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Association between adhering to a dietary approach to stop hypertension and risk of colorectal cancer: a systematic review and meta-analysis

Mohammad Mehdi Abbasi[1†], Paria Babaahmadi[2†], Fateme Nozari[3†], Farbod Khosravi[4], Zahra Golkar[5], Zahra Tavasoli[6], Venus Alizadeh[4], Marieh Nouriani[7], Mohammadsadegh Jafari[8], Niloufar Shabani[9], Hadis Hashemi Nezhad[10], Hossein Soltaninejad[11*] and Mohammad Rahmanian[12*]

Abstract

Background Colorectal cancer (CRC) is a high incidence cancer and health problem influenced by many factors emphasizes on the importance of identifying risk factors which can be modified. A dietary approach to stop hypertension (DASH) style promotes a balanced nutrition approach that might have effects on CRC. The aim of this study was to analyze existing evidence on the DASH diet's association with CRC.

Methods Databases, including Scopus, Web of Science, and PubMed, were searched to identify eligible studies up to March 2025. Observational studies investigating the association between adherence to the DASH diet and CRC were included. Effect sizes (ESs) and their confidence intervals (CIs) from fully adjusted models were extracted for the meta-analysis. A random-effects model was employed to calculate the combined ES and assess the relationship between the DASH diet and CRC. The publication bias was assessed using Egger's test and heterogeneity between studies was examined using the I^2 statistic.

Results Fourteen studies were included in this study. Adherence to DASH diet reduced CRC risk (RR = 0.81, 95% CI: 0.73–0.89). Subgroup analyses found consistent effects across cohorts and various factors, with no publication bias. For rectal cancer (RC), adherence to DASH dietary pattern reduced risk of RC (RR = 0.75, 95% CI: 0.66–0.86), particularly in males and cohort studies. Colon cancer risk was also reduced (RR = 0.83, 95% CI: 0.79–0.88), with stronger effects in males and cohort studies. For colorectal adenoma, DASH showed a significant risk reduction (RR = 0.42, 95% CI: 0.22–0.80).

Conclusions Our results highlight that following the DASH diet has a significant effect on lowering the risk of CRC which aligns with previous research. These findings support recommendation of following the DASH diet pattern reduces the burden of CRC.

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†Mohammad Mehdi Abbasi, Paria Babaahmadi and Fateme Nozari are co-first authors.

*Correspondence:
Hossein Soltaninejad
hossein.soltani@modares.ac.ir
Mohammad Rahmanian
mmdrahmanian@sbmu.ac.ir
Full list of author information is available at the end of the article

Keywords Dietary approaches to stop hypertension, Rectal neoplasms, Colonic neoplasms, Colorectal neoplasms, Meta-analysis

Introduction

Colorectal cancer (CRC) is a major health challenge particularly during the past decades as the third most common cancer worldwide and a prominent cause of cancer-related deaths [1]. It is estimated that between 24 and 47% of people aged 50 years or older with an average-risk, who are also asymptomatic, have adenomatous polyps. Adenomatous polyps considered as valuable findings since they1 are recognized as precursors to colorectal cancer [2]. Despite all progress in screening methods and therapeutic interventions, the increasing incidence of CRC [3] highlights the urgent need to identify modifiable risk factors and implement preventive measures. Several factors are involved in colorectal carcinogenesis, such as genetics, age, unfavorable socioeconomic conditions, alcohol consumption, tobacco smoking, inflammatory bowel disease, obesity, dietary factors, and physical inactivity [4]. However, some protective elements exist that reduce the risk of CRC, such as lowering body weight, higher intake of antioxidants, calcium, and folate as well as higher intake of vegetables and fruits [5, 6]. Epidemiological research highlights the crucial role of dietary elements in the etiology of CRC [7, 8], and it is believed that diet is involved in more than 40% of new cases and fatalities associated with CRC [9] and that adherence to a specific dietary pattern which consists of different elements might be easier to follow and have a stronger effect on overall health than of one specific nutrient [10, 11].

The Dietary Approaches to Stop Hypertension (DASH) eating pattern is known for its nutrient-dense composition. It was introduced at the beginning to maintain hypertension and reduce the risk of cardiovascular diseases but has transformed into a comprehensive dietary framework linked to various health advantages, due to its potential protective effects against several chronic diseases [12, 13].

This regimen has some basic characteristics, including greater levels of fruits, vegetables, lean proteins, whole grains, nuts, and low-fat dairy products intake while promotes low consumption of saturated fats, cholesterol, and sodium [12].

A high-fiber DASH diet may mitigate gut infections by promoting a healthy gut microbiota, fostering the proliferation of beneficial bacteria with anti-inflammatory and antipathogenic characteristics, and enhancing the synthesis of short-chain fatty acids that bolster digestive health [14].

Furthermore, DASH's focus on antioxidant-dense meals like fruits and vegetables might reduce oxidative stress, a significant factor in carcinogenesis [7].Reducing intake of red and processed meats also reduces exposure to carcinogens such as heterocyclic amines and N-nitroso compounds, which are connected to the development of colorectal cancer [15].

Additionally, since metabolic disorders are known to be a risk factor for colorectal cancer, the diet's ability to improve metabolic health—including increased insulin sensitivity and decreased obesity risk—may add to its protective benefits [12, 16].

Adherence to this diet evaluates via four indexes, Dixon's DASH index, Mellen's DASH index, Fung's DASH index, and Günther's DASH index. These scales are for quantifying adherence to DASH diet style via different guidelines that assess dietary pattens in relation to health issues and they all have different methodologies, scoring systems, and components [17].

Additionally, it is associated with better glycemic control, lower risks of diabetes mellitus(type II) or higher insulin sensitivity, and the ability to manage body mass [18], it may also contribute in protection against CRC, since metabolic disturbances are recognized as risk factors for CRC [12, 16]. This is particularly pertinent given that different habits such as high vegetable and fruit consumption, and low meat consumption, are associated with the etiology of this malignancy [18, 19].

The existing evidence on the association between adherence to the DASH diet and CRC risk remains inconclusive. Some studies demonstrate a significant protective effect, while others report weaker correlations or findings that vary by gender [19, 20], the lack of consensus underscores the need for a comprehensive synthesis of available data. This systematic review and meta-analysis aim to determine the associations between following the DASH diet and CRC on the basis of available evidence and offers a comprehensive analysis of the DASH dietary role in CRC prevention, with the aim of informing dietary guidelines and public health strategies to reduce the global burden of CRC.

Materials and methods

This review was conducted on the basis of Cochrane handbook [21] and PRISMA 2020 standards (Online Resource-Table 1) [22]. Our protocol which describes the inclusion criteria, search technique, and outcomes, was filed in the International Prospective Register

of Systematic Reviews (PROSPERO, registration ID: CRD42024569140) before the review's execution.

Search strategy

A systematic literature search was performed using the Scopus, Web of Science, PubMed, and Google Scholar databases, covering the period from up to April 2024. The details regarding the number of search results can be found in the Appendix. The search was updated at March 2025.

The electronic database search involved the use of both MeSH and free-text terms related to"colorectal cancer"and"DASH Diet"(Online Resource-Table 2). We used backward and forward citation research strategies to increase the depth of our literature search. To ensure that, important and foundational earlier research is included, backward citation searching is looking through the references of the included studies to locate additional relevant works that may have been initially overlooked. Newer research that has cited the included studies since their publication can be found through forward citation searching. This approach assists in capturing the most recent advancements in research as well as new trends by utilizing resources such as Google Scholar and Web of Science.

Eligibility criteria and study selection

First, two independent reviewers (F.Kh and Z.T) screened the previous studies on the basis of titles and abstracts and then, a secondary screening for full-text availability was performed. Conflicts were resolved via conversation, reaching a consensus, or seeking assistance from an external party (M.R). Studies were chosen on the basis of specific inclusion criteria: they investigated the association between the DASH dietary pattern and CRC through observational studies (case–control and cohort studies), and they reported primary outcomes as hazard ratios (HRs), odds ratios (ORs), or relative risks (RRs) with their corresponding 95% confidence intervals (CIs). Studies excluded from consideration lacked primary data, such as reviews, animal studies, interventional studies, cellular and molecular studies, and case reports, as well as notes, letters, conference papers, books, editorials, and studies conducted in other languages than English.

