95% CI: 2.13–7.55), respectively. In women, all the three models showed that TG was positively associated with risk for hyperuricemia (all  $p < 0.001$ ).

Multivariate logistic regression model showed that the positive association between hyperuricemia and TG was significant in men of 20~, 30 ~, 40 ~, 50 ~, 60 ~ and 80 ~ age subgroups ( $p < 0.05$ , Table 3). Increase in hyperuricemia in the severely damaged TG group was more significant for the 60~ age subgroup (OR = 12.07; 95%

**Table 1** Characteristics of the participants of physical examinations by fasting plasma triglyceride categories (mmol/L) in men and women

No. of participants	Men, fasting plasma triglyceride (mmol/L)					Women, fasting plasma triglyceride (mmol/L)					P-value
	< 1.21	1.21 ~	1.7 ~	2.83 ~	> 5.6	No. of participants	< 1.21	1.21 ~	1.7 ~	2.83 ~	
12,557	4293 (34.2)	3040 (24.2)	3335 (26.6)	1546 (12.3)	343 (2.7)	11,881	6023 (50.7)	2661 (22.4)	2353 (19.8)	747 (6.3)	97 (0.8)
	Age (years), n (%)										
< 20	33 (76.7)	4 (9.3)	5 (11.6)	0 (0.0)	1 (2.3)	22	17 (77.3)	3 (13.6)	2 (9.1)	0 (0.0)	0 (0.0)
20 ~	609 (46.0)	324 (24.5)	244 (18.4)	125 (9.4)	23 (1.7)	1880	1335 (71.0)	264 (14.0)	190 (10.1)	81 (4.3)	10 (0.5)
30 ~	702 (29.9)	540 (23.0)	669 (28.5)	342 (14.6)	95 (4.1)	2485	1582 (63.7)	473 (19.0)	324 (13.0)	89 (3.6)	17 (0.7)
40 ~	858 (27.4)	704 (22.5)	938 (29.9)	505 (16.1)	128 (4.1)	2652	1496 (56.4)	578 (21.8)	436 (16.4)	128 (4.8)	14 (0.5)
50 ~	879 (32.1)	680 (24.9)	764 (27.9)	349 (12.8)	63 (2.3)	2492	904 (36.3)	679 (27.3)	654 (26.2)	224 (9.0)	31 (1.2)
60 ~	684 (37.0)	474 (25.7)	510 (27.6)	157 (8.5)	23 (1.2)	1509	424 (28.1)	441 (29.2)	480 (31.8)	146 (9.7)	18 (1.2)
70 ~	386 (45.5)	233 (27.5)	166 (19.6)	56 (6.6)	7 (0.8)	679	214 (31.5)	172 (25.3)	222 (32.7)	64 (9.4)	7 (1.0)
80 ~	142 (51.3)	81 (29.2)	39 (14.1)	12 (4.3)	3 (1.1)	162	51 (31.5)	51 (31.5)	45 (27.8)	15 (9.3)	0 (0.0)
	Alanine Aminotransferase (U/L), n (%)										
<= 40	3974 (36.6)	2694 (24.8)	2812 (25.9)	1165 (10.7)	219 (2.0)	11,289	5856 (51.9)	2514 (22.3)	2172 (19.2)	661 (5.9)	86 (0.8)
> 40	319 (18.8)	346 (20.4)	523 (30.9)	381 (22.5)	124 (7.3)	592	167 (28.2)	147 (24.8)	181 (30.6)	86 (14.5)	11 (1.9)
	γ-Glutamyl Transpeptidase (U/L), n (%)										
< 16	1102 (64.0)	375 (21.8)	200 (11.6)	39 (2.3)	6 (0.4)	6207	4088 (65.9)	1253 (20.2)	716 (11.5)	138 (2.2)	12 (0.2)
16 ~ 73	3077 (31.6)	2509 (25.8)	2766 (28.5)	1168 (12.0)	204 (2.1)	5488	1892 (34.5)	1364 (24.9)	1578 (28.8)	575 (10.5)	79 (1.4)
> 73	114 (10.3)	156 (14.0)	369 (33.2)	339 (30.5)	133 (12.0)	186	43 (23.1)	44 (23.7)	59 (31.7)	34 (18.3)	6 (3.2)
	Serum Creatinine (mmol/L), n (%)										
Men < 54 or Women < 44	281 (39.1)	143 (19.9)	168 (23.4)	89 (12.4)	38 (5.3)	1383	688 (49.8)	311 (22.5)	261 (18.9)	107 (7.7)	16 (1.2)
Men: 54~106 or Women: 44~97	3978 (34.0)	2862 (24.4)	3143 (26.8)	1431 (12.2)	301 (2.6)	10,461	5325 (50.9)	2339 (22.4)	2085 (19.9)	632 (6.0)	80 (0.8)
Men > 106 or Women > 97	34 (27.6)	35 (28.5)	24 (19.5)	26 (21.1)	4 (3.3)	37	10 (27.0)	11 (29.7)	7 (18.9)	8 (21.6)	1 (2.7)
	Blood Urea Nitrogen (μmol/L), n (%)										
< 2.86	36 (35.6)	23 (22.8)	26 (25.7)	12 (11.9)	4 (4.0)	523	300 (57.4)	110 (21.0)	81 (15.5)	30 (5.7)	2 (0.4)
2.86 ~ 7.14	3853 (33.6)	2779 (24.2)	3103 (27.1)	1420 (12.4)	310 (2.7)	11,016	5570 (50.6)	2469 (22.4)	2196 (19.9)	690 (6.3)	91 (0.8)
> 7.14	404 (40.8)	238 (24.0)	206 (20.8)	114 (11.5)	29 (2.9)	342	153 (44.7)	82 (24.0)	76 (22.2)	27 (7.9)	4 (1.2)

