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The Impact of Physical Activity on Breast Cancer Prevention

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ABSTRACT

Introduction and aim: Breast cancer is the most frequently diagnosed malignant neoplasm among women in most countries worldwide and remains one of the leading causes of cancerrelated mortality. Despite advances in early detection and treatment methods, breast cancer incidence continues to rise, particularly in highly developed countries. Preventive strategies, especially those emphasizing the promotion of physical activity, play a crucial role in breast cancer prevention by positively influencing hormonal regulation, reducing systemic inflammation, and enhancing metabolic functions. The aim of this study is to analyze the association between physical activity and breast cancer risk.

Methods and materials: This comprehensive literature review utilized the PubMed and Google Scholar databases, focusing on studies published over the past 15 years from 2010 to 2025. The search strategy was designed to gather an extensive body of research examining the role of physical activity in the prevention of breast cancer. Key search terms employed included "breast cancer", "physical activity", "exercise" and "prevention". The selected studies were thoroughly evaluated to ensure quality and rigor, with a focus on their relevance, methodological soundness, and overall significance.

Results and conclusion: A comprehensive literature review confirms that regular physical activity reduces the risk of breast cancer by supporting metabolic, hormonal, and immune health in women, both pre- and postmenopausal, including carriers of genetic mutations. Physical activity also has therapeutic value following diagnosis, enhancing quality of life and reducing mortality rates.

Keywords: breast cancer, physical activity, exercise, cancer prevention

Breast cancer continues to pose a major public health challenge worldwide

It is the most frequently diagnosed malignant neoplasm among women in the majority of countries and remains one of the leading causes of cancer-related mortality. According to data from the World Health Organization, in 2020, for the first time, breast cancer surpassed lung cancer in terms of the number of newly diagnosed cases, accounting for 11.7% of all malignancies (WHO, 2021). In Poland, breast cancer represents approximately 23% of all cancers in women, with over 24,000 new cases reported annually (Polish National Cancer Registry, 2022). Despite significant progress in early detection and therapeutic strategies, the incidence of breast cancer continues to rise. WHO estimates indicate that in highly developed countries, one in twelve women will be diagnosed with breast cancer over the course of her lifetime, while one in seventy-one will die from the disease. The situation is even more critical in less developed regions¹. The incidence of breast cancer continues to exhibit a rising trajectory, particularly in high-income countries - a trend that is closely associated with demographic aging, increasing urbanization, and shifts in lifestyle behaviors. Despite enhanced detection capabilities and ongoing advances in oncological therapies, mortality rates remain unacceptably high. This persistent lethality is largely attributable to the disease's inherent tendency toward metastasis², as well as to late-stage diagnoses and the prevalence of biologically aggressive tumor phenotypes. In light of these challenges, the implementation of effective preventive strategies - most notably the promotion of physical activity - assumes critical significance in contemporary public health discourse.

The development of breast cancer is a multifactorial process, driven by complex interactions among biological, genetic, and environmental determinants. The most significant non-modifiable risk factors include increasing age, female sex, early onset of menarche, late onset of menopause, and a positive family history – particularly the presence of BRCA1 or BRCA2 gene mutations. It is important to emphasize that breast cancer predominantly affects women, with fewer than 1% of all cases occurring in men.³ Growing emphasis is being placed on modifiable risk factors, including obesity, excess body weight, physical inactivity, suboptimal dietary patterns, excessive alcohol consumption, and tobacco use⁴, as well as the use of hormonal contraceptives or hormone replacement therapy⁵. The identification of risk factors and the implementation of effective preventive strategies are essential components in combating this disease. Physical activity exerts a favorable influence on hormonal regulation, the reduction of systemic inflammation, and the enhancement of metabolic function – all of which may contribute to a decreased risk of breast cancer. In the case of BRCA mutation

carriers, engaging in regular physical activity during early life has been shown to significantly reduce the likelihood of developing the disease⁶.

