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Association Between Composite Dietary Antioxidant Index and Endometriosis from NHANES 2001–2006: A Cross-Sectional Study

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Purpose: To evaluate the association between Composite Dietary Antioxidant Index (CDAI) and the risk of endometriosis in American women.

Methods: The study adopted a cross-sectional design, incorporating 3862 women aged over 20 years, selected from the National Health and Nutrition Examination Survey (NHANES) dataset from 2001 to 2006. Six dietary antioxidants were taken into account in calculating CDAI. Endometriosis was determined based on self-report. To evaluate the association between CDAI and the risk of endometriosis, we employed models with multivariable logistic variables. For subgroup assessment in relation to CDAI, a stratified multivariate logistic regression model was utilized.

Results: Among all participants, 273 participants (7.1%) were found to exhibit endometriosis. The preliminary analysis showed a reverse association between CDAI and the likelihood of endometriosis (odds ratio [OR] = 0.95; 95% confidence interval [CI]: 0.92~0.98). Upon full adjustment within the multivariable logistic regression, the ORs (95% CI) for endometriosis prevalence per unit increase in CDAI were estimated to be 0.96 (0.93~1). When the CDAI levels were divided into quartiles, it was found that the ORs for endometriosis with CDAI levels in Q2 (−2.131–0.023), Q3 (0.023–2.650), and Q4 (2.650–42.854) were 0.74 (0.52, 1.05), 0.76 (0.53, 1.1), and 0.53 (0.36, 0.79), respectively, compared to those with CDAI levels in Q1 (−7.151–−2.131). We evaluated the association between CDAI and endometriosis using subgroups stratified by age, race/ethnicity, education level, body mass index (BMI), oral contraceptive, and menopausal status, revealing a substantial negative relationship.

Conclusion: In this cross-sectional study, increasing CDAI was proportionally associated with a reduced risk of endometriosis among American women, suggesting a diet high in antioxidants may play an important role in reducing the risk of endometriosis. The findings of NHANES data spanning 2001 to 2006 suggest that promoting antioxidant-rich diets could be an important prevention strategy for endometriosis.

Keywords: composite dietary antioxidant index, endometriosis, National Health and Nutrition Examination Survey, cross-sectional study

Introduction

Endometriosis refers to the presence of functional endometrial-like tissue outside the uterus, causing symptoms such as pelvic pain, dysmenorrhea, and infertility.[1] Endometriosis is a chronic disease that is estrogen-dependent, with an increasing incidence rate among women of reproductive age, accounting for 6–10%.[2] However, current treatments for endometriosis, including surgical removal of lesions and drug therapy, have limited efficacy. The high incidence and recurrence rates of endometriosis result in long-term treatment that imposes a huge economic and social burden on individuals, families and society, and has a serious impact on the physical and psychological health of patients.[3] Finding new strategies for prevention and management to control endometriosis is crucial.

Apoptosis and proliferation of endometrial cells may be involved in the pathogenesis of endometriosis.[4] In addition, oxidative stress plays an important role in the pathogenesis of endometriosis.[5] Within intricate biological mechanisms,

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oxidative stress arises from an imbalance between reactive oxygen species production and antioxidant capabilities.[6] Several studies have demonstrated a significant correlation between heightened oxidative stress and endometriosis.[7,8] This phenomenon may contribute to the pathophysiology of endometriosis by triggering a widespread inflammatory reaction in the peritoneal cavity.[6] Antioxidants have been shown to inhibit lipid peroxidation and scavenge free radicals, thereby mitigating oxidative stress-induced damage.[9] Enhanced intake of antioxidants may lower oxidative stress levels in the body, potentially alleviating symptoms of endometriosis.

The Composite Dietary Antioxidant Index (CDAI) is a valid and reliable nutritional tool for assessing the overall antioxidant profile of a personal diet, and is a composite score for a wide range of dietary antioxidants, including vitamins A, C and E, manganese, selenium and zinc.[10] Previous research has demonstrated that supplementation with vitamin E and vitamin C can alleviate chronic pelvic pain in women with endometriosis.[11] Furthermore, a study indicated that administering a combination of vitamin E, vitamin C, selenium, and zinc to patients with endometriosis resulted in a reduction in disease severity.[12] Limited research has been undertaken on the association between CDAI and endometriosis. An analysis of data from the National Health and Nutrition Examination Survey (NHANES) was conducted to investigate potential links between CDAI and the onset of endometriosis, with the objective of mitigating the prevalence of the condition through dietary interventions.

