

A Systematic Review of the Association between Dietary Patterns and Breast Cancer Risk

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Abstract

Background: Dietary patterns, which represent the amounts, proportions, variety or combinations of different foods and drinks in the diets, and the frequency with which they are regularly consumed, have been linked to the risk of numerous cancers. However, the association between dietary patterns and breast cancer risk is still unclear.

Objective: This systematic review was conducted to investigate and clarify the association between dietary patterns and breast cancer risk by assessing and appraising the literature published to date and evaluating the results of these studies.

Design: A broad, general and inclusive electronic literature search was conducted throughout the Google Scholar, and PubMed databases to identify studies written in English and published from 2001 to 2017.

Results: 2,215 articles were found and 112 articles were chosen for further review, of which 87 articles were excluded after reviewing the title and abstract of each article. The remaining 25 articles were included in the paper after a full review. Although in most of the articles included in this paper, no overall association was reported between the prudent, Mediterranean or Western dietary patterns and breast cancer risk, it was suggested that a Western or Western-type dietary pattern might increase the risk of breast cancer, and a prudent, Mediterranean and healthy dietary patterns might protect against estrogen receptive-negative tumors, mostly in postmenopausal women.

Conclusion: This systematic review provides evidence of an association between dietary patterns and breast cancer risk and highlights the need for further observational and interventional studies.

Keywords: Breast cancer; ER-positive breast cancer; ER-negative breast cancer; Western dietary pattern; Prudent dietary pattern; Mediterranean dietary pattern; Healthy dietary pattern

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Citation: Morgan A (2018) A Systematic Review of the Association between Dietary Patterns and Breast Cancer Risk. J Clin Nutr Diet Vol.4 No.1:3

Received: April 10, 2018; **Accepted:** April 19, 2018; **Published:** April 26, 2018

Introduction

Cancer is a major public health concern among women in the United States of America. Approximately 40% of American women are diagnosed with some type of non-dermatologic cancer during their lifetime [1] and despite all the new advancements in detection and treatment, breast cancer remains the second leading cause of mortality for women in the United States [2]. Every year, more than 200,000 women in the U.S. are diagnosed with aggressive breast cancer [3].

The etiology of breast cancer is considered multifactorial, and includes interactions between genetic, behavioral, and environmental factors [4]. Some well-established and strong risk factors for breast cancer such as: age, family and reproductive history, height reached by the adulthood, and exposure to high doses of ionizing radiation are not modifiable [4]; however, the adaptable lifestyle factors including diet, smoking status, physical activity, alcohol consumption, as well as body size and shape, that are directly associated with breast cancer risk, occurrence,

recurrence, and mortality rate, are easier to modify. Therefore, the American Cancer Society Nutrition and Physical Activity Guidelines Advisory Committee have issued an inclusive set of recommendations to help promote health for cancer survivors through health behavior adjustments [2]. According to these data, since many health behaviors occur in combination, a compound variable might be needed to capture how lifestyle factors act synergistically to influence the development of breast cancer and all-cause mortality [2]. Based on the findings of several studies, steady positive associations have been found between a combined lifestyle variable and both breast cancer risk [5-12] and all-cause mortality rates [5,6,13-16].

According to some studies, diet has a direct influence on breast cancer risk [17,18]. It is estimated that approximately one-third of breast cancer cases could be prevented just by dietary modifications, whereas 20% can be associated with consuming more than 2 alcoholic drinks per day [19]. This fact definitely emphasizes the theoretical possibility for the prevention of breast cancer through behavioral modifications [19]. From an epidemiologic point of view, foods and nutrients are never eaten in isolation and their effects usually interact with one another which have led the researchers to take a more inclusive approach to diet [19]. Through this approach the researchers can identify the patterns of the dietary intake that can help understand the complex interaction between foods and nutrients and recognize the confounding factors that can mask the true associations [19]. It is also necessary to investigate whether the associations between the dietary patterns and breast cancer risk are consistent across different populations [20].

In many studies, factor analysis or principal component analysis were used to develop dietary patterns [19]. These methods usually combined the variables and factors together to represent the different eating patterns of the study population; therefore, it was harder to make specific judgments on any possible association between dietary patterns and the risk of breast cancer [19].

Purpose

This systematic review aims to investigate and clarify the association between dietary patterns and breast cancer risk by evaluating and appraising the literature published to date and assessing the results of these studies.

Literature review

Recently, dietary pattern analysis has arisen as a complementary approach to investigate the relationship between diet and risk of chronic diseases [21]. Instead of looking at individual nutrients or foods, pattern analysis studies the effects of overall diet on the development of certain diseases [21]. Theoretically, dietary patterns signify a broader image of food and nutrient consumption, and may thus be more predictive of disease risk than individual foods or nutrients [21]. In addition, there is a growing interest in using dietary quality directories to assess whether adherence to a certain dietary pattern such as Mediterranean pattern, can

lower the risk of certain chronic diseases such as breast cancer in the long term [21].

This systematic review is aimed to analyze the literature published to date and assess the impact of dietary patterns on the risk, occurrence, recurrence, and mortality rates of breast cancer and identify the best dietary pattern that can help reduce the risk of breast cancer. This paper covers the following topics:

1. The difference between ER-positive and ER-negative breast cancer.
2. The relationship between dietary patterns and risk of breast cancer.
3. Types of dietary patterns that can help decrease the risk of breast cancer.

