

# Total Dietary Fats, Fatty Acids, and Omega-3/Omega-6 Ratio as Risk Factors of Breast Cancer in the Polish Population – a Case-Control Study

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**Abstract.** *Background/Aim:* Breast cancer is the most common type of cancer among women around the world and the leading cause of cancer-related death among women. The knowledge about modifiable risk factors, such as diet, can be an acceptable, cheap and non-pharmacological prevention tool. The aim of this study was to investigate the association between dietary fat, dietary fatty acids, fish intake, and breast cancer in women. *Patients and Methods:* A case-control study was designed. A total of 201 consecutive, newly diagnosed, Polish female cancer patients (mean age: 58 years) and 201 one-to-one age-matched controls were enrolled. A standardised questionnaire assessing various socio-demographic, clinical, lifestyle, and dietary characteristics was applied via face-to-face interviews. Detailed dietary intake information was assessed using a validated Food Frequency Questionnaire. Odds ratios (OR) and 95% confidence intervals (95%CI) were obtained using multiple unconditional logistic regression models controlling for non-dietary and dietary potential confounders. *Results:* Consumption of polyunsaturated fats (PUFA) over 10% of total energy intake was associated with a significantly lower risk of breast cancer compared to low intake of PUFA (OR=0.4, 95%CI=0.19-0.85). Low (<0.2) omega-3/omega-6 ratio (OR=2.04, 95%CI=0.996-4.17), fish consumption less than once every six months (OR=3.37, 95%CI=1.57-7.23) and being overweight (OR=2.07, 95%CI=1.3-3.3) were associated with increased risk of breast cancer. Residents of rural areas had a significantly higher risk compared to

women from urban areas (OR=1.8, 95%CI=1.06-3.03). *Conclusion:* High intake of PUFA can decrease the risk of breast cancer, while the low omega-3/omega-6 ratio increases the risk. In addition, overweight state, eliminating fish from the diet and living in rural areas can also increase the risk of breast cancer.

Breast cancer is the most common type of cancer among women around the world and the leading cause of cancer-related death among women. In 2018, 2.1 million new cases were diagnosed worldwide, while in the same year breast cancer was the cause of approximately 627 thousand deaths (1-3). In Poland the number of newly registered cases is constantly growing (4). Every year 18 thousand women are diagnosed with breast cancer, which accounts for 22% of all types of cancer among Polish women (5, 6).

While known risk factors for breast cancer, such as: age over 40 years, positive family history, early menstruation, late menopause, late age of first pregnancy (after the age of 35 years), duration of breastfeeding, and Caucasian race (7, 8) are basically unmodifiable, the knowledge of nutritional recommendations and the awareness that the diet has an impact on the risk of developing this type of cancer (7, 9) may be harbingers of a new primary prevention system. Many studies have drawn special attention to dietary fat and fatty acids (10-14); however, they do not provide a definitive answer to the question of the role of fat in the aetiology of breast cancer. The western diet, characteristic for the Polish population, is characterised by a low supply of omega-3 fatty acids and high omega-6 fatty acids. In the coastal side of Poland, fish consumption is low and decreasing year by year. This is largely due to the lack of awareness about the health properties and their relatively high price.

Until now, to our knowledge, the omega-3/omega-6 ratio in the context of breast cancer has not been analysed in the Polish population. The aim of our study was to assess the effect of total, saturated, and unsaturated fatty acids, cholesterol, omega-3 and omega-6 acids, and fish consumption on the risk of breast cancer.

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*Key Words:* Breast cancer, dietary fat, fish intake, omega-3/omega-6 ratio, case-control study, women's health.