Methods

Data Sources

During the NHANES, the US health and nutritional status of the non-institutionalized civilian population was analyzed in a series of complex, stratified, multistage, continuous, and nationally representative studies. In-depth details can be found in the methodological and analytical protocols of the NHANES. The NHANES collected comprehensive information on health topics, such as demographic factors, socioeconomic status, nutrition intake, and medical conditions through home interviews, which were further supplemented by blood tests. The National Center for Health Statistics research ethics review board approved the NHANES study protocol, and participants provided written informed consent at enrollment (the website is https://www.cdc.gov/nchs/nhanes/irba98.htm). Ethical approval and consent were not required as this study was based on publicly available deidentified data. The Ethics Committee of Deyang People's Hospital has granted an exemption from review for this particular study, ethics number was 2024–04-094.

Study Design and Population

The research scrutinized information gathered across three survey cycles of the NHANES, spanning from 2001 to 2006. The following exclusion parameters were set: individuals below the age of 20 (n = 16,739), males (n = 6945), participants lacking endometriosis data (n = 3411), absent CDAI component data (n = 79), missing demographic details such as race/ethnicity, education, marital status, and poverty income ratio (PIR) (n = 189), missing BMI data (n = 41), missing smoking data (n = 1), missing physical activity data (n = 1), and missing reproductive data (n = 59). In the end, 3589 individuals without endometriosis and 273 individuals with endometriosis participated in the study (Figure 1).

Measurement of CDAI

In the NHANES, participants were interviewed about their food consumption for 24 hours over the course of two consecutive days. The first recall interview took place in person, and the second took place by telephone within 3–10 days. Using data from dietary recalls for two days, average daily intakes were calculated. We calculated CDAI levels for all subjects based on a modified version.[10] Vitamins A, C, and E were included, as well as minerals from food sources (manganese, selenium, and zinc). Specifically, each antioxidant was standardized by subtracting the total mean and dividing the total standard deviation. Next, we summed the standardized intake of individual nutrient to obtain the CDAI according to the equation reported in previous study.[10]

