ORIGINAL ARTICLE

Retrospective Study

Association between triglyceride-glucose index and colorectal polyps: A retrospective cross-sectional study

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Abstract

BACKGROUND
Colorectal polyps (CPs) are frequently occurring abnormal growths in the colorectum, and are a primary precursor of colorectal cancer (CRC). The triglyceride-glucose (TyG) index is a novel marker that assesses metabolic health and insulin resistance, and has been linked to gastrointestinal cancers.

AIM
To investigate the potential association between the TyG index and CPs, as the relation between them has not been documented.

METHODS
A total of 2537 persons undergoing a routine health physical examination and colonoscopy at The First People's Hospital of Kunshan, Jiangsu Province, China, between January 2020 and December 2022 were included in this retrospective cross-sectional study. After excluding individuals who did not meet the eligibility criteria, descriptive statistics were used to compare characteristics between patients with and without CPs. Logistic regression analyses were conducted to determine the associations between the TyG index and the prevalence of CPs. The TyG index was calculated using the following formula: Ln [triglyceride (mg/dL) × glucose (mg/dL)/2]. The presence and types of CPs was determined based on data from colonoscopy reports and pathology reports.

RESULTS
A nonlinear relation between the TyG index and the prevalence of CPs was identified, and exhibited a curvilinear pattern with a cut-off point of 2.31. A significant association was observed before the turning point, with an odds ratio

(95% confidence interval) of 1.70 (1.40, 2.06), $P < 0.0001$. However, the association between the TyG index and CPs was not significant after the cut-off point, with an odds ratio (95% confidence interval) of 0.57 (0.27, 1.23), $P = 0.1521$.

CONCLUSION
Our study revealed a curvilinear association between the TyG index and CPs in Chinese individuals, suggesting its potential utility in developing colonoscopy screening strategies for preventing CRC.

Key Words: Triglyceride-glucose index; Colorectal polyps; Colorectal cancer; Insulin resistance; Cross-sectional study

Core Tip: This study represents the first exploration of the association between the triglyceride-glucose (TyG) index and colorectal polyps in a Chinese population. The results showed a curvilinear relation, with a significant association observed before a cut-off point of 2.31. Beyond this cut-off point the association was no longer significant. These results provide valuable insights for future research in this area. Importantly, monitoring the TyG index and managing insulin resistance could potentially aid in identifying individuals at a higher risk of developing colorectal polyps, and implementing timely interventions to prevent their progression to colorectal cancer. This study contributes novel perspectives and avenues for preventing colorectal cancer.
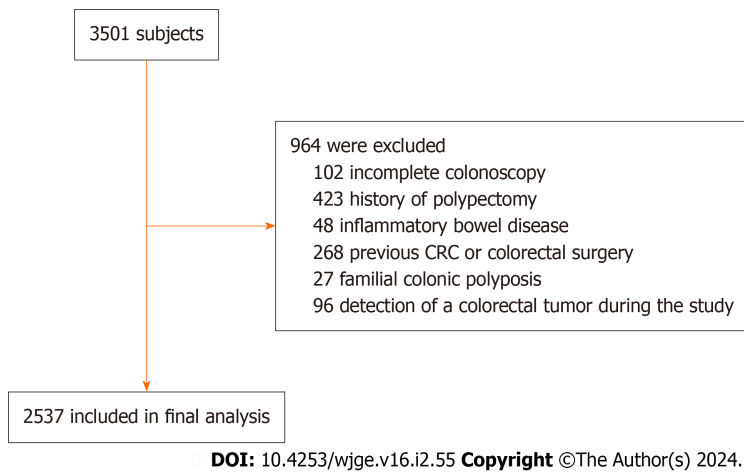
INTRODUCTION
Colorectal polyps (CPs) are common abnormal growths and protrusions on the surface of the colon and rectum[1]. There are various types, including adenomatous polyps and hyperplastic polyps, and they are recognized as the most common precursors of colorectal cancer (CRC)[2]. Adenomatous polyps are the most frequently observed premalignant lesions preceding the development of CRC, and CRC is the most commonly diagnosed cancer and the second most common cause of cancer death after lung cancer[3,4]. The incidence of CPs and CRC has been steadily increasing worldwide in recent decades, making them a significant public health concern[5]. Early detection and removal of CPs are crucial for preventing the development of CRC[6]. Identifying risk factors associated with CPs can help in developing effective screening strategies and implementing preventive measures[7]. Several risk factors have been identified for the development of CPs, including age, family history of CRC, genetic predisposition, dietary factors, and lifestyle choices such as smoking and alcohol consumption[8]. However, there is still a need to explore additional risk factors that may contribute to the development of CPs.