**Table 1** Characteristics of the participants of physical examinations by fasting plasma triglyceride categories (mmol/L) in men and women (Continued)

	Men, fasting plasma triglyceride (mmol/L)					Women, fasting plasma triglyceride (mmol/L)					P-value	
	< 1.21	1.21 ~	1.7 ~	2.83 ~	> 5.6	No. of participants	< 1.21	1.21 ~	1.7 ~	2.83 ~		> 5.6
Total Cholesterol (mmol/L), n (%)												
< 2.8	66 (80.5)	12 (14.6)	3 (3.7)	1 (1.2)	0 (0.0)	44	34 (77.3)	6 (13.6)	4 (9.1)	0 (0.0)	0 (0.0)	< 0.001
2.8 ~ 5.17	3252 (42.4)	1878 (24.5)	1777 (23.2)	671 (8.8)	87 (1.1)	7273	4561 (62.7)	1425 (19.6)	970 (13.3)	287 (4.0)	30 (0.4)	
> 5.17	975 (20.3)	1150 (23.9)	1555 (32.3)	874 (18.2)	256 (5.3)	4564	1428 (31.3)	1230 (27.0)	1379 (30.2)	460 (10.1)	67 (1.5)	
Fasting plasma glucose (mmol/L), n (%)												
< 3.9	9 (45.0)	6 (30.0)	2 (10.0)	3 (15.0)	0 (0.0)	20	9 (45.0)	5 (25.0)	3 (15.0)	2 (10.0)	1 (5.0)	< 0.001
3.9 ~	3591 (36.5)	2447 (24.9)	2521 (25.6)	1062 (10.8)	212 (2.2)	10,194	5607 (55.0)	2217 (21.8)	1814 (17.8)	497 (4.9)	59 (0.6)	
6.1 ~	368 (26.9)	309 (22.6)	416 (30.4)	218 (15.9)	59 (4.3)	933	245 (26.3)	263 (28.2)	290 (31.1)	119 (12.8)	16 (1.7)	
> 7.0	325 (24.4)	278 (20.8)	396 (29.7)	263 (19.7)	72 (5.4)	734	162 (22.1)	176 (24.0)	246 (33.5)	129 (17.6)	21 (2.9)	
High Density Lipoprotein Cholesterol (mmol/L), n (%)												
< 0.9	371 (16.3)	465 (20.5)	775 (34.1)	502 (22.1)	161 (7.1)	709	98 (13.8)	134 (18.9)	234 (33.0)	197 (27.8)	46 (6.5)	< 0.001
0.9 ~ 2.19	3904 (38.0)	2573 (25.1)	2559 (24.9)	1044 (10.2)	182 (1.8)	11,093	5865 (52.9)	2514 (22.7)	2115 (19.1)	548 (4.9)	51 (0.5)	
> 2.19	18 (85.7)	2 (9.5)	1 (4.8)	0 (0.0)	0 (0.0)	79	60 (76.0)	13 (16.5)	4 (5.1)	2 (2.5)	0 (0.0)	
Hyperuricemia (men > 440 μmol/L or women > 360 μmol/L)												
No	4068 (36.0)	2791 (24.7)	2948 (26.1)	1246 (11.0)	252 (2.2)	11,193	5877 (52.5)	2507 (22.4)	2112 (18.9)	614 (5.5)	83 (0.7)	< 0.001
Yes	225 (18.0)	249 (19.9)	387 (30.9)	300 (24.0)	91 (7.3)	688	146 (21.2)	154 (22.4)	241 (35.0)	133 (19.3)	14 (2.0)	

