Diet, Obesity, and Sedentary Lifestyle as Risk Factor of Breast Cancer among Women at Yogyakarta Province in Indonesia

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Abstract

BACKGROUND: Breast cancer prevalence remains high worldwide, including in Indonesia. Studies examining relationship between obesity, dietary habit, sedentary lifestyle, and breast cancer development are largely inconclusive.

AIM: This study aimed to determine relationship between obesity, dietary habit, sedentary lifestyle, and breast cancer risk among women at Yogyakarta Province in Indonesia.

METHODS: This was a cross-sectional study on 135 women selected purposely during March–May 2019. Binary logistic regression models were employed in the analysis with 0.05 considered significant.

RESULTS: Among study subjects, 54.07% and 40% were, respectively, >40 years old and smokers. About 53.33% consumed preserved food 3–6 times/week, and 49% and 50.37% consumed sweet food and beverage >1 time/day, respectively. High body mass index (BMI) and physical inactivity were associated with 93% and 85% breast cancer risk reductions (adjusted odds ratio [AOR]: 0.07, 95% confidence interval [CI]: 0.01–0.45, p < 0.01 and AOR: 0.15, 95% CI: 0.05–0.47, p < 0.001). Smoking showed no significant relationship. A waist circumference (WC) of ≤80 cm linked to 78% breast cancer risk reduction. Sweet food, sweet beverage, and energy drink consumption of >1 time/day led to 96%, 36%, and 84% reductions of invasive breast cancer risks. Meanwhile, consumption of preserved food 3–6 times/weeks and soft drinks >1 time/day correlated with an increased risk of breast cancer.

CONCLUSION: High BMI, physical inactivity, and lower WC were associated with the lower breast cancer risk, while preserved food and soft drink consumption significantly increase the risk. Although sedentary lifestyle seems to have a small protective effect, healthy lifestyle should be encouraged and effective strategies are required to encourage women to adopt healthy lifestyle.
Obesity has also been associated with reduced breast cancer survival [8]. A physically active lifestyle, in comparison with inactive lifestyle, has been shown to positively reduce the risk of breast cancer in several studies [9], [10]. In contrast, unhealthy eating habit such as consuming high-sugar drinks, foods containing saturated fat, and red/processed meat have been shown to increase the risk of breast cancer [11]. However, the relationship between physical activity and the incidence of breast cancer is still debatable [10]. Furthermore, whether the habit of consuming fatty food will affect the development of tumor cells in the breast or not still remains a controversy [12], [13]. Moreover, several previous studies revealed that, in women, BMI is inversely associated with an increase in breast cancer [14], [15], [16]. Hence, this study sought to examine the associations between obesity, diet, sedentary lifestyle, and breast cancer at Yogyakarta, Indonesia.

Methods

Study design and participants

This cross-sectional study was conducted after obtaining approval from the Ethics committee on Human Research of Ahmad Dahan University (011903016). Written informed consent was obtained from all subjects before interview. This study involved 135 subjects who were diagnosed to have breast cancer treated at the PKU Muhammadiyah Yogyakarta hospital which specializes in oncology and cancer treatment. We have selected the province of Yogyakarta based on cancer data by the Indonesian Ministry of health in 2020, which had the highest cancer incidence rate compared to any other province in Indonesia. The inclusion criteria for participation were ≥18 years old, Indonesian, and able to communicate verbally. The exclusion criteria were designed to avoid those with diabetes mellitus, liver and renal diseases, and rheumatoid arthritis because this disease condition may require adherence to “special diet,” which may interfere with the apparent effects of the dietary pattern studied and result in unwillingness to be interviewed.

Data measurement process

Lifestyle was measured based on previous research, in which regular exercise, absence of smoking habit, BMI, waist circumference (WC), and a healthy diet were used as indicators of healthy lifestyles. Poor lifestyle is said to trigger high morbidity and mortality of diseases, including breast cancer [17], [18]. In this study, physical activity was measured using the Global Physical Activity Questionnaire (GPAQ) through interviews that collected information on the participants’ physical activity during the past week. Rigorous physical activity was defined as doing physical activities at least 3 days in the past week with a total activity duration of at least 1500 metabolic equivalent of task (MET) minutes. MET minutes of rigorous activity are the duration (minutes) of activity in a week times eight calories. Moderate activity was defined as activities such as sweeping, mopping, and gardening for at least 5 days with a total duration of 150 min in the previous week. Subsequently, the participants who performed rigorous activities and/or moderate activities were categorized into adequately active. Participants who did physical activities but did not fall into rigorous activity and moderate activity categories were classified as physically inactive.