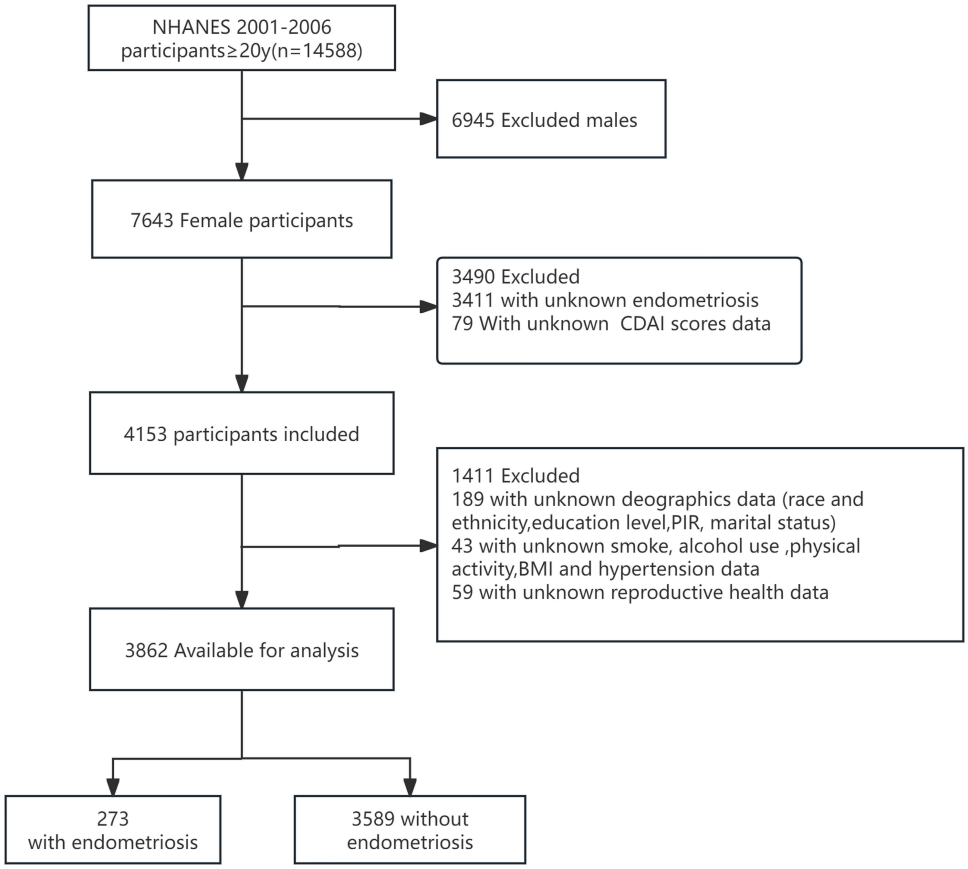

Figure 1 Flow chart of the participants selection.
Abbreviations: NHANES, National Health and Nutrition Examination Survey; CDAI, Composite Dietary Antioxidant Index, BMI, body mass index, PIR, poverty income ratio.

Endometriosis Assessment

The endometriosis metric, known in the survey as RHQ360, was determined based on answers to the Reproductive Health Questionnaire. If participants answered yes to the question, "Has a doctor or other health professional ever told you that you have endometriosis?", it was assumed they had endometriosis.

Covariates

Age, race/ethnicity, marital status, PIR, educational level, smoking status, alcohol drinker, BMI, physical activity, hypertension, age at menarche, menopausal status, at least one oophorectomy, uterine fibroids, and oral contraceptives were covariates in our study based on prior research.[13–15] Age at baseline was classified as 20–39, 40–49, and ≥50, based on the dates of birth and baseline assessment. Participants identified their own race or ethnicity as Mexican American, other Hispanic categories, non-Hispanic black, non-Hispanic white, or other groups. They indicated their marital status as married, never married, cohabitating with a partner, or within a category that covers widowed, divorced, or separated persons. Their level of education they had achieved was designated as below high school, high school or its equivalent, or something beyond high school. The PIR was segmented into groups of ≤1.30, 1.31–3.50, or >3.50. Smoking status was categorized into three groups: never (smoked less than 100 cigarettes in life), former (smoked more than 100 cigarettes in life and smoke not at all now), and now (smoked more than 100 cigarettes in life and smoke some days or every day).[16] Individuals disclosed their alcohol consumption habits, which were then classified into several groups: never drinkers (less than 12 total lifetime drinks), ex-drinkers (consumed 12 or more drinks within the past year but abstained last year, or lifetime consumption of 12 or more drinks with last year's abstinence), light drinkers (up to one drink daily for women), moderate drinkers (up to two drinks daily), and heavy drinkers (three or more daily drinks). BMI was calculated according to weight in kilograms (kg) divided by

the square of height in meters (m2), and was categorized into<25 kg/m^2, 25–29.9 kg/m^2, or ≥30 kg/m^2. Physical activity was classified as sedentary, moderate (at least 10 minutes of exercise in the past 30 days that caused only light sweating or a mild to moderate increase in breathing or heart rate), and vigorous (at least 10 minutes of activity in the past 30 days that caused heavy sweating or an increase in breathing or heart rate). It is defined as having a systolic blood pressure of at least 140 mmHg or a diastolic blood pressure of at least 90 mmHg, or taking antihypertensive medication, or having self-reported hypertension. Responses from the reproductive health questionnaire were used to know age at menarche, at least one oophorectomy, uterine fibroids, and oral contraceptives (variable names separately in the questionnaire: RHQ010, RHQ300, RHQ420 and RHQ380). Age at menarche, at least one oophorectomy, uterine fibroids, and oral contraceptives were separately obtained via the questions "How old were you when you had your first menstrual period?" "Have you had at least one ovary removed?" "Has a doctor or other health professional ever told you that you had uterine fibroids?" and "Have you ever taken birth control pills for any reason?". Regarding the classification of menopausal status (premenopausal and postmenopausal), women who report regular menstruation over the past year or who report irregular menstruation due to pregnancy, breastfeeding, or irregular menstrual cycles, are classified as premenopausal. Women who report the absence of menstruation over the past year due to menopause or having undergone bilateral oophorectomy are classified as postmenopausal. Women under the age of 50 who have not undergone bilateral oophorectomy or experienced the absence of menstruation for reasons other than menopause within the past year are categorized as premenopausal, while those aged 50 and above are classified as postmenopausal.