Primary prevention of breast cancer entails the mitigation or elimination of risk factors prior to the onset of disease. In the case of breast neoplasms, such preventive efforts are predominantly centered on the promotion of health-conscious behaviors, with particular emphasis on maintaining a healthy body weight and engaging in regular physical activity. A growing body of evidence from cohort studies and meta-analyses indicates that sustained physical activity is associated with a 20-30% reduction in breast cancer risk⁷. Primary prevention also holds particular relevance for high-risk populations - specifically women with inherited genetic susceptibilities, early menarche, delayed age at first childbirth, or prolonged exposure to hormone replacement therapy. Contemporary breast cancer prevention strategies incorporate both individualized and population-level approaches. At the individual level, critical interventions focus on targeted lifestyle modifications, including body weight reduction, decreased alcohol intake, adherence to a nutritionally balanced diet, and consistent engagement in physical activity⁸. At the population level, preventive efforts include organized screening programs (e.g., mammography), public health education campaigns, and policy recommendations issued by international bodies such as the World Health Organization, the American Cancer Society, and the European Code Against Cancer. In recent years, increasing emphasis has been placed on integrative health interventions that combine dietary and physical activity guidelines – for example, structured weight reduction programs targeting women at elevated risk⁹. There is a growing recognition of the need to personalize preventive strategies by taking into account factors such as age, hormonal status, baseline physical activity levels, and genetic risk profiles.

The objective of this study is to examine the association between physical activity and breast cancer risk.

Materials and method of research

This comprehensive literature review utilized the PubMed and Google Scholar databases, focusing on studies published over the past 15 years from 2010 to 2025. The search strategy was designed to gather an extensive body of research examining the role of physical activity in the prevention of breast cancer. Key search terms employed included "breast cancer", "physical activity", "exercise" and "prevention". The selected studies were thoroughly evaluated to ensure quality and rigor, with a focus on their relevance, methodological soundness, and overall significance.

Health benefits associated with regular physical activity

Physical activity is broadly characterized as any voluntary movement of the body generated by the contraction of skeletal muscles that leads to increased energy expenditure¹⁰.

Physical activity encompasses a wide range of movements, from routine daily tasks – such as walking, stair climbing, and household chores – to more structured and vigorous forms of exertion, including recreational exercise, athletic participation, and regimented training programs. Irrespective of its specific form or intensity, physical activity constitutes a cornerstone of health maintenance, conferring substantial benefits across multiple physiological domains, including the cardiovascular, metabolic, endocrine, and neuropsychological systems. Sustained engagement in physical activity has been shown to enhance overall quality of life, elevate energy levels, and fortify the immune response.