Data extraction and synthesis

Both reviewers (F.Kh and Z.T) independently assessed and extracted relevant details from every study that met the inclusion criteria. The publication year, first author's last name, study design, number of participants, exposure assessment method, length of the follow-up period, sex distribution, covariate adjustments, outcome assessment method, quality score of each study, and reported risk estimates (HR, OR, or RR) with corresponding 95% confidence intervals (CIs) were among the details extracted from the data.

Assessment of the risk of bias

Two investigators (S.M and Z.G) independently assessed the methodological quality of the retrieved studies. The quality of each cohort study was assessed using ROBINS-E [23]tool that includes seven main domains and others were evaluated using the Newcastle–Ottawa Scale (NOS) criteria, which are designed specifically for evaluating methodological quality [24]. The assessment was on the basis of eight criteria, focusing on three main aspects: 1) a scale of 0–4 points for rating the selection of study groups; 2) a scale of 0–2 points for evaluating the comparability of participants; and 3) a scale of 0–3 points for assessing clinical outcomes. The highest possible score is 9, with scores ranging from 7–9 as high quality, 4–6 as moderate quality, and 0–3 as low quality.

Statistical analysis and data synthesis

For each study, the effect sizes (ESs) were indicated using relative risks (RRs), odds ratios (ORs), and hazard ratios (HRs) with their respective 95% confidence intervals (CIs). A random-effects model was calculated the combined ES for the comparison between the highest and the lowest DASH diet categories, considering the heterogeneity between studies [25]. The random-effects model was applied to determine both the I^2 values and the Q-statistic as measures of heterogeneity. I^2 values under 50% were interpreted as no heterogeneity between studies, otherwise, they were considered high degrees of heterogeneity [26] and in the presence of significant heterogeneity, subgroup analyses were performed on the basis of factors such as participants'gender, sample size, geographical location, methods of assessing DASH diet adherence, type of effect size, study design, and adjustments for confounders like energy intake to find the major causes of heterogeneity.

Publication bias was also assessed via Begg's and Egger's regression asymmetry methods [26]. The overall effect was analyzed using the trim-and-fill method to identify the impact of probable missing studies [27].

A sensitivity analysis was performed using a fixed-effects model by excluding each study in turn, to determine if there is any particular effect of each study. Statistical analyses were conducted using STATA version 14.0, and statistical significance was defined as $P < 0.05$ for all tests, including Cochran's Q test.

Results

Study selection

A number of 143 papers were included in the process of our analysis during the first database search. After duplicates were omitted, 96 articles remained. Seventy-four studies were excluded because of title and abstract.

Furthermore, twenty-two remained for full text evaluation, eight more articles were excluded because four reported CRC survival, two were not related and did not meet the criteria, one reported DASH only as a covariant the other one was similar. Finally, 14 articles were eligible for inclusion in our systematic review and meta-analysis (Fig. 1).

Study characteristics

Among the remaining articles eight were cohort studies [19, 28–34], four were case–control studies [4, 20, 35, 36], one was cross-sectional study [16] and another one was a comparative analysis article [37] (Table 1). With respect to outcomes based on the anatomical location of cancer, nine studies evaluated colorectal cancers [20, 28–30, 32, 34–37], four articles reported rectal cancer (RC) as an outcome [28, 30, 36, 37], three evaluated colon cancer (CC) [28, 36, 37] and two other articles reported colorectal adenoma (CRA) [4, 35].

A total of 1,732,661 participants aged between 25 and 79 years with a follow-up duration of 11 to 26 years were evaluated in cohort studies.

Eight studies were conducted in the USA [4, 19, 28–31, 33, 37], two in Iran [20, 35] one each in China [32],Germany [16], Canada [36], and the UK [34]. Six studies involved both genders [19, 28, 30–32, 34] whereas two were conducted only on female participants [29, 33].

7093 cases and 37,450 controls were included in the case–control studies two of which were carried out in Iran [20, 35] one each in the USA [4] and Canada [36]. There were 14,309 participants in the one cross-sectional study which was conducted in Germany [16] and 218,181 participants in comparative analysis performed in the USA [37]. All six studies were conducted on both genders.

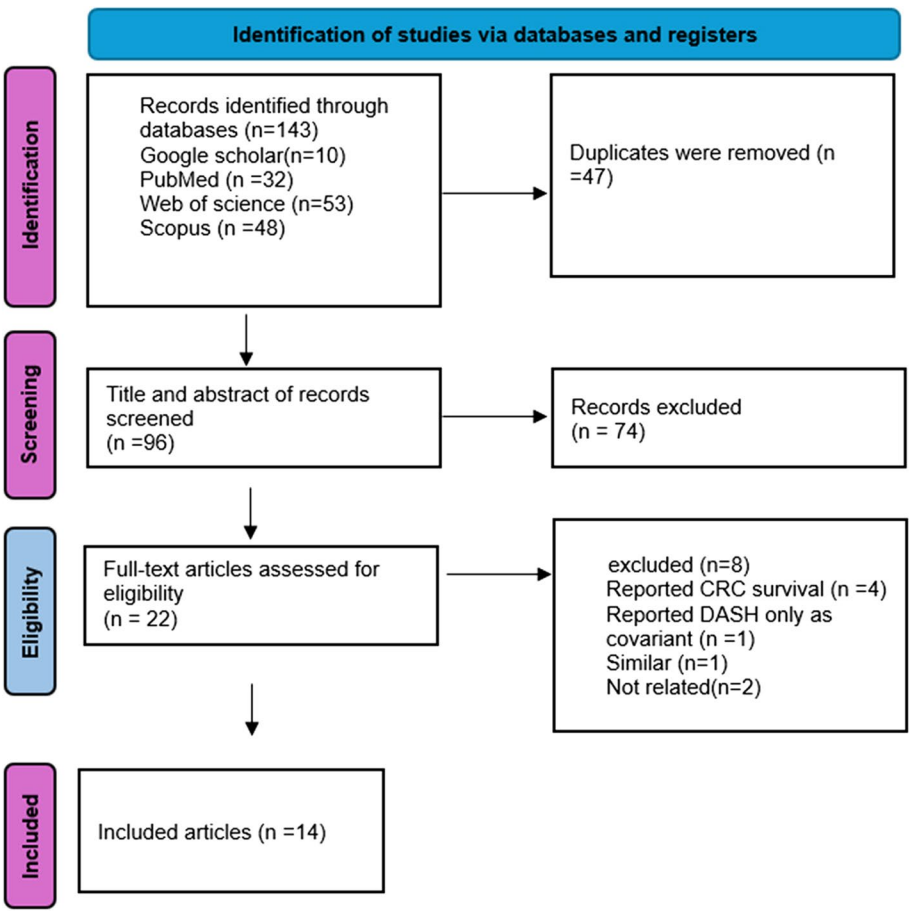

Fig. 1 Prisma flow diagram of study selection

Table 1 Characteristics of included studies

Author	Country	Type of study	Follow up duration	Population	Gender(female%)	Adjustments	Outcomes	Quality score
Cai et al., [34] 2024	UK	cohort	11.70 years	105,463	51.9%	Age, physical activity, Townsend deprivation index, gender, ethnicity, family history of GIC, heart diseases, smoking history, history of DM, HTN, heart disease, education status, alcohol consumption, BMI, energy intake	Following hPDI and DASH diet style is related to some kind of cancers in GI system Lowest risk of GI cancers among individuals with lower genetic risks and higher dietary scores	9
Yarmand et al., [20] 2024	Iran	case–control	-	213	50.7%	Fiber intake, smoking history, taking ibuprofen- acetaminophen, taking mineral supplement, taking aspirin, income, education status, using vegetables, positive family history of CRC in relatives	Following DASH dietary style is related to a higher Odds ratio of CRC No meaningful association with CRCs following MED dietary style	6
Wang et al., [37] 2023	USA	comparative analysis	24 years	218,181	77.81%	Age, physical activity, drinking alcohol, total energy intake, smoking history, regular usage of aspirin- NSAID-multivitamin, HRT after menopause, history of sigmoidoscopy or colonoscopy, positive history of CRC in first degree relatives	Following DASH dietary style might help preventing CRC Following a Western dietary style, EDIP, and EDIH are related to higher risks of CRC	8
Jafari Nasab et al., [35] 2021	Iran	Case control	-	499	48.29%	Smoking history, Socioeconomic status, medical history, family history of CRC and other cancers, alcohol, BMI, age, and usual cooking techniques	Following DASH dietary style might help preventing CRC and CRA, among men and women	6
Zheng et al., [33] 2021	USA	cohort	12 years	116 430	100%	Age, BMI, physical activity, total caloric intake, alcohol intake endoscopy (causes, the most recent one, time period, number of reported endoscopies, last time it performs) height, family history of colorectal cancer, menopausal status, smoking habits(pack/years), current use of multivitamin, regular use of aspirin, and regular use of NSAIDS	Western diets have higher risks of CRC DASH, prudent pattern, AMED and AHEI- 2010 scores is inversely associated with early-onset high-risk adenoma despite low-risk adenoma	8