Statistical Analysis

Continuous variables are expressed as mean (standard deviation, SD) or median (interquartile range, IQR), while categorical variables are presented as frequency or percentage (n, %). When analyzing baseline characteristics, continuous variables that are normally distributed are tested using one-way analysis of variance (ANOVA), continuous variables that are not normally distributed are tested using the Kruskal–Wallis test, and categorical variables are tested using the chi-square test.

CDAI was included as a continuous variable and categorized in quartiles (Q1: −7.151 ≤ CDAI < −2.131; Q2: −2.131 ≤ CDAI < 0.023; Q3: 0.023 ≤ CDAI < 2.650; Q4: 2.650 ≤ CDAI < 42.854), and the first quartile was used as the reference. We employed a multivariable logistic regression analysis to explore the distinct association between CDAI and endometriosis risk, controlling for possible confounding variables. Adjustments were made to the three regression models by incorporating significant variables from the univariate regression analysis (P<0.05) or clinically meaningful variables (if P≥0.05). These confounders were also selected based on their association with the outcomes of interest or a change in effect estimate greater than 10%. The crude model was adjusted for no covariates. Model 1 was adjusted for age, race/ethnicity, PIR and educational level. Model 2 was further adjusted for physical activity, menopausal status, at least one oophorectomy, uterine fibroids, and oral contraceptives.

Additionally, we performed interaction analyses and stratified analyses, stratifying factors including age (20–39, 40–49, and ≥50 years), race (non-Hispanic white, others), education level (below high school, high school or its equivalent, or something beyond high school), BMI (<25 kg/m^2, 25–29.9 kg/m^2, or≥30 kg/m^2), oral contraceptive (yes or no), and menopausal status (yes or no). Except for the stratification factor itself, factors in Model 3 were adjusted for each stratification. The P values for the interaction terms between CDAI and the stratified factors were used to estimate the significance of the interactions. Additionally, we deleted all missing variables data, since they ranged from 0% to 4.5%.

Statistical evaluations were conducted with the aid of the R 4.2.2 software suite and Free Statistics software version 1.9.2. All participants were included in a descriptive study, and a statistically significant difference was defined as P< 0.05 (two-sided).

Results

Baseline Characteristics

The study included 3862 women aged over 20 years. Among all participants, 273 participants (7.1%) were found to exhibit endometriosis. Table 1 shows the foundational characteristics of subjects stratified by CDAI quartiles (Q1: −7.151 ≤ CDAI < −2.131; Q2: −2.131 ≤ CDAI < 0.023; Q3: 0.023 ≤ CDAI < 2.650; Q4: 2.650 ≤ CDAI < 42.854). The average age of the