The anthropometric measurements were used to assess BMI and WC. BMI was measured by a trained research assistant with the participants in a standing position without shoes and outer clothing. A digital scale (Camry brand) is used and its calibration was monitored regularly before use in this study. BMI was calculated as weight (kg) divided by the square of height (m2), and categorized into four groups according to the standard for ASEAN people in the World Health Organization (WHO) guideline: Underweight (<18.5 kg/m2), normal weight (18.5–24.99 kg/m2), overweight (25.0–29.9 kg/m2), and obesity (30 kg/m2 or greater) [19].

WC measurement was conducted by referring to the WHO steps protocol where the measurement is made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest using a stretch-resistant tape that provides a constant 100 g tension. The participants were asked to be relaxed and breathe out gently during the measurement. Furthermore, they were asked to stand with feet close together, arms at the side, body weight evenly distributed, and wear fewer clothing. The tape was held firmly in the horizontal position and the measurement was repeated twice. If the measurements were within 1 cm of one another, the average should be calculated. If the difference between the two measurements exceeded 1 cm, the two measurements should be repeated based on the WHO cutoff points and risk of breast cancer incidence. WC are categorized into (1) high risk of breast cancer (>80 cm) and (2) less risk of breast cancer (≤80 cm). Measurement of dietary habit of the participants was conducted using the Food Frequency Questionnaire. Participants were asked about the average frequency of consuming one standard serving of specific food in three categories during the past month (1/day, 3–6/week, and <3/month). The responses on a frequency of consumption of a specific serving size for each item were converted into average daily intake. Subsequently, the consumption of daily foods was classified into sweet meals, sweet drinks, salty foods, fatty meals, roasted food, preserved food, seasoning, soft drinks, energy drinks, and instant...
noodle. Other variables were also asked to the participants, such as smoking (Yes/No), age, marital status, and occupation.

**Statistical analysis**

All statistical analyses were performed using STATA version 13. Means and standard deviations were used to interpret continuous variables, while count and percentage were used to represent variables of categories. Multiple logistics regression was used to calculate adjusted odds ratio (AOR) and confidence intervals (95% CI) for evaluating associations between independent and dependent variables. Age, marital status, occupation, BMI, smoking, physical activity, and WC were assessed as potential confounders variables. Chi-square was used to estimate the differences among categorical variables. The significance level was set at p < 0.05.

**Results**

The variable of participants’ age in this research was divided into two: Aged <40 (45.93%) and aged 40 years (54.07%). Of the total 135 participants, the majority of participants were married (76.30%) and 48.89% of them did not do physical activities. In details, the socio-demographic characteristics of the respondents are described in Table 1.

### Table 1: Selected characteristics of participants study

| Participant characteristics | n   | %    |
|----------------------------|-----|------|
| Age (years)                |     |      |
| <40                        | 62  | 45.93|
| ≥40                        | 73  | 54.07|
| Marital status             |     |      |
| Single                     | 27  | 20.00|
| Married                    | 103 | 76.30|
| Widowed/separate/discovered| 5   | 3.79 |
| Occupation                 |     |      |
| Unemployment               | 28  | 20.74|
| Labor                      | 77  | 57.04|
| Government/official/business| 30  | 22.22|
| BMI                        |     |      |
| <18.5                      | 7   | 5.19 |
| 18.5–22.99                 | 80  | 59.26|
| 23–24.99                   | 21  | 15.56|
| ≥25                        | 27  | 20.00|
| Smoking                    |     |      |
| Yes                        | 54  | 40.00|
| No                         | 81  | 60.00|
| Physical activity          |     |      |
| Inactivity                 | 66  | 48.89|
| Enough active              | 69  | 51.11|
| Waist circumference (cm)   |     |      |
| >80                        | 84  | 62.22|
| ≤80                        | 51  | 37.78|

More than half of the respondents (53.33%) consumed preserved food 3–6 times a week and 49% of the respondents consumed sweet food more than once per day. Sweet drinks were consumed more than once a day by 50.37% of the respondents. A more detailed description of the respondents’ daily food consumption is listed in Table 2.