**Table 2** Odds ratio of hyperuricemia among fasting plasma triglyceride (mmol/L) in men and women<sup>a</sup>

No. of participants	Men, fasting plasma triglyceride (mmol/L)					Women, fasting plasma triglyceride (mmol/L)						
	< 1.21	1.21 ~	1.7 ~	2.83 ~	> 5.6	P for trend <sup>b</sup>	< 1.21	1.21 ~	1.7 ~	2.83 ~	> 5.6	P for trend <sup>b</sup>
		4293	3040	3335	1546	343		6023	2661	2353	747	97
Hyperuricemia <sup>c</sup>												
Cases	225	249	387	300	91		146	154	241	133	14	
Rate (%)	5.2	8.2	11.6	19.4	26.5		2.4	5.8	10.2	17.8	14.4	
Model 1, OR (95% CI)	1.00	1.61 (1.34–1.94)	2.37 (2.00–2.82)	4.35 (3.62–5.23)	6.53 (4.96–8.59)	0.000	1.00	2.47 (1.96–3.12)	4.59 (3.72–5.68)	8.72 (6.80–11.19)	6.79 (3.77–12.24)	0.000
Model 2, OR (95% CI)	1.00	1.62 (1.35–1.96)	2.37 (2.00–2.81)	4.26 (3.54–5.12)	6.26 (4.76–8.25)	0.000	1.00	2.35 (1.86–2.97)	4.28 (3.44–5.33)	8.16 (6.33–10.53)	6.43 (3.56–11.61)	0.000
Model 3, OR (95% CI)	1.00	1.46 (1.21–1.77)	1.99 (1.65–2.39)	3.10 (2.51–3.82)	4.27 (3.13–5.83)	0.000	1.00	1.95 (1.53–2.50)	3.20 (2.51–4.08)	5.42 (4.03–7.28)	4.01 (2.13–7.55)	0.000

<sup>a</sup>Logistic regression. Model 1, univariate; Model 2, adjusted with age; Model 3, adjusted with age, alanine aminotransferase (U/L), γ-glutamyl transpeptidase (U/L), serum creatinine (mmol/L), blood urea nitrogen (μmol/L), total cholesterol (mmol/L), plasma glucose (mmol/l), and high density lipoprotein cholesterol (mmol/L). OR Odds ratio, CI Confidence interval

<sup>b</sup>Contrasts of marginal linear predictions after logistic regression with Stata13

