



Minimizing Breast Cancer Risk with Diet and Exercise

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Abstract

Purpose of Review This review critically evaluates recent literature to empower clinicians with evidence-based recommendations on the relationship between diet, exercise, and breast cancer risk for breast cancer prevention and survivors.

Recent Findings Low-fat, high-vegetable, and fruit diet may not significantly reduce breast cancer risk but linked to lower breast cancer mortality. Plant-based diets show an inverse association with breast cancer diagnosis. Alcohol consumption increases breast cancer risk. High-intensity exercise demonstrates a modest protective effect. Combined, a healthy diet and exercise significantly reduce body weight, fat, and visceral adipose in breast cancer survivors. Interventions for minority women remain underrepresented, emphasizing the need for tailored programs to address disparities.

Summary Diet and exercise remain critical aspects of modifiable risk in breast cancer prevention and management. Low-fat, high-fruit, and vegetable diets contribute to overall health and decrease post-diagnosis mortality. Moderate to high-intensity exercise shows a modest effect against breast cancer risk.

Keywords Breast cancer · Diet · Exercise · Risk Reduction · Mortality · Ethnic Minorities

Introduction

At the end of 2020, breast cancer became the world's most prevalent cancer, occurring in every country in the world [1]. In the USA specifically, 4 million women were living with a diagnosis of breast cancer, cancer-free or undergoing treatment, at the start of 2022. By the end of 2022, it was expected that approximately 339,250 would be diagnosed with breast cancer [2]. Despite advancements in early

detection and treatment, the prevention of breast cancer remains a critical goal.

Breast cancer risk is influenced by a complex interplay of genetic, hormonal, and environmental factors. Breast cancer risk continues to be evaluated predominately by risk calculators that focus on non-modifiable risk factors, such as age, family history, and certain gene mutations, which have been extensively studied. However, attention has now shifted towards modifiable lifestyle factors that can be targeted to reduce breast cancer risk. Obesity, physical inactivity, and weight gain in adulthood all increase the relative risk for invasive breast cancer by 1.1–2.0. Therefore, diet and exercise have emerged as modifiable factors that hold promise for risk reduction.

By exploring the available literature on diet and breast cancer risk, we will examine the impact of specific dietary components, diets, alcohol, and antioxidants. Additionally, we will evaluate the role of exercise in breast cancer risk reduction, including the optimal type, duration, and intensity of physical activity. Moreover, we will analyze studies investigating the combined effects of diet and exercise, focusing on potential synergistic or additive effects. Lastly, we will highlight specific considerations for high-risk populations and health care disparities, exploring potential benefits of

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tailored dietary interventions and exercise programs for these at-risk groups.

The Impact of Diet on Breast Cancer: Risk, Treatment, and Outcomes

Overview of the Role of Diet in Breast Cancer Development and Treatment

Diet plays a crucial role in our overall health, and emerging evidence suggests it also influences breast cancer risk. Several dietary factors, as well as dietary patterns, have been investigated for their potential impact on breast cancer development. The American Cancer Society guidelines detail a diet that reduces the risk of breast cancer which includes plant-based food, non-starchy vegetables, vegetables rich in carotenoids, and high in calcium while avoiding refined carbohydrates, animal products, and alcohol [3]. What is more, a Mediterranean diet and DASH diet hold promise as dietary patterns with impact on breast cancer risk [4–6]. A meta-analysis by Hou et al., evaluating the aforementioned dietary patterns, concluded women diagnosed with breast cancer benefit from healthy dietary patterns with improved all-cause mortality [7]. In this section, we will delve into the literature behind these dietary factors and patterns.

Possible Mechanisms Explaining the Association Between Diet, Breast Cancer Risk, and Treatment Outcomes

Several mechanisms have been proposed to explain the association between diet and breast cancer risk. These mechanisms involve hormonal, inflammatory, and oxidative stress pathways. The byproducts of some fruits and vegetables, like flavonoids and carotenoids, can help to inhibit tumor growth and ultimately decrease the development of breast cancer [8]. Circulating carotenoid levels were associated with lower breast cancer risk of hormone-negative breast cancers [9].