The triglyceride-glucose (TyG) index is a novel marker that has gained significant attention in recent research. It is a composite index that combines the levels of fasting plasma glucose and fasting triglycerides, and provides a comprehensive assessment of metabolic health[9]. Recently, the TyG index has become a popular method for assessing insulin resistance (IR), a forerunner of type 2 diabetes[10]. Studies have demonstrated that an elevation of the TyG index correlates with cardiovascular diseases, depression, erectile dysfunction, and gastrointestinal cancers[11-14]. However, its association with CPs is not clear.

Accumulating evidence has shown that IR may increase the risk of CPs. Qin *et al*[15] reported a significant correlation between IR and the occurrence of CPs and adenomatous polyps. Furthermore, Keku *et al*[16] conducted a comprehensive study involving 239 patients with colorectal adenoma and 517 adenoma-free persons, and the results suggested that IR is significantly associated with an elevated risk of developing adenomatous polyps. Additionally, the study revealed a decrease in apoptosis within the normal rectal mucosa among individuals with IR. Similarly, Flood *et al*[17] found that patients with elevated levels of insulin and glucose have a higher risk of recurrence of adenomatous polyps. Notably, patients with increased glucose levels exhibited an even greater increase in the risk of recurrent advanced adenomatous polyps.

Therefore, the purpose of this study was to investigate the potential association between the TyG index and CPs in a Chinese population. Understanding this association may provide valuable insights into the pathogenesis and early detection of CPs, leading to improved screening strategies and better prevention of CRC.

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3501 subjects
                        964 were excluded
                            102 incomplete colonoscopy
                            423 history of polypectomy
                            48 inflammatory bowel disease
                            268 previous CRC or colorectal surgery
                            27 familial colonic polyposis
                            96 detection of a colorectal tumor during the study

2537 included in final analysis
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Figure 1 Flow diagram of patient inclusion and exclusion. CRC: Colorectal cancer.

MATERIALS AND METHODS

Study population

The study included asymptomatic individuals who underwent colonoscopy as part of a comprehensive health screening program at The First People's Hospital of Kunshan, China, between January 2020 and December 2022. The retrospective review included patients between 18 and 79 years of age. Exclusion criteria consisted of incomplete colonoscopy results, history of polypectomy, inflammatory bowel disease, previous CRC or colorectal surgery, familial colonic polyposis, and detection of a colorectal tumor during the examination. The total number of patients included in this study was 2537 (Figure 1). The ethical committee of The First People's Hospital of Kunshan, China, approved the study, and the requirement for informed consent was waived due to its retrospective nature and the use of de-identified secondary data.

Biochemical analyses

After a 12-h overnight fasting period, blood samples were obtained from each participant. Biochemical analysis of the blood samples was performed using routine enzymatic methods on the VITROS 5600 Integrated System. The blood samples were tested for serum levels of triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), fasting plasma glucose (FPG), and uric acid (UA). Additionally, the concentrations of serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were determined using previously described methodologies. The TyG index was calculated as Ln [triglycerides (mg/dL) × fasting glucose (mg/dL)/2][18].

Colonoscopy and pathological examination

Prior to colonoscopy, all patients underwent a bowel preparation involving the use of polyethylene glycol electrolyte powder. The colonoscopies were performed using an ELUXEO 7000 endoscope system (FUJIFILM, Japan) by highly skilled gastroenterologists with a minimum of 5 years of experience in performing colonoscopies. Each endoscopist had performed over 1000 colonoscopies, and performed 6 or more colonoscopy examinations per day. Successful completion of the colonoscopy examination was defined as traversal of the colonoscope to the cecum, which was achieved in 97% of cases.

Pertinent colonoscopy features recorded included the presence or absence of polyps, which were subsequently biopsied or removed. The CPs included adenomatous and non-adenomatous polyps, and patients with polyps diagnosed as malignant were excluded from the study. The histological assessment of the polyps followed the established criteria outlined by the World Health Organization, and was conducted by experienced pathologists. Based on the combined colonoscopy and pathological findings, the patients were categorized into 2 distinct groups: A polyp-free group and a colorectal polyps group (one or more polyps). A subgroup analysis was also performed on the group with adenomatous polyps.