Extensive empirical evidence supports the multidimensional health benefits of regular physical activity. It contributes to the optimization of cardiovascular function through mechanisms such as blood pressure regulation, improvement of lipid profiles, and facilitation of more efficient systemic circulation. Moreover, consistent physical exertion has been associated with a delayed progression of atherosclerotic plaque formation, a key determinant in the primary prevention of cardiovascular diseases⁸. Furthermore, sustained engagement in physical activity exerts a cardioprotective effect by enhancing myocardial contractility and overall cardiac performance, thereby improving exercise tolerance and mitigating the long-term risk of developing heart failure. When integrated with a nutritionally balanced diet, regular physical activity constitutes one of the most efficacious modalities for the prevention and clinical management of obesity. It facilitates superior metabolic control by augmenting peripheral insulin sensitivity and promoting glycemic stability – mechanisms that are instrumental in reducing the incidence of type 2 diabetes mellitus¹¹. As a consequence, the risk of complications associated with insulin resistance – such as nephropathy and vascular endothelial dysfunction – is significantly diminished. Beyond its well-documented physiological benefits, physical activity also exerts a profound impact on mental health. Regular engagement in exercise has been shown to attenuate levels of psychological stress, alleviate symptoms of anxiety, and reduce the prevalence and severity of depressive disorders¹². Regular participation in physical exercise stimulates the endogenous production of endorphins - neurochemicals that possess analgesic properties and promote improved mood – thereby contributing to enhanced overall quality of life. The role of physical activity in the modulation of the endocrine system constitutes another critical dimension of its health benefits, as it may play a significant role in both the prevention and management of numerous chronic diseases. Habitual physical activity has been associated with a reduction in circulating cortisol levels – the principal stress hormone – which in turn fosters emotional stability and improved psychological well-being. Equally invaluable is the impact of physical activity on the musculoskeletal system. Resistance-based exercise routines promote increases in bone mineral density, thereby mitigating the risk of osteoporosis. Additionally, such activity enhances joint mobility and strengthens muscular structures, collectively contributing to improved physical function and a lower incidence of musculoskeletal injuries¹³. In older populations, regular physical activity is especially critical for the preservation of functional autonomy and the maintenance of independent living capacity¹⁴. Engagement in regular physical exercise also supports the development and maintenance of motor coordination, a factor of critical importance in mitigating the risk of falls and related injuries among the elderly. To optimize the health outcomes associated with physical activity, the World Health Organization (WHO) recommends that adults aged 18 to 64 years participate in a minimum of 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorousintensity aerobic activity per week - or an equivalent combination of both. Ideally, this should be supplemented with muscle-strengthening exercises targeting major muscle groups on two or more days per week. Furthermore, the WHO underscores that any amount of physical activity, irrespective of its intensity or duration, is markedly more beneficial than maintaining a sedentary lifestyle¹⁵.

The role of physical activity in cancer prevention

Physical activity constitutes a fundamental component in the primary prevention of a wide spectrum of chronic non-communicable diseases, including malignancies¹⁶. Physical activity contributes significantly to the maintenance of a healthy body weight, a key modifiable risk factor in the context of oncogenesis. Excess body weight has been strongly associated with an elevated risk of developing various malignancies, including breast, colorectal, endometrial, and other cancers. Moreover, type 2 diabetes mellitus has been implicated in the pathogenesis of certain cancers, suggesting that enhancements in insulin sensitivity and the stabilization of blood glucose levels – both achievable through regular physical activity – may contribute meaningfully to risk reduction. Importantly, cancer prevention is not solely mediated by metabolic regulation and weight control. Physical activity also exerts immunomodulatory effects, enhancing immune system function and attenuating systemic inflammation – both of which are critical in the suppression and elimination of malignant cells¹⁷. Furthermore, chronic psychological stress and affective disorders are known to exert immunosuppressive effects, thereby potentially heightening vulnerability to oncogenic processes. Regular engagement in

physical exercise has been demonstrated to confer significant anxiolytic and antidepressant effects, functioning as a non-pharmacological modulator of stress. These properties position physical activity as a valuable adjunct in cancer prevention, particularly through its capacity to enhance immunological surveillance and attenuate psychoneuroimmunological pathways implicated in tumorigenesis¹⁸.