The role of dietary fat in breast cancer risk has been extensively investigated. A high intake of saturated fats, commonly found in red meat and full-fat dairy products, has been associated with a potential increase in the risk of breast cancer. This association is thought to be linked to an elevation in circulating insulin-like growth factor (IGF-1), estrogen, and proinflammatory cytokines, which could promote tumorigenesis [10]. In contrast, diets rich in omega-3 fatty acids, such as those abundant in fatty fish (e.g., salmon and mackerel) and certain nuts and seeds, have demonstrated potential protective effects against breast cancer. These protective effects are believed to stem from the reduction of oxidative stress, which, in turn, has been shown to lower

chronic inflammation—a crucial factor in cancer development [11].

Experimental studies with mouse models, such as the work conducted by Dogan et al., have shed light on potential mechanisms underlying the relationship between a high-fat diet and breast cancer risk. Their findings demonstrated a high-fat diet increased mammary tumor incidence in obese MMTV-TGF- α female mice when compared to a low-fat diet, highlighting the influence of diet on mammary fat pad leptin apoptosis signaling proteins [12]. Additionally, polyphenols play a role in modulating breast cancer by regulating cellular signaling pathways and inhibiting the enzymatic activity of tumor-supportive proteins such as the transcriptional factor NF- κ B. Moreover, polyphenols also antagonize the estrogen-signaling pathway by inhibiting aromatase and estrogen production [8].

The association between diet and breast cancer risk is likely multifactorial, involving a combination of biological, hormonal, and metabolic pathways. Understanding these complex interactions will aid in developing effective strategies for breast cancer prevention and management.

Review of the Most Recent Studies on Dietary Factors and Breast Cancer Risk and Treatment Outcomes

In recent years, studies investigating the relationship between specific dietary factors and breast cancer risk provide valuable insight into the potential effects of various dietary components on breast cancer development.

The Women's Health Initiative Randomized Control Trial aimed to investigate whether a low-fat, high-vegetable, and -fruit diet could reduce the risk of breast cancer in postmenopausal women [13]. The study randomly assigned participants, with 19,541 women in the dietary management intervention group and 29,294 in the control group. Over an average follow-up period of 8.1 years, the trial did not find a statistically significant reduction in the risk of invasive breast cancer. However, secondary analyses revealed a lower hazard ratio among adherent women in the dietary management group, indicating a potential benefit for those who closely followed the dietary intervention [13].

Follow-up studies examined the long-term impact of the specific dietary pattern on breast cancer-related mortality both during the average 8.1 years of dietary intervention and over a median follow-up period of 16.1 years [14]. Post-breast cancer deaths were significantly reduced in the dietary management group at 0.025%, compared to 0.038% in the control group, with a hazard ratio (HR) of 0.65. Moreover, during the 16.1-year follow-up, post-breast cancer deaths remained lower in the dietary management group at 0.085%, as opposed to 0.11% in the control group [14].

In follow-up reports, the dietary intervention group continued to show a statistically significant reduction in deaths after breast cancer even after 19.6 years of follow-up, with rates of 0.12% compared to 0.14% in the control group [15]. Additionally, the study found a persistent statistically significant reduction in deaths as a result of breast cancer in the dietary intervention group. Although this study did not show a significant difference in risk reduction, it did show women who adhered to the dietary management had a lower mortality following breast cancer diagnosis.

Furthermore, numerous large epidemiologic studies have evaluated the impact of plant-based diets and their relationship to cancer. The aggregate of literature has suggested the consumption of fruits and vegetables, particularly cruciferous vegetables (such as broccoli and cabbage), is associated with a reduced risk of breast cancer onset and progression [10]. One epidemiologic study sought to evaluate the relationship of specific vegetarian dietary patterns and overall cancer incidence from participants of the Adventist Health Study-2 [16]. An inverse relationship was found between vegan diets and breast/gynecologic cancers potentially secondary to hormonal factors and lifestyle effects [16]. Similarly, a large epidemiologic study conducted by Key et al. observed the risk of certain cancers was lower in vegetarians and pescatarians compared to meat-eaters, although there was significant heterogeneity among cancer types [17].