ER-positive breast cancer versus ER-negative breast cancer:

Despite the intensive research, it has not yet been fully understood if ER-negative breast cancer is an advanced form of ER-positive breast cancer or whether ER⁺ and ER⁻ breast cancer are two biologically different diseases with different risk factors [22]. According to many studies, the prediction of survival rates of ER-breast cancer patients has been recognized to be lower than that of ER⁺ breast cancer patients, and it is found that the cancer tumors usually lose their estrogen dependency during their progression, leading to the theory that ER⁻ breast cancer may be a more advanced stage of ER⁺ breast cancer [22]. According to the literature, micronutrients from fruits and vegetables may prevent both types of breast cancer, but in ER⁺ breast cancer the estrogen level might override the preventive effects of the micronutrients, since it is the most important factor [22]. In ER⁻ breast cancer, on the other hand, the effects of fruits and vegetables may be observed better since ER⁻ breast cancer has a lower dependency on the estrogen level [22].

Different types of dietary patterns and risk of breast cancer:

Many epidemiologic studies have linked the consumption of individual foods to the risk of breast cancer [23]. An increased risk of breast cancer has been reported to be associated with high intakes of red meat, animal fat and refined carbohydrates [23]. Foods that are found to be inversely associated with breast cancer risk include fruits and vegetables, cereal, olive oil, low-fat dairy products and dietary calcium [23].

According to a prospective cohort study conducted from 1995 through 2007 to examine the relationship between different dietary patterns and breast cancer, a reduced breast cancer risk was reported to be associated with a prudent dietary pattern, a traditional southern dietary pattern, stew and traditional dietary patterns, a salad vegetable pattern, a vegetable/soy pattern, and Native Mexican and Mediterranean patterns [23]. All of these dietary patterns are higher in fruits and vegetables and lower in animal fats compared to the classic "Western" diet [23].

In general, the prudent dietary pattern is characterized by higher consumption of fruits, vegetables, whole grains, low-fat dairy products, fish and poultry, whereas the Western pattern is categorized by higher intake of red and processed meats, refined

grains, desserts and high-fat dairy products [24]. According to a study performed to examine the association between diet and the risk of postmenopausal breast cancer by using different approaches of dietary patterns, neither prudent nor Western dietary pattern was associated with overall risk of breast cancer among the study population; however, there was an inverse association between the prudent pattern and estrogen receptor-negative breast cancer [24]. It was also reported that among the main food groups, higher intakes of fruits and vegetables were significantly associated with decreased risk for ER⁻ breast cancer [24].

Based on the findings of a prospective Study of major dietary patterns and the risk of breast cancer on postmenopausal Swedish women, higher fat intake showed a slightly but not significantly increased risk with ER⁺ tumors, and a slightly but not significantly reduced risk with ER⁻ tumors [25].

A cohort study of 91,779 female teachers in California that was conducted to evaluate the relationship between dietary patterns and breast cancer, demonstrated that the plant-based pattern was associated with a reduction in breast cancer risk [26]. This risk reduction was higher for estrogen receptor-negative progesterone receptor-negative (ER-PR-) tumors [26]. The salad and wine pattern, on the other hand, was associated with an increased risk of estrogen receptor-positive progesterone receptor-positive tumors (ER+PR+); this effect was only slightly decreased after adjustment for alcohol consumption [26].

It is suggested that diets rich in dietary fiber, especially fiber from vegetables may be associated with a slight reduction in the risk of breast cancer, respectively [27]. According to a prospective study that was performed to investigate the relationship between dietary fiber intake and risk of hormonal receptor-defined breast cancer, breast cancer risk was inversely associated with high intakes of total dietary fiber and fiber from vegetables but not from fruits, cereals, or legumes [27]. For vegetable fiber, stronger associations were found for estrogen receptor-negative and progesterone receptor-negative tumors compared to estrogen receptor-positive and progesterone receptor-positive tumors [27]. Furthermore, based on the results of a large prospective study of 623,080 middle-aged UK women, little or no decrease were found in the incidence of breast cancer with the consumption of organic foods [28].

According to a prospective cohort study that was aimed to investigate the association between dietary protein sources and breast cancer incidence, it was found that higher red meat intake in early adulthood could be a risk factor for developing breast cancer [29]. Based on the findings of this study, substituting one serving/day of legumes for one serving/day of red meat could lower the risk of breast cancer among all women by 15% and among postmenopausal women by 19% [29]. Furthermore, substituting one serving/day of poultry for one serving/day of red meat was associated with 17% lower risk of breast cancer overall and 24% lower risk of postmenopausal breast cancer [29]. In addition, substituting one serving/day of mixed legumes, nuts, poultry, and fish for one serving/day of red meat was associated with a 14% lower risk of breast cancer overall [29].

It is also suggested that there is a positive association between Mediterranean dietary pattern and prevention of all breast cancer subtypes [30,31]. Traditionally the Mediterranean diet is categorized by a high consumption of vegetables, legumes, fruits, nuts, unrefined cereals, olive oil but a low intake of saturated fats, a moderately high intake of fish; a low-to-moderate intake of dairy products mostly in the form of cheese or yogurt; a low intake of meat and poultry, and a regular but moderate intake of alcohol, mainly in the form of wine and usually during the meals [32].

Therefore, based on the findings of these studies it is suggested that there is an increased risk of breast cancer among individuals who are on Western or Western-like dietary pattern compared to prudent, healthy, and Mediterranean dietary patterns [23]. It is also suggested that a high vegetable intake is associated with lower hormone receptor-negative breast cancer risk [33].