### Table 2: The daily food consumption risk from study participants

| The daily foods | n | %   |
|----------------|---|-----|
| Sweet meals    |   |     |
| >1 time/day    | 67 | 49.63|
| 3–6 times/week | 61 | 45.19|
| <3 times/month | 7  | 5.19 |
| Sweet drinks   |   |     |
| >1 time/day    | 68 | 50.37|
| 3–6 times/week | 61 | 45.19|
| <3 times/month | 6  | 4.44 |
| Salty foods    |   |     |
| >1 time/day    | 48 | 35.56|
| 3–6 times/week | 81 | 60.00|
| <3 times/month | 6  | 4.44 |
| Fatty meals    |   |     |
| >1 time/day    | 45 | 33.33|
| 3–6 times/week | 83 | 61.48|
| <3 times/month | 7  | 5.19 |
| Roasted food   |   |     |
| >1 time/day    | 9  | 6.67 |
| 3–6 times/week | 85 | 62.26|
| <3 times/month | 41 | 33.79|
| Preserved food |   |     |
| >1 time/day    | 26 | 19.26|
| 3–6 times/week | 72 | 53.33|
| <3 times/month | 37 | 27.41|
| Seasoning      |   |     |
| >1 time/day    | 10 | 7.41 |
| 3–6 times/week | 16 | 11.85|
| <3 times/month | 18 | 13.33|
| Soft drink     |   |     |
| >1 time/day    | 4  | 2.96 |
| 3–6 times/week | 41 | 30.37|
| <3 times/month | 90 | 66.67|
| Energy drink   |   |     |
| >1 time/day    | 5  | 3.70 |
| 3–6 times/week | 28 | 20.74|
| <3 times/month | 102| 75.56|
| Instant noodle |   |     |
| >1 time/day    | 4  | 2.96 |
| 3–6 times/week | 51 | 37.78|
| <3 times/month | 80 | 55.26|

The unadjusted and adjusted odd ratios representing the relationship between sedentary lifestyle and the breast cancer occurrence are shown in Table 3. After adjusting for other covariates, a higher BMI category was demonstrated to be significantly associated with increasing breast cancer incidence, with the odds of the risk for breast cancer decreased by 93% (AOR: 0.07, 95% CI: 0.01–0.45, p < 0.01). It was also demonstrated in this study that patients with the lack of physical activities had lower odd of developing breast cancer (AOR: 0.15, 95% CI: 0.05–0.47, p < 0.001). In contrast, smoking was shown to have no significant relationship with breast cancer incidence.

With regard to WC, the odds of increasing of breast cancer risk for someone who had a WC of more than 80 was 78% less than someone who had a waist circumstance of ≤80 (AOR: 0.22, 95% CI: 0.75–0.65, p < 0.01). In terms of age, respondents aged 40 years old or above presented 3.24 higher odds to have breast cancer compared to those who were ≤40 years old as illustrated in Table 4 (AOR: 3.24, 95% CI: 1.91–11.36, p < 0.05).

Table 4 presents the AOR and 95% CI for daily food consumption. Intake of sweet food seemed to increase the risk of developing breast cancer, with the odds of patients who consumed sweet meals once a day and 3–6 days a week had an increased breast cancer risk of 96% and 99%, respectively (AOR: 0.04, 95% CI: 0.01–0.05, p < 0.001; AOR: 0.01, 95% CI: 0.03–0.05, p < 0.01). The odds of breast cancer risk
Table 3: Crude odds ratio (OR) and adjusted odds ratio (AOR) for socio-demographic related to breast cancer incidence

| Variables                        | Breast cancer | Crude OR | 95% CI   | AOR      | 95% CI   |
|----------------------------------|---------------|----------|----------|----------|----------|
|                                  | Yes (%)       |         |          |          |          |
| Age (years)                      |               |          |          |          |          |
| <40                              | 8 (21.05)     | 1        | 1.01     | 1        | 1.90***  |
| ≥40                              | 30 (78.95)    | 1.26     |          | 3.24*    | 1.19–2.62|
| Marital status                   |               |          |          |          |          |
| Single                           | 2 (5.26)      |          |          |          | 0.03–0.05|
| Married                          | 33 (86.84)    | 1        | 0.01–9.07| 0.75–0.65| 0.53–3.01|
| Widowed/separate/discovered      | 3 (7.89)      | 1.77     | 1.98     | 0.94–4.91| 0.31–12.52|
| Occupation                       |               |          |          |          |          |
| Unemployment                     | 11 (28.95)    |          |          |          | 0.04–1.69|
| Labor                            | 11 (28.95)    |          |          |          | 0.09–0.89|
| Government/official/business     | 16 (42.11)    |          |          |          | 0.01–1.27|
| BMI                              |               |          |          |          |          |
| <18.5                            | 2 (5.26)      |          |          |          | 0.04–0.05|
| 18.5–22.99                       | 27 (71.05)    |          |          |          | 0.07–1.27|
| >23–24.99                        | 8 (21.05)     |          |          |          | 0.03–0.05|
| >25                              | 1 (2.63)      |          |          |          | 0.01–1.27|
| Smoking                          |               |          |          |          |          |
| No                               | 20 (52.63)    |          |          |          | 0.04–0.05|
| Yes                              | 18 (47.37)    |          |          |          | 0.01–1.27|
| Physical activity                |               |          |          |          |          |
| Enough active                    | 28 (73.68)    |          |          |          | 0.03–0.05|
| Inactivity                       | 10 (26.32)    |          |          |          | 0.04–1.77|
| Waist circumference (cm)          |               |          |          |          |          |
| ≤80                              | 23 (60.53)    |          |          |          | 0.03–0.05|
| >80                              | 36 (94.77)    |          |          |          | 0.01–3.72|

CI: Confidence interval; *p<0.05; ** p<0.01; *** p<0.001.

