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Research article

Physical Activity Modifies the Association between C-Reactive Protein - Triglyceride - Glucose Index (CTI) and Dyslipidemia: Evidence from a 10-Year Chinese Cohort

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Abstract
Dyslipidemia is a major contributor to cardiovascular disease. The C-reactive protein - triglyceride - glucose index (CTI), which reflects insulin resistance and systemic inflammation, has increasingly been recognized as a potential marker for metabolic disturbances. However, its predictive value for incident dyslipidemia remains uncertain, and the role of physical activity in this association requires further clarification. This study prospectively examined the association between CTI and the risk of dyslipidemia, and further assessed whether physical activity modifies this relationship in middle-aged and older Chinese adults. A total of 7,954 participants aged ≥45 years without dyslipidemia at baseline were enrolled, using data from the China Health and Retirement Longitudinal Study (2011 - 2020). Physical activity was assessed using the CHARLS physical activity questionnaire, which captures the frequency and duration of vigorous, moderate, and light activities. Based on the frequency and duration of these activities, participants were categorized into low, moderate, and high physical activity groups. CTI was derived from high-sensitivity C-reactive protein, fasting plasma glucose, and triglyceride levels. Incident dyslipidemia was defined based on abnormal lipid profiles, ongoing lipid-lowering treatment, or a physician's clinical diagnosis. Cox proportional hazards regression with restricted cubic splines was applied to evaluate associations, with stratified analyses by sex, age, and physical activity level. During 10 years of follow-up, 2,011 new cases of dyslipidemia were recorded. Each 1-unit increase in CTI corresponded to approximately a 9% higher risk of dyslipidemia (HR = 1.09, 95% CI: 1.01 - 1.18). Individuals in the highest CTI quartile had a 15% greater risk compared with those in the lowest quartile (HR = 1.15, 95% CI: 1.01 - 1.30). Stronger associations were observed in men (HR = 1.20, 95% CI: 1.05 - 1.36) and adults aged 45 - 59 years (HR = 1.22, 95% CI: 1.08 - 1.39), whereas no significant effect was found in women. When stratified by physical activity, a 1-unit CTI increase was linked to about a 10% higher risk in the light and moderate activity groups, and to a 28% higher risk in the vigorous activity group, with risk plateauing at higher CTI levels. Elevated CTI was prospectively associated with an increased risk of dyslipidemia, particularly in men and individuals in midlife. Physical activity appeared to influence this relationship, suggesting that CTI could serve as a practical marker for early risk stratification. These findings underscore the importance of regular exercise in preventing dyslipidemia.

Key words: C-reactive protein - triglyceride - glucose index (CTI), Dyslipidemia, Physical activity, Insulin resistance, Inflammation, CHARLS.

Introduction

Dyslipidemia is a common metabolic disorder and an important determinant of cardiovascular disease (CVD), which continues to be one of the leading causes of morbidity and mortality worldwide (Roth et al., 2020). Globally, dyslipidemia is a significant public-health issue, with its prevalence steadily increasing in aging populations across various regions. According to a recent systematic review and meta-analysis, the global prevalence among adults was approximately 24.1 % for hypercholesterolaemia (elevated total cholesterol), 28.8 % for hypertriglyceridaemia, 38.4 % for low HDL-cholesterol, and 18.9 % for elevated LDL-cholesterol (Ballena-Caicedo et al., 2025). This trend is particularly concerning given the strong association between dyslipidemia and cardiovascular diseases, which are major contributors to morbidity and mortality worldwide. In China, the prevalence of dyslipidemia among adults is high, with estimates ranging from 34% to over 40% (Lu et al., 2021; Opoku et al., 2021). Reported pooled prevalence rates reach 41.9% (Huang et al., 2014), while age- and sex-standardized prevalence has been estimated at 34.1% (Xia et al., 2023). Nevertheless, awareness, treatment, and control remain suboptimal, with only 42.7% of individuals aware, 18.9% receiving treatment, and 7.2% achieving lipid control (Xia et al., 2023; Opoku et al., 2021). These data emphasize the considerable public health burden posed by dyslipidemia in China, especially in the context of rapid population aging, urbanization, and lifestyle changes.

Insulin resistance and systemic inflammation are regarded as fundamental mechanisms contributing to dyslipidemia. The triglyceride - glucose (TyG) index is widely accepted as a surrogate for insulin resistance (Simental-Mendía et al., 2008; Khan et al., 2018), while high-sensitivity C-reactive protein (hsCRP) is a validated marker of systemic inflammation (Ridker, 2003; Ridker, 2007). To capture these processes simultaneously, the C-reactive protein - triglyceride - glucose index (CTI) has recently been introduced (Mei et al., 2024). Previous research has demonstrated its predictive value for type 2 diabetes (Ruan et al., 2022), metabolic syndrome (Xu et al., 2024), coronary heart disease (Zhang et al., 2025), and stroke in individuals with cardiometabolic multimorbidity (Tang et al., 2024). However, its role in predicting incident dyslipidemia remains unclear.

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The C-reactive protein - triglyceride - glucose index (CTI) has been proposed as a more comprehensive marker for predicting metabolic disturbances than individual biomarkers like the TyG index or hsCRP. While the TyG index primarily reflects insulin resistance and hsCRP serves as a marker of inflammation, CTI simultaneously captures both these processes, offering a more holistic view of metabolic risk (Mei et al., 2024). This unique combination of markers may make CTI a superior predictor of dyslipidemia, which involves both insulin resistance and systemic inflammation.

Physical activity is known to influence both inflammatory markers and insulin sensitivity, which are fundamental mechanisms of CTI. Regular exercise has been shown to reduce chronic low-grade inflammation and improve insulin sensitivity, both of which are closely linked with dyslipidemia. Exercise has been demonstrated to lower levels of inflammatory cytokines such as TNF-α and IL-6 (Krüger et al., 2022), and to increase insulin sensitivity, which can improve lipid metabolism (Ho et al., 2012). This interplay between physical activity, inflammation, and insulin sensitivity may modify the relationship between CTI and dyslipidemia. Physical activity is a well-established modifiable factor that can improve lipid metabolism by enhancing insulin sensitivity and reducing systemic inflammation (Krüger et al., 2022; Ho et al., 2012). Meta-analytic evidence shows that engaging in regular moderate-to-vigorous exercise lowers the risk of dyslipidemia and related cardiometabolic outcomes by approximately 15 - 25% (Wang and Xu, 2017; Zhao et al., 2021). Network meta-analyses further suggest that aerobic exercise may be particularly beneficial for improving lipid profiles in middle-aged and older adults (Smart et al., 2025). Moreover, traditional Chinese practices such as Wuqinxi and Tai Chi have been reported to improve lipid regulation and support cardiovascular health (Gao et al., 2021; Hartley et al., 2014). In contrast, sedentary behavior is consistently linked with a higher risk of dyslipidemia and CVD (Pandey et al., 2016; Wu et al., 2022).

Although previous studies have examined associations between CTI and various metabolic outcomes, the potential modifying role of physical activity in the relationship between CTI and dyslipidemia remains uncertain. Large-scale prospective studies specifically addressing this issue in Chinese populations are scarce. Therefore, using a decade of follow-up data from the China Health and Retirement Longitudinal Study (CHARLS, 2011 - 2020) (Zhao et al., 2014), this study aimed to explore the association between CTI and incident dyslipidemia, and to determine whether physical activity modifies this relationship.

Methods

Study design and population

This study utilized data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative cohort of Chinese residents aged ≥45 years, selected through a multistage stratified probability sampling design (Zhao et al., 2014; Zhao et al., 2020). The baseline survey was conducted in 2011, with follow-up waves in 2013, 2015, 2018, and 2020 (Zhao et al., 2020). The CHARLS study was approved by the Biomedical Ethics Review Committee of Peking University (IRB00001052-11015). All procedures involving human participants were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their participation in the study.

Participants aged 45 years or older with available baseline measurements of high-sensitivity C-reactive protein (CRP), fasting plasma glucose (FPG), triglycerides (TG), and dyslipidemia status were included (Xia et al., 2023; Opoku et al., 2021). Exclusion criteria were missing data on CRP (n = 6,072), FPG or TG (n = 28), or age (n = 461); being younger than 45 years; or having pre-existing dyslipidemia. Individuals with incomplete outcome data or who were lost to follow-up (n = 3,193) were also excluded (Simental-Mendía et al., 2008; Khan et al., 2018). After these exclusions, 7,954 participants were retained for the final analysis (Figure 1).

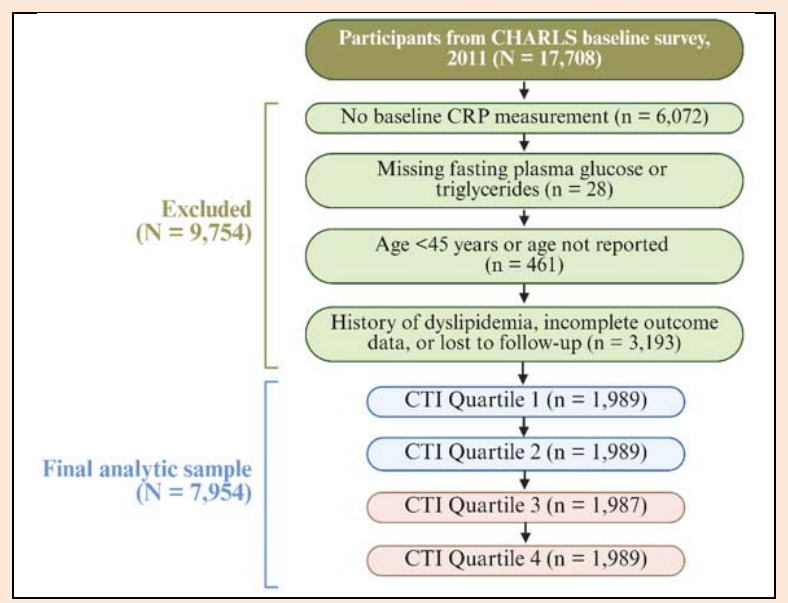

Figure 1. Flow diagram of participant inclusion based on the China Health and Retirement Longitudinal Study (CHARLS), 2011 - 2020.