Statistical analysis

All statistical analyses were performed with R (version 3.5.3) software. Demographic data and risk factors associated with CPs were reported as mean ± SD, or count (percentage). The Kruskal-Wallis test was used to compare continuous variables, while Fisher's exact test was used to compare categorical variables. Multivariate logistic regression was conducted to identify risk factors associated with both adenomatous and non-adenomatous polyps. The consistency of relation was inspected through the use of linear trend tests. Generalized Additive Models (GAMs) and smooth curve fittings were used to examine potential non-linear associations. From the smoothing curve, the turning point was calculated using a recursive algorithm before being subjected to a 2-piecewise linear regression model. A value of $P < 0.05$ was considered statistically significant.
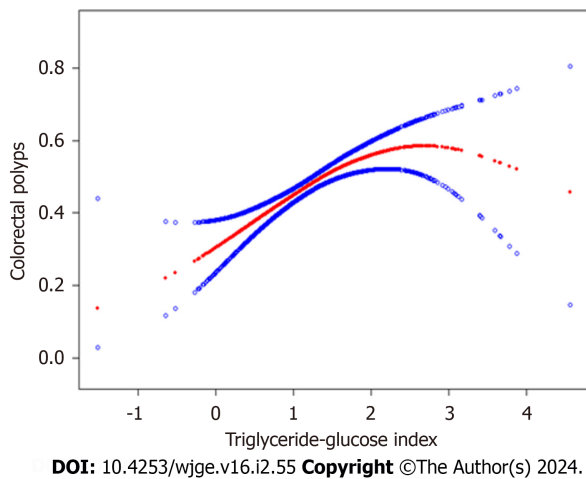
Figure 2 The association between triglyceride-glucose index and colorectal polyps. Age, sex, total cholesterol, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol were adjusted.

RESULTS

Baseline characteristics

The general characteristics of the study population in relation to colonoscopic findings are summarized in Table 1. In comparison to the polyp-free group, patients with CPs were older and predominantly male. The polyp-free group had lower levels of AST, and higher levels of TGs, TC, LDL-C, HDL-C, UA, and FPG, and a higher TyG index (Table 1).

Association between TyG index and CPs

A positive correlation between the TyG index and the risk of CPs was identified (Table 2). The association remained significant after adjusting for different variables. In Model I, no covariates were adjusted; in Model II, age and sex were adjusted; and in Model III adjustment was made for age, sex, TC, LDL-C, and HDL-C. The positive association persisted in Model III [odds ratio (OR) = 1.56; 95% confidence interval (CI): 1.03–1.86; $P < 0.0001$]. These results indicate that each unit increase in the TyG index was associated with a 56% higher risk of CPs. Stratifying the data by age or sex revealed consistent positive associations similar to those observed without stratification (Table 2).

The relation between the TyG index and the prevalence of CPs was non-linear, as evidenced by the GAM and smoothing curve analyses (Figure 2). Specifically, a curvilinear pattern with a cut-off point at 2.31 was identified. A significant association was detected before the cut-off point (OR = 1.70; 95%CI: 1.40–2.06; $P < 0.0001$). However, after the cut-off point the association was no longer significant (OR = 0.57; 95%CI: 0.27-1.23; $P = 0.1521$) (Table 3).

DISCUSSION

In this cross-sectional study conducted within a Chinese population, we examined the correlation between the TyG index and CPs. We observed a persistent positive association, even after adjusting for variables such as sex, age, TC, HDL-C, and LDL-C. The relation was non-linear, with a significant turning point at 2.31. Notably, prior to the turning point each unit increase in the TyG index was associated with a 56% higher risk of CPs. This study is the first to investigate the association between the TyG index and CPs in a Chinese population. It is also the first study to uncover a non-linear association between the TyG index and CPs, and subsequently conduct a threshold effects analysis to further examine the non-linear relation.

Our results showed a critical threshold at 2.31 in the non-linear relation between the TyG index and CPs. Specifically, our results suggest that increasing TyG index values are significantly associated with an increased risk of developing CPs up to the turning point of 2.31. Beyond this threshold the relation was no longer statistically significant. It is well established that the magnitude of the TyG index is positively associated with IR. Recently, the TyG index has been verified as a simple and dependable estimate of IR, and it is comparable to the euglycemic-hyperinsulinemic clamp method, which is considered the gold standard for evaluating IR[19]. Therefore, we postulate that treatment and management of IR might be beneficial to prevent the occurrence and progression of CPs and CRC.