Table 4: Adjusted odds ratio1 for the daily consumption of food of participants

| Items                              | Crude OR | 95% CI   | Adjusted OR | 95% CI   |
|------------------------------------|----------|----------|-------------|----------|
| Fatty meals (ref.<3 times/month)   |          |          |             |          |
| ≥1 time/day                        | 0.04***  | 0.01–0.25| 0.01–0.05   |          |
| 3–6 times/week                     | 0.32     | 0.01–1.77| 0.03–0.05   |          |
| Sweet drinks (ref.<3 times/month)  |          |          |             |          |
| ≥1 time/day                        | 0.23**   | 0.04–1.48| 0.03–0.07   |          |
| 3–6 times/week                     | 1.81***  | 0.30–10.64| 0.04–0.05  |          |
| Sweet foods (ref.<3 times/month)   |          |          |             |          |
| ≥1 time/day                        | 0.01**   | 0.01–0.14| 0.01–9.07   |          |
| 3–6 times/week                     | 0.34     | 0.06–1.99| 0.01–38.95  |          |
| Roasted food (ref.<3 times/month)  |          |          |             |          |
| ≥1 time/day                        | 3.00     | 0.34–27.23| 0.01–3.03  |          |
| 3–6 times/week                     | 2.16     | 0.25–18.99| 0.01–3.01  |          |
| Preserved foods (ref.<3 times/month)|         |          |             |          |
| ≥1 time/day                        | 3.39     | 0.98–11.72| 0.53–4.37  |          |
| 3–6 times/week                     | 3.20*    | 1.11–9.26| 0.54–29.50  |          |
| Soft drink (ref.<3 times/month)    |          |          |             |          |
| ≥1 time/day                        | 1.62     | 0.49–5.32| 0.02–6.14   |          |
| 3–6 times/week                     | 0.50     | 0.08–3.19| 0.01–1.74   |          |
| Energy drinks (ref.<3 times/month) |          |          |             |          |
| ≥1 time/day                        | 0.52     | 0.05–2.53| 2.01–1.39   |          |
| 3–6 times/week                     | 0.09*    | 0.02–3.06| 0.01–3.72   |          |
| Instant noodle (ref.<3 times/month)|          |          |             |          |
| ≥1 time/day                        | 0.48*    | 0.04–4.77| 0.01–1.32   |          |
| 3–6 times/week                     | 0.12*    | 0.03–0.37| 0.04–0.62   |          |

Estimates from binary logistic model adjusted for age, marital status, and occupation. Ref.: Reference. CI: Confidence interval; cm: Centimeter; *p<0.05; ** p<0.01; *** p<0.001.

Discussion

This study is the first attempt to evaluate the impact of obesity, poor food consumption patterns, and unfavorable lifestyles in relation to breast cancer risk in Indonesia. After taking into account, the characteristics of the respondents, obesity, certain food groups (sweet foods and drinks, preserved foods, and instant noodles), and physical inactivity are identified as factors that may be positively associated with the risk of breast cancer. Usually, BMI is used to evaluate obesity in general, while WC is used to evaluate central obesity. Several previous studies reported that obesity is significantly associated with an increased risk of breast cancer especially in premenopausal women [20, 21]. However, studies on premenopausal women who are survivors of breast cancer, the BMI is inversely associated with breast cancer risk [22, 23].

The results of this study support this finding as among 38 participants with breast cancer in our study, most have a BMI of 18.5–22.99 kg/m2 (71.05%) and >23–24.99 kg/m2 (21.05%). In line with a study conducted by Lyengar et al. (2019), this study also shows that breast cancer is more associated with the body fat level than with BMI [24]. The fact that obesity is a risk factor for some types of cancer is largely based on the use of anthropometric indexes such as BMI as an indirect measure of adiposity. This anthropometric measurement is a crude measure of body size that does not differentiate adiposity and muscle. People who have a normal BMI may actually have cardiometabolic disorders, which are collectively...
referred to as metabolic obesity in normal weight [25]. Another study using a meta-analysis shows that there is a linear relationship between BMI and breast cancer risk (p < 0.001), where an increase in BMI of 5 kg/m² is associated with a 2% increase in breast cancer risk with the summary relative risk (SRR) of 1.02 (95% CI: 1.01–1.04) thus showing that increased BMI can increase the risk of breast cancer [20]. Association between central obesity and breast cancer was identified in the findings of this study. This is in line with a case-control study among pre-menopause of Brazilian women that shows the association between WC and breast cancer risk (OR = 3.31, 95% CI 1.45–7.55) [23]. Based on a previous study, WC is more widely used to measure central obesity than other anthropometric measurement indicators. This consideration is based on the fact that WC is used to measure the risk of mortality risk caused by normal-weight central obesity and has the ability to identify pragmatic clinical measures to assist in identifying those at risk [26]. The central obesity can amplify the risk of estrogen receptor-negative breast cancers [27].