Soy supplements have been a controversial area regarding breast cancer risk, with some recommendations stating use with caution, if at all [3]. A prospective trial by Touillaud et al. showed in women > 50 years of age taking soy supplementation, with a first-degree family member with breast cancer or more than 5 years following menopause had a higher risk of ER-negative breast cancer [3]. Although a positive association for dietary soy in Asian populations with breast cancer risk, its applicability in Western populations is limited [3].

When evaluating dietary risk factors associated with breast cancer, it is essential to consider the impact of alcohol consumption. The Centers for Disease Control and Prevention lists alcohol consumption as a risk factor for developing breast cancer [18]. A meta-analysis by Wiggs et al. examined the association between alcohol consumption and breast cancer risk. They found even moderate alcohol consumption was associated with an increased risk of breast cancer, emphasizing the importance of limiting alcohol intake for breast cancer prevention [19]. One large cross-sectional study conducted by Rinaldi et al. revealed women consuming more than 25 g of alcohol per day exhibited a 20% increase in levels of free testosterone and estrone. These factors have been shown to increase the risk of developing breast cancer [20].

Discussion of the Evidence Linking Diet to Breast Cancer Risk and Treatment Outcomes

Many researchers have found inconsistencies in studying specific dietary factors and their association with breast cancer risk due to the complex interplay of dietary components. To compensate for this, the focus has shifted to research on specific well-known dietary patterns, such as the Mediterranean diet and the DASH diet.

The Mediterranean diet is a healthy dietary pattern that has been associated with a lower risk of certain chronic diseases and cancers. It is composed of abundant use of extra-virgin olive oil, high consumption of plant-based foods (such as vegetables, fruits, legumes, and nuts), fish, whole-grain cereals, and red wine. It also includes limited consumption of high-sugar foods and beverages, processed and red meats, milk, butter, and whole-fat dairy [4]. The Mediterranean diet exhibits a lipid-lowering effect, leading to protection against oxidative stress, inflammation, and platelet aggregation [4]. Additionally, these diets may impact hormonal and growth factor pathways involved with breast cancer [4]. Due to biologic mechanisms, several studies have postulated a Mediterranean diet could have a protective effect for breast cancer patients [4, 5]. One large cohort study by Couto et al. found no statistically significant association between adherence to a Mediterranean diet and reduced risk of breast cancer or breast tumor characteristics in both premenopausal and post-menopausal women [21]. Cade et al.'s British cohort study replicated the previous findings. Although not statistically significant, there was an encouraging trend indicating a potential lower breast cancer risk in premenopausal women adhering to a Mediterranean diet [22].

The Dietary Approach to Stop Hypertension (DASH) diet was initially created and recommended for the management of hypertension. It is high in fruits, vegetables, legumes, nuts, and medium to low-fat dairy. It also places an emphasis on whole-grain foods, minimizing consumption of sodium, sweetened beverages, as well as red and processed meats [6]. In a case-control study conducted by the Tehran University of Medical Sciences in Iran, researchers found adherence to the DASH diet could be associated with a 30% reduction in the risk of breast cancer [6].

The Impact of Exercise on Breast Cancer: Risk, Treatment, and Outcomes

Overview of the Role of Physical Activity in Breast Cancer Development and Treatment

There is an approximately 10–20% reduction in the risk of breast cancer for women who exercise on a consistent basis, potentially independent to BMI [2]. The American Cancer

Society guidelines for physical activity recommend to aid in cancer prevention one partake in a minimum of 150 min of moderate-intensity exercise or a minimum of 75 min of vigorous-intensity exercise. Specifically for breast cancer prevention, they encourage moderate to vigorous exercise to decrease post-menopausal, and possibly premenopausal breast cancer risk. Moreover, regular vigorous exercise lowers the risk for premenopausal breast cancer. In recently published ASCO guidelines, the importance of exercise within the context of active cancer treatment (systemic chemotherapy or radiotherapy) in adults [23] was highlighted. The Expert Panel gave strong recommendations, with low to moderate evidence, for integrating regular aerobic and resistance training into the cancer treatment plan to reduce the side effects of treatment ultimately improving fatigue, strength, endurance, quality of life, and mood [23].