## Patients and Methods

This study was based on a case-control scheme with face-to-face interviews with the participants. Caucasian women diagnosed with incident, primary, and histologically-confirmed breast cancer ( $n=201$ ) were hospitalised in the Oncological Surgery Clinic of the Medical University of Gdansk during the period from 01.2015 to 06.2017, while the diagnosis took place in the period no longer than three months preceding the study. Patients diagnosed more than three months in advance were not included (in order to avoid changes in their dietary habits or other behaviours). The other inclusion criteria for cases were: i) age between 50 and 69 years old, ii) agreement to participate and iii) ability to understand and answer the questionnaire. Women previously diagnosed with breast cancer and women who were unable to answer the questionnaire due to health, language or educational issues were excluded. Community controls included neighbourhood residents of the BCA cases, who had no self-reported breast cancer (e.g. had never been told by a doctor or health-care worker that they may be checked for breast cancer). Interviewers visited the selected control subjects or asked to fill the questionnaire and return by post. Control subjects were matched by age ( $\pm 5$  years), and socio-economic status (SES) to the corresponding case subjects. If a suitable control subject could not be located in the BCA community, the researchers tried to find the appropriate control using their own social contacts (this occurred in 20% of cases).

The study was approved by the Bioethical Commission of the Medical University of Gdansk number NKBBN/47/2014. Prior to the collection of any information, participants were informed about the aim and procedures of the study and provided their signed consent. After receiving the informed consent of the participants for the study, interviews were conducted on known and suspected breast cancer factors.

**Dietary Assessment.** A comprehensive Food Frequency Questionnaire (FFQ) was carried out in the study group by the interviewer. The patients received a second copy of the same questionnaire (in a freepost envelope) in order to pass it on to an unrelated, healthy woman (without breast cancer), approximately the same age ( $\geq 50$  years old), living in the same town, and leading a similar lifestyle. Such a selection of the control group guaranteed minimisation of disturbances related to the socio-economic status. Participants were asked about the usual consumption of about 110 products divided into groups: i) alcoholic and non-alcoholic beverages (and additives like sugar, sweetener), ii) fruits, iii) vegetables, iv) fats, v) cereals, vi) meat, vii) poultry, viii) fish, dairy products, sweets, crisps, soy products, and eggs, as well as dietary supplements, during the year preceding the test (for example: never, less than once every six months, once every 3-4 months, once a month, 1-2 times a week, every day). The questionnaire included the most commonly consumed products in Poland with the possibility of supplementing with other unlisted ones. The size of the portions, using food models and the frequency of consumption, were evaluated to estimate grams of intake.

**Other measurements.** The second part of the questionnaire provided knowledge about age and place of residence (city-village). Data on height and body weight were used to calculate body mass index (BMI) according to the procedure: weight in kilograms divided by height in metres squared. BMI was defined as normal body weight and overweight ( $\leq 29.99$ ) and obese ( $\geq 30$ ). Participants of the study

were asked about physical activity: i) daily physical activity was classified as high, ii) 2-3 times per week was classified as moderate, and iii) once a month or less frequently as lack of activity. Smoking cigarettes (current and former smoking, total years of smoking, and number of cigarettes smoked per day) were also recorded. Family history of breast cancer, gynaecological medical history (*i.e.* age of menarche ( $\leq 12 / > 12$ ), age of menopause ( $\leq 55 / > 55$ ), use of hormone replacement therapy-HRT) as well as the age of the first pregnancy, miscarriage/aborting the pregnancy, number of children, and duration of breastfeeding were recorded during the interview. The questionnaire also provided information on the occurrence of mononucleosis and exposure to ionising radiation during early childhood. These factors were selected among lifestyle-related variables because they have been reported to be risk factors for breast cancer (15).

**Statistical analysis.** After calculating the daily amounts of food consumed, the data from the FFQ questionnaire were introduced into the computer program "Diet-Pro" (Jacek Kwiatkowski Computer Services Company), which quickly calculates the dietary content of 83 nutrients (proteins, carbohydrates, total fats, fatty acids - including omega-3 and omega-6, fibre, vitamins, and minerals) along with the reference values and the Glycaemic Index (IG). The results of nutritional analysis were exported to Microsoft Excel and then to the Statistica 13 software. Continuous variables that were normally distributed were presented as mean $\pm$ SD. Normality was evaluated using the P-P plots. Student's *t*-test for independent samples was used to evaluate the mean differences of the normally distributed variables (*i.e.* BMI) between cases and controls, and in the case of skewed variables, the tested hypothesis was evaluated using the non-parametric *U*-test suggested by Mann and Whitney. The results are presented in Table I. The average daily amounts of consumed ingredients are presented in Table II. Multivariate logistic regression was used to assess the relationship between the diet, with particular reference to total saturated and unsaturated fats and individual fatty acids, and the occurrence of breast cancer (Tables III, IV). The analysis was adjusted for potential disruptive factors such as: i) age, ii) place of residence, iii) BMI ( $\text{kg}/\text{m}^2$ ), iv) history of smoking, v) drinking over 12 g of alcohol/day, vi) physical activity (no activity, moderate), vii) family history of breast cancer incidence, viii) age of menarche, ix) age of first pregnancy, x) childhood diseases - among others mononucleosis, and xi) the use of HRT. The variables for the model were selected using backward step regression. Finally, the model included variables at  $p \leq 0.05$ . The results of logistic regression are presented as an odds ratio with a 95% confidence interval (95%CI).