When assessing unfavorable lifestyle, the findings of this study indicate that physical inactivity is significantly associated with breast cancer. On the other hand, smoking is not shown to have any relation with breast cancer. In line with the Physical Activity Guidelines Committee for American scientific report in 2018, physical activities reduces the risk of breast cancer [28]. In addition, many studies have shown that physically active women have a lower risk of breast cancer than inactive women. Working women tend to have a low physical activity status that increases the risk of developing breast cancer [29], [30]. Low physical activity is also associated with malnutrition that can lead to an increased risk of breast cancer. Both underweight women and obese women tend to have lower activity than women with normal nutritional status, so they are more at risk of developing breast cancer [31]. Physical activity is associated with reduced risk of breast cancer through several mechanisms, including reducing the production of hormones such as estrogen. High levels of estrogen can stimulate the growth and division of breast epithelial cells, which may increase the risk of cancer by allowing the spread of genetic errors. Therefore, it is necessary to have adopt adequate physical activities to prevent breast cancer [32], [33].

In addition, the previous studies have proven for decades that nutrition plays an important influence on the risk of developing cancer [34], [35]. This study found that consuming sweet foods is associated with decreasing breast cancer risk. Furthermore, it was identified that that a high consumption of soft drink is significantly associated with increasing breast cancer risk (AOR: 1.60, 95%CI: 2.01 to 1.39, p < 0.05) while daily consumption of energy drink reduced the risk for developing breast cancer. Sugary drinks, also categorized as sugar-sweetened beverages or “soft” drinks, refer to any beverage added with sugar or other sweeteners (high fructose corn syrup, sucrose, fruit juice concentrates, and more). This includes soda, pop, cola, tonic, fruit punch, lemonade, sweetened powdered drinks, sports drinks, and energy drinks [36]. As a category, these beverages comprise the single largest source of calories and added sugar. Sugary drink consumption is rising dramatically due to the widespread urbanization and beverage marketing, particularly in developing countries, including Indonesia [37], [38]. Many studies showed that the consumption of sugary drinks and artificially sweetened beverages is significantly associated with the risk of overall cancer, including breast cancer [34], [39]. Cancer cells require glucose to produce energy to support their rapid growth and spread. They also need a lot of other nutrients such as amino acids and fats. Furthermore, sugary food and sugary drink consumption are associated with glucose metabolism which requires insulin that can increase tumorigenesis either through a direct effect on epithelial tissue or indirectly by influencing the levels of other modulators such as the insulin-like growth factor (IGF) receptor group, sex hormones, and adipokines. Hyperinsulinemia and higher IGF-1 levels are also well-known to be associated with breast cancer risk [40].

Findings in this study also show that processed food consumption is also associated with the incidence of breast cancer. This supports the finding of a previous cohort study stating that a 10% increase in the proportion of ultra-processed foods in the diet is significantly associated with a more than 10% increase in the overall risk of cancer, including breast cancer [41]. Preserved food often contains higher total fat, saturated fat, sugar, and salt, but lower in fiber and vitamins. In addition, it also has potential carcinogenic properties from food additives used, such as sodium nitrite in processed meat [42]. Although preservatives such as nitrate are generally considered safe, there are several concerns regarding their actual safety that raise from, among others, the formation of carcinogenic nitrosamines from nitrites [43]. Other food preservatives such as sodium benzoate and potassium sorbate are also associated with the risk of various health problems. Sodium benzoate is thought to be linked to the possibility of allergies and has immunosuppressive effects. Interactions between sorbate and nitrates in the digestive tract is also regarded to produce a series of genotoxic compounds [43]. Based on the recommendation from the WHO (2016) through the Joint FAO/WHO Expert Committee on Food Additives (JECFA), the acceptable daily intakes (ADIs) of benzoate and sorbate are 0–5 mg/kg body weight/day for benzoic acid (and benzoate salts) and 0–25 mg/kg body weight/day for sorbic acid (and sorbate salts).