Previous research has established a significant association between the TyG index and the development of CRC. It has also suggested that the TyG index should be considered an important factor in determining the need for screening colonoscopy. Okamura *et al*[20] conducted a historical cohort study involving 27944 participants (16454 men and 11490 women) to examine the impact of the TyG index on incident CRC. They used a Cox proportional hazard model and adjusted for covariates, and revealed a hazard ratio of 1.38 (95%CI: 1.00-1.91; $P = 0.049$) for the TyG index. Their covariate-adjusted receiver operating characteristic (ROC) curve analysis identified a cut-off value of 8.27 for the TyG index in relation to incident CRC [area under the ROC curve (AUC) = 0.687, 95%CI: 0.637-0.737, sensitivity = 0.620, specificity =

Table 1 Demographic and clinical characteristics of the subjects according to colonoscopic findings

	Polyp-free	Colorectal polyps	*P* value *vs* polyp-free	Adenomatous polyps	*P* value *vs* polyp-free
n (%)	1349 (53.17)	1188 (46.83)		276	
Male	680 (50.41)	772 (64.98)	< 0.001	170 (14.31)	< 0.001
Age (yr)	52.92 ± 15.49	55.87 ± 11.91	< 0.001	53.62 ± 12.70	< 0.449
WBC (× 10^9/L)	5.74 ± 2.00	5.74 ± 1.53	0.940	5.68 ± 1.43	0.235
ALT (U/L)	27.37 ± 50.07	24.96 ± 20.08	0.122	27.27 ± 20.16	< 0.001
AST (U/L)	25.12 ± 36.33	22.62 ± 11.14	0.023	23.24 ± 9.16	0.008
TG (mmol/L)	1.44 ± 1.25	1.64 ± 1.12	< 0.001	1.71 ± 1.37	0.001
TC (mmol/L)	4.29 ± 1.07	4.67 ± 0.96	< 0.001	4.59 ± 1.01	< 0.001
LDL-C (mmol/L)	2.62 ± 0.82	2.88 ± 0.77	< 0.001	2.82 ± 0.81	< 0.001
HDL-C (mmol/L)	1.33 ± 0.36	1.40 ± 0.31	< 0.001	1.39 ± 0.31	0.009
UA (mmol/L)	306.95 ± 90.30	332.52 ± 89.48	< 0.001	330.76 ± 88.24	< 0.001
GLU (mmol/L)	5.35 ± 1.32	5.46 ± 1.14	< 0.001	5.47 ± 1.06	0.002
TyG index	1.15 ± 0.62	1.32 ± 0.61	< 0.001	1.31 ± 0.69	< 0.001

ALT: Alanine aminotransferase; AST: Aspartate transaminase; TG: Triglycerides; TC: Total cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; UA: Uric acid; GLU: Glucose; TyG: Triglyceride-glucose.

0.668, *P* < 0.001]. These results suggest that the TyG index has predictive ability for the development of CRC. A prospective cohort study by Liu *et al*[21] investigated 93659 cancer-free participants in Northern China, and assed the TyG index and the TG/HDL-C ratio. The results showed an increased risk of developing CRC in adults with an elevated TyG index and TG/HDL-C ratio. The aforementioned studies support an association between and elevated TyG index and the development of CRC. Given that CPs have been shown to be associated with the development of CRC, it is imperative to delve further into the relation between CPs and the TyG index. Such investigation would provide novel evidence for the prevention of CRC.

The exact mechanisms underlying the relation between the TyG index and CRC development are not fully understood. However, there is substantial evidence linking IR to CRC, and the TyG index is a validated surrogate marker for IR, comparable to the commonly used Homeostatic Model Assessment of IR index[22]. Thus, it is biologically plausible to consider an elevated TyG index as a risk factor for CRC.

Previous studies have shown that IR is a significant risk factor for the development of CRC. Insulin and insulin-like growth factor (IGF) may contribute to CRC development through their anti-apoptotic and mitogenic effects[23]. In a Mendelian randomization analysis conducted by Murphy *et al*[24] that used blood samples from nearly 400000 persons in the United Kingdom Biobank, an association between circulating levels of IGF1 and CRC was demonstrated. Using genetic data from over 52000 patients with CRC and 46000 persons without CRC, they observed that genetically determined higher levels of IGF1 were associated with an increased risk of CRC. These findings suggest that the interaction of various processes, directly or indirectly regulated by IGF-1, may contribute to CRC development.