The relationship between physical activity and the risk of breast cancer

The association between physical activity and breast cancer risk has been extensively examined in the scientific literature, with the preponderance of evidence indicating a protective effect of sustained physical exercise. Contemporary research underscores the critical role of physical activity in both primary and secondary prevention, highlighting its capacity to significantly reduce the likelihood of disease onset and recurrence^{19,20}. Regular physical activity has been shown to reduce the risk of developing breast cancer by as much as 20%²¹. Other studies report an even greater protective effect, indicating up to a 30% reduction in risk when compared to women leading sedentary lifestyles²². A substantial body of evidence indicates that habitual physical activity is associated with a markedly reduced risk of breast cancer, particularly among postmenopausal women. The biological mechanisms underpinning this association are thought to involve favorable modulations in endogenous sex hormone concentrations, decreased adiposity, and enhanced insulin sensitivity. Notably, the protective effects of lifestyle modification have also been documented among premenopausal women, underscoring the relevance of physical activity across the reproductive lifespan²³. An analysis of data from the UK Biobank study indicates a 17–23% lower risk of breast cancer among women exhibiting higher levels of physical activity, both in the premenopausal and postmenopausal phases of life²⁴. These findings suggest that the intensity of physical activity may play a critical role in mediating the associated health benefits. Notably, postmenopausal women may require higher levels of exercise intensity to achieve outcomes comparable to those observed in premenopausal women. Moreover, physical activity appears to exert a significant influence not only on the initial risk of breast cancer but also on the likelihood of recurrence and all-cause mortality among women previously diagnosed with the disease. Evidence indicates that women who increased their physical activity following a breast cancer diagnosis experienced a 45% reduction in mortality risk, whereas those who decreased their activity exhibited a fourfold increase in risk. These findings underscore the necessity of integrating physical activity into both preventive and therapeutic frameworks for women - regardless of their oncological history.

However, it is important to acknowledge the methodological limitations inherent in studies examining the relationship between physical activity and breast cancer risk. Variability in study design, definitions and measurements of physical activity, as well as differences in the demographic and clinical characteristics of study populations, may contribute to inconsistencies in outcomes. Nevertheless, the current body of scientific evidence strongly supports the role of regular physical activity as a critical preventive factor that may substantially reduce breast cancer risk and improve women's overall health status.

The influence of obesity on breast cancer pathogenesis and the preventive role of physical activity in adiposity management

Obesity exerts a multifaceted influence on the initiation and progression of breast cancer, a relationship that has been particularly well-documented in postmenopausal women^{9,25}. Among postmenopausal women with obesity, the risk of developing breast cancer may be up to three times higher compared to those with a normal body weight⁴. The increased risk is attributed to various physiological mechanisms, including the production of estrogens in adipose tissue, the secretion of adipokines by fat cells, and the presence of chronic low-grade inflammation and metabolic disturbances. Adipose tissue, particularly in individuals with obesity, becomes the primary site of estrogen production postmenopause, once ovarian function ceases. This surplus of estrogen may stimulate the development of hormone-dependent breast cancers. Aromatase, the enzyme responsible for converting androgens into estrogens, is overexpressed in adipose tissue, further contributing to elevated estrogen levels. Additionally, adipose tissue secretes adipokines such as leptin and adiponectin, which can influence breast cancer pathogenesis. Leptin levels are typically elevated in obese individuals, potentially promoting cancer cell proliferation and angiogenesis²⁶. In contrast, adiponectin, which exhibits anti-cancer properties, is often found to be reduced in individuals with obesity. Effective weight management and lifestyle modifications represent key strategies for mitigating breast cancer risk, particularly among postmenopausal women. Obesity is characterized by a state of chronic, low-grade inflammation and metabolic dysregulation. Adipocytes secrete pro-inflammatory cytokines, which have the potential to facilitate tumorigenesis and the progression of malignancies²¹. Insulin resistance and hyperinsulinemia, both prevalent in individuals with obesity, may also contribute to tumorigenesis and the progression of malignancies²⁷. Insulin has the potential to exacerbate tumor progression both directly, by promoting cellular proliferation, and indirectly, through the activation of the insulin-like growth factor (IGF) axis, which plays a pivotal role in regulating cellular differentiation, proliferation, and apoptosis²⁷. Moreover, insulin possesses

mitogenic, proliferative, and anti-apoptotic properties, mediated by the activation of mitogenactivated protein kinase (MAPK) pathways, nuclear factor-kappa B (NF- κ B), and phosphoinositide 3-kinase (PI3K)/AKT/mammalian target of rapamycin (mTOR) signaling cascades. These molecular pathways contribute to the initiation and progression of breast cancer. Additionally, hyperinsulinemia increases the synthesis of IGF-1, a well-characterized mitogenic factor implicated in carcinogenesis. Such metabolic perturbations establish a tumorpromoting microenvironment. Regular physical activity and a balanced diet are integral to maintaining optimal body weight, underscoring the importance of lifestyle interventions in addressing obesity and mitigating the pathological mechanisms outlined above.