Table 1 (continued)

Author	Country	Type of study	Follow up duration	Population	Gender(female%)	Adjustments	Outcomes	Quality score
Nguyen et al., [32] 2020	China	cohort	13.4 years	132,606	54.63%	Education levels, metabolic conditions, total of energy intake, multivitamins usage, income levels, smoking history, physical activity, alcohol intake, BMI, and family history of CRC	Higher CHFP scores is followed by 23% lower risks of rectal cancer, and 15% lower risk of CRC The modified AHEI- 2010 and the modified DASH compliance scores: not associated with CRC risk	7
Petimar Joshua et al., [31] 2018	USA	cohort	26 years	124,707	62.55%	Alcohol intake, total energy intake, smoking history, physical activity, NSAID use, previous CRC screening via sigmoidoscopy or colonoscopy, history of polyps, family history of CRC, multivitamin use, BMI, and calcium supplementary intake	Following DASH, AMED, and AHEI- 2010 diets is related to a lower CRC risk in men, however it has no association in women	8
Erben et al., [16] 2018	Germany	cross- sectional study	8 years	14,309	49.9%	Sex, age, smoking history, education, physical activity, BMI, NSAIDs, hormone replacement therapy in women only, family history of CRC, history of colonoscopy, diabetes and alcohol intake (only for vegetarian/semi-vegetarian pattern)	Following a high HEI or DASH diet style is related to lower risks of advanced colorectal neoplasms	9
Park et al., [30] 2017	USA	Cohort	16 years	190,949		Colorectal polyps and colorectal cancers, smoking history (pack-years of), NSAIDS use, multivitamin use, alcohol intake, physical activity, BMI, hormone replacement therapy, and total energy, For the HEI- 2010 and DASH score models	All 4 DQIs (DASH, AHEI- 2010, HEI- 2010, MED) have protective effects on colorectal cancer in both genders	7
Jones-McLean et al., [36] 2015	Canada	Case control	-	6268	44.94%	Age, BMI, education, smoking history (pack-years), age of first pregnancy in women, calcium supplementation, moderate and strenuous activity, different provinces	Following a DASH diets leads to lower risks of CRC in men; however, it has no association in women	8
Vargas et al., [29] 2016	USA	cohort	12.4 years	78,273	100%	Ethnicity/race, Age, level of education, physical activity, hormone replacement therapy, smoking history	High score of DASH, and HEI- 2010 is related to lower risks of colon cancer, however, there is no association with aMED or AHEI	7

Table 1 (continued)

Author	Country	Type of study	Follow up duration	Population	Gender(female%)	Adjustments	Outcomes	Quality score
Miller et al., [28]2013	USA	cohort	11 years	491,841	40.37%	BMI, physical activity, education, total energy intake, alcohol intake, ethnicity, smoking history, age at entry, and in the case of women, HRT in woman after menopausal	There are lower risks of CRC in women with highest score in 3 indexes of DASH, and men with the highest scores on all 4 indexes	6
Fung et al., [19] 2010	USA	cohort	26 years	132,392	65.94%	BMI, and energy intake, age, physical activity, family history, alcohol intake, history of polyps, colonoscopy, multivitamin use, aspirin use, and smoking history	Inverse association with risk of colorectal cancer: DASH: YES, aMed: no/discriminating power: DASH > aMed	8
Dixon et al., [4] 2007	USA	Case control	7 years	3592	35.38%	Center, education, current BMI, smoking status, age, HRT use in women, race, energy intake, physical activity, ibuprofen; aspirin; and calcium supplement use	Lower risks of CRA in men following USDA Guide, MED dietary pattern, DASH dietary pattern/Impact on ↓ risk of CRA in Men: USDA > DASH > MED	7

DASH Dietary Approaches to Stop Hypertension, *GIC* gastrointestinal cancers, *CRC* Colorectal cancer, *MED* Mediterranean diets, *EDIH* Empirical dietary index for hyperinsulinemia, *EDIP* Empirical dietary inflammation pattern, *CRA* colorectal adenomas, *AMED* Alternative Mediterranean diet, *AHEI* Alternative Healthy Eating Index, *CHFP* Chinese Food Pagoda, *HEI* Healthy Eating Index, *DQIs* diet quality indexes, *hPDI* healthful Plant based diet Index, *HRT* Hormone Replacement Therapy

Quality assessment

Based on the ROBINS-E tool, all cohort studies had low risk of biases except the study by Miller et al. [28] which had moderate risk of bias. Moreover, on the basis of NOS quality assessment, this meta-analysis includes 4 case-controls studies of high quality (NOS score ≥7) [4, 16, 36, 37] and 2 studies of moderate quality (NOS score 5–6) [20, 35] (Tables 2, and 3).

All involved case–control articles were scored between 6 and 9, with a mean of 7.3, indicating a minimal likelihood of bias. Most of the studies (4 out of 6) are of high quality. They performed well in certain selection criteria (S1, S2, S4), comparability criteria (C1), and certain outcome criteria (O2, O3). Moderate-quality studies lost points often in certain outcome criteria (O1, O3).

Most studies scored highly in the comparability criteria (C1) and outcome criteria (O1, O2, O3), indicating a strong methodological design and reliable outcome measures. Some studies had lower scores in specific selection criteria (S3), which could impact the exposure ascertainment.

The certainty of evidence for each outcome (CRC, RC, CC, and CRA risk) was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. This framework evaluates evidence quality based on risk of bias, inconsistency, indirectness, imprecision, and publication bias. Observational studies started at'low'certainty and were upgraded as warranted based on factors such as large effect sizes or dose–response relationships, following GRADE guidelines [38].

Findings

Colorectal cancer

Thirteen effect sizes from nine articles were included in our meta-analysis evaluating the relationship between adherence to the DASH dietary pattern and the risk of CRC. Our analysis revealed that following the DASH dietary style lowered the risk of CRC among all subjects (RR (95%CI) =0.81, (0.73–0.89)) with significant heterogeneity between studies (I_2= 76.9%, $P_{heterogeneity}$< 0.001) (Fig. 2).

There was a significant decline in disease risk among all cohort studies (RR (95%CI) =0.81(0.79–0.84)) with no heterogeneity between studies (I_2= 24.6%, $P_{heterogeneity}$= 0.233) as well as in case–control studies with high heterogeneity between studies (RR (95%CI) =0.52(0.42–0.83, I_2= 89.8%, $P_{heterogeneity}$< 0.001) (Online Resource-Fig. 1A).

Analysis according to gender, country, energy adjustment, outcome assessment method, and quality of studies (Table 4) revealed that remaining on the DASH dietary pattern, might reduce the risk of CRC (RR (95%CI) =0.77(0.74–0.81) for males; 0.84(0.79–0.90) for females; 0.81(0.78–0.84) for studies of the USA; 0.85(0.77–0.95) for non-USA studies; 0.81(0.79–0.84) for adjusted energy; 0.72(0.57–0.89) for no energy adjustment; 0.81(0.67–0.97) for assessment by colonoscopy; 0.81(0.78–0.84) for assessment by medical records; 0.79(0.76–0.83) for the studies with moderate quality; and 0.84(0.80–0.89) for the studies with high quality) (Online Resource-Fig. 1.B-F).