Calculation of CTI

The C-reactive protein - triglyceride - glucose index (CTI) was computed according to the following formula (Simental-Mendía et al., 2008; Khan et al., 2018; Desquilbet and Mariotti, 2010):

$$CTI = 0.412 \times \ln(CRP\ [mg/L]) + \frac{\ln(TG\ [mg/dl] \times FPG\ [mg/dl])}{2}$$

Outcome assessment

The primary outcome was incident dyslipidemia, defined as meeting any of the following criteria during follow-up: triglycerides (TG) ≥150 mg/dL, total cholesterol (TC) ≥240 mg/dL, high-density lipoprotein cholesterol (HDL-C) <40 mg/dL, low-density lipoprotein cholesterol (LDL-C) ≥160 mg/dL, initiation of lipid-lowering therapy, or self-reported physician diagnosis (Simental-Mendía et al., 2008; Khan et al., 2018; Ridker, 2003). The time of onset was determined as the interval between the last survey wave free of dyslipidemia and the first wave in which dyslipidemia was documented.

Covariates

Baseline covariates included sociodemographic and lifestyle factors (sex, age, residence, marital status, education, smoking, and alcohol use), as well as major comorbidities such as joint disease, liver disease, kidney disease, gastrointestinal disorders, and asthma. In addition, medication use was considered, including anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication. Data on these variables were collected through structured questionnaires administered by trained interviewers (Zhao et al., 2014; Opoku et al., 2021).

Definitions

Dyslipidemia was defined according to the criteria noted above (Simental-Mendía et al., 2008; Khan et al., 2018). Physical activity was evaluated using the CHARLS physical activity questionnaire, which captured the frequency and duration of vigorous, moderate, and walking activities. Based on the CHARLS classification system, participants were categorized into low, moderate, and high physical activity groups (Zhao et al., 2020; Zhang et al., 2025). Specifically, light physical activity is defined as activities performed less than 600 MET-minutes per week, including low-intensity activities such as slow walking or light housework. Moderate physical activity is defined as activities performed between 600 and 3000 MET-minutes per week, including activities like brisk walking or moderate cycling. Vigorous physical activity is defined as activities performed more than 3000 MET-minutes per week, including running, vigorous cycling, or heavy lifting (Zhou and Tian, 2024).

Statistical analysis

Continuous variables were expressed as means with standard errors or as medians with interquartile ranges, while categorical variables were described as frequencies and percentages. Group differences were tested using one-way analysis of variance (ANOVA), the Kruskal-Wallis test, or the Chi-square test, as appropriate (Zhao et al., 2020; Zhang et al., 2025). To address missing covariates, chained multiple imputation was applied to reduce potential bias compared with complete-case analysis (Therneau and Grambsch, 2000; Desquilbet and Mariotti, 2010). A complete-case analysis was also performed as part of sensitivity checks.

CTI was analyzed both as quartiles (Q1 - Q4) and as a continuous variable (per 1-unit increase). Kaplan - Meier survival functions were generated to assess cumulative dyslipidemia incidence, and group differences were evaluated using log-rank tests (Therneau and Grambsch, 2000; Kaplan and Meier, 1958). Cox proportional hazards models were fitted to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) (Cox, 1972; Desquilbet and Mariotti, 2010).

Three models were specified:

Model 1: unadjusted

Model 2: adjusted for sociodemographic and lifestyle variables

Model 3: further adjusted for comorbidities and medication use (anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication).

Restricted cubic spline (RCS) regression was used to explore potential nonlinear associations between CTI and dyslipidemia risk (Desquilbet and Mariotti, 2010; Orsini and Greenland, 2011). Multicollinearity was assessed using variance inflation factors (VIFs), with all VIFs <5 (Supplementary Table S1) (Vandenbroucke and Pearce, 2012).

Subgroup analysis

Subgroup analyses were performed by sex, age group (45 - 59 vs. ≥60 years), and physical activity level. Effect modification was examined by incorporating interaction terms into the Cox regression models (VanderWeele and Ding, 2017; Zhao et al., 2021).

Sensitivity analysis

Multiple sensitivity analyses were conducted to evaluate the robustness of the findings. These included:

1. Complete-case analysis excluding individuals with missing covariates,
2. Removal of non-fasting participants,
3. Exclusion of individuals who died during follow-up, and
4. Logistic regression as an alternative validation method (Therneau and Grambsch, 2000; Kaplan and Meier, 1958).

E-values were further calculated to assess the potential impact of unmeasured confounding on the observed associations (VanderWeele and Ding, 2017; Mathur and VanderWeele, 2020). For HR >1, the E-value was derived as the point estimate of the hazard ratio plus the square root of {HR × (HR - 1)}; for HR <1, it was calculated as 1/HR plus the square root of {(1/HR) × (1/HR − 1)} (VanderWeele and Ding, 2017).

All statistical analyses were performed using R software (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria) (R Core Team, 2022), and two-sided p-values <0.05 were considered statistically significant (Rothman et al., 2008).

Table 1. Baseline characteristics of study participants stratified by quartiles of CTI.

Characteristic		Q1 (n = 1989)	Q2 (n = 1989)	Q3 (n = 1987)	Q4 (n = 1989)	p-value
Age, years		56.69 ± 8.98	57.93 ± 8.89	58.27 ± 8.86	58.42 ± 8.64	<0.0001
Sex, n (%)	Male	891 (44.8%)	888 (44.6%)	861 (43.3%)	856 (43.0%)	
	Female	1098 (55.2%)	1101 (55.4%)	1126 (56.7%)	1133 (57.0%)	
Residence, n (%)	Rural	1452 (73.0%)	1374 (69.1%)	1322 (66.5%)	1238 (62.2%)	
	Urban	537 (27.0%)	615 (30.9%)	665 (33.5%)	751 (37.8%)	
Marital status, n (%)	Married	1817 (91.4%)	1801 (90.5%)	1796 (90.4%)	1789 (89.9%)	
	Other	172 (8.6%)	188 (9.5%)	191 (9.6%)	200 (10.1%)	
Education level, n (%)	Below primary	929 (46.7%)	962 (48.4%)	942 (47.4%)	923 (46.4%)	
	Primary	456 (22.9%)	436 (21.9%)	428 (21.5%)	440 (22.1%)	
	Middle school	415 (20.9%)	383 (19.3%)	440 (22.1%)	399 (20.1%)	
	High school+	189 (9.5%)	208 (10.5%)	177 (8.9%)	227 (11.4%)	
Smoking status, n (%)	No	1272 (64.0%)	1253 (63.0%)	1246 (62.7%)	1272 (64.0%)	
	Yes	717 (36.0%)	736 (37.0%)	741 (37.3%)	717 (36.0%)	
Drinking status, n (%)	No	1236 (62.1%)	1234 (62.0%)	1251 (63.0%)	1255 (63.1%)	
	Yes	753 (37.9%)	755 (38.0%)	736 (37.0%)	734 (36.9%)	
Chronic disease, n (%)	No	741 (37.3%)	661 (33.2%)	588 (29.6%)	488 (24.5%)	
	Yes	1248 (62.7%)	1328 (66.8%)	1399 (70.4%)	1501 (75.5%)	
Arthritis, n (%)	No	1363 (68.5%)	1280 (64.4%)	1273 (64.1%)	1268 (63.8%)	
	Yes	626 (31.5%)	709 (35.6%)	714 (35.9%)	721 (36.2%)	
Liver disease, n (%)	No	1909 (96.0%)	1928 (96.9%)	1927 (97.0%)	1921 (96.6%)	
	Yes	80 (4.0%)	61 (3.1%)	60 (3.0%)	68 (3.4%)	
Asthma, n (%)	No	1954 (98.2%)	1959 (98.5%)	1956 (98.4%)	1954 (98.2%)	
	Yes	35 (1.8%)	30 (1.5%)	31 (1.6%)	35 (1.8%)	
Kidney disease, n (%)	No	1912 (96.1%)	1899 (95.5%)	1897 (95.5%)	1903 (95.7%)	
	Yes	77 (3.9%)	90 (4.5%)	90 (4.5%)	86 (4.3%)	
Stomach disease, n (%)	No	1851 (93.1%)	1831 (92.0%)	1816 (91.4%)	1811 (91.0%)	
	Yes	138 (6.9%)	158 (8.0%)	171 (8.6%)	178 (9.0%)	
Anti-diabetic medication, n (%)	No	1788 (89.9%)	1770 (89.0%)	1760 (88.6%)	1742 (87.6%)	
	Yes	201(10.1%)	219 (11.0%)	227 (11.4%)	247 (12.4%)	
Anti-hypertensive medication, n (%)	No	1611 (81.0%)	1592 (80.0%)	1572 (79.1%)	1563 (78.6%)	
	Yes	378 (19.0%)	397 (20.0%)	415 (20.9%)	426 (21.4%)	
Lipid-lowering medication, n (%)	No	1711 (86.0%)	1690 (85.0%)	1679 (84.5%)	1654 (83.2%)	
	Yes	278 (14.0%)	299 (15.0%)	308 (15.5%)	335 (16.8%)	

Continuous variables are shown as mean ± standard deviation (SD), and categorical variables as counts with percentages. P values were determined using analysis of variance (ANOVA) or the χ^2 test, as appropriate. CTI: C-reactive protein - triglyceride - glucose index.

Results

Baseline characteristics

Table 1 presents the baseline characteristics of participants grouped by quartiles of the C-reactive protein - triglyceride - glucose index (CTI). Participants with higher CTI tended to be older (mean age 58.4 years in Q4 vs. 56.7 years in Q1, $p < 0.0001$) and were more likely to live in urban areas (37.8% in Q4 vs. 27.0% in Q1, $p < 0.0001$). The prevalence of chronic diseases also increased across CTI quartiles, from 62.7% in Q1 to 75.5% in Q4 ($p < 0.0001$). Most sociodemographic and lifestyle factors - including sex distribution, marital status, education level, smoking, drinking, and comorbidities such as liver disease, kidney disease, asthma, and stomach disorders - did not differ significantly across quartiles. Arthritis was the only condition that showed a statistically significant increase with higher CTI levels (31.5% in Q1 vs. 36.2% in Q4, $p = 0.004$).

Main analysis

During a median follow-up of 10 years, a total of 2,011 participants developed dyslipidemia. As presented in Table 2, higher CTI values were consistently associated with an increased risk across all Cox regression models. In Model 3 (adjusted for the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication), the association between CTI and dyslipidemia remained significant. Each 1-unit increase in CTI corresponded to roughly a 9% elevation in dyslipidemia risk (HR = 1.08, 95% CI: 1.00 - 1.17). Furthermore, individuals in the highest CTI quartile had a significantly greater risk compared to those in the lowest quartile (HR = 1.12, 95% CI: 1.00 - 1.24), and a significant linear trend was observed across quartiles (p for trend = 0.02).