Previous studies have also shed light on the role of insulin/IGF-1 in CRC. It has been shown that insulin/IGF-1 activate signaling pathways such as PI3K/Akt/mTORC and Raf/MAPK, thereby promoting cancer progression. In addition, insulin/IGF-1 activation leads to the activation of glucose transporters like GLUT1 and key glycolytic enzymes including LDHA, LDH5, HK II, and PFKFB3. Moreover, abnormal expression of oncogenes such as *MYC* and *KRAS*, as well as overexpression of signaling proteins like HIF-1, TGF-β1, PI3K, ERK, Akt, and mTOR, have been observed in CRC [25-29].

Our study has several limitations which we would like to acknowledge. First, while missing data of covariates were assumed to be missing randomly and the sample size was adequately large to draw a conclusion, we did not use multiple imputation to account for the missing data, which may potentially affect the accuracy of the results. Second, since this was a cross-sectional study, causality between the TyG index and the risk of CPs cannot be determined. Third, this study was conducted at a single center, and therefore multi-center studies should be carried out to verify our findings.

CONCLUSION

In summary, the TyG index, as a surrogate measure of IR, may potentially mediate the association between insulin-related factors, such as IGF1, and the risk of CRC. Our results clearly demonstrate an association between the TyG index and the development of CPs, providing new evidence in support of colonoscopy screening. Despite the limitations of our study, our findings suggest the need for further research to evaluate the potential role of the TyG index in assessing the

Table 2 Adjusted ORs and 95%CIs for the occurrence of colorectal polyps in relation to triglyceride-glucose index based on multinomial logistic regression

Variable	Model I		Model II		Model III	
	Odds ratio (95%CI)	*P* value	Odds ratio (95%CI)	*P* value	Odds ratio (95%CI)	*P* value
Colorectal polyps						
TyG index	1.57 (1.37, 1.78)	< 0.0001	1.43 (1.25, 1.64)	< 0.0001	1.56 (1.30, 1.86)	< 0.0001
Sex						
Male	1.52 (1.29, 1.80)	< 0.0001	1.53 (1.29, 1.81)	< 0.0001	1.80 (1.42, 2.28)	< 0.0001
Female	1.45 (1.18, 1.78)	0.0005	1.36 (1.10, 1.68)	0.0050	1.32 (1.01, 1.76)	0.0457
Age (yr)						
< 50	1.81 (1.45, 2.27)	< 0.0001	1.62 (1.29, 2.04)	< 0.0001	1.66 (1.19, 2.30)	0.0027
> 50	1.37 (1.17, 1.61)	0.0001	1.33 (1.13, 1.57)	0.0006	1.37 (1.11, 1.70)	0.0037
Adenomous polyps						
TyG index	1.48 (1.21, 1.80)	< 0.0001	1.42 (1.16, 1.74)	0.0006	1.84 (1.34, 2.52)	0.0002
Sex						
Male	1.49 (1.16, 1.91)	0.0016	1.50 (1.17, 1.92)	0.0015	2.04 (1.42, 2.92)	0.0001
Female	1.32 (0.94, 1.84)	0.1097	1.33 (0.94, 1.89)	0.1028	1.33 (0.84, 2.11)	0.2258
Age (yr)						
< 50	1.94 (1.40, 2.70)	< 0.0001	1.85 (1.31, 2.60)	0.0004	2.26 (1.40, 3.64)	0.0008
> 50	1.24 (0.96, 1.60)	0.0963	1.22 (0.95, 1.58)	0.1197	1.40 (0.99, 1.97)	0.0578

Model I is non-adjusted. Model II is adjusted for age and sex. Model III is adjusted for age, sex, total cholesterol, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol. TyG: Triglyceride-glucose.

Table 3 Threshold effect analysis of triglyceride-glucose index on for the occurrence of colorectal polyps using a two-piecewise linear regression model

Colorectal polyps	Odds ratio (95%CI)	*P* value
TyG index		
Fitting by standard linear model	1.55 (1.30, 1.86)	< 0.0001
Fitting by two-piecewise linear model		
Inflection point	2.31	
< 2.31	1.7 (1.40, 2.06)	< 0.0001
> 2.31	0.57 (0.27, 1.23)	0.1521
Log-likelihood ratio	0.009	

Age, sex, total cholesterol, high-density lipoprotein cholesterol and low-density lipoprotein cholesterol were adjusted. TyG: Triglyceride-glucose.

risk for CPs and identifying patients who would benefit from colonoscopy screening.

ARTICLE HIGHLIGHTS

Research background

Colorectal polyps (CPs) are widely recognized as precursors to colorectal cancer (CRC), posing a significant global health concern. The triglyceride-glucose (TyG) index, an emerging biomarker, has shown associations with metabolic health and insulin resistance, making it a subject of interest in gastrointestinal cancer research.