A major strengths in this study are high response rate of the participants (100%), use of standardized protocol for data collections, and include the measurements of BMI and WC that are well known
to be factors that may predict the development of breast cancer. The biological mechanisms that may work for most of these lifestyle factors seem to be mediated by adipose tissue, with chronic low-grade inflammation creating an environment that encourages breast cancer to develop and grow. Sedentary lifestyle has also been linked to increased risk for estrogen receptor (ER)-positive breast cancer [44]. However, some limitations should be acknowledged. First, reporting of repeated diet history may be biased due to short memory of the respondents. Second, several factors related to lifestyle such as measurement of physical activity and smoking are in the form of self-reported questionnaires. As a result, they may have been misclassified. Third, this study is an observational study with a cross-sectional approach where the confounding variables are difficult to separate so that the causality relationship of the observed variables is difficult to determine. In addition, it is necessary to consider eating patterns and lifestyles that can be influenced by local culture or customs.

**Conclusion**

This study indicates that obesity, WC, smoking habit, and physical activity are associated with lower breast cancer risk. Unsurprisingly, smoking shows no significant relationship with increased breast cancer risk. Poor dietary habits characterized by the consumption of preserved food and soft drinks appear to be linked to increased risk for breast cancer, while sweet meals and sweet drinks are inversely associated with the increase in breast cancer. Although a small protective effect of sedentary lifestyle against breast cancer incidence is identified, the role of healthy lifestyle should still be emphasized using an integrated approach and an effective strategy is required to encourage women to adopt a healthy lifestyle.

**References**

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68(6):394-424. https://doi.org/10.3322/caac.21492
PMid:30207593

2. Schwingshackl L, Schwedhelm C, Galbete C, Hoffmann G. Adherence to mediterranean diet and risk of cancer: An updated systematic review and meta-analysis. Nutrients. 2017;9(10):1063. https://doi.org/10.3390/nu9101063
PMid:28954418

3. Sun YS, Zhao Z, Yang ZN, Xu F, Lu HJ, Zhu ZY, et al. Risk factors and prevention of breast cancer. Int J Biol Sci. 2017;13(11):1387-97.

4. Arthur RS, Wang T, Xue X, Kamensky V, Rohan TE. Genetic factors, adherence to healthy lifestyle behavior, and risk of invasive breast cancer among women in the UK Biobank. J Natl Cancer Inst. 2020;112(9):893-901. https://doi.org/10.1093/jnci/djz241
PMid:31899501

5. Argolo DF, Hudis CA, Iyengar NM. The impact of obesity on breast cancer. Curr Oncol Rep. 2018;20(6):47. https://doi.org/10.1007/s11912-018-0688-8
PMid:29644507

6. Lee K, Kruper L, Dieli-Conwright CM, Mortimer JE. The impact of obesity on breast cancer diagnosis and treatment. Curr Oncol Rep. 2019;21(5):41. https://doi.org/10.1007/s11912-019-0787-1
PMid:30919143

7. Fayanju OM, Hall CS, Bauldrey JB, Karhade M, Valad LM, Kuerer HM, et al. Body mass index mediates the prognostic significance of circulating tumor cells in inflammatory breast cancer. Am J Surg. 2017;214(4):666-71. https://doi.org/10.1016/j.amjsurg.2017.06.005
PMid:28720217

8. Blair CK, Wiggins CL, Nibbe AM, Storlie CB, Prossnitz ER, Royce M, et al. Obesity and survival among a cohort of breast cancer patients is partially mediated by tumor characteristics. NPJ Breast Cancer. 2019;5:33. https://doi.org/10.1038/s41523-019-0128-4
PMid:31602394

9. Pizot C, Boniol M, Mullie P, Koechlin A, Boniol M, Boyle P, et al. Physical activity, hormone replacement therapy and breast cancer risk: A meta-analysis of prospective studies. Eur J Cancer. 2016;52:138-54. https://doi.org/10.1016/j.ejca.2015.10.063
PMid:26687833

10. McTiernan A, Friedenreich CM, Katzmarzyk PT, Powell KE, Macko R, Buchner D, et al. Physical activity in cancer prevention and survival: A systematic review. Med Sci Sports Exerc. 2019;51(6):1252-61. https://doi.org/10.1249/MSS.0000000000001937
PMid:31095082

11. Skouroliakou M, Grosomanidis D, Massara P, Kostara C, Papandreou P, Ntoutaniotis D, et al. Serum antioxidant capacity, biochemical profile and body composition of breast cancer survivors in a randomized Mediterranean dietary intervention study. Eur J Nutr. 2018;57(6):2133-45. https://doi.org/10.1007/s00394-017-1489-9
PMid:28634625

