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Association between the C-reactive protein-triglyceride–glucose index and endometriosis: a cross-sectional study using data from the national health and nutrition examination survey, 1996–2006

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Abstract

Background The C-reactive protein–triglyceride glucose index (CTI) is a promising new marker for evaluating the severity of inflammation. Endometriosis (EM) is a prevalent chronic inflammatory condition influenced by estrogen, primarily affecting women of reproductive age. However, no study has demonstrated an association between the CTI and EM.

Methods This cross-sectional study sourced data from females 20–50 years of age from the National Health and Nutrition Examination Survey (NHANES) 1996–2006, and included those with self-reported diagnoses of EM and sufficient information to calculate the CTI, computed as 0.412 × ln (C-reactive protein [CRP]) + ln (triglycerides [mg/dL] × fasting plasma glucose [mg/dL]/2). Multivariate logistic regression, restricted cubic splines, and subgroup analyses were performed to examine the association between the CTI and EM.

Results Data from 2235 women (175 [7.82%] with EM, 2060 [92.18%] without EM [controls]), were included: those with EM exhibited a tendency toward higher CTI ($p = 0.005$), and CTI was positively associated with the prevalence of EM ($p = 0.011$). In Model 1, a 1 mg/dL increment in CTI was associated with a 56% higher prevalence of EM (odds ratio [OR] 1.563 [95% confidence interval (CI) 1.295–1.885]; $P < 0.001$). This association in Model 2 (OR 1.609 [95% CI 1.334–1.941]; $p < 0.001$) and Model 3 (OR 1.565 [95% CI 1.246–1.966]; $p < 0.001$) remained significant. Notably, individuals in the uppermost remnant cholesterol tertile exhibited a notably higher prevalence of EM than those in the lowest tertile (OR 3.029, $p = 0.051$). Restricted cubic splines revealed a nonlinear positive association between CTI and the prevalence of EM. In addition, greater EM prevalence was observed with CTI in those > 40 years of age (OR 1.57 [95% CI 1.16–2.13]), body mass index ≥ 25 kg/m^2 (OR 1.38 [95% CI 1.06–1.80]), smoking ≥ 100 cigarettes (OR 1.43 [95% CI 1.06–1.96]), married or living with partner (OR 1.41 [95% CI 1.09–1.85]), and oral contraceptive use (OR 1.35 [95% CI 1.07–1.69]).

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Conclusions CTI was positively associated with EM in women in the United States. Use of the CTI as an indicator of inflammation may provide new insights for the prevention and management of EM.

Keywords C-reactive protein-triglyceride glucose index, Endometriosis, Inflammation, NHANES

Background

Endometriosis is a common, chronic, inflammatory, and benign gynecological disorder characterized by the growth of endometrioid tissue outside the uterine cavity, with a prevalence of approximately 10% in women of childbearing age [1–3]]. The standard method for diagnosing endometriosis is laparoscopy-guided biopsy [4, 5]], which often leads to significant delays in diagnosis, typically ranging from to 6–11 years [6]]. The development of innovative diagnostic methods and predictive biomarkers is essential for improving diagnostic accuracy and sensitivity and, ultimately, enhancing patient quality of life.

The C-reactive protein (CRP)–triglyceride (TG)–glucose index (CTI) is gaining recognition as a new metric for thorough evaluation of the severity of inflammation and insulin resistance (IR). The CTI was calculated using the following formula: $0.412 \times \ln(\text{CRP}) + \ln[\text{TG (mg/dL)} \times \text{fasting plasma glucose [FPG] (mg/dL)}/2]$. A novel metric, termed the "CTI", provides a comprehensive assessment of both inflammatory status and IR [7]. The CTI is the sole metric that combines the intensity of inflammation and IR, and has been recognized to be valuable in predicting survival rates in the Chinese cancer population [7]. Additionally, the CTI is a straightforward and rapid indicator that incurs no additional costs beyond standard laboratory investigations. Consequently, in the general population, there is no further f [8]inancial burden on patients or the healthcare system. Elevated CRP levels indicate a systemic inflammatory response [9]. Endometriosis is a complex chronic inflammatory disease [10]. The classification of endometriosis as an inflammatory disorder is supported by various lines of evidence, including alterations in the peritoneal environment of affected women, the recruitment of numerous immune cells to endometriotic lesions, and the abnormal production of pro-inflammatory cytokines and regulatory proteins [11]. Elevated levels of pro-inflammatory markers, such as CRP, have been consistently observed in women diagnosed with endometriosis. These inflammatory responses are believed to promote lesion survival, vascularization, and cell proliferation, exacerbating the disease [12]. Recent studies have suggested a link between IR and inflammatory pathways in endometriosis, highlighting the multifaceted role of inflammation in disease development [8, 13, 14]. Considering these perspectives, it is important to investigate the potential link between CTI and the risk for developing endometriosis. As such, our aim was to explore the relationship between the CTI and endometriosis by analyzing data from the National Health and Nutrition Examination Survey (NHANES, 1999–2006), with the intention of offering compelling evidence supporting this association.

Materials and methods

Study population

NHANES, a nationally representative study approved by the Research Ethics Review Board of the National Center for Health Statistics (NCHS), was conducted by the Centers for Disease Control and Prevention. Informed consent was obtained from all participants at the time of enrollment.