<sup>c</sup>Hyperuricemia:(men > 440 μmol/L or women > 360 μmol/L

**Table 3** Odds ratio of hyperuricemia among fasting plasma triglyceride (mmol/L) and age in men and women<sup>a</sup>

No. of participants	Men, fasting plasma triglyceride (mmol/L)						Women, fasting plasma triglyceride (mmol/L)									
	No. of participants	Case Rate (%)	1.21 ~	1.7 ~	2.83 ~	> 5.6	P for trend <sup>b</sup>	No. of participants	Case Rate (%)	1.21 ~	1.7 ~	2.83 ~	> 5.6	P for trend <sup>b</sup>		
Hyperuricemia <sup>c</sup>	12,557	1252	10.0	4293	3040	3335	1546	343	11,881	688	5.8	6023	2661	2353	747	97
< 20 yrs	43	10	23.3	1.00	(-)	(-)	(-)	(-)	22	3	13.6	1.00	(-)	(-)	(-)	(-)
20~ yrs	1325	175	13.2	1.00	1.02	(0.63-1.64)	(0.92-2.45)	3.03	1880	116	6.2	1.00	2.26	2.17	5.98	7.42
30~ yrs	2348	304	12.9	1.00	1.70	(1.11-2.59)	(1.18-2.70)	3.88	2485	107	4.3	1.00	3.01	3.22	6.64	8.10
40~ yrs	3133	288	9.2	1.00	1.80	(1.10-2.93)	(2.06-5.02)	6.73	2652	74	2.8	1.00	3.48	3.95	6.13	(-)
50~ yrs	2735	241	8.8	1.00	1.38	(0.88-2.15)	(2.57-6.45)	7.48	2492	159	6.4	1.00	1.58	2.31	4.12	5.07
60~ yrs	1848	123	6.7	1.00	2.20	(1.16-4.15)	(2.29-7.59)	12.07	1509	123	8.2	1.00	0.82	3.79	5.59	1.15
70~ yrs	848	81	9.6	1.00	1.12	(0.58-2.16)	(0.51-2.25)	4.46	679	78	11.5	1.00	1.53	2.82	1.06	(-)
80~ yrs	277	30	10.8	1.00	4.80	(1.58-14.56)	(1.26-20.19)	10.13	162	28	17.3	1.00	1.70	3.75	16.75	(-)

<sup>a</sup>Logistic regression model adjusted with alanine aminotransferase (U/L), γ-glutamyl transpeptidase (U/L), serum creatinine (mmol/L), blood urea nitrogen (μmol/L), total cholesterol (mmol/L), plasma glucose (mmol/L), and high density lipoprotein cholesterol (mmol/L)

<sup>b</sup>Contrasts of marginal linear predictions from 3.9~ though > 7.0 groups after logistic regression with Stata 13

<sup>c</sup>Hyperuricemia:(men > 440 μmol/L or women > 360 μmol/L

CI: 3.63–40.16). In women, the positive association was the lowest in the 50~ age group with increase in TG. No significant increase in hyperuricemia was observed in the 60 ~ (women) and 70 ~ (women and men) age groups ( $p > 0.05$ ).

Considering the complicated relationship between triglyceride and glucose metabolism, we also analyzed the association of triglyceride-glucose index (TyG) with hyperuricemia. The results showed that TyG tended to be a better index of hyperuricemia in females than in males (Table 4). After being stratified by the age, the better behavior of TyG was concentrated in 40~ and 60~ age groups (Table 5).

## Discussion

In this study, we found a positive relationship of high triglyceride with hyperuricemia in both men and women, in agreement with an Indian study [14]. Dietary habits have been changing in both China and India, and obesity and hypertriglyceridemia have begun to occur in younger people.

The relationship of serum uric acid with triglyceridemia is still controversial. Earlier studies showed that hyperuricemia was always accompanied with hypertriglyceridemia initially [15, 16]. In addition, TG was more strongly associated with serum UA than HDL-C and TC, using the healthy examination data [17]. A Kuwait study further supported the close relation in dyslipidemic patients, a group already at high coronary artery disease risk [18]. Nevertheless, whether age and gender differences mediate the association between serum UA levels and TG is still controversial. In present study, we demonstrated that after adjustment with age (Model 2) and other confounding factors (Model 3), the OR still increased with the increase

in TG. These results suggest that TG levels independently affect the incidence of hyperuricemia. However, in multivariate logistic regression analysis, the positive association between hyperuricemia and TG showed a gender and age differences and the positive association was the lowest in the 50~ age group. Whether decreasing level of estrogen after menopause is responsible for the differences needs further studies.