Possible Mechanisms Explaining the Association Between Exercise, Breast Cancer Risk, and Treatment Outcomes

To understand the interplay of exercise and breast cancer risk, pointing out the differences in estrogen production between premenopausal and post-menopausal women is crucial. In post-menopausal women, unlike in premenopausal women, estrogen is produced through peripheral aromatization of androgens, postulated to arise from adipose cells due to aging and obesity. Increased circulating estrogen levels, in turn, can stimulate the growth of hormone-receptor-positive breast cancers [24–26]. From an endocrinologic standpoint, increased body fat can potentially be related to an increased risk of ER+ breast cancer recurrence due to increased aromatase activity coupled with elevated levels of circulating estrogens and androgens. This is further compounded by other factors such as disrupted insulin and adipokine metabolism, compromised anti-tumor immunity, and chronic low-grade systemic inflammation [27]. Furthermore, evidence suggests obesity has the potential to induce oxidative stress, which may result in damage to lipids, proteins, and DNA, including those associated with oncogenes and tumor suppressor genes [28]. It is imperative to note oxidative stress can be exacerbated further with both chemotherapy and radiation therapy [28].

Physical activity exerts a multifaceted impact on breast cancer-related factors, including hormonal regulation, insulin sensitivity, immune function, inflammation, and weight control [29]. Epidemiologic and animal studies have linked overstimulation of insulin and insulin-like growth factor (IGF-1) to heightened breast cancer risk [30]. Obesity leads to increased leptin production and a potential state of leptin resistance due to mechanisms like defective transport across the blood-brain barrier, impaired JAK-STAT signaling, endoplasmic reticulum stress, and inflammation [31].

Despite the JAK-STAT pathway attenuation, leptin can still stimulate cell proliferation through alternate pathways, indicating its continued potential to promote tumorigenesis in obesity-driven, post-menopausal breast cancer [31].

Regular physical activity results in an increased mitochondrial count, resulting in quicker reactions to oxidative stress, thereby reducing cell damage and bolstering antioxidant capacity. This intricate interplay of mechanisms presents a compelling rationale for the observed impact of exercise on breast cancer risk, treatment, and outcomes [28].

Overall, with exercise, maintenance of a healthy body weight limits adverse metabolic and endocrine implications, contributing to the observed reduction in breast cancer risk through exercise [30].

Review of the Most Recent Studies on Physical Activity and Breast Cancer Risk, Including Patients Undergoing Treatment

In recent years, numerous studies have provided valuable insight into the benefits of different types, durations, and intensities of physical activity on breast cancer prevention. A meta-analysis of 139 studies by Hardefeldt et al. showed a significant decrease in breast cancer risk with any type of exercise, cumulative duration of exercise, and menopausal status. When comparing high to low-intensity exercise, there was a small observed level of protection with high-intensity exercise [32].

In a systematic review conducted by Perez et al. of breast cancer survivors, most studies included multicomponent exercise interventions encompassing strength and aerobic training. Significant improvements were observed in cardiorespiratory fitness, muscular strength, body composition, quality of life, fatigue, anxiety, depression, and sleep compared to control groups [29].

The EFICAN randomized controlled trial conducted a thorough assessment of the effects of a 12-week intervention focused on structured resistance training [33]. This intervention targeted muscular strength and overall quality of life among individuals who have survived breast cancer. The study's principal outcome revealed the addition of two weekly supervised resistance training sessions to a home-based physical activity prescription produced significant increases in full-body muscular strength. Regrettably, the study's findings did not demonstrate any noteworthy improvements in patient-reported outcomes, such as fatigue, depressive symptoms, and overall quality of life. This observed trend parallels the outcomes elucidated in another strength based randomized controlled trial conducted by Ferreira-Junior et al. [34]. The researchers hypothesized a contributory factor to this observation could be attributed to the comparatively brief duration of the prescribed exercise regimen.

The Synergistic Effects of Diet and Exercise on Breast Cancer Risk and Treatment Outcomes

Overview of the Combined Effects of Diet and Exercise on Breast Cancer Risk, Including Patients Undergoing Treatment

While diet and exercise are often studied individually for their impact on breast cancer risk, their combined effects have garnered increasing attention. The interplay between diet and exercise can enhance their individual benefits and provide a synergistic effect in reducing breast cancer risk.