Data were sourced from 41,474 individuals in 4 consecutive two-year NHANES cycles (1999–2000, 2001–2002, 2003–2004, 2005–2006). Ultimately, data from 2235 female participants 20–50 years of age were included. Inclusion criteria were as follows: female sex; age 20–50 years; and available data regarding endometriosis diagnosis and relevant variables, including the CTI and other covariates. Individuals without complete data regarding endometriosis, CTI, or covariates such as body mass index (BMI), smoking status, or other relevant factors, were excluded. Additionally, individuals < 20 years of age and those with incomplete clinical data were also excluded. Participants who fulfilled the inclusion criteria were assigned to the endometriosis or control group according to their diagnosis.

Endometriosis

A questionnaire-based survey asking, "Has a doctor or other health professional ever told you that you had endometriosis (age at interview, 20–54 years)?" was collected to diagnose endometriosis. Participants who responded affirmatively were allocated the endometriosis group; otherwise, they were allocated to the control group. Although relying on questionnaire responses to determine the primary study outcome may introduce some degree of uncertainty, the lack of direct diagnostic methods, such as laparoscopy or pathological confirmation, in the NHANES dataset complicated the precise identification of endometriosis cases. However, previous studies have demonstrated the feasibility and acceptance of using questionnaires to identify the presence of endometriosis among NHANES participants [15–18].

Calculation of the CTI

The CTI [7] was calculated as follows: $\text{CTI} = 0.412 \times \ln(\text{CRP}) + \text{TyG}$ ($\text{TyG} = \ln$ [fasting triglyceride (TG) (mg/dL)

× fasting glucose (FPG) (mg/dL)/2]) [19]. Blood samples were collected in the morning after an 8.5 h fast and processed in NCHS-certified laboratories. Serum TG levels were assessed using chemistry analyzers (Modular P and Cobas 6000, Roche Diagnostics, Basel, Switzerland), whereas FPG levels were assessed using the oxygen rate method on a laboratory analyzer (DxC800, Beckman-Coulter Diagnostics, Brea, CA, USA) [20, 21]. CRP levels were determined using latex-enhanced nephelometry (CSL Behring, King of Prussia, PA, USA) [22]. Additional details regarding the laboratory procedures are available on the official NHANES website. An elevated CTI usually suggests a more severe level of inflammation and IR [19].

Covariables

Covariates included age, age at menarche (years), poverty income ratio (PIR), and BMI, smoked≥100 cigarettes, race/ethnicity, marital status, education level, hypertension, diabetes, alcohol intake, oral contraceptive use, infertility, CRP (mg/dL), fasting TG (mg/dL), FPG (mg/dl), TG glucose index (TyG), total cholesterol (mg/dL), and CTI. Age was categorized into 2 groups according to clinical relevance (≤40 and >40 years); BMI was classified as normal (<25 kg/m^2) or overweight (≥25 kg/m^2), based on clinical significance; and smoking status was categorized as having smoked at least 100 cigarettes in one's lifetime (yes, no). There were 3 levels for PIR: < 1.3; 1.5–3.0; and ≥3.0.

Statistical analysis

To assess differences between the 2 groups, the Student's *t*-test was used for continuous variables. This test helps determine whether there are statistically significant differences in the means between the 2 groups. For categorical variables, the chi-squared test was used to evaluate whether there was a significant association between categorical outcomes across groups. By selecting the appropriate statistical method(s), the analysis ensured robust data evaluation.

Logistic regression models were constructed to assess the relationship between CTI and endometriosis. Three models were constructed: Model 1 (unadjusted); Model 2 (adjusted for age and ethnicity); and Model 3 (additionally adjusted for PIR, BMI, education level, marital status, smoking habits, hypertension, diabetes, drinking status, age at menarche, total cholesterol, and use of oral contraceptives). The relationship between an increase in CTI of 1 mg/dL and endometriosis was determined. In addition, stratified analyses were performed according to participant age, BMI, age at menarche, smoking, drinking and marital status, and use of oral contraceptives. Prevalence was calculated as odds ratio (OR) and corresponding 95% confidence interval (CI). To flexibly model the association between CTI and the prevalence of endometriosis, restricted cubic splines with three knots was used. Statistical analysis was performed using R version 4.2 (R Foundation for Statistical Computing, Vienna, Austria) and EmpowerStats version 5.0 (http://www.empowerstats.net). Differences with $P<0.05$ were considered to be statistically significant.

Results

Baseline characteristics

Between 1999 and 2006, the NHANES included 6508 participants. Among them, 951 participants were excluded due to endometriosis, 3050 due to CTI, and 272 due to incomplete covariate data. Ultimately, data from 2235 participants were included in the final analysis. Based on the diagnosis of endometriosis, 175 (7.83%) participants comprised the endometriosis group while 2060 (92.17%) comprised the control group (Fig. 1). Participant characteristics are summarized in Table 1. Participants with endometriosis were more likely to have used oral contraceptives for birth control and were more often non-Hispanic White than those without endometriosis. Moreover, patients with endometriosis exhibited higher rates of smoking and marriage, and were more likely to be obese. Notably, CRP, TyG, fasting TG, total cholesterol, and CTI were higher in patients with endometriosis than in those without (Table 1).