Stelmach et al. investigated 607 Polish adults with hyperuricemia and demonstrated that the upper tertile of serum uric acid levels had higher TG values in males but not in females [19]. In contrast, Lippi et al. retrospectively enrolled a large cohort of unselected adult outpatients and showed that triglycerides were independently associated with serum UA in women but not in men [20]. Notably, in this study our data showed that high TG level was positively associated with the incidence of hyperuricemia in both men and women. This is consistent with a prospective study which demonstrated that hypertriglyceridemia in men might strengthen the effect of serum UA on the development of gout [21]. Chinese diet is characterized with a high-fat diet, particularly the overconsumption of cooking oil may be a significant risk factor for obesity [22, 23].

To investigate lipid abnormalities in acute myocardial infarction (AMI) patients, Wei et al. retrospectively analyzed 1213 AMI patients in East China and showed a significant difference in triglycerides for male but not for female AMI patients [24]. Xu et al. found that older Chinese people had moderate and high levels of unbalanced diets [25]. Significant differences were influenced by many factors, such as gender, marital status, work status, education levels. These findings highlight complex interaction between hyperuricemia and TG.

**Table 4** Odds ratio of hyperuricemia among triglyceride-glucose index in men and women<sup>a</sup>

	Men, triglyceride-glucose index (TyG)					Women, triglyceride-glucose index (TyG)				
	0 ~	1st quartile ~	2nd quartile ~	3rd quartile ~	P for trend <sup>b</sup>	0 ~	1st quartile ~	2nd quartile ~	3rd quartile ~	P for trend <sup>b</sup>
No. of participants	2169	3034	3410	3944		3924	3057	2701	2199	
Hyperuricemia <sup>c</sup>										
Cases	103	199	333	617		67	114	198	309	
Rate (%)	4.7	6.6	9.8	15.6		1.7	3.7	7.3	14.1	
Model 1, OR (95% CI)	1.00	1.40 (1.10–1.79)	2.16 (1.72–2.72)	3.72 (3.00–4.62)	< 0.001	1.00	2.23 (1.64–3.33)	4.53 (3.41–6.71)	9.41 (7.19–12.33)	< 0.001
Model 2, OR (95% CI)	1.00	1.47 (1.15–1.88)	2.26 (1.80–2.85)	3.90 (3.14–4.84)	< 0.001	1.00	2.19 (1.61–2.98)	4.39 (3.29–5.86)	9.08 (6.85–12.72)	< 0.001
Model 3, OR (95% CI)	1.00	1.32 (1.03–1.72)	1.85 (1.46–2.35)	2.68 (2.11–3.41)	< 0.001	1.00	1.90 (1.39–2.61)	3.32 (2.44–4.52)	6.08 (4.43–8.34)	< 0.001

<sup>a</sup>Logistic regression. Model 1, univariate; Model 2, adjusted with age; Model 3, adjusted with age, alanine aminotransferase (U/L),  $\gamma$ -glutamyl transpeptidase (U/L), serum creatinine (mmol/L), blood urea nitrogen ( $\mu$ mol/L), total cholesterol (mmol/L), and high density lipoprotein cholesterol (mmol/L). OR Odds ratio, CI Confidence interval

<sup>b</sup>Contrasts of marginal linear predictions after logistic regression with Stata13