Kaplan-Meier survival analysis demonstrated that the cumulative incidence of dyslipidemia rose progressively across increasing CTI categories (log-rank $p = 0.021$; Figure 2). In the overall sample, restricted cubic spline analysis revealed an approximately linear positive association between CTI and dyslipidemia risk, with no clear evidence of a threshold effect (Figure 3A). At higher CTI values, the confidence intervals became wider, reflecting fewer participants in the extreme ranges.

As shown in Table 3, the association between CTI and dyslipidemia was stronger in men than in women. Among men, each 1-unit rise in CTI was linked to a 20% higher risk of dyslipidemia in the fully adjusted model (HR = 1.18, 95% CI: 1.04 - 1.35; $p = 0.01$). Compared with Q1, men in Q4 had a significantly elevated risk (HR = 1.25, 95% CI: 1.04 - 1.56; $p = 0.03$), with a borderline linear trend across quartiles (p for trend = 0.05). In contrast, no significant associations were observed in women, either

when CTI was analyzed continuously (HR = 1.01, 95% CI: 0.92 - 1.12; p = 0.56) or by quartiles. Restricted cubic spline analysis further confirmed these findings: in men (Figure 3B), higher CTI showed a clear linear association with increased dyslipidemia risk (p < 0.05), whereas in women (Figure 3C) no significant association was detected (p = 0.14).

Table 2. Cox proportional hazards models for incident outcome by CTI.

Variable	Number of events, n	Model 1			Model 2			Model 3		
		HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
CTI (per 1 unit)	2011	1.09	1.01 - 1.18	0.02	1.09	1.01 - 1.18	0.02	1.08	1.00 - 1.17	0.03
CTI quartile										
Q1 (Ref)	474	Ref			Ref			Ref		
Q2	484	1.02	0.89 - 1.17	0.81	1.01	0.88 - 1.16	0.90	1.00	0.88 - 1.14	0.92
Q3	508	1.07	0.93 - 1.21	0.35	1.04	0.91 - 1.19	0.55	1.03	0.91 - 1.16	0.58
Q4	545	1.15	1.01 - 1.31	0.03	1.14	1.01 - 1.30	0.04	1.12	1.00 - 1.24	0.07
P for trend				0.02			0.02			0.02

HR = hazard ratio; CI = confidence interval. Q1 represents the lowest quartile and was used as the reference group. Model 1 included no covariate adjustment; Model 2 was adjusted for demographic and lifestyle factors (sex, age, residence, marital status, education, smoking, and alcohol use); and Model 3 additionally accounted for comorbid conditions such as chronic diseases, arthritis, liver disease, asthma, kidney disease, and gastrointestinal disorders, as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. The p for trend was estimated by treating the median value of each quartile as a continuous variable in the Cox regression model. Statistical significance was defined as a two-sided p < 0.05.

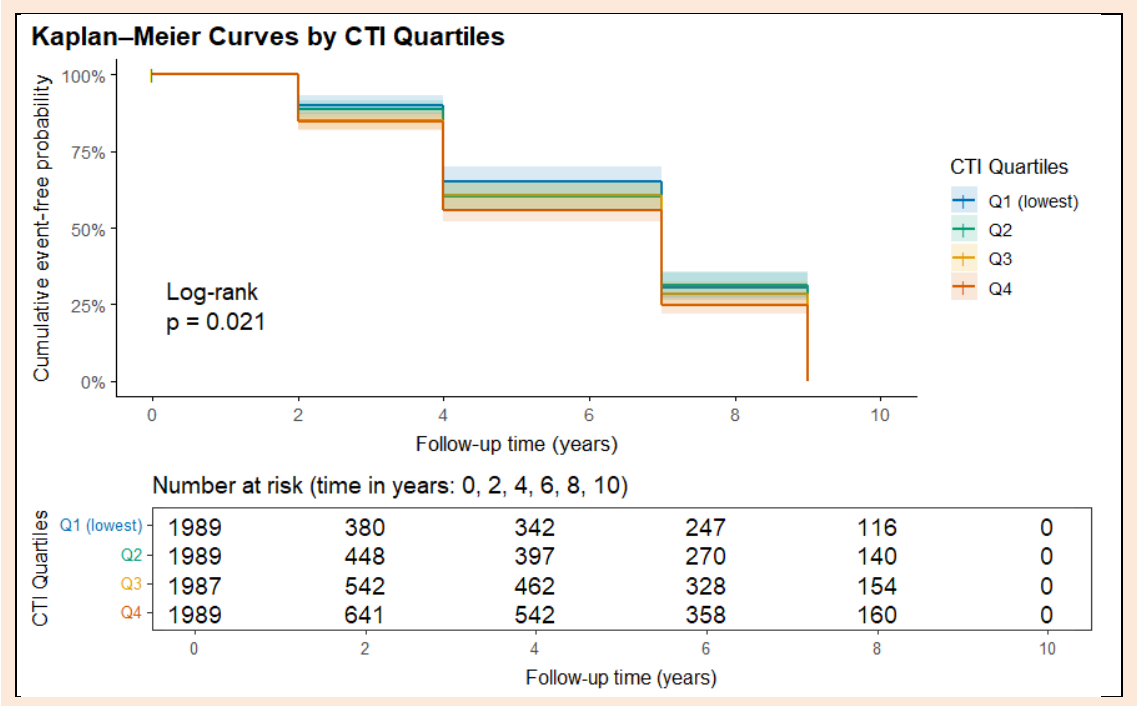

Figure 2. Kaplan - Meier survival curves showing the cumulative incidence of dyslipidemia across quartiles of the C-reactive protein - triglyceride - glucose index (CTI).

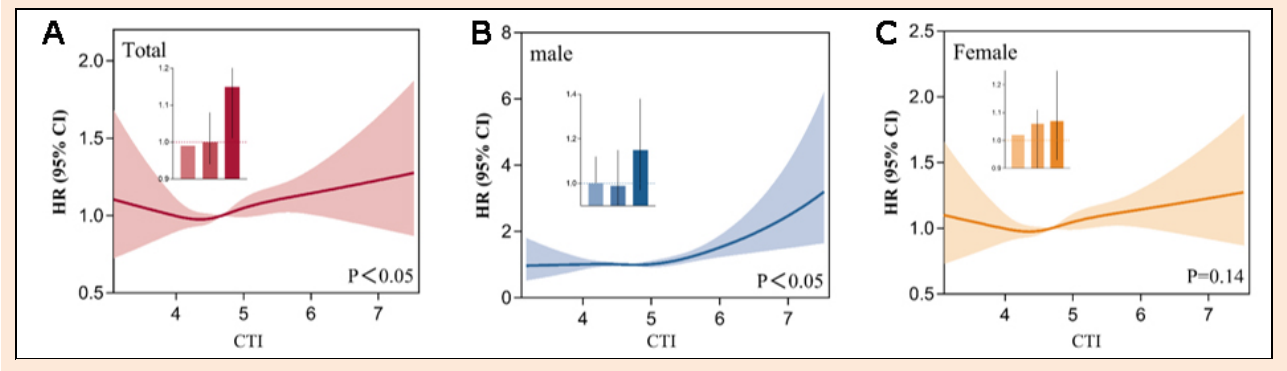

Figure 3. Restricted cubic spline analyses of the association between the C-reactive protein - triglyceride-glucose index (CTI) and risk of dyslipidemia in the overall population (A), male (B), and female (C).

Table 3. Gender-specific association of the CTI with dyslipidemia incidence.

Sex	Variable	Number of events, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Male	CTI (per 1-unit)	785	1.21	1.06 - 1.37	0.01	1.19	1.05 - 1.35	0.01	1.18	1.04 - 1.35	0.01
	Q1 (Ref)	148									
	Q2	178	1.07	0.86 - 1.33	0.53	1.05	0.85 - 1.31	0.65	1.00	0.83 - 1.31	0.51
	Q3	214	0.98	0.80 - 1.21	0.85	0.95	0.77 - 1.17	0.62	0.94	0.77 - 1.16	0.72
	Q4	245	1.28	1.04 - 1.57	0.02	1.24	1.01 - 1.53	0.04	1.25	1.04 - 1.56	0.03
	P for trend				0.04			0.07			0.05
Female	CTI (per 1-unit)	1226	1.04	0.95 - 1.14	0.41	1.04	0.95 - 1.14	0.40	1.01	0.92 - 1.12	0.56
	Q1 (Ref)	232									
	Q2	270	0.98	0.83 - 1.17	0.86	0.98	0.82 - 1.17	0.81	0.96	0.81 - 1.14	0.77
	Q3	328	1.13	0.95 - 1.33	0.16	1.11	0.93 - 1.31	0.24	1.08	0.92 - 1.28	0.29
	Q4	396	1.09	0.93 - 1.28	0.31	1.09	0.92 - 1.28	0.33	1.06	0.90 - 1.24	0.40
	P for trend				0.15			0.16			0.22

HR = hazard ratio; CI = confidence interval. Q1 denotes the lowest quartile, used as the reference category. Model 1 included no covariate adjustment; Model 2 was adjusted for demographic and lifestyle factors (age, residence, marital status, education, smoking, and alcohol consumption); and Model 3 additionally accounted for comorbid conditions such as chronic diseases, arthritis, liver disease, asthma, kidney disease, and gastrointestinal disorders, as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. The p for trend was estimated by modeling the median value of each quartile as a continuous variable in the Cox regression model.

Table 4 indicates that CTI correlated positively with dyslipidemia in both middle-aged (45 - 59 years) and older (≥60 years) adults, with a more pronounced effect in the younger group. Among participants aged 45 - 59 years, each 1-unit increase in CTI was related to a 22% higher risk in the fully adjusted model (HR = 1.21, 95% CI: 1.06 - 1.37; p = 0.01). Participants in Q4 showed a 36% higher risk than those in Q1 (HR = 1.35, 95% CI: 1.11 - 1.72; p = 0.01), and the trend across quartiles was significant (p for trend = 0.01). In adults ≥60 years, the effect size was smaller but remained statistically significant (HR per 1-unit increase = 1.12, 95% CI: 1.01 - 1.27; p = 0.04; Q4 vs. Q1 HR = 1.26, 95% CI: 1.00 - 1.62; p = 0.04). Restricted cubic spline analyses showed overall linear positive associations in both age groups. The slope appeared steeper in the younger group, although the overall spline-based tests did not reach statistical significance (p = 0.12 for ages 45 - 59; p = 0.22 for ≥60 years) (Figure 4A - B).