Association between CTI and endometriosis

Results reflecting the association between the CTI and endometriosis, analyzed using the 3 different models, are summarized in Table 2. In all models, a continuous increase in CTI was significantly associated with an elevated prevalence of endometriosis. Specifically, in the unadjusted model (i.e., Model 1), the OR for continuous CTI was 1.563 (95% CI 1.295–1.885; $p<0.001$), whereas in the model adjusted for age and ethnicity (i.e., Model 2), the OR increased slightly to 1.609 (95% CI 1.334–1.941; $p<0.001$). After further adjustment for various factors, including BMI, PIR, education level, and lifestyle habits (i.e., Model 3), the OR remained significant (1.565 [95% CI 1.246–1.966]; $p<0.001$), indicating a consistent relationship between higher CTI and the risk for endometriosis. When stratified according to quartiles, the highest CTI quartile (Q4) was associated with significantly increased odds of endometriosis across all models, with ORs of 3.430 (95% CI 1.589–7.402; $p=0.002$) in Model 1, 3.615 (95% CI 1.667–7.839; $p=0.002$) in Model 2, and 3.029 (95% CI 1.306–7.025; $p=0.011$) in Model 3. These results suggest that an elevated CTI is strongly associated with an increased risk for endometriosis even after controlling for multiple demographic and clinical factors.

Relationships between the predicted values were visualized by plotting restricted cubic splines (Fig. 2). A

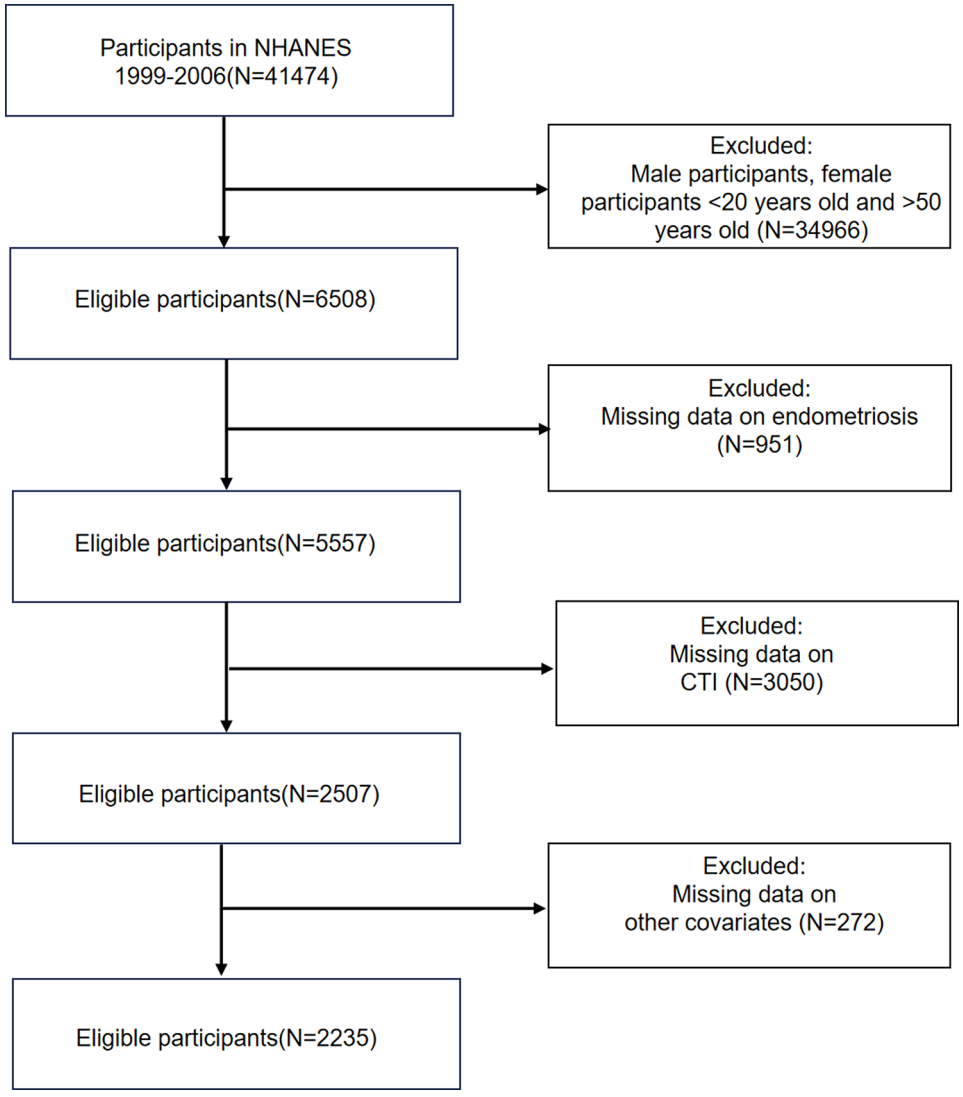

Fig. 1 Flow chart of eligible participants selection

nonlinear positive relationship between CTI and the prevalence of endometriosis was observed (nonlinearity, $p=0.603$), with a breakpoint identified at 8.053.

Subgroup analyses

The results of the stratified assessment according to age, age at menarche, BMI, smoking, drinking, marital status, and oral contraceptive use are presented in Fig. 3. Individuals >40 years of age, a BMI ≥ 25 kg/m^2, smoked ≥ 100 cigarettes, married or living with a partner, and oral contraceptive use exhibited more vulnerability. Following the stratification of analyses based on alcohol consumption habits, comparable results were found regarding positive associations between the CTI and the prevalence of endometriosis.