Table 1 Characteristics of the Study Population According to CDAI Quartiles

Characteristic	Overall	Quartile1 (−7.151, −2.131)	Quartile2 (−2.131, 0.023)	Quartile3 (0.023, 2.650)	Quartile4 (2.650, 42.854)	*P*-value
N	3862	966	965	965	965	
Age, years	36.1 ± 10.4	36.4 ± 10.7	36.0 ± 10.6	36.1 ± 10.3	36.0 ± 10.2	0.894
Age, n (%)						0.043
<40	2416 (62.6)	573 (59.3)	589 (61)	613 (63.5)	641 (66.4)	
40–50	1005 (26.0)	267 (27.6)	269 (27.9)	246 (25.5)	223 (23.1)	
≥50	441 (11.4)	126 (13)	107 (11.1)	106 (11)	102 (10.6)	
Race and ethnicity, n (%)						< 0.001
Non-Hispanic White	1880 (48.7)	450 (46.6)	493 (51.1)	479 (49.6)	458 (47.4)	
Non-Hispanic Black	826 (21.4)	259 (26.8)	178 (18.4)	193 (20)	196 (20.3)	
Mexican American	827 (21.4)	179 (18.5)	220 (22.8)	208 (21.6)	220 (22.8)	
Other Hispanic	154 (4.0)	40 (4.1)	39 (4)	43 (4.5)	32 (3.3)	
Other Race	175 (4.5)	38 (3.9)	35 (3.6)	42 (4.4)	60 (6.2)	
Marital status, n (%)						0.002
Married	2179 (56.4)	489 (50.6)	562 (58.2)	551 (57.1)	577 (59.7)	
Never married	773 (20.0)	222 (23)	187 (19.4)	181 (18.8)	183 (18.9)	
Living with partner	367 (9.5)	94 (9.7)	89 (9.2)	86 (8.9)	98 (10.1)	
Other	543 (14.1)	161 (16.7)	127 (13.2)	147 (15.2)	108 (11.2)	
PIR, n (%)						< 0.001
≤1.30	1094 (28.3)	328 (34)	262 (27.2)	259 (26.8)	245 (25.4)	
1.31–3.50	1431 (37.1)	371 (38.4)	356 (36.9)	362 (37.5)	342 (35.4)	
>3.50	1337 (34.6)	267 (27.6)	347 (36)	344 (35.6)	379 (39.2)	
Educational level, n (%)						< 0.001
Less than high school	850 (22.0)	251 (26)	199 (20.6)	192 (19.9)	208 (21.5)	
High school or equivalent	841 (21.8)	269 (27.8)	219 (22.7)	185 (19.2)	168 (17.4)	
Above high school	2171 (56.2)	446 (46.2)	547 (56.7)	588 (60.9)	590 (61.1)	
Smoking status, n (%)						< 0.001
Never	2383 (61.7)	544 (56.3)	589 (61)	617 (63.9)	633 (65.5)	
Former	635 (16.4)	129 (13.4)	161 (16.7)	168 (17.4)	177 (18.3)	
Now	844 (21.9)	293 (30.3)	215 (22.3)	180 (18.7)	156 (16.1)	
Alcohol drinker, n (%)						0.069
Never	693 (17.9)	191 (19.8)	158 (16.4)	180 (18.7)	164 (17)	
Former	623 (16.1)	154 (15.9)	144 (14.9)	147 (15.2)	178 (18.4)	
Mild	947 (24.5)	216 (22.4)	260 (26.9)	240 (24.9)	231 (23.9)	
Moderate	797 (20.6)	184 (19)	202 (20.9)	196 (20.3)	215 (22.3)	
Heavy	802 (20.8)	221 (22.9)	201 (20.8)	202 (20.9)	178 (18.4)	
BMI(Kg/m2), n (%),						0.395
<25	1343 (34.8)	322 (33.3)	330 (34.2)	360 (37.3)	331 (34.3)	
25–30	1084 (28.1)	264 (27.3)	287 (29.7)	258 (26.7)	275 (28.5)	
≥30	1435 (37.2)	380 (39.3)	348 (36.1)	347 (36)	360 (37.3)	
Physical activity, n (%)						< 0.001
Sedentary	1374 (35.6)	411 (42.5)	325 (33.7)	332 (34.4)	306 (31.7)	
Moderate	1251 (32.4)	288 (29.8)	305 (31.6)	322 (33.4)	336 (34.8)	
Vigorous	1237 (32.0)	267 (27.6)	335 (34.7)	311 (32.2)	324 (33.5)	
Hypertension, n (%)						0.12
NO	3050 (79.0)	737 (76.3)	766 (79.4)	771 (79.9)	776 (80.3)	
YES	812 (21.0)	229 (23.7)	199 (20.6)	194 (20.1)	190 (19.7)	
Age at menarche, years	12.6 ± 1.7	12.5 ± 1.8	12.5 ± 1.6	12.6 ± 1.7	12.6 ± 1.7	0.83
Menopausal status, n (%)						< 0.001
Premenopausal	3446 (89.2)	836 (86.5)	850 (88.1)	874 (90.6)	886 (91.7)	
Postmenopausal	416 (10.8)	130 (13.5)	115 (11.9)	91 (9.4)	80 (8.3)	

(*Continued*)

Table 1 (Continued).

Characteristic	Overall	Quartile1 (−7.151, −2.131)	Quartile2 (−2.131, 0.023)	Quartile3 (0.023, 2.650)	Quartile4 (2.650, 42.854)	*P*-value
At least one oophorectomy, n (%)						< 0.001
NO	3565 (92.3)	857 (88.7)	884 (91.6)	914 (94.7)	910 (94.2)	
YES	297 (7.7)	109 (11.3)	81 (8.4)	51 (5.3)	56 (5.8)	
Uterine fibroids, n (%)						0.156
NO	3371 (87.3)	850 (88)	826 (85.6)	837 (86.7)	858 (88.8)	
YES	491 (12.7)	116 (12)	139 (14.4)	128 (13.3)	108 (11.2)	
Oral Contraceptive, n (%)						0.019
NO	885 (22.9)	257 (26.6)	210 (21.8)	208 (21.6)	210 (21.7)	
YES	2977 (77.1)	709 (73.4)	755 (78.2)	757 (78.4)	756 (78.3)	
CDAI	0.0 (−2.1, 2.6)	−3.3 (−4.2, −2.7)	−1.1 (−1.6, −0.5)	1.2 (0.6, 1.9)	4.9 (3.7, 7.2)	< 0.001
Endometriosis, n (%)						0.002
NO	3589 (92.9)	876 (90.7)	893 (92.5)	901 (93.4)	919 (95.1)	
YES	273 (7.1)	90 (9.3)	72 (7.5)	64 (6.6)	47 (4.9)	