Table 4. Age-specific association of the CTI with incident dyslipidemia

Age group	Variable	Number of events, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
45 - 59	CTI (per 1-unit)	1229	1.25	1.10 - 1.42	0.01	1.23	1.09 - 1.40	0.01	1.21	1.06 - 1.37	0.01
	Q1 (Ref)	220									
	Q2	280	1.05	0.85 - 1.30	0.65	1.04	0.84 - 1.28	0.70	1.02	0.81 - 1.25	0.71
	Q3	320	1.12	0.90 - 1.39	0.32	1.10	0.88 - 1.37	0.38	1.07	0.85 - 1.34	0.40
	Q4	409	1.40	1.12 - 1.75	0.01	1.38	1.11 - 1.73	0.01	1.35	1.11 - 1.72	0.01
	P for trend				0.01			0.01			0.01
≥60	CTI (per 1-unit)	782	1.15	1.02 - 1.31	0.02	1.14	1.01 - 1.29	0.03	1.12	1.01 - 1.27	0.04
	Q1 (Ref)	180									
	Q2	190	1.08	0.86 - 1.36	0.52	1.07	0.85 - 1.34	0.56	1.04	0.83 - 1.32	0.57
	Q3	200	1.15	0.92 - 1.45	0.23	1.14	0.91 - 1.43	0.25	1.11	0.91 - 1.41	0.26
	Q4	212	1.32	1.05 - 1.66	0.02	1.30	1.03 - 1.63	0.03	1.26	1.00 - 1.62	0.04
	P for trend				0.02			0.03			0.04

HR = hazard ratio; CI = confidence interval. Q1 denotes the lowest quartile, which served as the reference category. Model 1 included no covariate adjustment; Model 2 was adjusted for demographic and lifestyle factors (sex, residence, marital status, education, smoking, and alcohol consumption); and Model 3 additionally accounted for comorbid conditions such as chronic diseases, arthritis, liver disease, asthma, kidney disease, and gastrointestinal disorders, as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. The p for trend was estimated by modeling the median value of each quartile as a continuous variable in the Cox regression model. Statistical significance was defined as a two-sided $p < 0.05$.

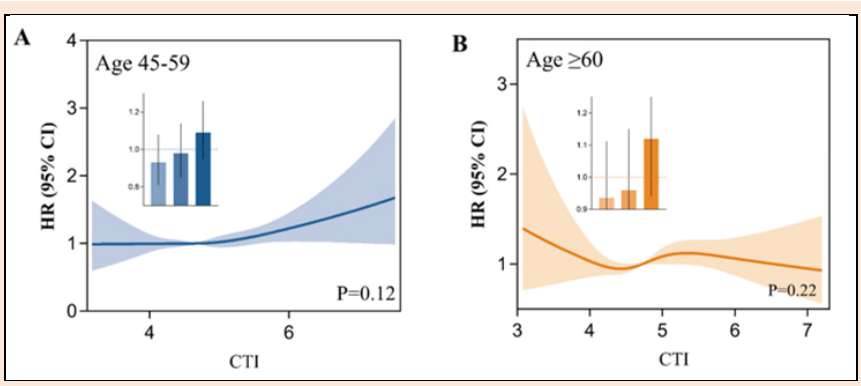

Figure 4. Restricted cubic spline analysis of the relationship between the C-reactive protein - triglyceride - glucose index (CTI) and dyslipidemia risk among participants aged 45 - 59 years (A) and those aged ≥60 years (B).

Table 5. Association of the CTI with dyslipidemia incidence across physical activity levels.

Physical activity	Variable	Number of events, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Light	CTI (per 1-unit)	634	1.11	1.02 - 1.20	0.03	1.10	1.01 - 1.19	0.04	1.11	1.02 - 1.18	0.04
	Q1 (Ref)	122									
	Q2	141	1.03	0.87 - 1.22	0.72	1.02	0.86 - 1.21	0.76	1.03	0.85 - 1.22	0.77
	Q3	170	1.07	0.91 - 1.27	0.33	1.06	0.90 - 1.26	0.36	1.04	0.87 - 1.23	0.36
	Q4	201	1.25	1.05 - 1.49	0.02	1.23	1.04 - 1.47	0.03	1.21	1.02 - 1.44	0.03
	P for trend				0.02			0.03			0.03
Moderate	CTI (per 1-unit)	982	1.12	1.03 - 1.21	0.01	1.11	1.02 - 1.20	0.02	1.11	1.02 - 1.17	0.02
	Q1 (Ref)	163									
	Q2	218	1.01	0.86 - 1.18	0.90	1.01	0.86 - 1.18	0.91	1.01	0.84 - 1.17	0.93
	Q3	290	1.09	0.93 - 1.27	0.25	1.08	0.92 - 1.26	0.28	1.06	0.92 - 1.24	0.31
	Q4	311	1.28	1.09 - 1.50	0.01	1.26	1.07 - 1.49	0.01	1.24	1.05 - 1.46	0.02
	P for trend				0.01			0.02			0.02
Vigorous	CTI (per 1-unit)	395	1.30	1.08 - 1.56	0.01	1.29	1.07 - 1.55	0.01	1.26	1.05 - 1.53	0.02
	Q1 (Ref)	95									
	Q2	89	1.18	0.84 - 1.65	0.33	1.16	0.83 - 1.62	0.35	1.14	0.81 - 1.62	0.34
	Q3	82	1.25	0.90 - 1.74	0.15	1.23	0.88 - 1.72	0.18	1.21	0.86 - 1.72	0.20
	Q4	129	1.49	1.11 - 2.01	0.01	1.47	1.09 - 1.98	0.02	1.44	1.07 - 1.94	0.02
	P for trend				0.01			0.02			0.02

HR = hazard ratio; CI = confidence interval. Q1 denotes the lowest quartile, which served as the reference category. Model 1 included no covariate adjustment; Model 2 was adjusted for demographic and lifestyle characteristics (sex, age, residence, marital status, education, smoking, and alcohol consumption); and Model 3 additionally accounted for comorbid conditions such as chronic diseases, arthritis, liver disease, asthma, kidney disease, and gastrointestinal disorders, as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. The p for trend was estimated by modeling the median value of each quartile as a continuous variable in the Cox regression model. Statistical significance was defined as a two-sided $p < 0.05$.

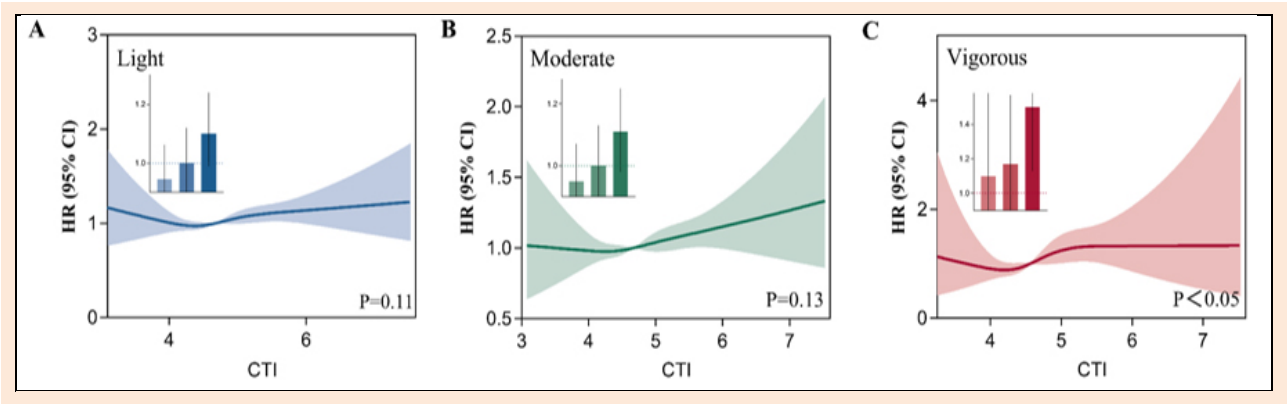

Figure 5. Restricted cubic spline analyses of the association between the C-reactive protein - triglyceride-glucose index (CTI) and risk of dyslipidemia in participants with light physical activity (A), moderate physical activity (B), and vigorous physical activity (C).

CTI and dyslipidemia risk across physical activity levels

As shown in Table 5, higher CTI levels were consistently associated with an increased risk of dyslipidemia across all physical activity categories. In the light activity group, each 1-unit increase in CTI was linked to about a 10% higher risk, and individuals in the highest quartile (Q4) had a significantly greater risk compared with those in the lowest quartile (Q1) after full adjustment (HR = 1.21, 95% CI: 1.02 - 1.44; p = 0.03). In the moderate activity group, each 1-unit rise in CTI corresponded to a 10% higher risk, and individuals in Q4 had a 25% greater risk than those in Q1 (HR = 1.24, 95% CI: 1.05 - 1.46; p = 0.02). The strongest association was found in the vigorous activity group, where each 1-unit rise in CTI corresponded to a 28% higher risk, and Q4 participants had a 45% greater risk relative to Q1 (HR = 1.44, 95% CI: 1.07 - 1.94; p = 0.02). Restricted cubic spline analyses (Figure 5) indicated upward trends in both the light and moderate activity groups (p = 0.11 and 0.13, respectively), while a significant non-linear association was evident in the vigorous activity group ($p < 0.05$), with the risk curve steepening at higher CTI levels.

Subgroup analysis

To further explore potential effect modification, subgroup analyses were conducted (Figure 6). The positive association between CTI and dyslipidemia risk was generally consistent across most demographic and clinical strata, including age group, residence, education, and marital status. Similar associations were observed irrespective of smoking and drinking status, as well as in participants with or without common chronic conditions. However, significant interactions were detected for sex (p for interaction = 0.025), smoking status (p = 0.007), chronic disease (p = 0.023), liver disease (p = 0.041), asthma (p = 0.017), kidney disease (p = 0.038), and stomach disease (p = 0.045), suggesting that the strength of the association may vary across these subgroups.