Furthermore, a higher endometriosis prevalence was observed among those with CTI in >40 years of age (OR 1.57 [95% CI 1.16–2.13]), BMI ≥ 25 kg/m^2 (OR 1.38 [95% CI 1.06–1.80]), smoking ≥ 100 cigarettes (OR 1.43 [95% CI 1.06–1.96]), being married or living with a partner (OR 1.41 [95% CI 1.09–1.85]) and oral contraceptive use (OR 1.35 95% CI 1.07–1.69]).

Discussion

This cross-sectional study, involving data from 2235 representative participants, found positive associations between the CTI and endometriosis, with a threshold concentration of approximately 8.053 mg/dL. Our results indicate that individuals with endometriosis were generally older and primarily non-Hispanic White. The diagnosis of endometriosis is frequently delayed, typically occurring 6–11 years after the initial symptoms appear, which likely accounts for the older age of these patients [6]. The increased incidence among White individuals

Table 1 Characteristics of participants

Characteristics	Overall (*N* = 2235)	Non-endometriosis (*N* = 2060)	Endometriosis (*N* = 175)	*P* value
Age (years)				0.095
≤ 40	1455 (58.2%)	1368 (59.0%)	87 (51.3%)	
> 40	780 (41.8%)	692 (41.0%)	88 (48.7%)	
Age at menarche (years)				0.387
< 12	509 (21.3%)	464 (20.8%)	45 (25.0%)	
12–13	1187 (54.6%)	1089 (54.7%)	98 (53.9%)	
≥ 14	539 (24.2%)	507 (24.5%)	32 (21.1%)	
PIR				0.419
< 1.3	623 (21.5%)	584 (21.5%)	39 (21.8%)	
1.3-3.0	807 (34.5%)	751 (35.3%)	56 (28.1%)	
> 3.0	805 (43.9%)	725 (43.2%)	80 (50.1%)	
BMI (kg/m^2)				0.149
< 25	776 (42.0%)	720 (42.6%)	56 (36.5%)	
≥ 25	1459 (58.0%)	1340 (57.4%)	119 (63.5%)	
Smoked ≥ 100cigarettes				0.002
Yes	858 (43.1%)	768 (41.4%)	90 (57.6%)	
No	1377 (56.9%)	1292 (58.6%)	85 (42.4%)	
Race/ethnicity				0.001
Mexican American	497 (7.4%)	488 (8.0%)	9 (1.4%)	
Other Hispanic	96 (5.7%)	91 (6.1%)	5 (2.0%)	
Non-Hispanic White	1088 (70.6%)	965 (69.0%)	123 (84.8%)	
Non-Hispanic Black	457 (11.6%)	425 (12.1%)	32 (7.9%)	
Other	97 (4.7%)	91 (4.8%)	6 (3.9%)	
Marital status				0.010
Married/Living with partner	1499 (68.3%)	1380 (67.3%)	119 (77.3%)	
Never married	414 (14.6%)	391 (18.2%)	23 (7.3%)	
Widowed/Divorced/Separated	322 (17.0%)	289 (14.5%)	33 (15.4%)	
Education level				0.112
High school and below	507 (15.8%)	486 (16.2%)	21 (11.5%)	
Above high school	1728 (84.2%)	1574 (83.8%)	154 (88.5%)	
Hypertension				0.287
Yes	406 (18.9%)	358 (18.5%)	48 (21.9%)	
No	1829 (81.1%)	1702 (81.5%)	127 (78.1%)	
Diabetes				0.436
Yes	97 (3.4%)	90 (3.5%)	7 (2.6%)	
No	2138 (96.6%)	1970 (96.5%)	168 (97.4%)	
Alcohol intake				0.850
Yes	1376 (68.2%)	1257 (68.1%)	119 (69.1%)	
No	859 (31.8%)	803 (31.9%)	56 (30.9%)	
Oral contraceptive				0.020
Yes	1742 (80.8%)	1586 (79.9%)	156 (89.3%)	
No	493 (19.2%)	474 (20.1%)	19 (10.7%)	
Infertility				0.160
Yes	311 (17.1%)	286 (12.0%) %)	25 (17.7%)	
No	1924 (82.9%)	1774 (88.0%)	150 (82.3%)	
CRP (mg/dL)	0.47 (0.73)	0.46 (0.74)	0.57 (0.67)	0.041
Fasting triglyceride (mg/dL)	121.62 (99.40)	117.20 (81.42)	160.52 (192.34)	0.007
Fasting glucose, mg/dl	94.32 (20.48)	94.29 (20.45)	94.56 (20.84)	0.857
TyG	8.48 (0.58)	8.45 (0.56)	8.68 (0.68)	< 0.001
Total cholesterol (mg/dL)	195.51 (40.22)	194.35 (39.89)	205.78 (41.79)	0.001
CTI	7.83 (0.95)	7.79 (0.94)	8.20 (0.98)	< 0.001

Values are mean±SD or number (%). P<0.05 was deemed significant. BMI body mass index, CRP C-reactive protein, TyG triglyceride glucose index, CTI C-reactive protein-triglyceride glucose index, PIR poverty income ratio

Table 2 Association between CTI and endometriosis

Exposures	OR (95% CI) *P*		
	Model 1	Model 2	Model 3
CTI (continuous)	1.563 (1.295–1.885) <0.001	1.609 (1.334–1.941) <0.001	1.565 (1.246–1.966) <0.001
CTI (Quartiles)			
Q1	Reference	Reference	Reference
Q2	2.105 (0.965–4.593) 0.061	2.153 (0.976–4.747) 0.057	2.000 (0.901–4.442) 0.087
Q3	1.838 (0.850–3.976) 0.120	1.976 (0.895–4.363) 0.090	1.695 (0.777–3.698) 0.179
Q4	3.430 (1.589–7.402) 0.002	3.615 (1.667–7.839) 0.002	3.029 (1.306–7.025) 0.011
P for trend	0.005	0.003	0.051