Methodology

A broad, general and comprehensive electronic literature search was conducted throughout Google Scholar and PubMed databases to identify human studies written in the English language and published from 2001 to 2017. Search terms used with all databases were: breast, cancer, carcinoma, breast cancer, diet, dietary patterns, breast cancer and diet, dietary patterns and risk of breast cancer, types of breast cancer, ER-positive breast cancer, ER-negative breast cancer, the impact of diet on breast cancer, the relationship between breast cancer and weight, types of dietary patterns, Western dietary pattern, prudent dietary pattern, healthy dietary pattern, Mediterranean dietary pattern, interventions to reduce breast cancer risk, and healthy life style and breast cancer risk.

To minimize error, only the most common dietary patterns were identified from the articles such as: 'Western dietary pattern', 'prudent dietary pattern', 'healthy dietary pattern', and 'Mediterranean dietary pattern'. The references in all of the retrieved systematic review articles were checked for additional related articles.

Inclusion criteria

Inclusion Criteria for all searches contained of peer reviewed articles that were related to the key terms of this systematic review paper such as: breast, cancer, carcinoma, breast cancer, ER-positive breast cancer, ER-negative breast cancer, breast cancer risks, diet, dietary patterns, Western dietary pattern, prudent dietary pattern, Mediterranean dietary pattern, healthy dietary pattern, and healthy life style. The publication date range was from 2001 to 2017 in order to find only articles that were up-to-date.

Exclusion criteria

Articles that were excluded did not contain the key terms for this systematic review paper including breast, cancer, carcinoma, breast cancer, ER-positive breast cancer, ER-negative breast cancer, breast cancer risks, diet, dietary patterns, Western dietary pattern, prudent dietary pattern, healthy dietary pattern, Mediterranean dietary pattern, weight, and healthy life style.

Information extracted from each article included exact duration of follow-ups, the exact number of cancer cases in each study, risk estimates with Cancer Incidence, and some factors that were adjusted due to the design of the studies. The peer reviewed articles before 2001 were also excluded. No specific study design was excluded from this systematic review.

Results

In total, 2, 215 articles were found and 112 articles were chosen for further review, of which 87 articles were excluded after reviewing the title and abstract of each article. The remaining 25 articles were included in the paper after a full review. The total number of articles is presented in **Table 1**.

In 22 of the articles used in this systematic review, an association was found between dietary patterns and breast cancer risk. Three of the selected studies did not show any association between dietary patterns and breast cancer risk. The descriptions of all the 25 articles used in this paper are displayed in **Table 2** and their results are discussed. Studies that showed an association

between dietary patterns and breast cancer risk are identified in **Table 3** and studies that did not suggest any association between dietary patterns and breast cancer risk are discussed in **Table 4**.

According to 6 of the studies included in this paper, Western or Western-type dietary pattern are associated with breast cancer risk [24,30,34-37]. Based on the findings of 5 of the articles used in this systematic review, drinker dietary pattern [25], higher consumption of total red meat [29], high-fat dairy products [38], starch-rich dietary pattern [39], and meat-sweet dietary pattern [35] are also related to the development of breast cancer, particularly among postmenopausal women.

According to 16 of the studies used in this paper, prudent dietary pattern [23,24]; Mediterranean dietary pattern [30,31,36]; high consumption of raw vegetables, fruits and olive oil [22,26,33,40]; diets rich in dietary fiber [27]; diets high in 3 fatty acids abundant in fish [41]; low intake of meat/starches and a high intake of legumes [42]; traditional, healthy, and stew diets [34]; low consumption of Western dietary pattern plus effective weight control [35]; substituting red meat with a combination

Table 1 Total number of articles found for this study.

Total Articles Found	2215
Total Articles Selected for Further Review	112
Total Articles Used	25

Table 2 Descriptions of the Studies Included in this Systematic Review of Dietary Patterns and Breast Cancer Risk.

Study	Title	Location	Design	Sample Size	Diet-Assessment Method	Results
Sieri et al., (2004)	Dietary Patterns and Risk of Breast Cancer in the ORDET Cohort	Italy	Cohort	8, 984	Food-frequency questionnaire	Four dietary patterns were identified: <i>salad vegetables</i> (mainly consisting of raw vegetables and olive oil); <i>Western</i> (mainly consisting of potatoes, red meat, eggs and butter); <i>canteen</i> (pasta and tomato sauce); and <i>prudent</i> (cooked vegetables, pulses, and fish, with negative loading on wines and spirits). After adjustment for potential confounders, only the <i>salad vegetables</i> pattern was associated with significantly lower (34–35%) breast cancer incidence (RR = 0.66, CI _{95%} = 0.47±0.95 comparing highest with lowest tertile) with a significant linear trend (P = 0.016).
Fung et al., (2005)	Dietary patterns and the risk of postmenopausal breast cancer	USA	Cohort	71, 058	Food-frequency questionnaire	Although no overall association was observed between the <i>prudent</i> or <i>Western</i> patterns and breast cancer risk, it was suggested that a <i>Western-type</i> diet might increase the risk of breast cancer among smokers (relative risk = 1.44, comparing top to bottom quintiles; 95% CI = 1.02–2.03; p for trend = 0.03), and a <i>prudent</i> diet might protect against estrogen receptive-negative tumors. (relative risk = 0.62; 95% CI = 0.45–0.88; p for trend = 0.006)
Olsen et al., (2003)	Fruits and Vegetables Intake Differentially Affects Estrogen Receptor Negative and Positive Breast Cancer Incidence Rates	Denmark	Cohort	23,798	Food-frequency questionnaire	The intake of fruits and vegetables does not necessarily have a preventive effect on the development of postmenopausal breast cancer. However, increasing the intake of fruits and vegetables is associated with a lower incidence of ER ⁻ breast cancer IRR: 0.90 (95% CI, 0.81–0.99), suggesting that fruits and vegetables either cause a delayed progression from ER ⁺ to ER ⁻ tumors, or that the development of ER ⁺ and ER ⁻ cancers react differently to the consumption of fruits and vegetables.
Terry et al., (2001)	A Prospective Study of Major Dietary Patterns and the Risk of Breast Cancer	Sweden	Cohort	61, 463	Food-frequency questionnaire	There was no association between the <i>Western</i> dietary pattern or the <i>healthy</i> dietary pattern and breast cancer risk. However, women who were in the highest category of the <i>drinker</i> dietary pattern had a moderately increased risk (rate ratio = 1.27; 95% confidence interval, 1.06–1.52; P for trend, 0.002).