When we analyzed the studies according to different DASH indexes, we observed protective effects of following the DASH diet against CRC (RR (95%CI) =0.84(0.78–0.90) for Dixon's index; 0.78(0.72–0.85) for Mellen's index; 0.79(0.75–0.84) for Fung's index; 0.82(0.76–0.89) for Gunther's index; and 0.88(0.77–1.00) for modified DASH index) (Online Resource-Figure. 1.G).

We could not find any sign of publication bias using Egger's (P= 0.136) and Begg's test(p= 161) and sensitivity analysis also represented no specific article with a significant influence on the results (Table 5).

Rectal cancer

Our analysis illustrated that DASH style might decrease the occurrence of RC without heterogeneity between all included studies (RR (95%CI) =0.75(0.66–0.86), I2 =53.2%, Pheterogeneity =0.058) moreover, when it divided into gender subgroups and assessing based on quality of the studies (Table 4), also declared similar protective results(RR (95%CI) =0.70 (0.63–0.77) for males; and ES (95%CI) =0.82(0.70–0.96) for females; RR (95%CI) =0.73(0.67–0.79) for moderate quality studies; and RR (95%CI) =0.76(0.66–0.87) for high quality studies)(Online Resource-Figures 2.A-C).

Two case–control studies and Four cohort studies were analyzed in our meta-analysis. Cohort studies has have shown reduction in the risk of RC with high degrees of heterogeneity between studies (RR (95%CI) =0.74(0.68–0.79), I_2= 64.6%, $P_{heterogeneity}$= 0.037), while, there was no meaningful association between RC and DASH in case-controls (RR (95%CI) =0.77(0.48–1.24, I_2= 54%, $P_{heterogeneity}$= 0.140)) (Figure 3).

Further subgroup analysis reported protective effects of DASH dietary pattern against RC among the US studies (ES (95%CI) =0.74(0.68–0.79)), however we didn't reach a significant effect on non-US studies (ES (95%CI) =0.77(0.48–1.24)) (Online Resource-Figure 2.D).

This protective effect was also obvious among studies that had assessed different DASH indexes (RR (95%CI) =0.67(0.57–0.79) for Mellen's index; 0.78(0.68–0.90) for Dixon's index; 0.70(0.62–0.79) for Fung's index; 0.80(0.68–0.93) for Gunther's index) whereas studies that had

modified DASH index, didn't show any association (RR (95%CI) =0.77(0.48–1.24)) (Online Resource-Fig. 2. E).

We could not find any sign of publication bias based on Egger's (P= 0.765) and Begg's test(p= 1.000); sensitivity analysis indicated that no particular article with a significant influence on results (Table 5).

Colon cancer

Meta-analysis of three studies with 5 effect sizes showed preventive effects of adherence to DASH dietary style against CC without heterogeneity between involved studies (RR (95%CI) =0.83(0.79–0.88), I_2= 29.5%, $P_{heterogeneity}$= 0.225) (Fig. 4).

More stratified analysis following gender and quality of the included studies, revealed similar protective results (RR(95%CI) =0.81(0.76–0.0.87) for males; 0.87(0.80–0.95) for females, 0.83(0.79–0.87) in studies with moderate quality; and 0.86(0.74–1.00) in high qualified ones). The risk of CC was significantly lower among cohort studies (RR (95%CI) =0.83(0.79–0.87)), without any apparent association in case-controls (RR (95%CI) =1.11(0.68–1.79)) as well as studies on non-US studies (RR (95%CI) =1.11(0.68–1.79)), however, the US studies continued to exhibit protective effects (RR (95%CI) =0.83(0.79–0.87)) (Online Resource-Figures 3.A- D).

Similarly, in the case of relation between CC and adherence to DASH dietary pattern, we clearly observed the protective effect among different studies (ES (95%CI) =0.86(0.78–0.95) for Dixon's index; 0.82(0.75–0.91) for Mellen's index; 0.80(0.73–0.88) for Fung's index; and 0.83(0.76–0.92) for Gunther's index), whilst no association was found in studies that evaluated CC and modified DASH index(RR (95%CI) =1.11(0.68–1.74)) (Online Resource-Figure 3.E).

We could not find any sign of publication bias using Egger's test (P= 0 388) and Begg's test(p= 0.806) and sensitivity analysis indicated that no particular article had a significant impress on the results (Table 5).

Colorectal adenoma

Two studies with 4 effect sizes were included in our meta-analysis of evaluating the effects of following a DASH diet style on CRA and showed a decrease in the risk of CRA with a significant heterogeneity between studies (RR (95%CI) =0.42(0.22–0.80), I_2= 90.7%, $P_{heterogeneity}$< 0.001))(Fig. 5).

Subgroup analysis according to different countries revealed protective effects of DASH against CRA in both US studies RR (95%CI) =0.85(0.73–0.99) and non-US studies (moderate quality articles) RR (95%CI) =0.09(0.04–0.21) (Table 4). However, When we excluded each one of these studies, the associations become no more apparent RR(CI95%) =0.19(0.03–1.12) after eliminating one study from Dixon et al. [4], and RR(CI95%) =0.70(0.435–1.135) after excluding one study from Jafari Nasab et al. [35](Online Resource-Figures 4.A-C).

Subgroup analysis on the basis of participants'gender, illustrated protective effects against CRA in males with significant heterogeneity among studies RR(95%CI) =0.72(0.60–0.87), I_2= 86.4%, $P_{heterogeneity}$= 0.007), however, no association was found in female subgroup RR (95%CI) =0.92(0.73–1.16), I_2= 95.6%, $P_{heterogeneity}$< 0.001) (Online Resource-Fig. 4. D).

Studies following two types of DASH indexes revealed decreasing the risk of CRA among studies with RR (95%CI) =0.85(0.73–0.99) for Dixon's index; and 0.09(0.04–0.21) for Fung's index (Online Resource Fig. 4. E).

We could not find any sign of publication bias using Egger's test (P= 0.141) and Begg's test(p= 0.734) (Table 5).

Subgroup analysis and sources of heterogeneity

Geographical location and heterogeneity

A comparison between U.S.-based and non-U.S. studies demonstrated notable variations in the risk reduction associated with adherence to the DASH diet. In U.S. populations, the protective effect was statistically significant (RR =0.81, 95% CI: 0.78–0.84) with minimal heterogeneity (I^2= 23.4%, p= 0.258). However, non-U.S. studies yielded a slightly attenuated association (RR =0.85, 95% CI: 0.77–0.95) with considerably higher heterogeneity (I^2= 86.5%, p< 0.001). These variations are likely attributed to cultural dietary practices, baseline nutritional patterns, and regional differences in food quality and accessibility.

Socioeconomic status and dietary adherence

Higher socioeconomic status was associated with greater adherence to the DASH dietary pattern due to increased availability of fresh, unprocessed foods and better health literacy. People with lower incomes encountered challenges in following DASH because they lacked access to fresh produce and experienced financial limitations, which could decrease the protective benefits of the diet [39].

Dietary assessment methods and variability in findings

The evaluation methods for DASH diet adherence continued to affect the observed inconsistencies between research findings. The studies used different dietary scoring approaches, including Dixon's Mel, Len's Fung's, and Günther's DASH indices. Risk reductions ranged from 16 to 22% across these assessments, but the modified DASH index yielded non-significant results (RR =0.88,

Table 2 Quality assessment of non-cohort studies

First author	Year	S1	S2	S3	S4	C1	O1	O2	O3	Total NOS
Dixon et al., 2007 [4]	2007	*	*		*	**		*	*	7
Jafari nasab et al., 2021 [35]	2021	*	*	*		**		*		6
Wang et al., 2023 [37]	2023	*	*		*	**	*	*	*	8
Yarmand et al., 2024 [20]	2024		*	*	*	*		*	*	6
Jones-McLean et al., 2015 [36]	2015	*	*	*	*	**		*	*	8
Erben et al., 2018 [16]	2018	*	*	*	**	*	**	*	-	9