Model 1: unadjusted model

Model 2: adjusted for age, ethnicity

Model 3: further adjusted for PIR, BMI, education level, marital status, smoking habits, hypertension, diabetes, drinking status, age at menarche, total cholesterol, and the use of contraceptive pills

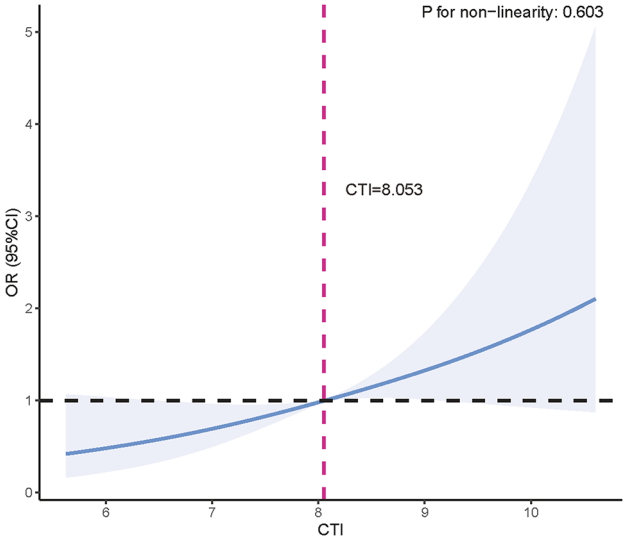

Fig. 2 Restricted cubic splines for associations between CTI and endometriosis

may be associated with greater racial susceptibility. Additionally, we found that individuals with obesity or those with a history of smoking were more likely to develop endometriosis. This may be due to the inflammatory response triggered by smoking [23, 24], whereas higher estrogen levels in patients with obesity could promote the development of endometriosis [25].

Endometriosis is a chronic condition, prevalent among women of reproductive age, that affects approximately 10% of this population [2, 3, 26]. There are several hypotheses regarding the pathogenesis of endometriosis, with the leading being that ectopic endometrial-like glands and stroma may arise from metaplasia of local tissue or from the transplanted ectopic endometrium [27, 28]. This finding implies that normal endometrial cells may undergo changes in other parts of the body, resulting in the formation of new pathological tissue(s). Furthermore, elevated levels of local estrogen are believed to play a crucial role in this process because they not only aid in the survival and implantation of ectopic endometriotic lesions, but also promote their proliferation [3, 25]. However, its exact pathophysiology remains unclear. Recent studies have highlighted the potential contributions of inflammation and oxidative stress in this context [29–33]. A cohort study from Japan also suggested that consuming a diverse range of anti-inflammatory foods, such as vegetables, may ultimately affect perinatal mortality and morbidity in patients with endometriosis [34, 35]. A recent cross-sectional analysis revealed that the dietary inflammatory index is positively associated with the prevalence of endometriosis [34, 36]. The inflammatory nature of endometriosis is well-established [37, 38]. Considering the central role of inflammation in the pathogenesis of endometriosis, addressing inflammatory dysfunction has emerged as a promising strategy for developing new treatments [17, 39]. This approach provides an avenue for exploring innovative options for prevention and management of this disease.

The results of our investigation are consistent with those of earlier studies reporting the significant association between inflammation and endometriosis [40]. Similarly, several studies have shown that chronic inflammation plays a crucial role in the pathogenesis of endometriosis [17, 35]. For example, research using the Dietary Inflammatory Index revealed a positive association between pro-inflammatory diets and the prevalence of endometriosis [18, 41]. Similar to our findings, higher levels of inflammatory indicators, such as CRP and the TyG index, are significantly associated with endometriosis [42–45]. This similarity emphasizes the role of systemic inflammation in the progression of endometriosis, and supports the hypothesis that inflammatory processes are central to disease development [43, 46].

Furthermore, the roles of demographic and lifestyle factors, including smoking and BMI [47, 48], were more prominently analyzed in our study, revealing that these factors may modulate the relationship between inflammation and endometriosis. This provides a more nuanced understanding of how lifestyle and metabolic factors interact with inflammatory processes to influence the risk for endometriosis.

The key strength of this study is its foundation in a weighted and representative population with a substantial sample size. It should be emphasized that we also performed restricted cubic splines analysis. Nevertheless, this study had several limitations, the first of which was its cross-sectional design, making it difficult to determine causation between CTI and endometriosis. Second, because participants < 20 years of age were excluded,