Emaus et al., (2015)	Vegetable and fruit consumption and the risk of hormone receptor-defined breast cancer in the EPIC cohort	Europe	Cohort	335, 054	Country-specific questionnaire	The highest quintile of vegetable intake was associated with a lower risk of overall breast cancer (HR _{quintile 5-quintile 1} : 0.87; 95% CI: 0.80, 0.94). Although the inverse association was most apparent for ER-PR- breast cancer (ER-PR-: HR _{quintile 5-quintile 1} : 0.74; 95% CI: 0.57, 0.96; <i>P</i> -trend = 0.03; ER+PR+: HR _{quintile 5-quintile 1} : 0.91; 95% CI: 0.79, 1.05; <i>P</i> -trend = 0.14).
Link et al., (2013)	Dietary patterns and breast cancer risk in the California Teachers Study	USA	Cohort	91, 779	Food- frequency questionnaire	The <i>plant-based</i> pattern was associated with a reduction in breast cancer risk (RR: 0.85; 95% CI: 0.76, 0.95 for the highest compared with the lowest consumption quintile; <i>P</i> -trend = 0.003); risk reduction was higher for estrogen receptor-negative progesterone receptor-negative (ER-PR-) tumors (RR: 0.66; 95% CI: 0.48, 0.91; <i>P</i> -trend = 0.03).
Ferrari et al., (2013)	Dietary fiber intake and risk of hormonal receptor-defined breast cancer in the European Prospective Investigation into Cancer and Nutrition study	10 European countries	Cohort	334, 849	Country-specific dietary questionnaire	Diets rich in dietary fiber, especially fiber from vegetables were associated with a minor reduction in the risk of breast cancer (0.90; 0.84, 0.96; <i>P</i> -trend < 0.01).
Wakai et al., (2005)	Dietary intakes of fat and fatty acids and risk of breast cancer: A prospective study in Japan	Japan	Cohort	26, 291	Food- frequency questionnaire	This prospective study did not support any increase in the risk of breast cancer associated with total or saturated fat intake, but it suggested the protective effects of the long-chain n-3 fatty acids that are abundant in fish on the risk of breast cancer. RR 0.56 (95% CI 0.33-0.94) and 0.50 (0.30-0.85).
Castello et al., (2014)	Spanish Mediterranean diet and other dietary patterns and breast cancer risk: case-control EpiGEICAM study	9 of the 17 Spanish regions	Case-Control	1017 BC cases/ 1017 controls	Food- frequency questionnaire	Adherence to the <i>Western</i> dietary pattern was associated with a higher risk of breast cancer, (OR for the top vs. the bottom quartile 1.46 (95% CI 1.06-2.01)), especially in premenopausal women (OR=1.75; 95% CI 1.14-2.67). In contrast, the <i>Mediterranean</i> dietary pattern was associated with a lower risk of breast cancer. (OR for the top quartile vs. the bottom quartile 0.56 (95% CI 0.40-0.79)). No association was observed between the <i>prudent</i> pattern and breast cancer risk.
Buckland et al., (2013)	Adherence to the Mediterranean diet and risk of breast cancer in the European prospective investigation into cancer and nutrition cohort study	10 European countries	Cohort	335, 062	Food- frequency questionnaire	Adherence to <i>Mediterranean</i> diet excluding alcohol was related to a modest decreased risk of breast cancer in postmenopausal women, (high vs. low arMED score; hazard ratio [HR] = 0.94 [95% confidence interval [CI]: 0.88, 1.00] <i>p</i> _{trend} = 0.048, and HR = 0.93 [95% CI: 0.87, 0.99] <i>p</i> _{trend} = 0.037, respectively), and this association was stronger in receptor-negative tumors (HR = 0.80 [95% CI: 0.65, 0.99] <i>p</i> _{trend} = 0.043).
McKenzie et al., (2015)	Healthy lifestyle and risk of breast cancer among postmenopausal women in the European Prospective Investigation into Cancer and Nutrition cohort study	10 European countries	Cohort	242, 918	Food- frequency questionnaire/ Diet history questionnaire	Having a high score on an index of combined healthy behaviors helped reduce the risk of developing breast cancer among postmenopausal women, when fourth versus second (reference) categories were compared [adjusted HR = 0.74; 95% confidence interval (CI): 0.66-0.83]. The fourth versus the second category of the HLIS was associated with a lower risk for hormone receptor double positive (adjusted HR = 0.81, 95% CI: 0.67-0.98) and hormone receptor double negative breast cancer (adjusted HR = 0.60, 95% CI: 0.40-0.90).