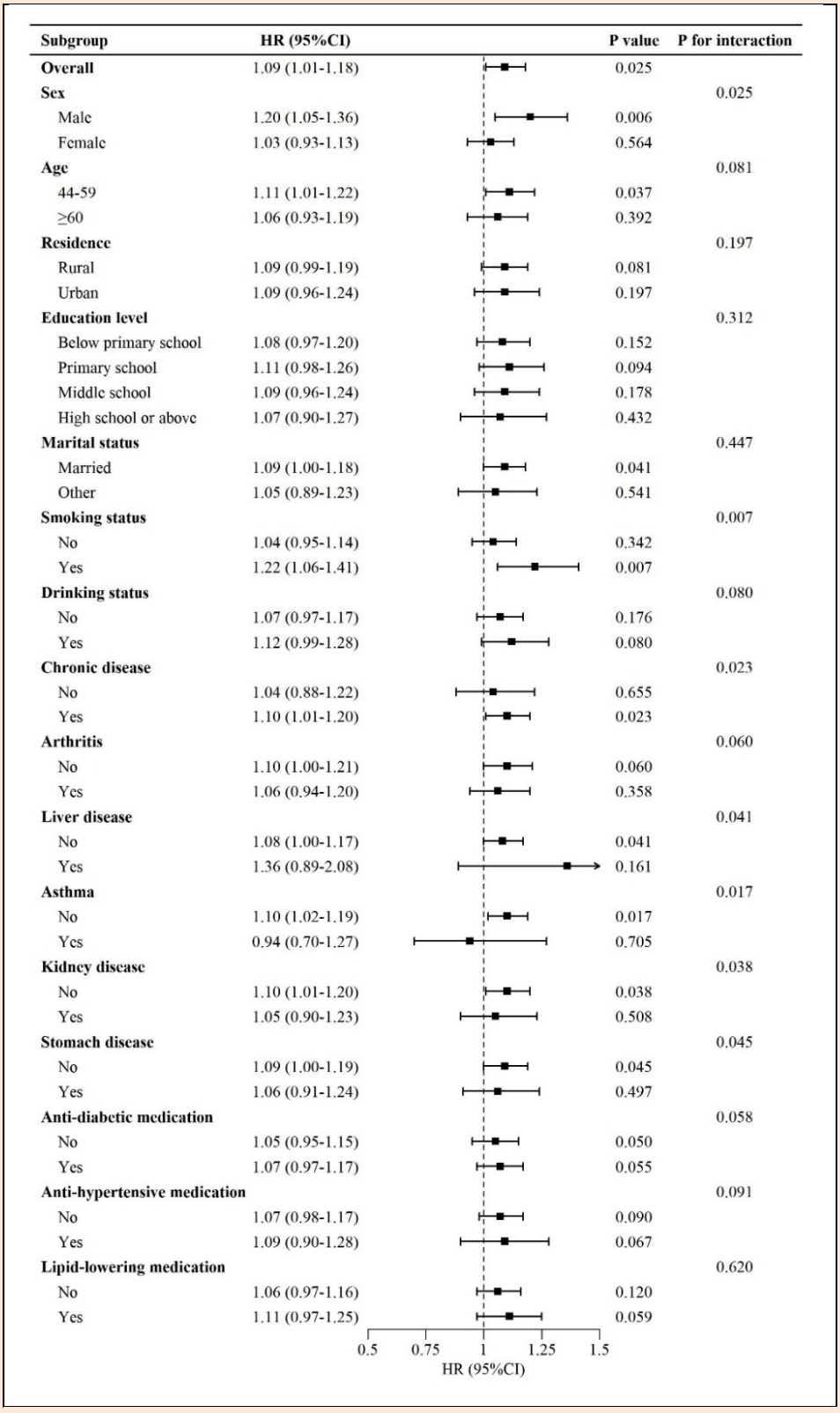

Figure 6. Subgroup analyses of the association between the C-reactive protein - triglyceride-glucose index (CTI) and risk of dyslipidemia.

Sensitivity analysis

Several sensitivity analyses were performed to test the robustness of the findings (Supplementary Tables S2 - S17). Excluding participants with missing covariates, restricting analyses to fasting individuals, or removing those who died during follow-up did not materially alter the results. Logistic regression models yielded estimates consistent with the Cox regression findings. The E-value for CTI in Model 3 was 1.40, suggesting that an unmeasured confounder associated with both CTI and dyslipidemia by a risk ratio of

at least 1.40 would be necessary to fully account for the observed association.

Discussion

In this large, nationally representative cohort of Chinese adults aged ≥45 years, we found that higher CTI levels were consistently associated with an elevated risk of incident dyslipidemia over a 10-year follow-up. These results were robust across multiple sensitivity analyses, including complete-case, fasting-only, and mortality-excluded models, which reduced the likelihood of bias. Subgroup analyses indicated that the association was stronger in men, adults aged 45 - 59 years, and individuals engaging in vigorous physical activity, while no significant relationship was observed in women. This sex-specific pattern may reflect biological differences in body fat distribution and sex hormones, particularly the cardiometabolic protection conferred by estrogen before menopause and its decline thereafter, as well as social and behavioral differences in physical activity patterns and health-seeking behaviors between men and women. In addition, the non-significant findings in women may be partly attributable to lower statistical power and potential sex differences in the accuracy of self-reported dyslipidemia, which together could attenuate the observed association. Restricted cubic spline analysis further suggested a nonlinear association in the vigorous activity group, with risk increasing at moderate CTI levels and plateauing at higher values. Collectively, these findings highlight CTI as a valuable predictor of dyslipidemia, with its clinical utility potentially varying according to demographic and lifestyle factors.

Importantly, in Model 3, which adjusted for the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication, the association between CTI and dyslipidemia remained significant. This suggests that even after accounting for the use of these common medications, CTI still provides a meaningful risk prediction for dyslipidemia. Earlier studies have mainly focused on its links with type 2 diabetes, metabolic syndrome, and cardiovascular outcomes (Mei et al., 2024; Ruan et al., 2022; Zhang et al., 2025). For example, elevated CTI has been shown to predict cardiovascular risk among individuals with cardiometabolic multimorbidity (Tang et al., 2024) and to be associated with all-cause and cardiovascular mortality in patients with coronary heart disease and diabetes (Gao et al., 2021). Moreover, CTI components - the TyG index and CRP - have been consistently linked to hypertension, metabolic syndrome, and mortality (Simental-Mendía et al., 2008; Khan et al., 2018). However, dyslipidemia, a key factor in both metabolic syndrome and cardiovascular disease, has not been thoroughly evaluated in relation to CTI (Xia et al., 2023; Opoku et al., 2021). By demonstrating in a large Chinese cohort that CTI is prospectively associated with dyslipidemia risk (Zhao et al., 2020), our study fills this important gap. Importantly, we also identified physical activity as a significant effect modifier (Pandey et al., 2016), an aspect rarely addressed in prior research (Zhao et al., 2021; Zhang et al., 2025).

The observed effect modification by physical activity is biologically plausible. The potential modifying role of these medications on the CTI-dyslipidemia relationship warrants further investigation, particularly in populations with high rates of medication use. Insulin resistance and systemic inflammation are known to disrupt lipid metabolism by impairing insulin-mediated lipolysis, promoting hepatic de novo lipogenesis, elevating very-low-density lipoprotein secretion, and lowering HDL-C levels (Ridker, 2003; 2007). In addition, inflammatory pathways, such as interleukin-6 and tumor necrosis factor-α signaling, may further enhance hepatic lipid synthesis, alter apolipoprotein metabolism, and accelerate atherosclerosis (Hansson, 2005). Insulin resistance and inflammation likely reinforce each other, creating a cycle of metabolic dysfunction (Shoelson et al., 2006). Regular physical activity has been shown to improve insulin-mediated glucose uptake and reduce chronic low-grade inflammation, lowering basal levels of CRP as well as key pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-α, thereby directly targeting the components captured by CTI. This synergistic interaction provides a rationale for why CTI outperforms TyG or CRP alone as a predictor of lipid-related risk (Simental-Mendía et al., 2008; Khan et al., 2018), and explains why its adverse effects may be mitigated through lifestyle interventions, particularly regular physical activity (Krüger et al., 2022; Ho et al., 2012).

Our stratified analyses revealed differential associations across physical activity levels. Among participants engaging in light or moderate activity, the CTI - dyslipidemia relationship was linear and modest. By contrast, in the vigorous activity group, risk increased at moderate CTI levels but appeared to flatten at higher values. One plausible explanation is that sustained vigorous activity exerts strong protective effects on glucose and lipid metabolism, thereby buffering against the incremental risk conferred by very high CTI levels. Exercise enhances skeletal muscle glucose uptake, improves mitochondrial function, increases lipoprotein lipase activity, and reduces hepatic fat accumulation (Wang and Xu, 2017; Zhao et al., 2021). It also has pronounced anti-inflammatory effects, lowering circulating CRP and pro-inflammatory cytokines such as interleukin-6 and tumor necrosis factor-α while upregulating protective mediators such as adiponectin and interleukin-10 (Smart et al., 2025; Zhang et al., 2025). These adaptations may account for the plateauing of risk in highly active individuals (Gao et al., 2021; Hartley et al., 2014). This pattern is consistent with a dose - response framework in which higher-intensity or larger volumes of activity produce greater improvements in insulin sensitivity and inflammatory profiles, leading to stronger attenuation of CTI-related dyslipidemia risk. In contrast, those with insufficient physical activity lack such compensatory mechanisms, leading to a stronger and more linear manifestation of CTI's adverse effects. Taken together, these findings underscore the modifying role of physical activity and suggest that lifestyle behaviors can meaningfully influence biomarker-based risk prediction.

Public health implications

The growing burden of dyslipidemia in China poses major Challenges for cardiovascular prevention. Awareness, treatment, and control rates remain unsatisfactorily low,

often with treatment rates below 20% and control rates in the single digits (Zhao et al., 2021; Li et al., 2024). Given the simplicity of its calculation from routine laboratory tests, CTI has potential as a practical, integrative biomarker for early risk identification that can be automatically derived from existing electronic health record data without additional laboratory costs or complex procedures. Incorporating CTI into regular health check-ups could facilitate targeted interventions among subgroups most at risk, such as men, middle-aged adults, and those with low physical activity levels (Pandey et al., 2016; Zhang et al., 2025). In older adults and other high-risk groups, CTI-based risk stratification could be used to trigger more intensive counseling and follow-up, including structured physical activity programs and multi-component lifestyle interventions. Embedding CTI-based stratification into community and primary care settings could also align with national strategies to enhance cardiovascular prevention and reduce disease burden (Zhao et al., 2020; Zhang et al., 2025). Importantly, our findings reaffirm the critical role of physical activity, both as a preventive measure and as a potential attenuator of CTI-related risk. Promoting regular exercise remains a cornerstone of public health, and tailoring interventions to integrate biomarker assessment with lifestyle promotion may represent a promising approach to reduce lipid-related disease burden (Smart et al., 2025; Zhang et al., 2025). Beyond physical activity, integrating CTI-guided risk communication with dietary counseling, weight management, smoking and alcohol reduction, sleep hygiene, and stress management could provide a more comprehensive framework for dyslipidemia prevention, especially in aging populations.