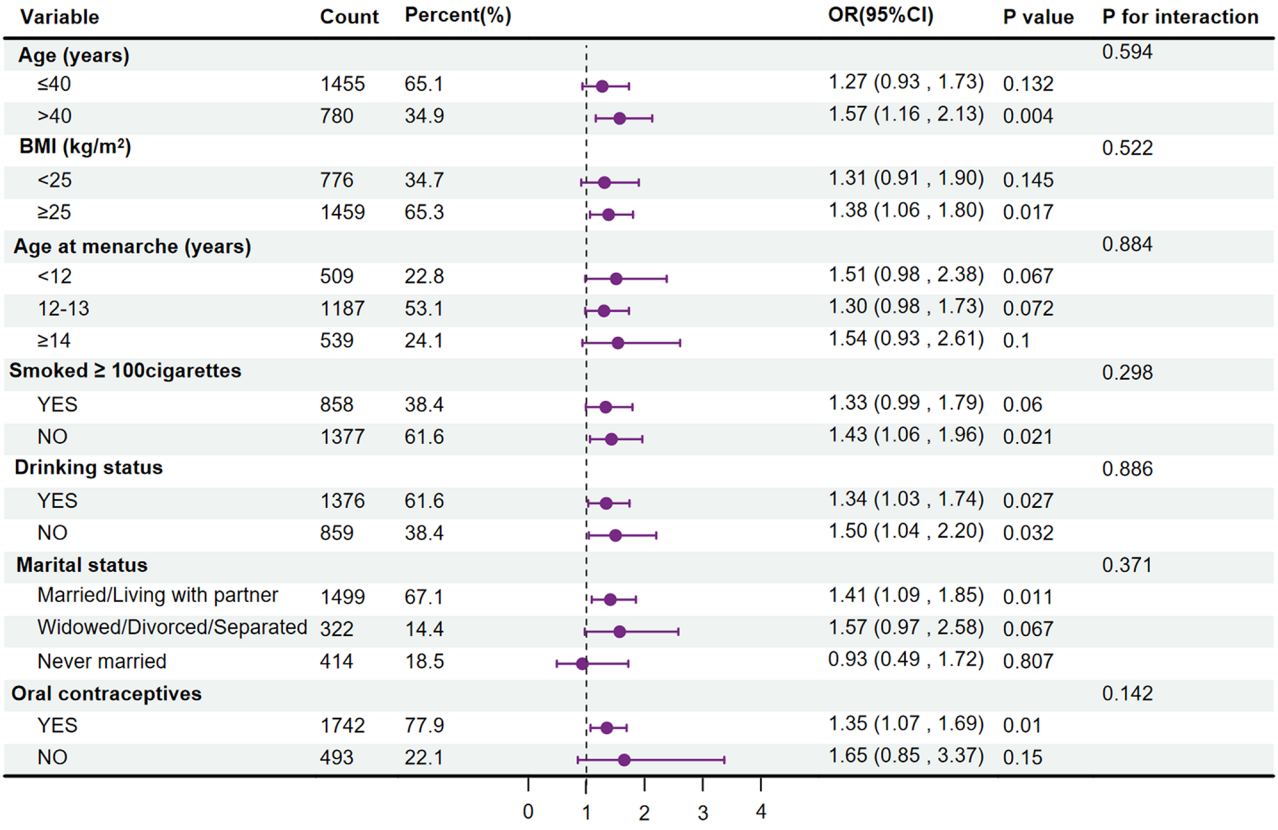

Fig. 3 Subgroup analysis of the association between the remnant CTI and endometriosis

these findings may not be generalizable to younger patients. Third, because most of the data were gathered through self-report questionnaires or interviews, the control group may have unintentionally included individuals with undiagnosed endometriosis, potentially resulting in recall and reporting bias. Finally, due to limitations of the database, we could not incorporate data regrading all covariates related to endometriosis and inflammation levels to ensure a sufficiently large sample size. Therefore, future research should involve a more diverse population and consider additional potential covariates to clarify the causal association between the CTI and endometriosis.

Conclusion

Results of the present study revealed a strong positive association between the CTI and endometriosis. Therefore, actively managing blood glucose levels and minimizing inflammatory responses may aid in decreasing the prevalence of endometriosis; however, additional foundational research is necessary to investigate the possible relationships between them.

Abbreviations

BMI Body mass index
CI Confidence interval
CTI C-reactive protein–triglyceride–glucose index
FPG Fasting plasma glucose
NHANES National Health and Nutrition Examination Survey
OR Odds ratio
PIR Poverty income ratio
TyG index Triglyceride–glucose index