Farvid et al., (2014)	Dietary protein sources in early adulthood and breast cancer incidence: prospective cohort study	USA	Cohort	88, 803	Food- frequency questionnaire	Higher consumption of total red meat was associated with an increased risk of breast cancer overall (relative risk 1.22, 95% confidence interval 1.06 to 1.40; $P_{\text{trend}}=0.01$, for highest fifth v lowest fifth of intake). However, higher consumptions of poultry, fish, eggs, legumes, and nuts were not related to breast cancer overall. In postmenopausal women, higher intake of poultry was associated with a lower risk of breast cancer (0.73, 0.58 to 0.91; $P_{\text{trend}}=0.02$, for highest fifth v lowest fifth of intake).
Lowcock et al., (2013)	Consumption of flaxseed, a rich source of lignans, is associated with reduced breast cancer risk	Canada	Case-Control	2,999 BC cases/ 3,370 controls	Food-frequency questionnaire	This Canadian study is the first to announce the relationship between flaxseed alone and breast cancer risk and report that the consumption of flaxseed (OR= 0.82, 95% CI 0.69–0.97), and flax bread (OR = 0.77, 95% CI 0.67–0.89) are associated with a significant reduction in breast cancer risk.
Velie et al., (2005)	Empirically derived dietary patterns and risk of postmenopausal breast cancer in a large prospective cohort study ^{1,2,3}	USA	Cohort	40, 559	Food- frequency questionnaire	Three major dietary patterns found: <i>vegetable-fish/poultry-fruit</i> , <i>beef/pork-starch</i> , and <i>traditional southern</i> . Labeled <i>vegetable-fish/poultry-fruit</i> , was characterized by high intakes of vegetables and broiled or baked fish and chicken and low intakes of sweets and white bread. Labeled <i>beef/pork-starch</i> , was characterized by high intakes of pork, beef, processed meat, French fries, and eggs and low intakes of bran cereal, skim milk, broiled or baked fish and chicken, and dark bread. Labeled <i>traditional southern</i> , was characterized by high intakes of traditional rural southern US foods, including cooked greens, cooked beans and legumes, sweet potatoes, cornbread, cabbage, fried fish and chicken, and rice and low intakes of cheese, mayonnaise–salad dressing, wine, liquor, and salty snacks. The <i>traditional southern</i> diet or its components are associated with a reduced risk of invasive breast cancer in postmenopausal women (relative hazard = 0.78; 95% CI = 0.65, 0.95; P for trend = 0.003).
Kroenke et al., (2013)	High- and Low-Fat Dairy Intake, Recurrence, and Mortality after Breast Cancer Diagnosis	USA	Cohort	1893	Food-frequency questionnaire	Although the overall dairy intake was unrelated to breast cancer–specific outcomes, it was positively associated with the overall mortality rate. It was suggested that low-fat dairy intake was unrelated to recurrence or survival. However, high-fat dairy intake was associated with a higher risk of mortality after breast cancer diagnosis (0.5 to <1.0 servings/day: hazard ratio [HR] = 1.20, 95% confidence interval [CI] = 0.82 to 1.77; and ≥ 1.0 servings/day: HR = 1.49, 95% CI = 1.00 to 2.24, $P_{\text{trend}} = .05$).
Ronco et al., (2006)	Food patterns and risk of breast cancer: A factor analysis study in Uruguay	Uruguay	Case–Control	442 cases/ 442 controls	Food-frequency questionnaire	The highest risk for breast cancer was directly associated with the <i>western</i> diet (OR 1.31, 95% CI 1.13–1.51), whereas the <i>traditional</i> (OR 0.77, 95% CI 0.64–0.93), <i>healthy</i> (OR 0.84, 95% CI 0.73–0.98), and <i>stew</i> (OR 0.83, 95% CI 0.71–0.98) diets were significantly protective. Women who reported a history of breast cancer among mother and sisters displayed strong elevations in risk for <i>western</i> (OR 2.03, 95% CI 1.11–3.72) and <i>high-fat</i> (OR 2.72, 95%CI 1.16–6.37) dietary patterns.
Wu et al., (2009)	Dietary patterns and breast cancer risk in Asian American women	USA	Case-control	1248 BC cases/ 1148 controls	food-frequency questionnaire	Women who were high consumers of <i>Western</i> and <i>ethnic meat/starch</i> and low consumers of the <i>vegetables/soy</i> diets showed the highest risk (OR: 2.19; 95% CI: 1.40, 3.42; P for trend = 0.0005). A diet characterized by a low intake of meat/starches and a high intake of legumes is associated with a reduced risk of breast cancer in Asian Americans (P for trend = 0.069).
Edefonti et al., (2008)	Nutrient dietary patterns and the risk of breast and ovarian cancers	Italy	Case-control	2569 BC, 1031 OC cases/ 3413 controls	Food-frequency questionnaire	The <i>animal products</i> pattern and the <i>unsaturated fats</i> pattern were inversely associated with breast cancer (OR = 0.74, 95% CI: 0.61–0.91 and OR = 0.83, 95% CI: 0.68–1.00, respectively, for the highest consumption quartile), whereas the <i>starch-rich</i> pattern was directly associated with it (OR = 1.34, 95% CI: 1.10–1.65).