Table 3 Quality assessment of included cohort studies

First author	Year	1. Confounding	2. Selection of Participants	3. Exposure Classification	4. Deviations from Intended Exposures	5. Missing Data	6. Outcome Measurement	7. Selective Reporting	Overall
Fung et al	2010	low	low	moderate	No information	low	low	low	low
Miller et al	2013	low	moderate	moderate	No information	low	low	low	moderate
Vargas et al	2016	low	low	moderate	No information	low	low	low	low
Park et al	2017	moderate	low	low	No information	low	low	low	low
Petimar et al	2018	low	low	moderate	No information	Low	low	low	low
Nguyen et al	2020	low	low	moderate	No information	low	low	low	low
Cai et al	2024	low	low	moderate	No information	low	low	low	low
Zheng et al	2021	low	low	moderate	No information	low	moderate	low	low

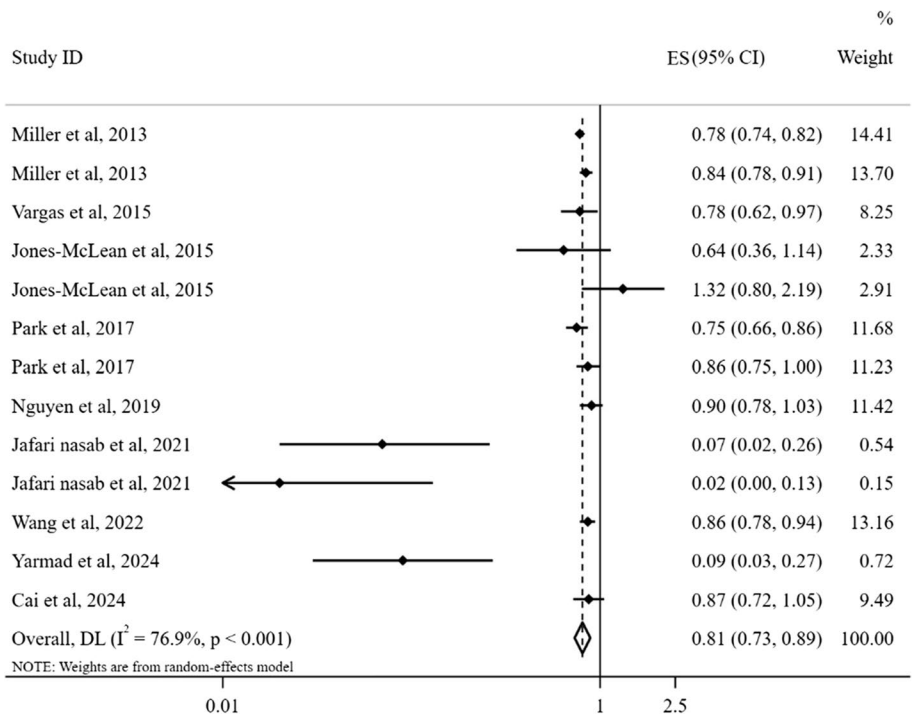

Fig. 2 Forest plot for highest versus lowest degrees of following DASH diet and risk of CRC in all included studies

Table 4 Subgroup analysis using fixed-effects models

		Number of effect sizes	ES[a]	95%CI[b]	I^2	$P_{heterogeneity}$
Association between DASH and CRC						
Overall		13	0.81	0.73–0.89	76.9%	< 0.001
Gender	Male	4	0.77	0.74–0.81	68.1%	0.025
	Female	5	0.84	0.79–0.90	77.8%	
Country	USA	6	0.81	0.78–0.84	23.4%	0.258
	Non-US countries	7	0.85	0.77–0.95	86.5%	< 0.001
Study design	Cohort	8	0.81	0.79–0.84	24.6%	0.233
	Case–Control	5	0.59	0.42–0.83	89.8%	< 0.001
Quality of studies	High quality	8	0.84	0.80–0.89	18.5%	0.283
	Moderate quality	5	0.79	0.76–0.83	90%	< 0.001
Energy adjustment	Energy adjusted	11	0.81	0.79–0.84	72..5%	< 0.001
	No adjustment	2	0.72	0.57–0.89	93%	< 0.001
Outcome assessment	Colonoscopy	3	0.81	0.67–0.97	91.5%	< 0.001
	Medical records	10	0.81	0.78–0.84	68.3%	< 0.001
Exposure assessment	Dixon's index	3	0.84	0.78–0.90	58.1%	0.092
	Mellen's index	2	0.78	0.72–0.85	0.0%	0.886
	Fung's index	8	0.79	0.75–0.84	74.3%	< 0.001
	Gunther's index	2	0.82	0.76–0.89	0.0%	0.680
	Modified DASH index	4	0.88	0.77–1.00	85.2%	< 0.001
Association between DASH and RC						
Overall		6	0.75	0.66–0.86	53.2%	0.058
Gender	Male	2	0.70	0.63–0.77	0.0%	0.382
	Female	2	0.82	0.70–0.96	0.0%	0.447
Country	USA	4	0.74	0.68–0.79	64.6%	0.037
	Non-US countries	2	0.77	0.48–1.24	54.0%	0.140
Study design	Cohort	4	0.74	0.68–0.79	64.4%	0.037
	Case–Control	2	0.77	0.48–1.24	54.0%	0.140
Quality of studies	High quality	4	0.76	0.66–0.87	63.2%	0.043
	Moderate quality	2	0.73	0.67–0.79	56.5%	0.130
Energy adjustment		6	0.75	0.66–0.86	53.2%	0.058
Outcome assessment		6	0.75	0.66–0.86	53.2%	0.058
Exposure assessment	Dixon's index	3	0.78	0.68–0.90	72.7%	0.026
	Mellen's index	2	0.67	0.57–0.79	0.0%	0.813
	Fung's index	3	0.70	0.62–0.79	53.9%	0.114
	Gunther's index	2	0.80	0.68–0.93	0.0%	0.569
	Modified DASH index	2	0.77	0.48–1.24	54.0%	0.140
Association between DASH and CC						
Overall		5	0.83	0.79–0.88	29.5%	0.225
Gender	Male	2	0.81	0.76–0.87	0.0%	0.658
	Female	2	0.87	0.80–0.95	73.5%	0.052
Country	USA	3	0.83	0.79–0.87	0.0%	0.559
	Non-US countries	2	1.11	0.68–1.79	68.3%	0.076
Study design	Cohort	3	0.83	0.79–0.87	0.0%	0.559
	Case–Control	2	1.11	0.68–1.79	68.3%	0.076
Quality of studies	High quality	3	0.86	0.74–1.00	53.4%	0.117
	Moderate quality	2	0.83	0.79–0.87	12%	0.286
Energy adjustment		5	0.83	0.79–0.88	29.5%	0.225
Outcome assessment		5	0.83	0.79–0.88	29.5%	0.225

Table 4 (continued)

		Number of effect sizes	ES[a]	95%CI[b]	I^2	$P_{heterogeneity}$
Exposure assessment	Dixon's index	3	0.86	0.78–0.95	0.0%	0.487
	Mellen's index	2	0.82	0.75–0.91	0.0%	0.815
	Fung's index	2	0.80	0.73–0.88	0.0%	0.459
	Gunther's index	2	0.83	0.76–0.92	0.0%	0.423
	Modified DASH index	2	1.11	0.68–1.79	68.3%	0.076
Association between DASH and CRA						
Overall		4	0.42	0.22–0.80	90.7%	< 0.001
Gender	Male	2	0.72	0.60–0.87	86.4%	0.007
	Female	2	0.92	0.73–1.16	95.6%	< 0.001
Country	USA	2	0.85	0.73–0.99	76%	0.041
	Non-US countries	2	0.09	0.04–0.21	0.0%	0.318
Study design	Case-controls	4	0.42	0.22–0.80	90.7%	< 0.001
	Cohort					
Quality of studies	High quality	2	0.85	0.73–0.99	76%	0.041
	Moderate quality	2	0.09	0.04–0.21	0.0%	0.318
Energy adjustment		4	0.42	0.22–0.80	90.7%	< 0.001
Outcome assessment		4	0.42	0.22–0.80	90.7%	< 0.001
Exposure assessment	Dixon's index	2	0.85	0.73–0.99	76%	0.041
	Fung's index	2	0.09	0.04–0.21	0.0%	0.318

[a] *ES* Effect Size

[b] *CI* Confidence Interval

Table 5 Assessment of publication bias among included studies

	Number of effect sizes	Egger's test *p*-value	Begg's test *p*-value
Association between DASH and CRC			
Overall	13	0.136	0.161
Cohort	8	0.283	1.000
Case–Control	5	0.068	0.462
Association between DASH and RC			
Overall	6	0.765	1.000
Cohort	4	0.632	1.000
Case–Control	2	-	1.000
Association between DASH and CC			
Overall	5	0.806	0.388
Cohort	3	0.684	1.000
Case–Control	2	-	1.000
Association between DASH and CRA			
Overall	4	0.141	0.734
Cohort	0	-	-
Case–Control	4	0.141	0.734

95% CI: 0.77–1.00, $I^2 = 85.2\%$, $p < 0.001$). The diversity in research outcomes demonstrates how measurement methods, data collection techniques, potential measurement errors, and divergent dietary focus points affect the results of each index. The different priorities between sodium restriction and macronutrient balance in dietary indices result in conflicting study results.