Strengths and limitations

This study has several strengths. First, it was based on the CHARLS, a nationally representative cohort with a large sample size and nearly a decade of follow-up, ensuring strong statistical power and generalizability (Zhao et al., 2014). Second, we simultaneously examined CTI and physical activity, enabling a novel assessment of potential effect modification, which has seldom been addressed in metabolic or cardiovascular research (Zhao et al., 2021; Zhang et al., 2025). Third, our results were reinforced by multiple analytic strategies, including Cox proportional hazards models, restricted cubic spline analyses, and sensitivity checks, all of which supported the robustness of the findings (Sterne et al., 2009; Kaplan and Meier, 1958).

Nonetheless, certain limitations should be acknowledged. Dyslipidemia was partly determined using self-reported physician diagnoses, which may introduce misclassification despite validation efforts in large-scale epidemiological studies (Brennan et al., 2021). Such misclassification is likely to be non-differential with respect to CTI and physical activity, which would bias our estimates toward the null and may partially attenuate associations in specific subgroups, including women. Physical activity itself was also assessed by self-report, and differences in recall or social desirability across sex, urban versus rural residence, or cultural context may have influenced the observed effect modification. Potential confounding from unmeasured factors, such as dietary intake or genetic predisposition, cannot be excluded (Shoelson et al., 2006). Other lifestyle factors - including alcohol consumption, smoking, sleep patterns, and psychosocial stress - were not comprehensively captured and may contribute to residual confounding in the CTI - dyslipidemia relationship. In addition, the CHARLS dataset lacked detailed lipid subtypes beyond TG, TC, HDL-C, and LDL-C, limiting further exploration of associations with apolipoproteins or lipoprotein(a) (Gao et al., 2021; Hartley et al., 2014). Finally, because participants were middle-aged and older Chinese adults, caution is needed when generalizing these results to younger populations or non-Chinese settings. Within China, substantial urban - rural and regional differences in occupational and leisure-time physical activity, as well as in dietary patterns and traditional forms of exercise, may further constrain the applicability of our findings to other cultural contexts. CTI thresholds and the magnitude of its association with dyslipidemia may therefore require recalibration before use in different populations. Future research should aim to replicate these findings in diverse cohorts and investigate whether interventions that lower CTI - particularly lifestyle modifications - can reduce dyslipidemia risk and improve long-term cardiovascular outcomes (VanderWeele and Ding, 2017; Mathur and VanderWeele, 2020).

Conclusion

In conclusion, this large nationally representative prospective cohort of Chinese adults aged ≥45 years is the first to systematically show that elevated CTI is independently associated with a higher risk of incident dyslipidemia. The associations were more pronounced in men and middle-aged adults, while vigorous physical activity appeared to alleviate part of the excess risk linked to high CTI levels. These findings underscore the value of CTI as a practical integrative biomarker for early risk identification and highlight the importance of lifestyle factors - particularly regular physical activity - in moderating metabolic risk. Future research should replicate these associations in younger and more diverse populations, clarify the underlying biological mechanisms, and evaluate whether CTI-based prevention strategies can improve long-term cardiovascular outcomes.

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Key points

- CTI was positively associated with incident dyslipidemia in Chinese adults over 10 years of follow-up.
- The association between CTI and dyslipidemia was stronger in men and in adults aged 45–59 years.
- Physical activity modified this relationship, with higher CTI predicting greater dyslipidemia risk across all activity levels.

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Supplementary Materials

Table S1. Variance inflation factor (VIF) and tolerance for baseline covariates.

Term	VIF	VIF 95% CI (low)	VIF 95% CI (high)	SE factor	Tolerance	Tolerance 95% CI (low)	Tolerance 95% CI (high)
CTI	1.01	0.95	1.10	1.00	0.99	0.91	1.05
Joint disease	1.03	0.96	1.12	1.02	0.97	0.89	1.04
Education level	1.05	0.97	1.15	1.02	0.95	0.87	1.03
Smoking status	1.41	1.20	1.65	1.19	0.71	0.61	0.83
Asthma	1.01	0.94	1.10	1.00	0.99	0.91	1.06
Marital status	1.05	0.96	1.16	1.02	0.96	0.86	1.04
Residence	1.04	0.95	1.14	1.02	0.97	0.88	1.05
Age	1.10	1.00	1.25	1.05	0.91	0.80	1.00
Sex	1.55	1.30	1.85	1.24	0.65	0.54	0.77
Liver disease	1.01	0.94	1.11	1.00	0.99	0.90	1.06
Kidney disease	1.01	0.94	1.11	1.00	0.99	0.90	1.06
Gastrointestinal disease	1.03	0.95	1.14	1.01	0.97	0.88	1.05
Drinking status	1.20	1.05	1.40	1.10	0.83	0.71	0.95

VIF = variance inflation factor; SE factor = √VIF. Generally, VIF < 5 indicates acceptable collinearity, whereas VIF ≥ 10 suggests severe multicollinearity.

Table S2. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia.

Characteristic	Event, n	Model 1			Model 2			Model 3		
		HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
CTI (per 1-unit increase)	1776	1.10	1.01 - 1.19	<0.05	1.11	1.02 - 1.21	<0.05	1.11	1.01 - 1.21	<0.05
Q1 (Ref)	339	Ref			Ref			Ref		
Q2	398	1.06	0.92 - 1.23	0.43	1.00	0.87 - 1.16	0.97	1.03	0.92 - 1.17	0.63
Q3	483	1.06	0.92 - 1.22	0.44	1.12	0.97 - 1.30	0.13	1.07	0.94 - 1.22	0.27
Q4	556	1.25	1.09 - 1.44	<0.05	1.15	0.99 - 1.33	0.07	1.12	1.01 - 1.27	<0.05
P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S3. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to sex.

Sex	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Male	**CTI (per 1-unit)**	680	1.21	1.05 - 1.39	<0.05	1.23	1.07 - 1.41	<0.05	1.21	1.05 - 1.42	<0.05
	Q1 (Ref)	138	Ref			Ref			Ref		
	Q2	153	1.10	0.86 - 1.41	0.45	1.04	0.81 - 1.33	0.77	1.05	0.83 - 1.32	0.61
	Q3	182	1.17	0.92 - 1.49	0.20	1.25	0.98 - 1.60	0.07	1.17	0.94 - 1.45	0.10
	Q4	207	1.43	1.13 - 1.81	<0.05	1.29	1.01 - 1.65	<0.05	1.25	1.03 - 1.55	<0.05
	P for trend				<0.05			<0.05			<0.05
Female	**CTI (per 1-unit)**	1,096	1.15	1.05 - 1.26	<0.05	1.16	1.06 - 1.28	<0.05	1.16	1.05 - 1.28	<0.05
	Q1 (Ref)	201	Ref			Ref			Ref		
	Q2	245	1.15	0.95 - 1.40	0.12	1.16	0.96 - 1.41	0.10	1.16	0.96 - 1.44	0.07
	Q3	301	1.22	1.02 - 1.46	<0.05	1.23	1.03 - 1.48	<0.05	1.22	1.03 - 1.51	<0.05
	Q4	349	1.41	1.18 - 1.69	<0.05	1.40	1.17 - 1.68	<0.05	1.42	1.16 - 1.67	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for age, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S4. **Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to age group.**

Age group	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
45 - 59 years	CTI (per 1-unit)	1042	1.20	1.08 - 1.34	<0.05	1.19	1.07 - 1.33	<0.05	1.16	1.04 - 1.31	<0.05
	Q1 (Ref)	198	Ref			Ref			Ref		
	Q2	236	1.12	0.89 - 1.40	0.33	1.11	0.88 - 1.39	0.36	1.11	0.88 - 1.37	0.35
	Q3	289	1.34	1.07 - 1.67	<0.05	1.33	1.06 - 1.67	<0.05	1.33	1.04 - 1.65	<0.05
	Q4	319	1.58	1.27 - 1.97	<0.05	1.56	1.25 - 1.95	<0.05	1.52	1.21 - 1.94	<0.05
	P for trend				<0.05			<0.05			<0.05
≥60 years	CTI (per 1-unit)	734	1.14	1.02 - 1.28	<0.05	1.13	1.01 - 1.27	<0.05	1.11	1.01 - 1.25	<0.05
	Q1 (Ref)	141	Ref			Ref			Ref		
	Q2	166	1.09	0.84 - 1.42	0.52	1.08	0.83 - 1.41	0.56	1.05	0.81 - 1.38	0.61
	Q3	192	1.26	0.97 - 1.63	0.09	1.24	0.96 - 1.61	0.10	1.21	0.94 - 1.62	0.11
	Q4	235	1.41	1.10 - 1.81	<0.05	1.39	1.08 - 1.79	<0.05	1.36	1.05 - 1.76	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S5. **Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to physical activity**

Physical activity	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Light	CTI (per 1-unit)	559	1.60	1.20 - 2.13	<0.05	1.61	1.19 - 2.16	<0.05	1.61	1.20 - 2.17	<0.05
	Q1 (Ref)	108	Ref			Ref			Ref		
	Q2	124	0.77	0.47 - 1.27	0.31	0.79	0.48 - 1.31	0.36	0.81	0.48 - 1.36	0.41
	Q3	150	0.98	0.60 - 1.58	0.93	0.95	0.58 - 1.56	0.85	0.95	0.56 - 1.57	0.85
	Q4	177	1.87	1.19 - 2.95	<0.05	1.86	1.17 - 2.96	<0.05	1.91	1.21 - 3.05	<0.05
	P for trend				<0.05			<0.05			<0.05
Moderate	CTI (per 1-unit)	863	1.56	1.41 - 1.73	<0.05	1.56	1.41 - 1.73	<0.05	1.54	1.42 - 1.74	<0.05
	Q1 (Ref)	143	Ref			Ref			Ref		
	Q2	191	1.18	0.98 - 1.42	0.08	1.18	0.98 - 1.42	0.07	1.17	0.97 - 1.43	0.07
	Q3	254	1.78	1.49 - 2.12	<0.05	1.80	1.51 - 2.15	<0.05	1.82	1.53 - 2.17	<0.05
	Q4	275	2.02	1.70 - 2.40	<0.05	2.01	1.69 - 2.40	<0.05	2.02	1.66 - 2.41	<0.05
	P for trend				<0.05			<0.05			<0.05
Vigorous	CTI (per 1-unit)	354	1.40	1.11 - 1.76	<0.05	1.43	1.13 - 1.81	<0.05	1.43	1.13 - 1.84	<0.05
	Q1 (Ref)	76	Ref			Ref			Ref		
	Q2	83	1.24	0.84 - 1.81	0.28	1.21	0.82 - 1.79	0.33	1.21	0.82 - 1.78	0.36
	Q3	81	1.17	0.80 - 1.72	0.42	1.13	0.77 - 1.67	0.54	1.12	0.73 - 1.65	0.60
	Q4	114	1.66	1.15 - 2.40	<0.05	1.66	1.14 - 2.42	<0.05	1.67	1.14 - 2.47	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education, and smoking and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S6. **Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia**