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Author contributions

RY, XR, and SL designed the research. RY, ZJ, and JY collected and analyzed the data and drafted the manuscript. SL and WY revised the manuscript. All the authors contributed to the article and approved the submitted version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The portions of this study involving human participants, human materials, or human data were conducted in accordance with the Declaration of Helsinki and were approved by the NCHS Ethics Review Board. The patients/participants provided written informed consent to participate in this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Huang Y, Yan S, Dong X, Jiao X, Wang S, Li D, Wang G. Deficiency of MST1 in endometriosis related peritoneal macrophages promoted the autophagy of ectopic endometrial stromal cells by IL-10. Front Immunol. 2022;13:993788.
2. Bulun SE, Yilmaz BD, Sison C, Miyazaki K, Bernardi L, Liu S, Kohlmeier A, Yin P, Milad M, Wei J, Endometriosis. Endocr Rev. 2019;40(4):1048–79.
3. França PRC, Lontra ACP, Fernandes PD. Endometriosis: a Disease with few Direct Treatment options. Molecules 2022, 27(13).
4. Cui X, Zhou S, Lin Y. Long non-coding RNA DHRS4 antisense RNA 1 inhibits ectopic endometrial cell proliferation, migration, and invasion in endometriosis by regulating microRNA-139-5p expression. Bioengineered. 2022;13(4):9792–804.
5. Méar L, Com E, Fathallah K, Guillot L, Lavigne R, Guével B, Fauconnier A, Vialard F, Pineau C. The Eutopic Endometrium Proteome in Endometriosis reveals candidate markers and molecular mechanisms of Physiopathology. Diagnostics (Basel) 2022, 12(2).
6. Chapron C, Lafay-Pillet MC, Santulli P, Bourdon M, Maignien C, Gaudet-Chardonnet A, Maitrot-Mantelet L, Borghese B, Marcellin L. A new validated screening method for endometriosis diagnosis based on patient questionnaires. EClinicalMedicine. 2022;44:101263.
7. Ruan GT, Xie HL, Zhang HY, Liu CA, Ge YZ, Zhang Q, Wang ZW, Zhang X, Tang M, Song MM, et al. A novel inflammation and insulin resistance related Indicator to predict the survival of patients with Cancer. Front Endocrinol (Lausanne). 2022;13:905266.
8. Akbaba E, Sezgin B, Edgünlü T. The role of adropin, salusin-α, netrin-1, and nesfatin-1 in endometriosis and their association with insulin resistance. Turk J Obstet Gynecol. 2021;18(3):175–80.
9. Argiles JM, Lopez-Soriano FJ, Busquets S. Counteracting inflammation: a promising therapy in cachexia. Crit Rev Oncog. 2012;17(3):253–62.
10. Matarese G, De Placido G, Nikas Y, Alviggi C. Pathogenesis of endometriosis: natural immunity dysfunction or autoimmune disease? Trends Mol Med. 2003;9(5):223–8.
11. Saunders PTK, Horne AW. Endometriosis: etiology, pathobiology, and therapeutic prospects. Cell. 2021;184(11):2807–24.
12. Cuffaro F, Russo E, Amedei A. Endometriosis, Pain, and related psychological disorders: unveiling the interplay among the Microbiome, inflammation, and oxidative stress as a common thread. Int J Mol Sci 2024, 25(12).
13. Park S, Kim C, Wu X. Development and validation of an insulin Resistance Predicting Model using a machine-learning Approach in a Population-based cohort in Korea. Diagnostics (Basel) 2022, 12(1).
14. Ueda-Wakagi M, Nagayasu H, Yamashita Y, Ashida AH. Green Tea ameliorates hyperglycemia by promoting the translocation of glucose transporter 4 in the skeletal muscle of Diabetic rodents. Int J Mol Sci 2019, 20(10).
15. Weuve J, Hauser R, Calafat AM, Missmer SA, Wise LA. Association of exposure to phthalates with endometriosis and uterine leiomyomata: findings from NHANES, 1999–2004. Environ Health Perspect. 2010;118(6):825–32.
16. Pan G, Zhang P, Li S, Cao L, Yang C. Association of endometriosis with asthma: a study of the NHANES database in 1999–2006. J Health Popul Nutr. 2024;43(1):50.
17. Hu PW, Yang BR, Zhang XL, Yan XT, Ma JJ, Qi C, Jiang GJ. The association between dietary inflammatory index with endometriosis: NHANES 2001–2006. PLoS ONE. 2023;18(4):e0283216.
18. Li K, Zhang W. The Association between Daily Intake of Dietary supplements and self-reported endometriosis: a NHANES-Based study. Reprod Sci. 2024;31(7):1936–47.
19. Sánchez-García A, Rodríguez-Gutiérrez R, Mancillas-Adame L, González-Nava V, Díaz González-Colmenero A, Solis RC. Álvarez-Villalobos NA, González-González JG: Diagnostic Accuracy of the Triglyceride and Glucose Index for Insulin Resistance: A Systematic Review. *Int J Endocrinol* 2020, 2020:4678526.
20. Novotny JA, Baer DJ, Khoo C, Gebauer SK, Charron CS. Cranberry juice consumption lowers markers of cardiometabolic risk, including blood pressure and circulating C-reactive protein, triglyceride, and glucose concentrations in adults. J Nutr. 2015;145(6):1185–93.
21. Mei Y, Li Y, Zhang B, Xu R, Feng X. Association between the C-reactive protein-triglyceride glucose index and erectile dysfunction in US males: results from NHANES 2001–2004. Int J Impot Res 2024.
22. Zhang Z, Lin W, Gan Q, Lei M, Gong B, Zhang C, Henrique JS, Han J, Tian H, Tao Q et al. The influences of ApoE isoforms on endothelial adherens junctions and actin cytoskeleton responding to mCRP. *Angiogenesis* 2024.
23. Brody JS, Steiling K. Interaction of cigarette exposure and airway epithelial cell gene expression. Annu Rev Physiol. 2011;73:437–56.
24. Choi WJ, Lee JW, Cho AR, Lee YJ. Dose-dependent toxic effect of cotinine-verified Tobacco Smoking on systemic inflammation in apparently healthy men and women: a Nationwide Population-based study. Int J Environ Res Public Health 2019, 16(3).
25. Zhang L, Yang X. Association between exposure to polycyclic aromatic hydrocarbons and endometriosis: data from the NHANES 2001–2006. Front Public Health 2024, 11.
26. Hogg C, Horne AW, Greaves E. Endometriosis-Associated macrophages: Origin, phenotype, and function. Front Endocrinol (Lausanne). 2020;11:7.
27. Mu F, Rich-Edwards J, Rimm EB, Spiegelman D, Forman JP, Missmer SA. Association between endometriosis and Hypercholesterolemia or Hypertension. Hypertension. 2017;70(1):59–65.
28. Lee AW, Eata V. Association of environmental phenols with endometriosis and uterine leiomyoma: an analysis of NHANES, 2003–2006. Reprod Toxicol. 2022;113:30–4.
29. Samimi M, Pourhanifeh MH, Mehdizadehkashi A, Eftekhar T, Asemi Z. The role of inflammation, oxidative stress, angiogenesis, and apoptosis in the pathophysiology of endometriosis: Basic science and new insights based on gene expression. J Cell Physiol. 2019;234(11):19384–92.
30. Wei Y, Liang Y, Lin H, Dai Y, Yao S. Autonomic nervous system and inflammation interaction in endometriosis-associated pain. J Neuroinflammation. 2020;17(1):80.
31. Forster R, Sarginson A, Velichkova A, Hogg C, Dorning A, Horne AW, Saunders PTK, Greaves E. Macrophage-derived insulin-like growth factor-1 is a key neurotrophic and nerve-sensitizing factor in pain associated with endometriosis. Faseb j. 2019;33(10):11210–22.
32. Kato T, Yasuda K, Matsushita K, Ishii KJ, Hirota S, Yoshimoto T, Shibahara H. Interleukin-1/-33 signaling pathways as therapeutic targets for endometriosis. Front Immunol. 2019;10:2021.
33. Moazzami B, Chaichian S, Samie S, Zolbin MM, Jesmi F, Akhlaghdoust M, Pishkuhi MA, Mirshafiei ZS, Khalilzadeh F, Safari D. Does endometriosis increase susceptibility to COVID-19 infections? A case-control study in women of reproductive age. BMC Womens Health. 2021;21(1):119.
34. Kyozuka H, Nishigori H, Murata T, Fukuda T, Yamaguchi A, Kanno A, Yasuda S, Sato A, Ogata Y, Kuse M, et al. Prepregnancy antiinflammatory diet in pregnant women with endometriosis: the Japan Environment and Children's study. Nutrition. 2021;85:111129.
35. Peng L, Luo X, Cao B, Wang X. Exploring the link: systemic immune-inflammation index as a marker in endometriosis-insights from the NHANES 2001–2006 cross-sectional study. PLoS ONE. 2024;19(6):e0304591.
36. Clower L, Fleshman T, Geldenhuys WJ, Santanam N. Targeting oxidative stress involved in endometriosis and its Pain. Biomolecules 2022, 12(8).
37. Vercellini P, Viganò P, Somigliana E, Fedele L. Endometriosis: pathogenesis and treatment. Nat Rev Endocrinol. 2014;10(5):261–75.
38. Viganò P, Ottolina J, Bartiromo L, Bonavina G, Schimberni M, Villanacci R, Candiani M. Cellular Components contributing to Fibrosis in Endometriosis: A literature review. J Minim Invasive Gynecol. 2020;27(2):287–95.
39. Giacomini E, Minetto S, Li Piani L, Pagliardini L, Somigliana E, Viganò P. Genetics and inflammation in endometriosis: improving knowledge for development of new pharmacological strategies. Int J Mol Sci 2021, 22(16).
40. Gleason JL, Thoma ME, Zukerman Willinger N, Shenassa ED. Endometriosis and uterine fibroids and their associations with elevated C-Reactive protein and leukocyte telomere length among a Representative Sample of U.S. women: data from the National Health and Nutrition Examination Survey, 1999–2002. J Womens Health (Larchmt). 2022;31(7):1020–8.
41. Banerjee S, Xu W, Doctor A, Driss A, Nezhat C, Sidell N, Taylor RN, Thompson WE, Chowdhury I. TNFα-Induced altered miRNA expression links to NF-κB signaling pathway in endometriosis. Inflammation. 2023;46(6):2055–70.
42. Liu P, Wang Y, Ji X, Kong W, Pan Z, Xu C, Geng Y, Miao J. Association between triglyceride-glucose index and risk of endometriosis in US population: results from the national health and nutrition examination survey (1999–2006). Front Endocrinol (Lausanne). 2024;15:1371393.