Cui et al., (2007)	Dietary Patterns and Breast Cancer Risk in the Shanghai Breast Cancer Study	Shanghai/China	Case-Control	1446 cases/ 1549 controls	Food-frequency questionnaire	It was found that the <i>Western</i> diet increases breast cancer risk in postmenopausal Chinese women. It was also found that <i>meat-sweet</i> dietary pattern increased the risk of estrogen receptor-positive breast cancer among postmenopausal women. (4th versus 1st quartile: odds ratio, 1.9; 95% confidence interval, 1.1-3.3; $P_{\text{trend}} = 0.03$) Therefore, it was suggested that for postmenopausal women, low consumption of <i>Western</i> dietary pattern plus effective weight control may help protect against breast cancer in a traditionally low-risk Asian population.
Cottet et al., (2009)	Postmenopausal Breast Cancer Risk and Dietary Patterns in the E3N-EPIC Prospective Cohort Study	France	Cohort	65, 374 (2381 cases)	Diet-history questionnaire	Two dietary patterns were identified in this study: <i>alcohol/Western</i> and <i>healthy/Mediterranean</i> . <i>Alcohol/Western</i> pattern was positively associated with breast cancer risk (hazard ratio = 1.20, 95% confidence interval (CI): 1.03, 1.38; $P = 0.007$ for linear trend), especially when tumors were estrogen receptor-positive/progesterone receptor-positive. On the other hand, the <i>healthy/Mediterranean</i> pattern was negatively associated with breast cancer risk (hazard ratio = 0.85, 95% CI: 0.75, 0.95; $P = 0.003$ for linear trend), especially when tumors were estrogen receptor-positive/progesterone receptor-negative. Based on the findings of this study, adherence to a diet containing mostly fruits, vegetables, fish, and olive/sunflower oil, along with avoidance of <i>Western-type</i> foods, may help reduce breast cancer risk in postmenopausal women.
Agurs-Collins et al., (2009)	Dietary patterns and breast cancer risk in women participating in the Black Women's Health Study ^{1,2,3,4}	USA	Cohort	50, 778	Health questionnaire	Two dietary patterns were identified: <i>Western</i> and <i>prudent</i> . The <i>prudent</i> diet was weakly associated with lower breast cancer risk overall; P for trend = 0.06. In analyses stratified by body mass index, the <i>prudent</i> dietary pattern was associated with a significantly lower risk of breast cancer in women with a BMI <25 (IRR: 0.64; 95% CI: 0.43, 0.93; P for trend = 0.01). The <i>prudent</i> dietary pattern was also associated with a significantly lower risk of breast cancer in premenopausal women (IRR: 0.70; 95% CI: 0.52, 0.96; P for trend = 0.01), and a significant inverse association for the <i>prudent</i> dietary pattern and estrogen receptor-negative breast cancer was found, as well (IRR: 0.52; 95% CI: 0.28, 0.94; P for trend <0.01).
Shin et al., (2016)	Dietary pattern and breast cancer risk in Japanese women: the Japan Public Health Center-based Prospective Study (JPHC Study)	Japan	Cohort	49, 552	Food- frequency questionnaire	Three dietary patterns were identified in this study including <i>prudent</i> , <i>Westernized</i> and <i>traditional Japanese</i> dietary patterns. The <i>Westernized</i> dietary pattern was associated with a 32% increase in breast cancer risk among Japanese women (hazard ratios (HR) 1.32; 95 % CI 1.03, 1.70; P trend=0.04). With regard to hormone receptor status, the <i>Westernized</i> dietary pattern was also associated with an increased risk of estrogen receptor-positive/progesterone receptor-positive tumors (HR 2.49; 95 % CI 1.40, 4.43; P trend<0.01). The other dietary patterns did not have any association with breast cancer.
Couto et al., (2013)	Mediterranean Dietary Pattern and Risk of Breast Cancer	Sweden	Cohort	49, 258	Food- frequency questionnaire	Adherence to a <i>Mediterranean</i> dietary pattern was not statistically significantly associated with reduced risk of breast cancer overall, or with specific breast tumor characteristics. A RR (95% confidence interval) for breast cancer associated with a two-point increment in the <i>Mediterranean</i> diet score was 1.08 (1.00–1.15) in all women, and 1.10 (1.01–1.21) and 1.02 (0.91–1.15) in premenopausal and postmenopausal women, respectively.
Prentice et al., (2006)	Low-Fat Dietary Pattern and Risk of Invasive Breast Cancer The Women's Health Initiative Randomized Controlled Dietary Modification Trial	USA	Clinical trial	48, 835	Food- frequency questionnaire	A <i>low-fat</i> dietary pattern was not associated with a significant reduction in invasive breast cancer risk among postmenopausal women. The number of women who developed invasive breast cancer over the 8.1-year average follow-up period was 0.42% in the intervention group and 0.45% in the comparison group (hazard ratio, 0.91; 95% confidence interval, 0.83-1.01 for the comparison between the 2 groups).

Hirko et al., (2016)	Healthy dietary patterns and risk of breast cancer by molecular subtype	USA	Cohort	100, 643	Food- frequency questionnaire	Adherence to the Alternative Healthy Eating Index (AHEI), alternate Mediterranean diet (aMED), and Dietary Approaches to Stop Hypertension (DASH) dietary patterns, were not strongly associated with breast cancer molecular subtypes. No heterogeneity in associations between AHEI ($p_{het} = 0.25$), aMED ($p_{het} = 0.71$), and DASH ($p_{het} = 0.12$) dietary patterns and breast cancer by subtype was observed.
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Table 3 Studies that Show a Significant Association between Dietary Patterns and Breast Cancer Risk.