Study design and its impact on heterogeneity

Cohort studies consistently demonstrated a robust protective effect (RR = 0.81, 95% CI: 0.79–0.84, $I^2 = 24.6\%$, $p = 0.233$), whereas case–control studies exhibited significantly higher variability (RR = 0.59, 95% CI: 0.42–0.83, $I^2 = 89.8\%$, $p < 0.001$). Heterogeneity in case–control studies increases through two significant factors: participant selection bias during recruitment and participant recall bias regarding dietary intake. Cohort studies deliver better results in measuring long-running diet patterns and their association with CRC risk.

Gender-based differences in risk reduction

Men experienced a more significant reduction in CRC risk (RR = 0.77, 95% CI: 0.74–0.81) than women (RR = 0.84, 95% CI: 0.79–0.90). This difference may be attributed to several biological and behavioral factors. Cancer

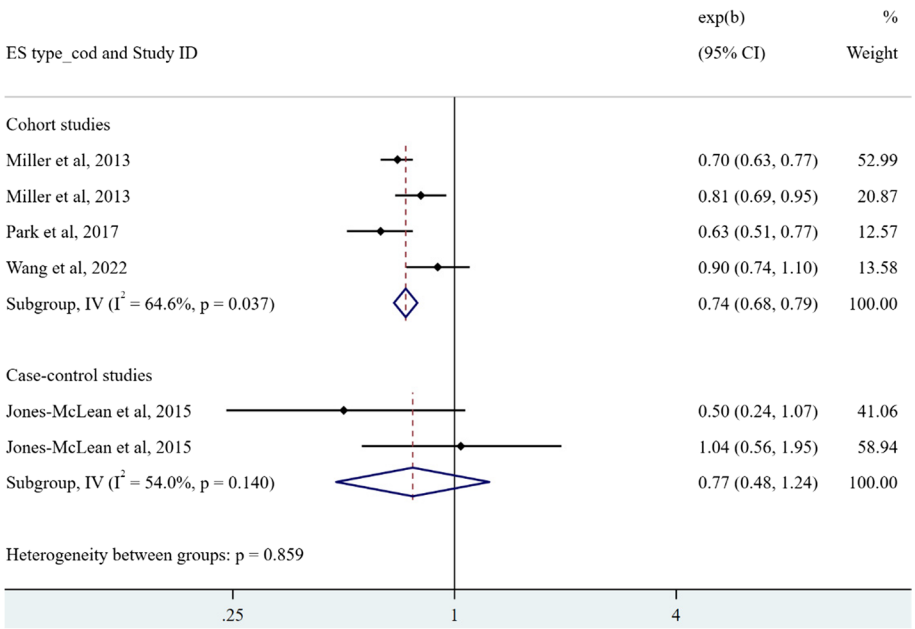

Fig. 3 Forest plot for highest versus lowest degrees of adherence to DASH diet and RC risk in cohort and case–control studies, separately

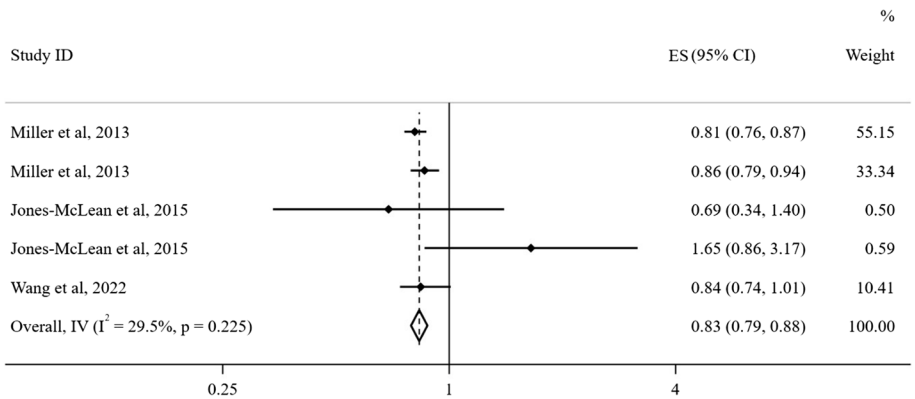

Fig. 4 Forest plot for highest versus lowest degrees of adherence to DASH diet and CC risk in the involved studies

risk in women benefits from estrogen protection against CRC development, which could reduce the impact of dietary patterns on overall risk [40]. The increased red and processed meat consumption among men leads to more noticeable benefits from following a DASH diet plan. Gender-specific metabolic variations between men and women affect how well DASH diet adherences reduce CRC risk.

GARDE assessment

The certainty of evidence for the association between DASH diet adherence and CRC-related outcomes was evaluated using the GRADE approach (Table 6). For all types of cancers, the level certainty was very low.

Discussion

Our current review confirms and updates previous findings regarding high compliance with the DASH diet and lower risks of CRC. The summary effect sizes were in the range of 0.79–0.85, with uniformly protective effects in multiple studies, which supports the idea of preventive effects of the DASH diet on risks of CRC.

We considered each study once and followed all the procedures for the meta-analysis. We performed subgroup analysis when necessary or when high grades of heterogeneity appeared between studies. Moreover, we performed sensitivity analysis to determine if whether any study particularly affected the results.

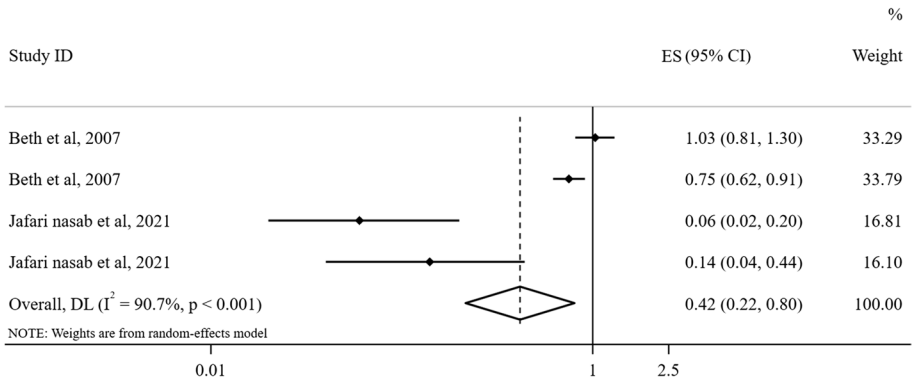

Fig. 5 Forest plot for highest versus lowest degrees of adherence to DASH diet and CRA risk in the involved studies

Assessing the role of different elements in carcinogenesis is challenging to interpret since there are various nutritional factors involved or sometimes coexist as a part of a single pattern. Thus, a collaborative effort is necessary to enhance the research evidence on the interaction between quality of diet and risk of CRC [27, 35]. A healthy diet is a proper mixture of micronutrients and macronutrients that is found in different scientifically developed diets such as DASH or traditional diets such as Asian or Mediterranean.All of these diets share common features that would be a good solution to be considered in regard to diet-related disorders [41]. One study investigated unhealthy diets (rich in carbohydrates, sugary drinks, red and processed meat, salty snacks, cooking at high temperature, etc..) and reported higher risk of CRC among individuals following an unhealthy diet, with a higher incidence among women [42]. The DASH diet was originally developed to reduce the risk of hypertension and cardiovascular disease. However, research has shown that its primary recommendations, including the consumption of vegetables, fruits, and whole grains, can help prevent CRC [43]. Whole grains, due to their fiber content, increase stool volume, shorten transit time, and dilute carcinogens in the stool, which in turn reduces the exposure of the colorectal lining to harmful substances [44, 45].