Research motivation

The increasing incidence of CPs and CRC worldwide underscores the need for effective screening strategies. This study aims to fill the gap in knowledge by exploring the potential link between the TyG index and CPs in a Chinese population. Understanding this relationship could have implications for developing preventative measures and screening strategies.

Research objectives

The primary objective is to investigate the association between the TyG index and CPs, marking a pioneering exploration in a Chinese demographic. The study endeavors to identify a potential turning point in this relationship, offering valuable insights for future research and interventions.

Research methods

The retrospective cross-sectional study involves 2537 participants undergoing health examinations and colonoscopies. Thoroughly described methods include participant selection criteria, TyG index calculation, and statistical analyses. By employing logistic regression and a comprehensive approach, the study aims to reveal the nuances of the TyG index's association with CPs.

Research results

The study unveils a non-linear relationship between the TyG index and CP prevalence, delineating a significant turning point at 2.31. The analysis indicates a heightened risk of CPs before this threshold, while the association diminishes beyond it. The results contribute to the understanding of the TyG index's role in colorectal health, with potential implications for risk assessment and screening strategies.

Research conclusions

This study's novel findings confirm a curvilinear association between the TyG index and colorectal polyps, with a critical cut-off point at 2.31. The persistent positive association before this point highlights the potential utility of the TyG index in identifying individuals at risk. This study's conclusion emphasizes the relevance of these findings in shaping colonoscopy screening strategies for CRC prevention.

Research perspectives

The study prompts further investigation into the mechanisms linking the TyG index, insulin resistance, and colorectal health. Advocating for multi-center studies, the research perspectives underscore the importance of validating findings across diverse populations. The TyG index's potential role in informing future screening guidelines and its broader applicability for assessing colorectal polyp risk remain promising avenues for future research.

FOOTNOTES

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REFERENCES

1   **Meseeha M**, Attia M. Colon Polyps. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [PMID: 28613512]

2   **Zhu Y**, Qiao L, Zhou Y, Ma N, Wang C, Zhou J. Long non-coding RNA FOXD2-AS1 contributes to colorectal cancer proliferation through its interaction with microRNA-185-5p. *Cancer Sci* 2018; **109**: 2235-2242 [PMID: 29737580 DOI: 10.1111/cas.13632]

3   **Kaźmierczak-Siedlecka K**, Dvořák A, Folwarski M, Daca A, Przewłócka K, Makarewicz W. Fungal Gut Microbiota Dysbiosis and Its Role in Colorectal, Oral, and Pancreatic Carcinogenesis. *Cancers (Basel)* 2020; **12** [PMID: 32455985 DOI: 10.3390/cancers12051326]

4   **Sung H**, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J Clin* 2021; **71**: 209-249 [PMID: 33538338 DOI: 10.3322/caac.21660]

5   **Arnold M**, Sierra MS, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global patterns and trends in colorectal cancer incidence and mortality. *Gut* 2017; **66**: 683-691 [PMID: 26818619 DOI: 10.1136/gutjnl-2015-310912]

6   **Kawamura T**, Takeuchi Y, Asai S, Yokota I, Akamine E, Kato M, Akamatsu T, Tada K, Komeda Y, Iwatate M, Kawakami K, Nishikawa M, Watanabe D, Yamauchi A, Fukata N, Shimatani M, Ooi M, Fujita K, Sano Y, Kashida H, Hirose S, Iwagami H, Uedo N, Teramukai S, Tanaka K. A comparison of the resection rate for cold and hot snare polypectomy for 4-9 mm colorectal polyps: a multicentre randomised controlled trial (CRESCENT study). *Gut* 2018; **67**: 1950-1957 [PMID: 28970290 DOI: 10.1136/gutjnl-2017-314215]

7   **Liljegren A**, Lindblom A, Rotstein S, Nilsson B, Rubio C, Jaramillo E. Prevalence and incidence of hyperplastic polyps and adenomas in familial colorectal cancer: correlation between the two types of colon polyps. *Gut* 2003; **52**: 1140-1147 [PMID: 12865272 DOI: 10.1136/gut.52.8.1140]

8   **He X**, Wu K, Ogino S, Giovannucci EL, Chan AT, Song M. Association Between Risk Factors for Colorectal Cancer and Risk of Serrated Polyps and Conventional Adenomas. *Gastroenterology* 2018; **155**: 355-373.e18 [PMID: 29702117 DOI: 10.1053/j.gastro.2018.04.019]