Discussion of the Evidence Supporting the Combined Effects of Diet and Exercise on Breast Cancer Risk and Treatment Outcomes

Intuitively, a combination of diet and exercise can lead to weight maintenance or weight loss. Weight gain during or after breast cancer treatment increases the risk of recurrence and reduces overall survival rate [35].

Studies suggest reducing the amount of body fat after diagnosis decreases the risk of breast cancer recurrence [36]. There is also evidence that adherence to a high-quality diet, low-fat diet, or prudent diet after diagnosis is associated with a decreased risk of all-cause mortality in breast cancer patients. One large retrospective cohort study found all-cause mortality was significantly associated to BMI and physical activity, regardless of if assessed pre- or post-diagnosis (in women ≥ 65 years, pre-diagnosis hazard ratio HR 1.27, 95% CI 1.14–1.41; post-diagnosis, HR 1.19, 95% confidence interval CI 1.04, 1.36). On the contrary, neither pre- nor post-diagnosis physical activity was associated with mortality [36].

Recent studies have explored the combined effects of diet and exercise on breast cancer survivors, investigating whether their simultaneous implementation yields greater benefits than each factor alone. Brown et al. conducted a randomized controlled trial examining the effects of a combined intervention involving a healthy diet and regular exercise on the body composition of breast cancer survivors who were overweight or obese. The study demonstrated the combined intervention led to significant reductions in body weight, total body fat, and visceral adipose tissue [37]. Among breast cancer survivors, an abundance of subcutaneous adipose tissue has shown a correlation with a heightened risk of mortality [38], whereas excess visceral adipose tissue has been specifically associated with a higher risk of myocardial infarction, stroke, and cardiovascular death [39]. These findings suggest adopting a healthy diet and engaging in

regular exercise concurrently can have an impact on reducing breast cancer risk as well as on outcomes after breast cancer treatment.

Impact of Diet and Exercise on Breast Cancer Risk in Patients Undergoing Post-Treatment Care

The impact of diet and exercise on post-treatment patients' risk for breast cancer is an important consideration. After completing treatment, adopting a healthy lifestyle becomes crucial for maintaining long-term health and reducing the risk of recurrence.

Studies have indicated a healthy diet and regular exercise can positively influence post-treatment outcomes and overall survival rates among breast cancer survivors. Engaging in regular physical activity has been associated with improvements in quality of life, reduced fatigue, and decreased risk of comorbidities such as cardiovascular disease and diabetes, which are often elevated in cancer survivors. A large meta-analysis of randomized controlled trials by Fong et al. reported physical exercise had positive effects on physical functions, body weight, and quality of life in patients after treatment of breast cancer [40].

In a randomized controlled trial by Lee et al., the collective impact of a 16-week intervention combining aerobic and resistance exercises on the risk of cardiovascular disease (CVD) in women recovering from early-stage breast cancer was evaluated [41]. The trial employed the Framingham risk score (FRS) as a tool to gauge the 10-year probability of CVD development. The comprehensive findings from this trial unveiled the prescribed exercise regimen led to an impressive 11% reduction in the FRS when compared to the control group. This reduction therefore represented lowered levels of LDL cholesterol, systolic blood pressure (SBP), and diabetes markers (DM), concurrently with a notable elevation in HDL cholesterol.

By adopting a combined approach of a healthy diet and regular exercise, post-treatment patients can optimize their overall health and reduce the likelihood of future breast cancer recurrence.

Exploring the Impact of Diet and Exercise on Breast Cancer Risk: High-Risk Populations and Health Disparities

Although the incidence of breast cancer in White women supersedes that of Black and Hispanic women, breast cancer is the number one cause of cancer deaths in the USA for Black and Hispanic women [2]. Thus, highlighting the importance of examining the effects of diet and exercise specifically in high-risk populations, to promote health equity and improve breast cancer outcomes for all.