## Results

The basic characteristics of patients and controls are presented in Table I. Cases and controls were of similar age (mean age:  $58 \pm 6$  years old). Cases compared to the control group had a less frequently declared breastfeeding (63.18% vs. 73.63%,  $p=0.02$ ) and were more often obese compared to healthy women (34% vs. 20%,  $p=0.016$ ). With regard to the main research hypothesis, a strong association between fish consumption and the presence of breast cancer was observed. In particular, cases were more likely to consume less fish compared to controls; 15.4% of cases

Table I. Characteristics of the cases and controls by socio-demographic and selected variables.

Age (years) mean±SD	Cases 59±6		Controls 58±6		p-Value
	n	%	n	%	
Characteristics					
Ionising radiation in childhood					
Yes	13	6.47%	5	2.49%	0.48
No	167	83.08%	176	87.56%	
I don't know	21	10.45%	20	9.95%	
Physical activity					
No	102	51%	110	55%	0.7
Moderate	63	31%	50	25%	
High	36	18%	41	20%	
Smoking					
Never	85	43%	90	45%	0.3
Former	86	43%	69	34%	
Active	30	14%	42	21%	
Alcohol intake					
≤12 g/day	186	92.5%	191	95%	0.3
>12 g/day	15	7.5%	10	5%	
Age at menarche (years)					
≤12	39	19%	40	20%	0.9
>12	162	81%	161	80%	
Mononucleosis in childhood					
Yes	3	1.5%	3	1.5%	0.5
No	171	85%	178	88.5%	
I don't know	27	13.5%	20	10%	
Number of live births					
0	34	17%	25	12%	0.9
1	44	22%	53	26%	
2	73	36%	77	38%	
3	29	14%	28	14%	
≥4	21	11%	18	10%	
Breastfeeding					
Yes	127	63.18%	148	73.63%	0.02
No	74	36.82%	53	26.37%	
HRT (Hormon Replacement Therapy)					
Yes	54	27%	38	19%	0.06
No	147	73%	163	81%	
Age of menopause:					
Premenopausal	41	20%	52	26%	0.9
≤55	98	49%	98	49%	
>55	62	31%	51	25%	
Family history of breast cancer:					
Yes	52	26%	45	22%	0.4
No	149	74%	156	78%	
Family history of breast cancer at <55 years old					
Yes	30	15%	21	10%	0.2
No	171	85%	180	80%	
Residence area:					
Urban	151	75%	171	85%	0.01
Rural	50	25%	30	15%	
BMI					
≤29,99	133	66%	161	80%	0.02
≥30	68	34%	40	20%	
Fish intake					
Yes	170	84.6%	191	95%	0.001
No	31	15.4%	10	5%	

\*Reported p-Values were calculated using t test or Mann-Whitney U-test.

Table II. Average daily amounts of ingredients consumed.

	Cases	Controls	p-Value
Energy (kcal)	1721±538	1710±532	0.9
Energy from fat %	34%	33%	0.8
Saturated fat (g)	23.4±9.6	23.2±9.3	0.8
MUFA (g)	25.9±8.8	25.4±9.2	0.6
PUFA (g)	11±3.8	11±3.9	0.6
Omega 3 (g)	2±1	1.9±1	0.09
Omega 6 (g)	9.3±3.3	9.2±3.3	0.7
Omega-3/omega-6	0.23±0.1	0.2±0.1	0.9
Cholesterol (mg)	287±115	279±122	0.5