43. Krabbenborg I, de Roos N, van der Grinten P, Nap A. Diet quality and perceived effects of dietary changes in Dutch endometriosis patients: an observational study. Reprod Biomed Online. 2021;43(5):952–61.
44. Yaron G, Brill A, Dashevsky O, Yosef-Levi IM, Grad E, Danenberg HD, Varon D. C-reactive protein promotes platelet adhesion to endothelial cells: a potential pathway in atherothrombosis. Br J Haematol. 2006;134(4):426–31.
45. Riccio LGC, Baracat EC, Chapron C, Batteux F, Abrão MS. The role of the B lymphocytes in endometriosis: a systematic review. J Reprod Immunol. 2017;123:29–34.
46. Vercellini P, Salmeri N, Somigliana E, Piccini M, Caprara F, Viganò P, De Matteis S. Müllerian anomalies and endometriosis as potential explanatory models for the retrograde menstruation/implantation and the embryonic remnants/celomic metaplasia pathogenic theories: a systematic review and meta-analysis. Hum Reprod 2024.
47. Schink M, Konturek PC, Herbert SL, Renner SP, Burghaus S, Blum S, Fasching PA, Neurath MF, Zopf Y. Different nutrient intake and prevalence of gastrointestinal comorbidities in women with endometriosis. J Physiol Pharmacol 2019, 70(2).
48. Dang K, Wang X, Hu J, Zhang Y, Cheng L, Qi X, Liu L, Ming Z, Tao X, Li Y. The association between triglyceride-glucose index and its combination with obesity indicators and cardiovascular disease: NHANES 2003–2018. Cardiovasc Diabetol. 2024;23(1):8.

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