12. Guo J, Wei W, Zhan L. Red and processed meat intake and risk of breast cancer: A meta-analysis of prospective studies. Breast Cancer Res Treat. 2015;151(1):191-8. https://doi.org/10.1007/s10549-015-3380-9
PMid:25893586

13. Taha Z, Eltom SE. The role of diet and lifestyle in women with breast cancer: An update review of related research in the middle east. Bioren Open Access. 2018;7(1):73-80. https://doi.org/10.1089/boires.2018.0004
PMid:29862141

14. Chan DS, Abar L, Carilou M, Nanu N, Greenwood DC, Bandera EV, et al. World cancer research fund international: Continuous update project-systematic literature review and meta-analysis of observational cohort studies on physical activity, sedentary behavior, adiposity, and weight change and breast cancer risk. Cancer Causes Control. 2019;30(11):1183-200. https://doi.org/10.1007/s10552-019-01223-w
PMid:31471762

15. Gui Y, Pan Q, Chen X, Xu S, Luo X, Chen L. The association between obesity related adipokines and risk of breast cancer.
A meta-analysis. Oncotarget. 2017;8(43):75389-99. https://doi.org/10.18632/oncotarget.17853 
PMid:29088874

16. Engin A. Obesity-associated breast cancer: Analysis of risk factors. In: Engin AB, Engin A, editors. Obesity and Lipotoxicity. Cham: Springer International Publishing; 2017. p. 571-606. https://doi.org/10.1007/978-3-319-48382-5_25

17. Adams ML, Katz DL, Shenson D. A healthy lifestyle composite measure: Significance and potential uses. Prev Med. 2016;84:41-7. https://doi.org/10.1016/j.ypmed.2015.12.005 
PMid:26724520

18. Li Y, Pan A, Wang DD, Liu X, Dhana K, Franco OH, et al. Impact of healthy lifestyle factors on life expectancies in the US population. Circulation. 2018;138(4):345-55. https://doi.org/10.1161/circulationaha.117.032047 
PMid:29712712

19. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363(9403):157-63. https://doi.org/10.1016/s0140-6736(03)15268-3 
PMid:14726171

20. Liu K, Zhang W, Dai Z, Wang M, Tian T, Liu X, et al. Association between body-mass index and breast cancer risk: Evidence based on a dose-response meta-analysis. Cancer Manag Res. 2018;10:143-51. https://doi.org/10.2147/cmar.s144619 
PMid:29403312

21. Seiler A, Chen MA, Brown RL, Fagundes CP. Obesity, dietary factors, nutrition, and breast cancer risk. Curr Breast Cancer Rep. 2018;10(1):14-27. https://doi.org/10.1007/s12609-018-0264-0 
PMid:30662586

22. Dal Maso L, Zucchetto A, Talamini R, Serraino D, Stocco CF, Vercelli M, et al. Effect of obesity and other lifestyle factors on mortality in women with breast cancer. Int J Cancer. 2008;123(9):2188-94. https://doi.org/10.1002/ijc.23747 
PMid:18711698

23. Godinho-Mota JC, Gonçalves LV, Mota JF, Soares LR, Schincaglia RM, Martins KA, et al. Sedentary behavior and alcohol consumption increase breast cancer risk regardless of menopausal status: A case-control study. Nutrients. 2019;11(8):1871. https://doi.org/10.3390/nu11081871 
PMid:31408930

24. Iyengar NM, Arthur R, Manson JE, Chlebowski RT, Kroenke CH, Schincaglia RM, Martins KA, et al. Sedentary behavior and alcohol consumption increase breast cancer risk regardless of menopausal status: A case-control study. Nutrients. 2019;11(8):1871. https://doi.org/10.3390/nu11081871 
PMid:31408930

25. Gómez-Ambrosi J, Silva C, Catalán V, Rodriguez A, Galofré JC, Escalada J, et al. Clinical usefulness of a new equation for estimating body fat. Diabetes Care. 2012;35(2):383-8. https://doi.org/10.2337/dc11-1334 
PMid:22179957

26. Bosomworth NJ. Normal-weight central obesity: Unique hazard of the toxic waist. Can Fam Physician. 2019;65(6):399-408. 
PMid:31189627

27. Kerlikowske K, Gard CC, Tice JA, Ziv E, Cummings SR, Miglioretti DL, et al. Risk factors that increase risk of estrogen receptor-positive and-negative breast cancer. J Natl Cancer Inst. 2016;108(5):djw276. https://doi.org/10.1093/jnci/djw276 
PMid:28040694

28. Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: US Department of Health and Human Services; 2018. https://doi.org/10.1037/e255442010-001

29. Steindorf K, Ritte R, Eomosis PP, Lukanova A, Tjonneland A, Johnsen NF, et al. Physical activity and risk of breast cancer overall and by hormone receptor status: The European prospective investigation into cancer and nutrition. Int J Cancer. 2013;132(7):1667-78. https://doi.org/10.1002/ijc.27778 
PMid:22903273

30. Niehoff NM, Nichols HB, Zhao S, White AJ, Sandler DP. Adult physical activity and breast cancer risk in women with a family history of breast cancer. Cancer Epidemiol Biomarkers Prev. 2019;28(1):51-8. https://doi.org/10.1158/1055-9966.epi-18-0674 
PMid:30333218

31. Hunedii SA, Wright NC, Atkinson A, Bhatia S, Singh P. Factors associated with physical inactivity in adult breast cancer survivors-A population-based study. Cancer Med. 2018;7(12):6331-9. https://doi.org/10.1002/cam4.1847 
PMid:30358141

32. Dieli-Conwright CM, Lee K, Kiwata JR. Reducing the risk of breast cancer recurrence: An evaluation of the effects and mechanisms of diet and exercise. Curr Breast Cancer Rep. 2016;8(3):139-50. https://doi.org/10.1007/s12609-016-0218-3 
PMid:27909546

33. de Boer MC, Wörner EA, Verlaan D, van Leeuwen PA. The mechanisms and effects of physical activity on breast cancer. Clin Breast Cancer. 2017;17(4):272-8. https://doi.org/10.1016/j.clbc.2017.01.006 
PMid:28233686

34. Romanos-Nanclares A, Toledo E, Gardeazabal I, Jiménez-Moleón JJ, Martínez-González MA, Gea A. Sugar-sweetened beverage consumption and incidence of breast cancer: The Seguimiento Universidad de Navarra (SUN) project. Eur J Nutr. 2019;58(7):2875-86. https://doi.org/10.1007/s00394-018-1839-2 
PMid:30284064

35. Key TJ, Bradbury KE, Perez-Cornago A, Sinha R, Tsilidis KK, Tsugane S. Diet, nutrition, and cancer risk: What do we know and what is the way forward? BMJ. 2020;368:m511. https://doi.org/10.1136/bmj.m511 
PMid:32139373

36. Hu FB, Malik VS. Sugar-sweetened beverages and risk of obesity and Type 2 diabetes: Epidemiologic evidence. Physiol Behav. 2010;100(1):47-54. https://doi.org/10.1016/j.physbeh.2010.01.036 
PMid:20138901

37. Shrapnel WS, Butcher BE. Sales of sugar-sweetened beverages in Australia: A trend analysis from 1997 to 2018. Nutrients. 2020;12(4):1016. https://doi.org/10.3390/nu12041016 
PMid:32272711

38. Imanningsih N, Jahari AB, Permaesih ID, Chan P, Amarra MS. Consumption and sources of added sugar in Indonesia: A review. Asia Pac J Clin Nutr. 2018;27(1):47-64. 
PMid:2922880

39. Chazelas E, Bruder C, Scibilla C, Kesse-Guyot E, Julia C, Deschamps V, Deschamps V, et al. Insulin/IGF axis in breast cancer: Clinical evidence and translational insights. Biomolecules. 2021;11(1):125. https://doi.org/10.3390/biom11010125 
PMid:33477996

40. Fiolet T, Srour B, Sellem L, Kesse-Guyot E, Allèes B, Mèjean C, ...
et al. Consumption of ultra-processed foods and cancer risk: Results from NutriNet-Santé prospective cohort. BMJ. 2018;360:k322. https://doi.org/10.1136/bmj.k322
PMid:2944771

42. Poti JM, Mendez MA, Ng SW, Popkin BM. Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households? Am J Clin Nutr. 2015;101(6):1251-62. https://doi.org/10.1093/ajcn/ fasebj.29.1_supplement.597.9
PMid:25948666

43. Javanmardi F, Rahmani J, Ghiasi F, Hashemi Gahruie H, Mousavi Khaneghah A. The association between the preservative agents in foods and the risk of breast cancer. Nutr Cancer. 2019;71(8):1229-40. https://doi.org/10.1080/01635581.2019.1608266
PMid:31044613

44. Lofterød T, Frydenberg H, Flote V, Eggen AE, McTiernan A, Mortensen ES, et al. Exploring the effects of lifestyle on breast cancer risk, age at diagnosis, and survival: The EBBA-life study. Breast Cancer Res Treat. 2020;182(1):215-27. https://doi.org/10.1007/s10549-020-05679-2
PMid:32436147