Abbreviations: NHANES, National Health and Nutrition Examination Survey; CDAI, Composite Dietary Antioxidant Index, PIR, poverty income ratio, BMI, body mass index.

participants was 36.1 ± 10.4 years. Subjects in the highest CDAI quartile (Q4) exhibited a greater propensity among participants who were younger, non-Hispanic White, married, college-educated, non-smokers, wealthier, with moderate physical activity, premenopausal, without ovary removal, with oral contraceptives and without endometriosis, in contrast to those in the lowest quartile (Q1) (all *P* values < 0.050). Nevertheless, there were no statistically significant variances in alcohol use, BMI, hypertension, age at menarche, and uterine fibroids across the four groups (all *P* values > 0.05).

Association of CDAI and Endometriosis

Table 2 presents the outcomes of the multivariable logistic regression analyses. We evaluated the association between CDAI and endometriosis using three different models with different confounders. The preliminary analysis showed a reverse association between CDAI and the likelihood of endometriosis (odds ratio [OR] = 0.95; 95% confidence interval [CI]: 0.92~0.98). Upon full adjustment within the multivariable logistic regression, the ORs (95% CI) for endometriosis prevalence per unit increase in CDAI were estimated to be 0.96 (0.93~1). In conducting sensitivity analysis, the CDAI was transformed from a continuous variable to a categorical variable in quartiles. Results indicated that the ORs for endometriosis with CDAI levels in Q2 (−2.131–0.023), Q3 (0.023–2.650), and Q4 (2.650–42.854) were 0.74 (0.52, 1.05), 0.76 (0.53, 1.1), and 0.53 (0.36, 0.79), respectively, compared to those with CDAI levels in Q1 (−7.151–−2.131).

Table 2 Association of Composite Dietary Antioxidant Index and Endometriosis

	Crude model		Model 1[a]		Model 2[b]	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR(95% CI)	*P* value
CDAI	0.95 (0.92~0.98)	0.003	0.95 (0.92~0.99)	0.009	0.96 (0.93~1)	0.044
Lowest quartiles	1(Ref)		1(Ref)		1(Ref)	
2nd	0.78 (0.57~1.08)	0.142	0.76 (0.54~1.06)	0.106	0.74 (0.52~1.05)	0.093
3rd	0.69 (0.5~0.97)	0.03	0.69 (0.49~0.97)	0.033	0.76 (0.53~1.1)	0.148
4th	0.50(0.35~0.72)	<0.001	0.51 (0.35~0.74)	<0.001	0.53 (0.36~0.79)	0.002
Trend test	0.80 (0.72~0.9)	<0.001	0.81 (0.72~0.91)	<0.001	0.83 (0.74~0.94)	0.004

Notes: Crude model: No covariate were adjusted. [a]Adjusted for age, race/ethnicity, PIR and educational level. [b]Adjusted for age, race/ethnicity, PIR, educational level, physical activity, menopausal status, at least one oophorectomy, uterine fibroids, oral contraceptives.

Abbreviations: PIR, poverty income ratio, BMI, body mass index, CDAI, Composite Dietary Antioxidant Index; OR, odd ratio; CI, confidence interval.