9   **Lee SB**, Ahn CW, Lee BK, Kang S, Nam JS, You JH, Kim MJ, Kim MK, Park JS. Association between triglyceride glucose index and arterial stiffness in Korean adults. *Cardiovasc Diabetol* 2018; **17**: 41 [PMID: 29562908 DOI: 10.1186/s12933-018-0692-1]

10   **da Silva A**, Caldas APS, Rocha DMUP, Bressan J. Triglyceride-glucose index predicts independently type 2 diabetes mellitus risk: A systematic review and meta-analysis of cohort studies. *Prim Care Diabetes* 2020; **14**: 584-593 [PMID: 32928692 DOI: 10.1016/j.pcd.2020.09.001]

11   **Tao LC**, Xu JN, Wang TT, Hua F, Li JJ. Triglyceride-glucose index as a marker in cardiovascular diseases: landscape and limitations. *Cardiovasc Diabetol* 2022; **21**: 68 [PMID: 35524263 DOI: 10.1186/s12933-022-01511-x]

12   **Shi YY**, Zheng R, Cai JJ, Qian SZ. The association between triglyceride glucose index and depression: data from NHANES 2005-2018. *BMC Psychiatry* 2021; **21**: 267 [PMID: 34030657 DOI: 10.1186/s12888-021-03275-2]

13   **Yilmaz M**, Karaaslan M, Tonyali S, Celik M, Toprak T, Odabas O. Triglyceride-Glucose Index (TyG) is associated with erectile dysfunction: A cross-sectional study. *Andrology* 2021; **9**: 238-244 [PMID: 32936988 DOI: 10.1111/andr.12904]

14   **Fritz J**, Bjørge T, Nagel G, Manjer J, Engeland A, Häggström C, Concin H, Teleka S, Tretli S, Gylling B, Lang A, Stattin P, Stocks T, Ulmer H. The triglyceride-glucose index as a measure of insulin resistance and risk of obesity-related cancers. *Int J Epidemiol* 2020; **49**: 193-204 [PMID: 30945727 DOI: 10.1093/ije/dyz053]

15   **Qin M**, Wang HP, Song B, Sun YL, Wang DY, Chen M, Shi HX, Zhang H, Li ZJ. [Relationship between insulin resistance, serum VCAM-1, FGF19, IGF-1 and colorectal polyps]. *Zhonghua Zhong Liu Za Zhi* 2021; **43**: 553-562 [PMID: 34034475 DOI: 10.3760/cma.j.cn112152-20210219-00146]

16   **Keku TO**, Lund PK, Galanko J, Simmons JG, Woosley JT, Sandler RS. Insulin resistance, apoptosis, and colorectal adenoma risk. *Cancer Epidemiol Biomarkers Prev* 2005; **14**: 2076-2081 [PMID: 16172212 DOI: 10.1158/1055-9965.EPI-05-0239]

17   **Flood A**, Mai V, Pfeiffer R, Kahle L, Remaley AT, Lanza E, Schatzkin A. Elevated serum concentrations of insulin and glucose increase risk of recurrent colorectal adenomas. *Gastroenterology* 2007; **133**: 1423-1429 [PMID: 17904132 DOI: 10.1053/j.gastro.2007.08.040]

18   **Liu XC**, He GD, Lo K, Huang YQ, Feng YQ. The Triglyceride-Glucose Index, an Insulin Resistance Marker, Was Non-linear Associated With All-Cause and Cardiovascular Mortality in the General Population. *Front Cardiovasc Med* 2020; **7**: 628109 [PMID: 33521071 DOI: 10.3389/fcvm.2020.628109]

19   **Guerrero-Romero F**, Simental-Mendía LE, González-Ortiz M, Martínez-Abundis E, Ramos-Zavala MG, Hernández-González SO, Jacques-Camarena O, Rodríguez-Morán M. The product of triglycerides and glucose, a simple measure of insulin sensitivity. Comparison with the euglycemic-hyperinsulinemic clamp. *J Clin Endocrinol Metab* 2010; **95**: 3347-3351 [PMID: 20484475 DOI: 10.1210/jc.2010-0288]

20   **Okamura T**, Hashimoto Y, Hamaguchi M, Obora A, Kojima T, Fukui M. Triglyceride-glucose index (TyG index) is a predictor of incident colorectal cancer: a population-based longitudinal study. *BMC Endocr Disord* 2020; **20**: 113 [PMID: 32709256 DOI: 10.1186/s12902-020-00581-w]