The impact of physical activity on immune mediators and inflammatory biomarkers in the context of breast cancer

The reduction of chronic inflammation is crucial in cancer prevention, as it promotes cancer cell proliferation, angiogenesis, and the establishment of an immunosuppressive tumor microenvironment¹⁷. Regular physical activity plays a pivotal role in the prevention of breast cancer by influencing a range of biological processes, including the modulation of immune mediators and inflammatory biomarkers. The underlying mechanisms through which physical activity impacts these immune and inflammatory pathways are intricate and not fully understood. Proposed mechanisms include, among others, the secretion of myokines by skeletal muscles, reductions in adipose tissue, and alterations in hormonal signaling pathways. Notably, myokines released by skeletal muscles in response to exercise have been shown to exert significant anti-inflammatory effects, contributing to the attenuation of tumor-promoting inflammation²¹.Additionally, adipose tissue serves as a source of pro-inflammatory cytokines, and a reduction in adipose mass may contribute to a decrease in systemic inflammation. A metaanalysis of interventional studies has demonstrated that physical exercise leads to a reduction in key inflammatory markers, such as C-reactive protein (CRP), tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and leptin. Importantly, the same study found no significant effect of physical activity on adiponectin levels^{27,28}. These findings highlight the beneficial effects of exercise on inflammatory marker levels in women who have survived breast cancer. Neutrophils, as the first immune cells to respond to pathogens, play a pivotal role in the immune response. Their functions are modulated by pro-inflammatory cytokines, including interleukin-6 (IL-6) and interleukin-8 (IL-8). Chronic exposure to inflammatory states, characteristic of cancer progression, may lead to the suppression of neutrophil function²⁹. The influence of physical activity on the immune response, both at the systemic level and within the tumor

microenvironment, is of considerable significance, suggesting its potential to attenuate tumor growth and reduce metastatic risk. A substantial body of evidence supports the notion that physical activity can modulate immune mediators and inflammatory biomarkers, thereby contributing to a reduction in the risk of breast cancer development. However, it is crucial to note the limitations in the current evidence base, which are attributed to the considerable heterogeneity among studies, wide confidence intervals, and the potential for publication bias. Consequently, further investigations, particularly those focusing on the molecular mechanisms and their impact on the tumor microenvironment, are imperative to comprehensively understand this intricate relationship.

The impact of sex hormones on breast cancer risk and the role of physical activity in regulating their levels

Physical activity may play a crucial role in breast cancer prevention, partly by modulating the levels of sex hormones. This relationship is especially significant in postmenopausal women, where higher levels of estrogens - primarily synthesized in adipose tissue - and androgens produced by the adrenal glands (either directly or as precursors for aromatization into estrogens) may heighten the risk of breast cancer development³⁰. Elevated levels of estrogens may exert mutagenic effects on the mammary gland, stimulating cellular proliferation and inducing genetic damage. Furthermore, estrogens can enhance the production of reactive oxygen species (ROS), thereby exacerbating oxidative stress³¹. Observational and interventional studies confirm that regular physical activity can reduce levels of estrogens and androgens, while simultaneously increasing the levels of sex hormone-binding globulin (SHBG)²⁷. SHBG binds to estrogens and androgens, thereby inactivating them, which may contribute to a reduction in breast cancer risk³². For premenopausal women, additional research is warranted to fully elucidate the relationship between physical activity and hormonal regulation. Notably, studies have shown that vigorous physical exertion can influence menstrual disturbances and may even delay the onset of menarche^{32(p1)}. It is important to recognize that the impact of physical activity on breast cancer risk is multifaceted and dependent on various factors, including menopausal status, the type and intensity of physical activity, and individual genetic predispositions. Therefore, further research is essential to gain a deeper understanding of these interrelationships and to develop effective breast cancer prevention strategies based on physical activity.