While previous studies highlight the protective effects of the DASH diet on CRC risk, it is crucial to consider the influence of potential confounders that can modify this association. Several underlying health conditions including diabetes, hypertension, obesity, and metabolic syndrome, may significantly impact the observed relationship between DASH adherence and CRC risk.

For instance, chronic hyperinsulinemia, commonly seen in type 2 diabetes, promotes tumorigenesis via insulin-like growth factor 1 (IGF- 1) activity, cell proliferation, and inhibition of apoptosis [46–48]. Since the DASH diet is known to improve insulin sensitivity, part of its protective effect against CRC may stem from its role in mitigating these metabolic disruptions. Additionally, hypertension has been implicated in CRC pathophysiology due to its association with endothelial dysfunction, oxidative stress, and chronic low-grade inflammation. The DASH diet, originally designed to reduce hypertension, is rich in potassium, magnesium, antioxidants, and polyphenols. Flavonoids like kaempferol and quercetin are known factors which eliminate free radicals, decrease oxidative stress, and suppresses inflammatory pathways which lead to lower cancer cell growth and enhance vascular function [49, 50]. Improved endothelial health may reduce CRC risk by limiting pro-inflammatory cytokine production and decreasing the accumulation of reactive oxygen species, which can induce DNA damage and promote tumorigenesis.

Obesity, an independent risk factor for CRC, contributes to systemic inflammation, insulin resistance, and altered adipokine signaling. Excess adipose tissue secretes pro-inflammatory cytokines, such as interleukin- 6 (IL- 6) and tumor necrosis factor-alpha (TNF-α), which promote chronic inflammation, a well-established driver of colorectal carcinogenesis. The DASH diet, known for its role in weight management, may counteract these mechanisms by improving metabolic balance and reducing systemic inflammation through its high fiber and polyphenol content [47, 51].

Furthermore, the gut microbiome plays a pivotal role in CRC development, with diet-induced dysbiosis linked to tumor progression. The DASH diet promotes gut health by increasing the intake of both soluble and insoluble fibers. Soluble fibers support the growth of short-chain fatty acid (SCFA)-producing bacteria. SCFAs, particularly butyrate, exhibit anti-carcinogenic properties by enhancing mucosal barrier integrity, modulating immune responses, and suppressing inflammatory pathways in

the colon [52–54]. Insoluble fiber, on the other hand, could increase stool bulk and decrease transient time in the GI system. A study by Zhong et al. [55] showed that every 10 g increase in fiber intake per day, could decrease CRC risk, by 10% which helps decrease the exposure of the colonic mucosa to carcinogens and strengths mucosal barrier which inhibits pathogen entrance and inflammation.

Finally, dysregulated lipid metabolism has been proposed as a key contributor to CRC development. High cholesterol levels and secondary bile acids have been shown to exert pro-tumorigenic effects by inducing oxidative stress, activating Wnt signaling pathways, and promoting colonic epithelial proliferation [56]. The DASH diet, by incorporating healthy fats while limiting saturated fats and red meat, helps decrease cholesterol and bile acid production, thereby potentially reducing CRC risk [57, 58].

These findings underscore the necessity of accounting for metabolic comorbidities in future studies assessing dietary interventions. Moreover, considering additional lifestyle factors, including medication use (e.g., metformin, statins, aspirin) and genetic predisposition, will further clarify the independent effects of the DASH diet. Future prospective studies with rigorous statistical adjustments for these variables are necessary to disentangle the independent effects of the DASH diet from underlying metabolic conditions. Addressing these confounders reinforces the DASH dietary pattern as an effective public health strategy for CRC prevention.

Prior research has extensively investigated on the association between the effects of diet and nutrition on different health issues such as diabetes mellitus and hypertension. In the study of Quan et al. [59] adhering DASH dietary style was associated with 18% reduction in risk of diabetes mellitus. DASH diet is mostly consists of fruit and vegetables which have low glycemic index leading to a better glycemic control, better weight maintenance, and lower risk of diabetes progression [60]. Moreover, the high fibers content of DASH diet can delay gastric emptying and results in lower carbohydrate absorption [61]. Another potential explanation in reducing the risk of diabetes mellitus is high levels of antioxidants and carotenoids that are related to lower risks of diabetes mellitus and hypertension. In the study of Siervo et al. [62] a significant reduction in lowering systolic and diastolic blood pressure was observed following DASH dietary pattern. Low amount of sodium intake, and promoting high intake of vegetables, fruits, and minerals are some of contributing factors in reducing blood pressure following DASH dietary pattern [20, 63].

In the study of Schwingshackl et al. [64] different macronutrients were evaluated for their effects on CRC, and a protective association was found for whole grains, vegetables, and fruits, and positive association was observed for processed and red meat.

It has represented that high amounts of carbohydrates and calories in diets, increase the risk of CRC [65] and low-carbohydrate diets or restricted carbohydrate diets such as the ketogenic diet, might have protective effects against CRC [66], however, these diets are rich in fat and meat and might produce greater amounts of reactive oxygen species which can promote tumorigenesis [67, 68]. In another study, different types of nuts consumption were evaluated and significant protective effects against CRC were found [69].

Our findings in this current meta-analysis are closely align with previous studies about protective effects of DASH dietary pattern against CRC with reducing the risk of CRC by 19% (RR (95%CI) = 0.81, (0.73–0.89)). Wang et al. evaluated different dietary patterns based on three extensive prospective cohort studies with 218,181 participants and reported the DASH diet, reduces the CRC incidence by 14% (HR (95% CI) = 0.86, (0.78–0.94)) [37]. Another study conducted by Fung et al. represents 20% lower risk of CRC for people of middle age who had high adherence to DASH diet [19]. In one meta-analysis by Moazzen et al. it was represented that following high quality diets like DASH diet, decreased the risk of CRC, significantly CRC (OR(95%CI) = 0.83,(0.78–0.89)) [70]. Jones-McLean et al. [36] also reported 33% lower risks of adherence to DASH diet only among men with no association related to women, similar to study of Petimar et al. [31] that could not find any association between following the DASH dietary pattern and CRC in women, but reported protective effects among men, whereas our analysis revealed 16% lower risks of CRC among women who were more adhere to the DASH pattern, and a 23% risk reduction in men following the diet.

One potential explanation for this sex-specific discrepancy is the role of sex hormones. The protective role of post-menopausal hormonal therapy and endogenous estrogen against CRC has been reported previously. As a result, women—particularly those with higher levels of estrogen—might have different risk profiles and, consequently, may exhibit less observable risk reduction in CRC following adherence to the DASH dietary pattern [31, 71]. Moreover, women are more likely to follow healthier diets than men and [72] and they may have lower room for improvement after transition to DASH dietary pattern. Additionally, different baseline physical activities, lifestyle behaviors, and genetic backgrounds across populations ought to be acknowledged.

Furthermore, our results about consistency are highly comparable to those of Tangestani et al. [73] who

Table 6 GRADE summary of findings

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**highest adherence to DASH diet**	**lowest adherence to DASH diet**	**Relative (95% CI)**	**Absolute (95% CI)**		
Colorectal cancer (follow-up: range 11 years to 24 years; assessed with: colonoscopy, sigmoidoscopy, or medical records)												
14	non-randomised studies	serious[a]	not serious[b]	not serious	not serious	none	3371 cases 3479 controls 1862/414029 exposed 1951/382541 unexposed		**RR 0.81** (0.73 to 0.89)	-	⨁◯◯◯ Very low[a,b]	CRITICAL
							-	0.5%		**1 fewer per 1,000** (from 1 to 1 fewer)		
Colon cancer (follow-up: range 11 years to 24 years; assessed with: colonoscopy, sigmoidoscopy, or medical records)												
5	non-randomised studies	serious[a]	not serious	not serious	not serious	none	3171 cases 3097 controls		**RR 0.83** (0.79 to 0.88)	-	⨁◯◯◯ Very low[a]	CRITICAL
							-	0.4%		**1 fewer per 1,000** (from 1 to 0 fewer)		
Rectal cancer (follow-up: range 11 years to 24 years; assessed with: colonoscopy, sigmoidoscopy, or medical records)												
6	non-randomised studies	serious[a]	not serious[b]	not serious	not serious	none	3161 cases 3097 controls 910/43645 exposed 991/41668 unexposed		**RR 0.75** (0.66 to 0.86)	-	⨁◯◯◯ Very low[a,b]	CRITICAL
							-	0.2%		**1 fewer per 1,000** (from 1 to 0 fewer)		
Colorectal adenoma (assessed with: colonoscopy, sigmoidoscopy, or medical records)												
4	non-randomised studies	serious[a]	not serious[b]	not serious	not serious	strong association	3721 cases 34,211 controls		**OR 0.42** (0.22 to 0.80)	-	⨁⨁◯◯ Low[a,b]	CRITICAL
							-	0.1%		**1 fewer per 1,000** (from 1 to 0 fewer)		

CI confidence interval, *OR* odds ratio, *RR* risk ratio

evaluated the association between following the DASH diet style and the risk of CRC. They clearly reported that following the DASH diet was accompanied by a reduction in CRC risk of 20% (RR =0.80 95% CI 0.74–0.85) which aligns completely with our results.