<sup>c</sup>Hyperuricemia:(men > 440  $\mu$ mol/L or women > 360  $\mu$ mol/L

**Table 5** Odds ratio of hyperuricemia among triglyceride-glucose index and age in men and women<sup>a</sup>

No. of participants	Men, triglyceride-glucose index (TyG)					Women, triglyceride-glucose index (TyG)						
	No. of participants	Case Rate (%)	0 ~ 1st quartile ~	2nd quartile ~	3rd quartile ~	P for trend <sup>b</sup>	No. of participants	Case Rate (%)	0 ~ 1st quartile ~	2nd quartile ~	3rd quartile ~	P for trend <sup>b</sup>
Hyperuricemia <sup>c</sup>	12,557	10.0	2169	3034	3410	3944	11,881	5.8	3924	3057	2701	2199
< 20 yrs	43	23.3	1.00	4.98 (0.37-66.42)	73.31 (1.18-4529.68)	7.78 (0.20-297.59)	22	13.6	1.00 (-)	(-)	(-)	(-)
20~ yrs	1325	17.5	13.2	1.00	1.19 (0.70-2.77)	2.44 (1.41-4.24)	1880	6.2	1.00	2.77 (1.50-5.97)	2.49 (1.23-5.23)	5.72 (2.82-11.61)
30~ yrs	2348	30.4	12.9	1.00	1.30 (0.77-2.21)	2.27 (1.36-3.78)	2485	4.3	1.00	1.89 (0.96-3.69)	4.15 (2.18-7.89)	5.95 (2.92-12.11)
40~ yrs	3133	28.8	9.2	1.00	0.98 (0.51-1.89)	3.77 (2.12-6.72)	2652	2.8	1.00	3.61 (1.29-13.86)	9.42 (3.42-25.97)	11.42 (3.87-33.73)
50~ yrs	2735	24.1	8.8	1.00	1.54 (0.81-2.93)	3.31 (1.80-6.75)	2492	6.4	1.00	0.91 (0.46-1.79)	1.64 (0.87-3.57)	2.86 (1.51-5.42)
60~ yrs	1848	12.3	6.7	1.00	3.17 (1.06-9.46)	6.46 (2.19-19.53)	1509	8.2	1.00	2.27 (0.62-8.31)	3.98 (1.18-13.47)	10.67 (3.17-35.98)
70~ yrs	848	8.1	9.6	1.00	1.48 (0.62-3.54)	1.34 (0.53-3.41)	679	11.5	1.00	0.97 (0.30-3.14)	1.60 (0.53-4.78)	2.25 (0.74-6.83)
80~ yrs	277	3.0	10.8	1.00	1.39 (0.29-6.72)	3.68 (0.72-18.71)	162	17.3	(-)	1.00	3.08 (0.67-14.27)	5.24 (1.10-24.87)

<sup>a</sup>Logistic regression model adjusted with alanine aminotransferase (U/L), γ-glutamyl transpeptidase (U/L), serum creatinine (mmol/L), blood urea nitrogen (μmol/L), total cholesterol (mmol/L), and high density lipoprotein cholesterol (mmol/L)

<sup>b</sup>Contrasts of marginal linear predictions from 3.9~ though > 7.0 groups after logistic regression with Stata13

<sup>c</sup>Hyperuricemia: men > 440 μmol/L or women > 360 μmol/L

Differences in dietary patterns such as the proportion of carbohydrate or fat may be responsible for the variability in the relationship between serum uric acid and triglyceridemia.

TyG index is proposed as a marker of moderate insulin resistance. Therefore, we analyzed the association of TyG with hyperuricemia. We found that TyG could be a better index of hyperuricemia in females than in males. However, a recent study indicated that TyG index presented the significant risks for chronic kidney disease in both men and women [26]. The reason for the disparities is unclear and need additional investigations.

Our study has two main limitations. First, our study was conducted in a special group, so the generalizability of our findings to other population needs confirmation in future studies. Second, confounding factors such as diet patterns and health concerns among people of different ages were not included in our analysis, which may have an impact on the results. Further studies are required to elucidate the association between triglyceride and hyperuricemia in different gender and age groups.

## Conclusions

Our study demonstrated that high triglyceride was positively associated with hyperuricemia in both men and women, and this association was age-related, especially in women.

## Abbreviations

ALT: Alanine aminotransferase; BUN: Blood urea nitrogen; HDL-C: High-density lipoprotein cholesterol; SCr: Serum creatinine; TC: Total cholesterol; TG: Triglyceride; UA: Uric acid;  $\gamma$ -GT:  $\gamma$ -glutamyl transpeptidase

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## Authors' contributions

GC and YL designed the study. LZ, QW, YZ, JX, CY, YM, MX, RH collected the data. YL and XZ analyzed the data. LZ and GC wrote the manuscript. All authors read and approved the final manuscript.

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## Availability of data and materials

All data and material are available upon request.

## Ethics approval and consent to participate

This study was approved by Ethics Committee of Huaihe Hospital of Henan University and all subjected provided written consent.

## Consent for publication

Not applicable.

## Competing interests

The authors declare that they have no competing interests.

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