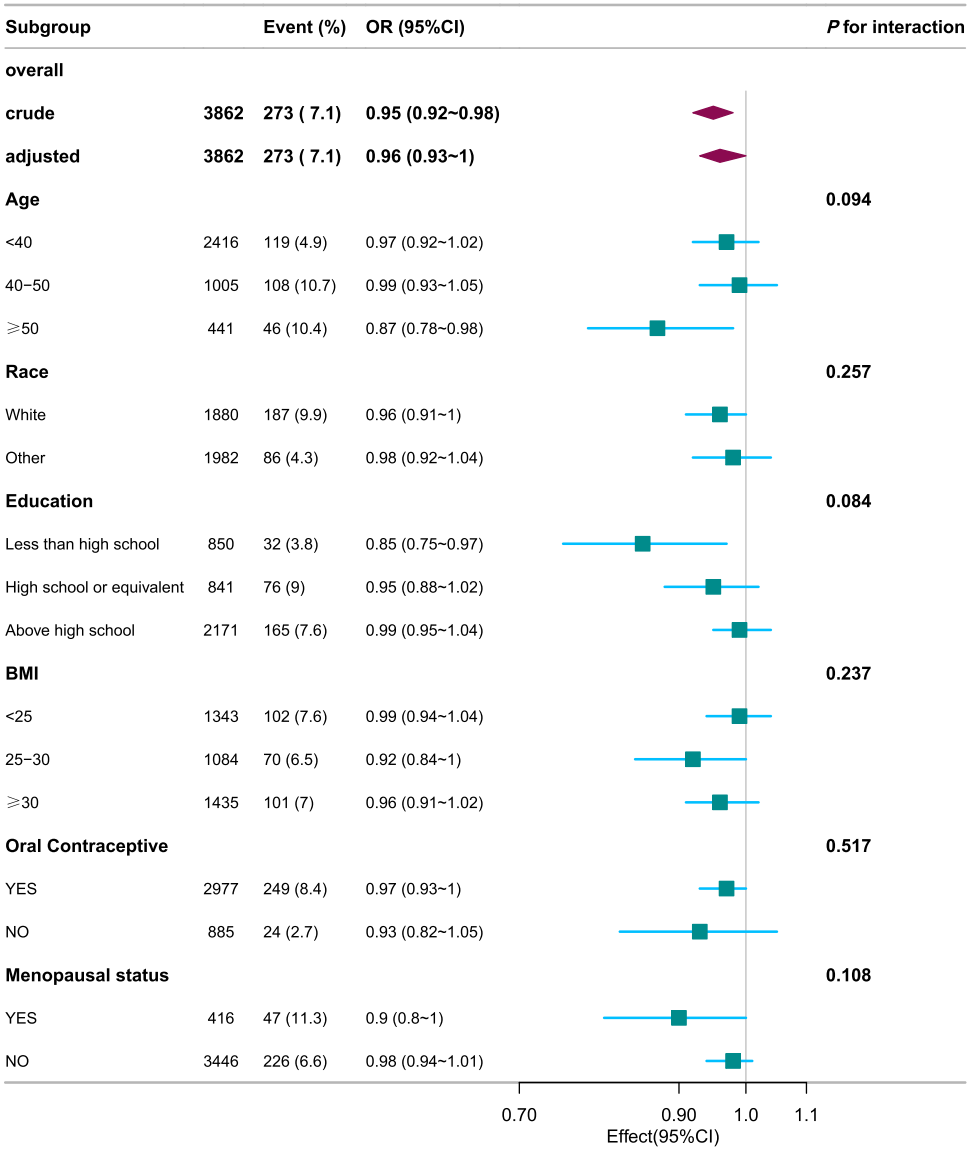

Figure 2 Subgroup analysis of the association of Composite Dietary Antioxidant Index and endometriosis. Each stratification was adjusted for for age (as a continuous variable), race/ethnicity, PIR, educational level, physical activity, menopausal status, at least one oophorectomy, uterine fibroids, and oral contraceptives.

Subgroup Analysis

Subgroup analysis results are displayed (Figure 2). We evaluated the association between CDAI and endometriosis using subgroups stratified by age, race/ethnicity, education level, BMI, oral contraceptive, and menopausal status, revealing a substantial negative relationship.

Discussion

The prevalence of endometriosis was estimated to be 7.1% among women in this cross-sectional study (mean age, 36.1 ± 10.4 years), which was within the reported national prevalence (6–10%).[2] We found that as the level of CDAI increased, a valid and reliable nutritional tool for assessing the overall antioxidant profile of an individual's diet, there was an observable downward trend in the risk of endometriosis among US women. Even after adjusting for potential confounding factors, this association remains significant, which showed each unit increase in CDAI was associated with a 4% decrease in the risk of endometriosis. All subgroup analyses revealed a substantial negative relationship. According to this study, CDAI may provide protection against developing endometriosis.