These consistent findings further support that the DASH diet has inverse association with CRC. Here we analyzed previous investigations that evaluated four already available indexes and all reported significantly lower risks of CRCs for individuals following the DASH diet(between 16 and 22% lower risks) which are in line with the findings of Miller et al. [28] that reported reduced CRC risk for all four indexes among men, and for all but not Dixon (HR: 1.01; 95% CI: 0.80, 1.28) among women which might have occurred following variations in the scoring system or components that used in each index.

In the study of Godos et al. [74] a 19% risk reduction in CRA was reported following the DASH diet which is in line with previous reports of Dixon et al. [4] that showed a 33% lower risk of CRA among men who followed the DASH style, however, no associations were found for women who adhered to the DASH pattern. Considering the possibility of transforming CRA to neoplasms, we evaluated to determine is there any relationship between DASH diet and CRA and ascertained that adherence to DASH diet decreases the risk of CRA among men (ES (95%CI) =0.72(0.60–0.87)) without any association among women, however, more studies should be conducted to explore this association.

In an Iranian hospital-based case–control study, with high levels of adherence to the DASH diet, there was a corresponding marked reduction in CRC risk, with odds ratios of 0.33 and 0.09 in the second and the highest tertiles of adherence, respectively. This is likely due to the DASH diet's emphasis on high intake of whole grains, fruits, vegetables, and low-fat dairy, and low consumption of sodium, red, and processed meat. In contrast, the Mediterranean diet, which encourages a high intake of vegetables, whole grains, and fruits and a moderate intake of fish and olive oil, had less consistent evidence of CRC risk reduction. Nevertheless, the Iranian study did not find a meaningful association between adherence to the Mediterranean diet and CRC risk (highest tertile OR =0.62). Therefore, although both diets are beneficial, the protective effect of the DASH diet against CRCs is more prominent. One prominent cause is low red meat consumption and sodium intake (key nutrients in CRC) in DASH dietary pattern [20]. Among Mediterranean populations, Mediterranean diet is a traditional already existed diet that together with low variability in diet quality, making it harder to gain additional advantages following the Mediterranean diet [19]. Another possible cause may be populations differences such as overall life style factors, genetic backgrounds, and traditional eating habits. Moreover, case–control studies sometimes demonstrate a stronger protective effect for DASH, probably as a result of potential recall bias or differences in exposure measurement [20].

Moreover, the diet decreases the intake of carcinogenic chemicals like N-nitroso compounds and heterocyclic amines by highlighting lower intake of processed and red meat. Chan D. S. et al. [75] reported that high intake of red meat is related to a 17% increased risk of CRC. Finally, the DASH diet supplies necessary calcium, which binds to fatty acids and bile to decrease their carcinogenic potential through insoluble complex formation [28, 31, 73]. Huncharek M. et al. noted that higher calcium intake is associated with lower risks of CRC, with a risk reduction of 15% for high calcium intake compared to low intake [76].

In order to confirm and release a new update about the association between DASH diet and CRC cancer, we performed a systematic review and meta-analysis on prior studies in this field. Our current study has many strengths. Our findings considerably advances the study of Mohseni et al. [77] and Tangestani et al. [73] which reported the protective effects of following DASH dietary pattern in reducing CRC risks. However, while these studies have included 6 and 8 studies, respectively; here we included 14 studies to our meta-analysis. Moreover, we have updated our search till March 2025 that together enhance statistical power and captures very recent evidence. Additionally, we utilized different subgroup analysis such as gender-specific differences, and various anatomical sites in our study that provides a more comprehensive understanding of the association between DASH dietary pattern and CRC. The results are expressed clearly that provide clear understanding in addition to sample size variety that make our study a proper reference for future research, moreover we used different DASH indexes which allow us to include a broad range of adherence to the diet and more relevant studies. The DASH diet can be a valuable component of a personalized plan for many in high-risk groups, but it shouldn't be presented as a one-size-fits-all solution. Registered dietitians and healthcare professionals play a crucial role in creating tailored dietary plans that are both effective and achievable for each individual. Lastly, our study contributes to the growing body of knowledge on one of the most important variables for CRC prevention.

However, our study has several limitations. First, the studies included in our meta-analysis, used different insides to assess adherence to DASH additionally, the application of DASH dietary pattern can vary across different cultures and populations, leading to

inconsistency in adherence assessment between different available insides. Second, the differences among various cooking styles, such as grilling, which might induce carcinogenesis, are not addressed. We were unable to evaluate proximal and distal colon cancers separately due to limited information in the included studies. Moreover, none of our included studies evaluated colon adenoma or rectal adenoma, which led us to evaluate colorectal adenoma in general.

An important strand of future research in the area is the mechanisms through which the observed protective effects of DASH against CRC operate, including mechanistic studies of foods and nutrients and their genes and lifestyle interactions. Randomized controlled trials are needed to declare causality and confirm the observational findings. This would make the current findings more generalizable.

Conclusion

In conclusion, this study expands the existing body of evidence supporting the protective effect adherence to DASH dietary pattern against CRC. The consistency observed in results among various studies and populations, reinforces the recommendation of the DASH dietary pattern as a potent strategy for CRC prevention. Such findings could significantly impact nutritional guidelines and public health policies with the aim of reducing the burden of CRC.

Abbreviations

CC	Colon cancer
CRA	Colorectal adenoma
CRC	Colorectal cancer
DASH	Dietary approach to stop hypertension
Ess	Effect sizes
HRs	Hazard ratios
ORs	Odds ratios
RRs	Relative risks
RC	Rectal cancer
CI	Confidence intervals

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-025-03859-2.

Additional file 1.

Authors' contributions

All authors were involved in writing the manuscript. M.R was mostly responsible for conceptualization, administration and supervision. H.S. was responsible for supervision and administration. M.M.A was responsible for data analysis. P.B was mostly responsible for editing the final format. F.N , F.Kh, Z.T, Z.G,V.A, H.S., M.N, M.J, N.Sh, and H.H.N conducted search study, study selection, and data extraction. All authors reviewed the manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Corresponding author: Mohammad Rahmanian. mmdrahmanian@sbmu.ac.ir.

Declarations

Ethics approval and consent to participate

As a meta-analysis, our paper did not require any referral to our institutional clinical ethics committee.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Student Research Committee, Faculty of Nutrition and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [2]Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran. [3]Student Research Committee, Tehran University of Medical Sciences, Tehran, Iran. [4]Shahid Beheshti University of Medical Sciences, Tehran, Iran. [5]Student Research Committee, Isfahan University of Medical Sciences, Isfahan, Iran. [6]Student Research Committee, School of Dentistry, Islamic Azad University, IAU (Khorasgan Branch), Isfahan, Iran. [7]Babol University of Medical Sciences, Babol, Iran. [8]Universal Scientific Education and Research Network (USERN), Tehran, Iran. [9]School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran. [10]Student Research Committee, Jondishapoor University of Medical Science, Ahvaz, Iran. [11]Department of Stem Cells Technology and Tissue Regeneration, Faculty of Interdisciplinary Science and Technologies, Tarbiat Modares University, Tehran, Iran. [12] Student Research Committee, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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