Intensity and duration of physical activity in relation to breast cancer risk reduction

Studies indicate that regular physical exercise can significantly reduce the risk of breast cancer, and for individuals already affected by the disease, it can improve quality of life and extend

survival. It has been shown that even a few hours of moderate to vigorous recreational activity per week can effectively reduce the risk of breast cancer²¹. The benefits are not limited to formal exercise training. Some studies suggest that even moderate physical activity associated with professional work or household duties may contribute to a reduction in cancer risk. The American Cancer Society recommends at least 30 minutes of moderate physical activity daily, ideally 45-60 minutes, at least five days a week. General guidelines advocate for a target of 150–300 minutes of physical activity per week to improve overall health and prevent cancer, with exceeding 300 minutes providing additional benefits. However, any level of physical activity is valuable – even short walks positively impact fitness and well-being⁸. Particularly noteworthy are the findings from studies involving women with BRCA1 and BRCA2 mutations. These studies suggest that early initiation of regular physical activity, especially during adolescence and early adulthood, can help reduce or delay the risk of breast cancer development⁶. This implies that for genetically predisposed women, early education regarding the beneficial effects of physical activity and recommendations on its appropriate dosage should be prioritized. An important factor in this regard is consistency – the selection of enjoyable activities can enhance motivation for regular physical engagement. Walking, one of the simplest and most accessible forms of activity, is suitable for most individuals. It requires no special equipment or significant financial investment, yet offers numerous health benefits. To ensure that physical activity is safe and effective, particularly when introduced in secondary prevention for individuals undergoing oncological treatment or those previously diagnosed with breast cancer, consulting with a healthcare provider prior to starting a new exercise regimen is advisable.

Conclusion

A comprehensive review of the literature confirms that regular physical activity reduces the risk of breast cancer, while also supporting metabolic, hormonal, and immune health. The benefits extend to women both pre- and postmenopause, including those with genetic mutations. Physical activity also holds therapeutic value following a diagnosis – improving quality of life and reducing mortality rates. Health programs targeted at women should incorporate physical activity as an integral component. This is particularly important for populations at higher risk – such as BRCA1/2 mutation carriers, postmenopausal women, and those with overweight or obesity. Additionally, women following a breast cancer diagnosis can also benefit – mortality rates were reduced by up to 45% among women who increased their physical activity after diagnosis. These interventions may take the form of group activities, motivational counseling,

or digital applications that support physical activity. Tailoring the program to individual factors – such as age, physical capabilities, and lifestyle – further enhances their effectiveness.

Author's contribution:

Conceptualization: Krystian Zukierski, Weronika Jarych, Katarzyna Michalak Methodology: Krystian Zukierski, Weronika Jarych, Katarzyna Michalak Investigation: Krystian Zukierski, Weronika Jarych, Katarzyna Michalak Software: Krystian Zukierski, Katarzyna Żak, Hubert Jucha, Agnieszka Kluz Check: Agnieszka Kluz, Katarzyna Madyniak, Aleksandra Pliszka Data Curation: Aleksandra Pliszka, Hubert Jucha Visualization: Katarzyna Madyniak, Michał Mazur Project Administration: Michał Mazur, Katarzyna Żak Writing - Rough Preparation: Weronika Jarych, Krystian Zukierski Formal Analysis: Katarzyna Michalak, Aleksandra Pliszka Writing - Review and Editing: Katarzyna Madyniak, Hubert Jucha Resources: Michał Mazur, Krystian Zukierski, Weronika Jarych Supervison: Agnieszka Kluz, Hubert Jucha, Katarzyna Żak All authors have read and agreed with the published version of the manuscript.

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