Table 1 Diet and exercise recommendation based on current literature

Diet factors [45]	<ul style="list-style-type: none"> ● Low fat ● High intake of fruit, fish, chicken, vegetables, whole grains, and unsaturated fats ● High intake of phytochemicals ● Moderate intake of red meat or simple carbohydrates ● Limited consumption of processed foods
Diet patterns [4, 6, 45]	<ul style="list-style-type: none"> ● Mediterranean diet ● DASH diet
Exercise type [46]	<ul style="list-style-type: none"> ● Moderate to intense exercise ● Resistance training and stretching exercises at least 2 days/week
Exercise duration [46]	<ul style="list-style-type: none"> ● 75–150 min every week

Obesity increases the risk of post-menopausal breast cancer [2]. The high prevalence of obesity disproportionality affects non-Hispanic Black women (57%) and Hispanic women (44%) [42]. The overall role of diet contributing to this disparity is multifaceted. Dietary patterns and food availability vary across racial and ethnic groups, with some ethnic minorities facing obstacles related to access to supermarkets with healthy, affordable, high-quality food, contributing to differences in nutrient intake and overall diet quality. The Women’s Healthy Eating and Living Study examined 118 Black and 165 Hispanic breast cancer survivors and found Black and Hispanic breast cancer survivors had a higher percentage of fat and fewer percentage of fruits and vegetables in their diets compared to their non-Hispanic White counterparts at baseline. Positive changes in their dietary patterns after the intervention were also smaller [43]. Regrettably, the study did not identify any decreases in the rates of breast cancer recurrence or enhancements in overall survival across any racial cohorts.

The increased mortality rate seen in Black women is partly due to increased numbers of estrogen-receptor-negative cancers, like triple-negative breast cancers. These cancers can also be seen in Hispanic patients as well. Drawing conclusions from data presented in this paper, ethnic minorities may benefit from diets low in soy products and high in non-starchy vegetables and vegetables high in carotenoids. This is an area for additional study and possible dietary intervention.

Similarly, the role of exercise in mitigating these disparities is also significant. From an advocacy standpoint, the ACS recommends policy promoting “safe, enjoyable, and accessible opportunities for physical activity,” which can help eliminate some barriers ethnic minorities face with engaging in physical activity [3]. Dash et al. reported improvements in metabolic syndrome following a 6-month home-based or supervised aerobic exercise program for post-menopausal Black women who were at a high risk for breast cancer with metabolic abnormalities between age 45 and 65 [44]. Given the shift to a healthier metabolic profile, exercise offers optimism in being able to positively modify breast cancer risk in this high-risk group. Many studies have

supported the benefits of exercise in breast cancer survivors; however, ethnic minority breast cancer survivors are often underrepresented in exercise interventions. There is a pressing need for culturally tailored exercise interventions among minority patients to improve health outcomes and to reduce disease burden.

Conclusion

This review emphasizes the significance of incorporating diet and exercise in breast cancer prevention and management. Based on our review, we will continue to counsel patients towards a diet rich in fruits and vegetables, low fat, abstinent to low alcohol intake with caution towards soy supplementation. The dietary benefits are most notable for post-diagnosis mortality, emphasizing the need for continuation of diet throughout and post-treatment. Dietary patterns, like the Mediterranean and DASH diets, provide a framework of comprehensive diet recommendations to offer. Aiming for 30 min of moderate exercise, at least 5 days a week, is a goal we have our patients strive towards. While evidence underscores the favorable effects of physical activity on breast cancer prevention, treatment, and post-treatment phases, research remains limited on the specific exercise modalities, frequencies, intensities, and durations. Consequently, until more data is available, there is less emphasis on the type of activity, as the benefits extend past risk reduction. Culturally competent emphasis of diet and exercise should be made for high-risk populations, like ethnic minorities, where obesity and breast cancer mortality are not favorable, to mitigate their modifiable risk factors. By empowering individuals to make healthier choices and raising awareness of the impact of diet and exercise, we can collectively work towards minimizing breast cancer risk and improving patient outcomes. See Table 1 for a summary of recommendations.

Future research should focus on exploring the long-term effects of dietary interventions and exercise programs on breast cancer risk reduction, particularly in high-risk populations. Investigating the mechanisms underlying the combined effects of diet and exercise can provide valuable insights for

developing targeted interventions and personalized approaches. By implementing evidence-based strategies and advancing our knowledge through continued research, we can strive towards a future with reduced breast cancer incidence, improved patient outcomes for all, and enhanced public health.

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Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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