Study	Dietary Pattern Increasing Breast Cancer Risk	Dietary Pattern Decreasing Breast Cancer Risk
Sieri et al., (2004)		Raw vegetables and olive oil (P = 0.016)
Fung et al., (2005)	Western-type diet might increase the risk of breast cancer among smokers (p for trend = 0.03)	Prudent diet might protect against estrogen receptive-negative tumors. (p for trend = 0.006)
Olsen et al., (2003)		Increasing the intake of fruits and vegetables is associated with a lower incidence of ER ⁻ breast cancer IRR: 0.90 (95% CI, 0.81–0.99)
Terry et al., (2001)	Drinker dietary pattern (P for trend, 0.002)	
Emaus et al., (2015)		High vegetable intake mainly in ER–PR– breast cancer (P-trend = 0.03)
Link et al., (2013)		Larger consumption of a plant-based dietary pattern reduces breast cancer risk, particularly for ER–PR– tumors. (P-trend = 0.03)
Ferrari et al., (2013)		Diets rich in dietary fiber, especially fiber from vegetables (P-trend < 0.01)
Wakai et al., (2005)		Long-chain n-3 fatty acids that are abundant in fish (trend P = 0.066)
Castello et al., (2014)	Western dietary pattern especially in premenopausal women (OR=1.75; 95% CI 1.14–2.67)	Mediterranean dietary pattern (OR for the top quartile vs. the bottom quartile 0.56 (95% CI 0.40–0.79))
Buckland et al., (2013)		Mediterranean diet excluding alcohol in postmenopausal women, particularly in receptor-negative tumors (ptrend = 0.043)
McKenzie et al., (2015)		Combined healthy behaviors (adjusted HR = 0.74; 95% CI: 0.66–0.83)
Farvid et al., (2014)	Higher consumption of total red meat (Ptrend=0.01)	Substituting red meat with a combination of legumes, poultry, nuts and fish. In postmenopausal women, higher intake of poultry (Ptrend=0.02)
Lowcock et al., (2013)		Consumption of flaxseed and flax bread (OR= 0.82, 95% CI 0.69–0.97) and (OR = 0.77, 95% CI 0.67–0.89)
Velie et al., (2005)		Traditional southern diet in postmenopausal women (P for trend = 0.003)
Kroenke et al., (2013)	High-fat dairy intake is associated with a higher risk of mortality after breast cancer diagnosis. (Ptrend = .05)	
Ronco et al., (2006)	Western diet (OR 1.31, 95% CI 1.13–1.51)	Traditional, healthy, and stew diets (OR 0.77, 95% CI 0.64–0.93), (OR 0.84, 95% CI 0.73–0.98) and (OR 0.83, 95% CI 0.71–0.98)
Wu et al., (2009)	Western and ethnic meat/starch and low consumption of vegetables/soy diets (P for trend = 0.0005)	Low intake of meat/starches and a high intake of legumes (P for trend = 0.069)
Edefonti et al., (2008)	Starch-rich dietary pattern (OR = 1.34, 95% CI: 1.10–1.65)	Animal products pattern and unsaturated fats pattern (OR = 0.74, 95% CI: 0.61–0.91 and OR = 0.83, 95% CI: 0.68–1.0)
Cui et al., (2007)	Western diet increases breast cancer risk in postmenopausal Chinese women.	Low consumption of Western dietary pattern plus effective weight control
	Meat-sweet dietary pattern increased the risk of estrogen receptor–positive breast cancer among postmenopausal women with high BMI. (Ptrend = 0.03)	
Cottet et al., (2009)	Alcohol/Western pattern (P = 0.007)	Healthy/Mediterranean pattern (P = 0.003)
Agurs-Collins et al., (2009)		Prudent dietary pattern (P for trend = 0.06)
Shin et al., (2016)	Westernized dietary pattern (P trend=0.04)	

Table 4 Studies that do not Show any Association between Dietary Patterns and Breast Cancer Risk.

Study	Summary
Couto et al., (2013)	No association was found between Mediterranean dietary pattern and breast cancer risk
Prentice et al., (2006)	A low-fat dietary pattern was not associated with any reduction in invasive breast cancer risk among postmenopausal women.
Hirko et al., (2016)	Alternative Healthy Eating Index, alternate Mediterranean diet, and Dietary Approaches to Stop Hypertension, were not associated with breast cancer molecular subtypes.

of legumes, poultry, nuts and fish [29]; and combined healthy behaviors [43] can help reduce the risk of breast cancer, mostly in postmenopausal women particularly in estrogen receptor-negative tumors.

One of the studies included in this paper suggests that the consumption of animal products and the vitamins and fiber patterns can help decrease the risk of breast cancer, as well [39]. Based on the results of one of the studies, consumption of flaxseed and flax bread is also associated with significant reduction of breast cancer incidence [44]. Traditional Southern Diet is also reported to help reduce breast cancer risk [45].

In 3 studies used in this paper, on the other hand, no association was found between any dietary patterns and the risk of breast cancer [46-48].

Discussion

The findings reported in this systematic review are in agreement with some of the previously published systematic reviews. In a systematic review and meta-analysis that was conducted by Brennan et al, in which 16 studies published between 2001 and 2009 were included, it was suggested that there was a possible inverse association between breast cancer and a dietary pattern characterized by consuming vegetables, fruits, legumes, whole cereals, fish, chicken, and foods with a low fat content [19]. In another systematic review conducted by Edefonti et al., in which 19 articles between 1995 and 2008 were included, it was reported that a diet rich in high-fat and high-sugar foods was associated with an increased risk of breast cancer [49]. On the other hand, a diet rich in vegetables, fruits, fish, and white meat was associated with a reduced risk of breast cancer [49]. According to a meta-analysis conducted by Aune et al., in which 14 cohort studies and one nested case-control study were included, it was found that high versus low intake of fruits and combined fruits and vegetables, but not vegetables alone, were associated with small, but statistically significant reduction in breast cancer risk [50].