Characteristic	Event, n	Model 1			Model 2			Model 3		
		HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
CTI (per 1-unit)	1691	1.14	1.07 - 1.22	<0.05	1.13	1.06 - 1.21	<0.05	1.11	1.04 - 1.22	<0.05
Q1 (Ref)	282	Ref			Ref			Ref		
Q2	405	1.08	0.90 - 1.28	0.40	1.07	0.89 - 1.28	0.44	1.04	0.86 - 1.27	0.41
Q3	496	1.42	1.19 - 1.70	<0.05	1.40	1.17 - 1.68	<0.05	1.36	1.14 - 1.67	<0.05
Q4	508	1.78	1.48 - 2.14	<0.05	1.75	1.45 - 2.11	<0.05	1.71	1.40 - 2.05	<0.05
P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S7. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to sex

Sex	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Male	CTI (per 1-unit)	689	1.16	1.05 - 1.28	<0.05	1.15	1.04 - 1.27	<0.05	1.11	1.01 - 1.27	<0.05
	Q1 (Ref)	120	Ref			Ref			Ref		
	Q2	173	1.09	0.82 - 1.44	0.55	1.07	0.81 - 1.42	0.61	1.05	0.81 - 1.43	0.61
	Q3	197	1.43	1.09 - 1.87	<0.05	1.41	1.07 - 1.85	<0.05	1.37	1.04 - 1.81	<0.05
	Q4	199	1.72	1.32 - 2.23	<0.05	1.69	1.30 - 2.20	<0.05	1.66	1.26 - 2.16	<0.05
	P for trend				<0.05			<0.05			<0.05
Female	CTI (per 1-unit)	1002	1.12	1.03 - 1.21	<0.05	1.11	1.02 - 1.20	<0.05	1.11	1.02 - 1.17	<0.05
	Q1 (Ref)	162	Ref			Ref			Ref		
	Q2	232	1.07	0.85 - 1.34	0.56	1.06	0.84 - 1.34	0.60	1.04	0.82 - 1.34	0.65
	Q3	299	1.38	1.11 - 1.71	<0.05	1.37	1.10 - 1.70	<0.05	1.35	1.08 - 1.68	<0.05
	Q4	309	1.65	1.33 - 2.06	<0.05	1.62	1.30 - 2.04	<0.05	1.62	1.27 - 2.04	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for age, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S8. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to age group.

Age group	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
45 - 59	CTI (per 1-unit)	1010	1.19	1.09 - 1.29	<0.05	1.18	1.08 - 1.29	<0.05	1.15	1.06 - 1.28	<0.05
	Q1 (Ref)	185	Ref			Ref			Ref		
	Q2	237	1.09	0.86 - 1.39	0.48	1.08	0.85 - 1.38	0.52	1.05	0.81 - 1.36	0.51
	Q3	295	1.46	1.17 - 1.83	<0.05	1.44	1.15 - 1.81	<0.05	1.41	1.12 - 1.78	<0.05
	Q4	293	1.82	1.45 - 2.29	<0.05	1.79	1.43 - 2.26	<0.05	1.78	1.40 - 2.21	<0.05
	P for trend				<0.05			<0.05			<0.05
≥60	CTI (per 1-unit)	681	1.09	0.98 - 1.22	0.11	1.08	0.97 - 1.21	0.13	1.05	0.94 - 1.21	0.13
	Q1 (Ref)	97	Ref			Ref			Ref		
	Q2	141	1.10	0.81 - 1.48	0.55	1.08	0.80 - 1.46	0.59	1.05	0.78 - 1.44	0.55
	Q3	200	1.33	1.02 - 1.73	<0.05	1.31	1.00 - 1.71	<0.05	1.31	0.97 - 1.71	0.06
	Q4	243	1.57	1.22 - 2.03	<0.05	1.55	1.20 - 2.00	<0.05	1.52	1.17 - 1.98	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S9. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to physical activity

Physical activity	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Light	CTI (per 1-unit)	634	1.13	1.01 - 1.27	<0.05	1.12	1.00 - 1.26	<0.05	1.12	0.97 - 1.26	0.06
	Q1 (Ref)	122	Ref			Ref			Ref		
	Q2	141	1.02	0.78 - 1.34	0.88	1.01	0.77 - 1.33	0.91	1.01	0.75 - 1.31	0.91
	Q3	170	1.15	0.89 - 1.49	0.28	1.14	0.88 - 1.48	0.31	1.12	0.88 - 1.45	0.32
	Q4	201	1.39	1.08 - 1.78	<0.05	1.38	1.07 - 1.77	<0.05	1.34	1.05 - 1.74	<0.05
	P for trend				<0.05			<0.05			<0.05
Moderate	CTI (per 1-unit)	982	1.15	1.06 - 1.26	<0.05	1.14	1.05 - 1.25	<0.05	1.12	1.03 - 1.25	<0.05
	Q1 (Ref)	163	Ref			Ref			Ref		
	Q2	218	1.09	0.83 - 1.43	0.53	1.08	0.82 - 1.42	0.57	1.05	0.82 - 1.43	0.59
	Q3	290	1.47	1.15 - 1.88	<0.05	1.45	1.13 - 1.86	<0.05	1.41	1.11 - 1.84	<0.05
	Q4	311	1.68	1.32 - 2.13	<0.05	1.66	1.31 - 2.11	<0.05	1.62	1.27 - 2.08	<0.05
	P for trend				<0.05			<0.05			<0.05
Vigorous	CTI (per 1-unit)	395	1.21	1.02 - 1.44	<0.05	1.20	1.01 - 1.43	<0.05	1.17	1.01 - 1.41	0.05
	Q1 (Ref)	95	Ref			Ref			Ref		
	Q2	89	1.08	0.75 - 1.57	0.68	1.07	0.74 - 1.56	0.71	1.05	0.72 - 1.53	0.72
	Q3	82	1.28	0.89 - 1.85	0.18	1.27	0.88 - 1.83	0.20	1.24	0.85 - 1.83	0.20
	Q4	129	1.61	1.16 - 2.23	<0.05	1.59	1.15 - 2.21	<0.05	1.56	1.12 - 2.17	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education, and smoking and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S10. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia

Characteristic	Event, n	Model 1			Model 2			Model 3		
		HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
CTI (per 1-unit increase)	1980	1.54	1.40 - 1.69	<0.05	1.53	1.39 - 1.68	<0.05	1.51	1.36 - 1.68	<0.05
Q1 (Ref)	377	Ref			Ref			Ref		
Q2	445	1.05	0.90 - 1.22	0.52	1.04	0.89 - 1.21	0.57	1.02	0.85 - 1.21	0.58
Q3	540	1.56	1.34 - 1.82	<0.05	1.54	1.32 - 1.80	<0.05	1.51	1.31 - 1.76	<0.05
Q4	618	1.97	1.70 - 2.28	<0.05	1.94	1.67 - 2.25	<0.05	1.92	1.62 - 2.21	<0.05
P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education level, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S11. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to sex

Sex	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Male	CTI (per 1-unit)	771	1.48	1.29 - 1.69	<0.05	1.47	1.28 - 1.69	<0.05	1.44	1.25 - 1.65	<0.05
	Q1 (Ref)	144	Ref			Ref			Ref		
	Q2	170	1.06	0.85 - 1.32	0.58	1.05	0.84 - 1.31	0.61	1.04	0.81 - 1.31	0.60
	Q3	212	1.61	1.27 - 2.05	<0.05	1.59	1.25 - 2.02	<0.05	1.56	1.22 - 2.03	<0.05
	Q4	245	1.93	1.54 - 2.43	<0.05	1.90	1.51 - 2.40	<0.05	1.85	1.47 - 2.34	<0.05
	P for trend				<0.05			<0.05			<0.05
Female	CTI (per 1-unit)	1209	1.59	1.41 - 1.79	<0.05	1.61	1.43 - 1.82	<0.05	1.61	1.42 - 1.85	<0.05
	Q1 (Ref)	233	Ref			Ref			Ref		
	Q2	275	1.07	0.87 - 1.31	0.52	1.08	0.88 - 1.32	0.49	1.07	0.87 - 1.31	0.42
	Q3	328	1.58	1.29 - 1.92	<0.05	1.60	1.30 - 1.95	<0.05	1.62	1.32 - 1.93	<0.05
	Q4	373	2.01	1.66 - 2.43	<0.05	2.04	1.68 - 2.47	<0.05	2.04	1.71 - 2.53	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for age, residence, marital status, education level, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S12. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to age group

Age group	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
45 - 59	CTI (per 1-unit)	1165	1.65	1.47 - 1.85	<0.05	1.66	1.48 - 1.87	<0.05	1.65	1.46 - 1.85	<0.05
	Q1 (Ref)	215	Ref			Ref			Ref		
	Q2	246	1.10	0.89 - 1.36	0.36	1.10	0.89 - 1.35	0.37	1.07	0.85 - 1.34	0.37
	Q3	319	1.65	1.35 - 2.01	<0.05	1.64	1.34 - 2.00	<0.05	1.63	1.33 - 2.01	<0.05
	Q4	385	2.20	1.80 - 2.67	<0.05	2.22	1.81 - 2.71	<0.05	2.23	1.82 - 2.73	<0.05
	P for trend				<0.05			<0.05			<0.05
≥60	CTI (per 1-unit)	815	1.38	1.20 - 1.58	<0.05	1.35	1.17 - 1.55	<0.05	1.35	1.15 - 1.57	<0.05
	Q1 (Ref)	162	Ref			Ref			Ref		
	Q2	181	1.07	0.84 - 1.37	0.57	1.06	0.83 - 1.36	0.59	1.05	0.82 - 1.38	0.54
	Q3	221	1.39	1.09 - 1.77	<0.05	1.35	1.06 - 1.72	<0.05	1.36	1.05 - 1.73	<0.05
	Q4	251	1.59	1.25 - 2.02	<0.05	1.51	1.18 - 1.94	<0.05	1.51	1.17 - 1.94	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education level, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S13. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to physical activity