This imbalance between antioxidants and pro-oxidants, known as oxidative stress, can result in damage to tissues and organs. The accumulation of reactive oxygen species (ROS) can lead to oxidative damage to DNA, proteins, carbohydrates, and lipids, as well as apoptosis and organ dysfunction.[17] The regulation of plasma redox state by diet serves as an external factor that protects against reactive oxygen species (ROS) and reactive nitrogen species. Antioxidants play a crucial role in maintaining biological stability by scavenging oxidants and preventing oxidative stress.[18] Several studies indicate that oxidative stress is implicated in the pathogenesis and progression of endometriosis.[5,19,20]

Among American women who participated in the NHANES from 2001 to 2006, this is the first study to examine the relationship between CDAI and endometriosis. Although the relationship between CDAI levels and endometriosis risk remains inconclusive, there has been extensive discussion on the potential benefits of dietary antioxidants. A study involving 60 reproductive-aged women (15–45 years) demonstrated that the consumption of vitamin C and vitamin E supplements effectively alleviated dysmenorrhea severity and improved dyspareunia and pelvic pain, common symptoms of endometriosis.[21] Furthermore, an experimental animal study indicated that vitamin C supplementation significantly reduced the volume and weight of endometriosis cysts.[22] Moreover, the Nurses' Health Study II found that individuals with endometriosis had lower magnesium intakes from foods, including fortified foods.[23] Additionally, some studies reported a 22% and 43% decrease in serum zinc concentrations in endometriosis patients compared to a control group.[24,25] A study also noted reduced levels of vitamins A, C, E, zinc, and selenium in individuals with endometriosis compared to those with tubal infertility.[26] The findings of these studies are consistent with our own observations.

The administration of multivitamins and minerals is thought to enhance the antioxidant defense mechanisms in women with endometriosis by mitigating oxidative stress. Specifically, vitamins C and E, known for their antioxidant properties, have been associated with cellular proliferation in the presence of chronic inflammation and reactive oxygen species (ROS) in endometriosis. This interaction may be pivotal in the growth and propagation of cells, ultimately leading to a decrease in endometriosis. The antioxidant capabilities of these vitamins may also alleviate the clinical manifestations of endometriosis.[27] Zinc is known to be essential in various cellular processes, with its deficiency linked to elevated levels of inflammatory cytokines and markers of inflammation like interleukin (IL)-6 and IL-8 in both in vitro and in vivo studies.[28] Furthermore, zinc is involved in the regulation of redox homeostasis through the activation of antioxidant enzymes.[29] A study suggests that individuals with endometriosis experience irregular and spasmodic contractions of their fallopian tubes, and that magnesium may alleviate endometriosis by relaxing smooth muscle and reducing retrograde menstrual blood flow, a primary contributor to the condition.[30] Research conducted both in vitro and in vivo suggests that selenium plays a role in regulating various proteins, leading to the reduction of inflammation.[31]

This study presents both strengths and limitations. Firstly, this is the inaugural investigation to explore the correlation between CDAI and endometriosis within a representative sample of the United States. Secondly, the utilization of the NHANES database facilitated meticulous screening of measurement techniques and protocols. Additionally, adjustments were made for confounding variables across various subgroups to ensure the validity of the findings. Nevertheless, the study is constrained by certain limitations, such as the exclusive representation of American adults in the NHANES dataset, thereby restricting the generalizability of the results to other populations. Furthermore, the cross-sectional design of NHANES restricts the ability to draw definitive conclusions regarding a causal relationship between CDIA and endometriosis. Additionally, potential misclassification of endometriosis cases may have occurred as all cases were self-reported rather than confirmed through surgical means. Finally, we take into account patients with a diagnosis of endometriosis and thus missing all the patients with endometriosis not yet diagnosed.

Conclusion

In this cross-sectional study, increasing CDAI was proportionally associated with a reduced risk of endometriosis among US women, suggesting a diet high in antioxidants may play an important role in reducing the risk of endometriosis. The findings of the NHANES data spanning 2001 to 2006 suggest that promoting antioxidant-rich diets could be an important prevention strategy for endometriosis.

Data Sharing Statement

Data compiled or examined in this study are contained within the article that has been made public. The corresponding author is available for additional questions.

Ethics Approval and Informed Consent

Every individual involved provided their signed acknowledgment of informed consent, while the NCHS Ethics Review Board approved the survey procedures. All the techniques utilized during the research adhered to the appropriate rules and directives. Consent for publication Not applicable.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The researchers state to have no conflicts of interest.

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