The Pooling Project of Prospective Studies of Diet and Cancer, also analyzed the data collected from 993,466 women from 20 cohort studies, in which 19,869 cases of ER+ cancer and 4,821 cases of ER- cancer were included [51]. In this systematic review, the total fruit consumption was inversely associated with risk of ER-breast cancer but not breast cancer in general or the ER+ subtype [51]. The combined total consumption of fruits and vegetables was inversely associated with the risk of ER- breast cancer, but not with the risk of breast cancer in general or ER+ tumors [51]. According to this systematic review, the inverse association for ER- tumors was primarily observed for the consumption of vegetables [51].

There are several potential mechanisms that can explain the inverse association between the consumption of fruits and vegetables and breast cancer risk. Fruits and vegetables are good sources of fiber, which can prevent breast cancer by binding estrogens during the process of enterohepatic reabsorption of estrogen that takes place in the colon [50]. Fruits and vegetables are also very good sources of various antioxidants including glucosinolates, carotenoids, indoles, and isothiocyanates, which can help prevent breast cancer by inducing the process of detoxifying enzymes, and decreasing oxidative stress and inflammation [50].

This systematic review aimed to investigate the association between dietary patterns and breast cancer risk. Although in most of the articles included in this systematic review, no overall association was observed between the prudent, Mediterranean or Western dietary patterns and breast cancer risk, it was suggested that a Western or Western-type dietary pattern might increase the risk of breast cancer, and a prudent, Mediterranean and healthy dietary patterns might protect against estrogen receptive-negative tumors particularly in postmenopausal women [23,24,30,31,34-37]. According to the results, although the intake of fruits and vegetables might not necessarily have a significant preventive effect on the development of postmenopausal breast cancer, increasing the intake of fruits and vegetables is associated with a lower incidence of ER- breast cancer, suggesting that fruits and vegetables might either cause a delayed progression from ER+ to ER- tumors, or that the development of ER+ and ER- breast cancers react differently to the consumption of fruits and vegetables, respectively [22].

According to the results of 22 studies in this systematic review, the prudent; Mediterranean; healthy dietary patterns; high intakes of fruits, vegetable, olive oil/sunflower oil; high intakes of dietary fiber, especially fiber from vegetables; substituting red meat with a combination of legumes, poultry, nuts and fish; and low intakes of red meat, high fat meats, and high fat dairy products were associated with a decrease in the risk of breast cancer, particularly in estrogen receptive-negative tumors in postmenopausal women. This inverse association remained the same when the results of just the cohort studies alone, among these 22 studies, were also analyzed.

Food- frequency questionnaire was used in 21 out of 25 articles included in this paper, to assess the dietary intake [22,24-26,29-31,34,35,37-48]. Country-specific questionnaire was used in 2 articles [27,33]. Diet-history questionnaire was used in one of the studies [36] and Health questionnaire was used in the last article [23]. According to the studies reviewed in this paper, food-frequency questionnaire appears to be the most common tool for the assessment of the dietary intakes across the populations.

Limitations

There are potential limitations to this systematic review. The pooled results discussed in this paper, are directly retrieved from the included studies, which have their own individual strengths and weaknesses in terms of study design [19]. It is also possible that there may have been a misclassification within the healthy, prudent and Mediterranean dietary patterns in the articles reviewed in this paper. The healthy, prudent and Mediterranean dietary patterns included in this paper, all contained high consumption of plant-based foods and low consumption of red, high-fat and processed meat, which are the recommended dietary patterns suggested by the American Cancer Society to prevent cancer across the populations [52]. There are disadvantages to this type of analysis. Since the exact amount of consumption of individual foods in the prudent, Mediterranean, and healthy dietary patterns were not exactly identical among the studies in this paper, it could have led to some misclassification errors. Even very small measurement errors can dramatically affect the measures of the risk for a disease; therefore, it is possible that the small inverse association observed could have been due to a combination of dietary measurement errors and misclassification of women into the dietary pattern categories [19].

In order to minimize the risk of bias, the authors of the selected articles generally discussed the most commonly identified dietary patterns across the populations. Therefore, other types of dietary patterns that could be relevant to breast cancer risk were not included in this review. The tools used to collect dietary information in this systematic review were also different among the studies. Although the food frequency questionnaire was used

in most cases, this tool is known to be subject to measurement errors [4]. Therefore, it is not the most reliable tool to detect a significant association between a dietary pattern and breast cancer risk.

Conclusion

In conclusion, Western or Western-type dietary patterns which mainly include high consumption of red meat products, French fries, appetizers, rice, pasta, potatoes, pizza, pies, canned fish, eggs, alcoholic beverages, cakes, mayonnaise, and butter/cream [36]; are positively associated with breast cancer risk. Adherence to healthy, Mediterranean, and prudent dietary patterns, which essentially include vegetables, fruits, seafood, poultry, nuts, legumes, olive oil, and sunflower oil; on the other hand, are negatively associated with breast cancer risk in postmenopausal women, and this association is stronger in estrogen receptor-negative tumors. Therefore, adherence to a diet containing mostly fruits, vegetables, fish, nuts, and olive/sunflower oil, along with avoidance of Western-type foods, may contribute to a significant reduction in postmenopausal breast cancer risk [36]. The results of this systematic review support the potential chance for breast cancer prevention through dietary modifications. These results also highlight the need for further observational and interventional studies to explain the role of dietary patterns and breast cancer risk across populations.

Financial Support

This research received no specific grant from any funding agency, commercial or not-for-profit sectors.

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