Physical activity	Characteristic	Event, n	Model 1			Model 2			Model 3		
			HR	95% CI	p	HR	95% CI	p	HR	95% CI	p
Light activity	CTI (per 1-unit)	191	1.59	1.20 - 2.11	<0.05	1.61	1.21 - 2.15	<0.05	1.61	1.21 - 2.16	<0.05
	Q1 (Ref)	44	Ref			Ref			Ref		
	Q2	36	1.01	0.65 - 1.58	0.94	1.02	0.65 - 1.59	0.92	1.01	0.64 - 1.62	0.85
	Q3	43	1.05	0.68 - 1.62	0.83	1.04	0.67 - 1.61	0.85	1.04	0.66 - 1.63	0.82
	Q4	68	1.85	1.18 - 2.90	<0.05	1.86	1.18 - 2.93	<0.05	1.91	1.21 - 2.97	<0.05
	P for trend				<0.05			<0.05			<0.05
Moderate activity	CTI (per 1-unit)	982	1.54	1.38 - 1.71	<0.05	1.55	1.39 - 1.73	<0.05	1.53	1.37 - 1.74	<0.05
	Q1 (Ref)	268	Ref			Ref			Ref		
	Q2	305	1.04	0.86 - 1.25	0.70	1.04	0.86 - 1.25	0.71	1.04	0.85 - 1.25	0.64
	Q3	415	1.76	1.47 - 2.11	<0.05	1.78	1.48 - 2.14	<0.05	1.77	1.47 - 2.13	<0.05
	Q4	453	1.99	1.67 - 2.38	<0.05	1.98	1.66 - 2.37	<0.05	1.98	1.65 - 2.37	<0.05
	P for trend				<0.05			<0.05			<0.05
Vigorous activity	CTI (per 1-unit)	607	1.39	1.11 - 1.76	<0.05	1.41	1.13 - 1.79	<0.05	1.41	1.12 - 1.83	<0.05
	Q1 (Ref)	65	Ref			Ref			Ref		
	Q2	91	1.09	0.81 - 1.46	0.59	1.08	0.80 - 1.45	0.61	1.07	0.81 - 1.46	0.53
	Q3	86	1.16	0.79 - 1.71	0.43	1.14	0.77 - 1.68	0.50	1.14	0.74 - 1.68	0.51
	Q4	135	1.63	1.14 - 2.34	<0.05	1.62	1.13 - 2.33	<0.05	1.65	1.15 - 2.37	<0.05
	P for trend				<0.05			<0.05			<0.05

HR = hazard ratio; CI = confidence interval. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education level, and smoking and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates.

Table S14. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia based on logistic regression models

Characteristic	Event, n	Model 1			Model 2			Model 3		
		OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
CTI (per 1 unit)	2011	1.13	1.04 - 1.23	0.02	1.13	1.04 - 1.23	0.02	1.12	1.01 - 1.21	0.03
Q1 (Ref)	474	1.00			1.00			1.00		
Q2	484	1.05	0.91 - 1.21	0.80	1.04	0.90 - 1.20	0.89	1.03	0.91 - 1.22	0.82
Q3	508	1.11	0.97 - 1.27	0.34	1.08	0.94 - 1.24	0.54	1.07	0.93 - 1.23	0.44
Q4	545	1.19	1.04 - 1.36	0.03	1.18	1.03 - 1.35	0.04	1.17	1.01 - 1.33	0.04
P for trend		1.06	1.02 - 1.11	0.02	1.06	1.02 - 1.11	0.02	1.04	1.01 - 1.14	0.02

OR = odds ratio; CI = confidence interval. Q1 represents the lowest quartile and was used as the reference group. Model 1: unadjusted; Model 2: adjusted for sex, age, residence, marital status, education, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. P for trend was calculated by entering the median value of each quartile as a continuous variable in the logistic regression model.

Table S15. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to sex based on logistic regression models

Sex	Characteristic	Event, n	Model 1			Model 2			Model 3		
			OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Male	CTI (per 1-unit)	785	1.25	1.09 - 1.43	0.01	1.23	1.08 - 1.41	0.01	1.22	1.06 - 1.41	0.01
	Q1 (Ref)	148									
	Q2	178	1.11	0.89 - 1.39	0.53	1.09	0.88 - 1.36	0.65	1.12	0.87 - 1.37	0.50
	Q3	214	1.02	0.83 - 1.26	0.85	0.98	0.79 - 1.20	0.62	0.97	0.81 - 1.23	0.71
	Q4	245	1.32	1.07 - 1.63	0.02	1.28	1.04 - 1.58	0.04	1.31	1.05 - 1.62	0.03
	P for trend				0.04			0.07			0.05
Female	CTI (per 1-unit)	1226	1.07	0.97 - 1.17	0.41	1.07	0.97 - 1.17	0.40	1.05	0.97 - 1.15	0.56
	Q1 (Ref)	232									
	Q2	270	1.02	0.86 - 1.22	0.86	1.02	0.86 - 1.22	0.81	1.02	0.85 - 1.22	0.75
	Q3	328	1.17	0.98 - 1.39	0.16	1.15	0.96 - 1.37	0.24	1.12	0.94 - 1.37	0.30
	Q4	396	1.13	0.96 - 1.33	0.31	1.13	0.96 - 1.33	0.33	1.12	0.93 - 1.32	0.42
	P for trend				0.15			0.16			0.22

OR = odds ratio; CI = confidence interval. Q1 represents the lowest quartile and was used as the reference group. Model 1: unadjusted; Model 2: adjusted for age, residence, marital status, education level, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. P for trend was calculated by entering the median value of each quartile as a continuous variable in the logistic regression model.

Table S16. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to age group based on logistic regression models

Age group	Characteristic	Event, n	Model 1			Model 2			Model 3		
			OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
45 - 59	CTI (per 1-unit)	1229	1.29	1.13 - 1.47	0.01	1.27	1.12 - 1.45	0.01	1.24	1.12 - 1.41	0.01
	Q1 (Ref)	220									
	Q2	280	1.09	0.88 - 1.35	0.65	1.08	0.87 - 1.33	0.70	1.05	0.86 - 1.33	0.70
	Q3	320	1.16	0.93 - 1.44	0.32	1.14	0.91 - 1.41	0.38	1.14	0.92 - 1.41	0.42
	Q4	409	1.45	1.16 - 1.82	0.01	1.43	1.15 - 1.79	0.01	1.42	1.13 - 1.75	0.01
	P for trend				0.01			0.01			0.01
≥60	CTI (per 1-unit)	782	1.19	1.05 - 1.35	0.02	1.18	1.04 - 1.33	0.03	1.15	1.02 - 1.31	0.04
	Q1 (Ref)	180									
	Q2	190	1.12	0.89 - 1.41	0.52	1.11	0.88 - 1.39	0.56	1.11	0.85 - 1.36	0.56
	Q3	200	1.19	0.95 - 1.50	0.23	1.18	0.94 - 1.48	0.25	1.15	0.91 - 1.45	0.25
	Q4	212	1.36	1.08 - 1.72	0.02	1.34	1.06 - 1.67	0.03	1.31	1.04 - 1.64	0.04
	P for trend				0.02			0.03			0.04

OR = odds ratio; CI = confidence interval. Q1 represents the lowest quartile and was used as the reference group. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education level, smoking, and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. P for trend was calculated by entering the median value of each quartile as a continuous variable in the logistic regression model.

Table S17. Association between the C-reactive protein - triglyceride - glucose index (CTI) and incident dyslipidemia according to physical activity level based on logistic regression models

Physical activity	Characteristic	Event, n	Model 1			Model 2			Model 3		
			OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Light	CTI (per 1-unit)	634	1.15	1.05 - 1.25	0.03	1.14	1.04 - 1.23	0.04	1.12	1.04 - 1.19	0.04
	Q1 (Ref)	122									
	Q2	141	1.07	0.90 - 1.27	0.72	1.06	0.90 - 1.26	0.76	1.07	0.89 - 1.24	0.76
	Q3	170	1.11	0.94 - 1.32	0.33	1.10	0.93 - 1.31	0.36	1.05	0.97 - 1.32	0.35
	Q4	201	1.29	1.08 - 1.54	0.02	1.27	1.07 - 1.51	0.03	1.23	1.09 - 1.54	0.03
	P for trend				0.02			0.03			0.03
Moderate	CTI (per 1-unit)	982	1.16	1.06 - 1.26	0.01	1.15	1.05 - 1.25	0.02	1.11	1.01 - 1.24	0.02
	Q1 (Ref)	163									
	Q2	218	1.05	0.89 - 1.24	0.90	1.05	0.89 - 1.24	0.91	1.02	0.84 - 1.20	0.91
	Q3	290	1.13	0.96 - 1.33	0.25	1.12	0.95 - 1.32	0.28	1.10	0.92 - 1.28	0.32
	Q4	311	1.33	1.13 - 1.56	0.01	1.31	1.12 - 1.54	0.01	1.32	1.12 - 1.53	0.02
	P for trend				0.01			0.02			0.02
Vigorous	CTI (per 1-unit)	395	1.34	1.11 - 1.61	0.01	1.33	1.11 - 1.60	0.01	1.30	1.13 - 1.60	0.02
	Q1 (Ref)	95									
	Q2	89	1.22	0.87 - 1.71	0.33	1.20	0.86 - 1.67	0.35	1.17	0.81 - 1.62	0.37
	Q3	82	1.30	0.93 - 1.81	0.15	1.28	0.92 - 1.78	0.18	1.25	0.92 - 1.75	0.22
	Q4	129	1.54	1.15 - 2.08	0.01	1.52	1.13 - 2.04	0.02	1.51	1.12 - 1.96	0.02
	P for trend				0.01			0.02			0.02

OR = odds ratio; CI = confidence interval. Q1 represents the lowest quartile and was used as the reference group. Model 1: unadjusted; Model 2: adjusted for sex, residence, marital status, education level, and smoking and drinking; Model 3: Further adjusted for chronic diseases (joint disease, liver disease, asthma, kidney disease, and gastrointestinal disease), as well as the use of anti-diabetic medication, anti-hypertensive medication, and lipid-lowering medication as covariates. P for trend was calculated by entering the median value of each quartile as a continuous variable in the logistic regression model.