21   **Liu T**, Zhang Q, Wang Y, Ma X, Song M, Cao L, Shi H. Association between the TyG index and TG/HDL-C ratio as insulin resistance markers and the risk of colorectal cancer. *BMC Cancer* 2022; **22**: 1007 [PMID: 36138391 DOI: 10.1186/s12885-022-10100-w]

22   **Low S**, Khoo KCJ, Irwan B, Sum CF, Subramaniam T, Lim SC, Wong TKM. The role of triglyceride glucose index in development of Type 2 diabetes mellitus. *Diabetes Res Clin Pract* 2018; **143**: 43-49 [PMID: 29936253 DOI: 10.1016/j.diabres.2018.06.006]

23   **Wu Y**, Yakar S, Zhao L, Hennighausen L, LeRoith D. Circulating insulin-like growth factor-I levels regulate colon cancer growth and metastasis. *Cancer Res* 2002; **62**: 1030-1035 [PMID: 11861378]

24   **Murphy N**, Carreras-Torres R, Song M, Chan AT, Martin RM, Papadimitriou N, Dimou N, Tsilidis KK, Banbury B, Bradbury KE, Besevic J, Rinaldi S, Riboli E, Cross AJ, Travis RC, Agnoli C, Albanes D, Berndt SI, Bézieau S, Bishop DT, Brenner H, Buchanan DD, Onland-Moret NC, Burnett-Hartman A, Campbell PT, Casey G, Castellví-Bel S, Chang-Claude J, Chirlaque MD, de la Chapelle A, English D, Figueiredo JC, Gallinger SJ, Giles GG, Gruber SB, Gsur A, Hampe J, Hampel H, Harrison TA, Hoffmeister M, Hsu L, Huang WY, Huyghe JR, Jenkins MA, Keku TO, Kühn T, Kweon SS, Le Marchand L, Li CI, Li L, Lindblom A, Martín V, Milne RL, Moreno V, Newcomb PA, Offit K, Ogino S, Ose J, Perduca V, Phipps AI, Platz EA, Potter JD, Qu C, Rennert G, Sakoda LC, Schafmayer C, Schoen RE, Slattery ML, Tangen CM, Ulrich CM, van Duijnhoven FJB, Van Guelpen B, Visvanathan K, Vodicka P, Vodickova L, Vymetalkova V, Wang H, White E, Wolk A, Woods MO,

Wu AH, Zheng W, Peters U, Gunter MJ. Circulating Levels of Insulin-like Growth Factor 1 and Insulin-like Growth Factor Binding Protein 3 Associate With Risk of Colorectal Cancer Based on Serologic and Mendelian Randomization Analyses. *Gastroenterology* 2020; **158**: 1300-1312.e20 [PMID: 31884074 DOI: 10.1053/j.gastro.2019.12.020]

25 **Khan KH**, Yap TA, Yan L, Cunningham D. Targeting the PI3K-AKT-mTOR signaling network in cancer. *Chin J Cancer* 2013; **32**: 253-265 [PMID: 23642907 DOI: 10.5732/cjc.013.10057]

26 **Wei H**, Dong C, Shen Z. Kallikrein-related peptidase (KLK10) cessation blunts colorectal cancer cell growth and glucose metabolism by regulating the PI3K/Akt/mTOR pathway. *Neoplasma* 2020; **67**: 889-897 [PMID: 32386481 DOI: 10.4149/neo_2020_190814N758]

27 **Zhang Y**, Liu X, Yu M, Xu M, Xiao Y, Ma W, Huang L, Li X, Ye X. Berberine inhibits proliferation and induces G0/G1 phase arrest in colorectal cancer cells by downregulating IGF2BP3. *Life Sci* 2020; **260**: 118413 [PMID: 32926933 DOI: 10.1016/j.lfs.2020.118413]

28 **Mao L**, Chen Q, Gong K, Xu X, Xie Y, Zhang W, Cao H, Hu T, Hong X, Zhan YY. Berberine decelerates glucose metabolism *via* suppression of mTOR-dependent HIF-1α protein synthesis in colon cancer cells. *Oncol Rep* 2018; **39**: 2436-2442 [PMID: 29565467 DOI: 10.3892/or.2018.6318]

29 **Zhang XL**, Li KJ, Feng JX, Liu GJ, Feng YL. Blocking the IGF2BP1-promoted glucose metabolism of colon cancer cells *via* direct de-stabilizing mRNA of the LDHA enhances anticancer effects. *Mol Ther Nucleic Acids* 2021; **23**: 835-846 [PMID: 33614233 DOI: 10.1016/j.omtn.2020.12.020]

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