vs. 5% in the control group did not consume any fish at all ( $p=0.001$ ). Residents of rural areas had a significantly higher risk compared to women from urban areas ( $OR=1.8$ ,  $95\%CI=1.06-3.03$ ). There were no statistically significant differences regarding smoking, alcohol consumption, physical activity, or menopausal status. Women from both groups were also characterised by a similar family history (occurrence of breast cancer in the family, as well as pathologies predisposing them to the disease, *i.e.* hereditary breast cancer – site-specific, breast cancer-ovarian cancer syndrome, Li-Fraumeni syndrome, Lynch II syndrome, Cowden’s disease, Peutz-Jaeghers syndrome, ataxia-telangiectasia, Klinefelter syndrome (16). It is also worth noting that the use of HRT by women ( $OR=1.6$ ,  $95\%CI=0.98-2.52$ ,  $p=0.06$ ) – perhaps with a larger population it would turn out to be significant - is higher in comparison to women who had not used HRT. In any case, this matter should be subjected to further analysis with a larger cohort. Analysis of diet using the Diet-Pro software provided information on the total average daily energy (kcal/day) and fats (total amount, saturated, unsaturated, cholesterol, MUFA, PUFA - omega-3, and omega-6). There were no statistically significant differences for individual fat components in the diet (Table II). Results of univariate and multivariate logistic regression analysis assessing the association between risk factors and breast cancer are presented in Table III.

The univariate analysis did not show a relationship between PUFA and omega-3/omega-6 ratio and risk of breast cancer. The study also did not show a relationship between the total dietary fat, saturated and unsaturated fats altogether, cholesterol, protein, fibre, vitamins A, D, E, folate and microelements in the diet. The analysis showed that high intake of Vitamin B12 was significantly associated with increased risk of breast cancer ( $OR=2.13$ ,  $95\%CI=0.99-4.56$ ,  $p=0.05$ ) (Table III).

*Fat and fish consumption and breast cancer.* Odds ratios calculated in a multivariate analysis (Table IV) showed a statistically significant relationship between consumption of

PUFA ( $OR=0.4$ ,  $95\%CI=0.19-0.85$ ,  $p=0.02$ ), low omega-3/omega-6 ratio ( $OR=2.04$ ,  $95\%CI=0.996-4.17$ ,  $p=0.05$ ), eliminating fish from the diet ( $OR=3.37$ ,  $95\%CI=1.57-7.23$ ,  $p=0.002$ ), being overweight ( $OR=2.07$ ,  $95\%CI=1.3-3.3$ ,  $p=0.002$ ) and the risk of breast cancer. PUFA intake  $\geq 10\%$  of the total daily amount of energy was associated with a reducing risk by 60% compared to women with a daily consumption of PUFA covering less than 10% of the total daily amount of energy. At the same time, low omega-3/omega-6 ratio ( $<0.2$ ) and being overweight ( $BMI\geq 30$ ) both gave a two-fold increase in risk, while eliminating fish from the diet (regardless of frequency of intake) was associated with a 3.37-fold increase in the risk of breast cancer.

## Discussion

The relationship between fat consumption and the risk of breast cancer is still very controversial. Scientists have been interested in this topic for many decades. The origins of research date back to the 1970s and were undertaken due to the high global variability of breast cancer incidence (17). Looking for the reason of this phenomenon, attention was paid to differences in fat consumption per capita in the world. An important role was also played by changes in the incidence of breast cancer among Japanese immigrants. There have been more frequent cases of this disease compared to the incidence of breast cancer in Japan (18-21). A meta-analysis of studies, carried out in the 1990s, suggested a potential relationship between high fat consumption and an increased risk of breast cancer (22).

In a case-control study, the characteristics of the control group were compared with those of the Polish population from which certain cases were selected (23,24) to exclude the possibility of a selection bias. This study showed that low omega-3/omega-6 ratio was associated with increased a risk of the disease. A similar correlation also concerning high BMI. There was no relationship between the total dietary fat, saturated, unsaturated, and monounsaturated fatty acids and cholesterol in the diet of the study participants. Studies conducted previously, similarly to our study, showed that a high omega-3/omega-6 ratio is associated with a lower risk of breast cancer (25-32). This result was also obtained in Tolland County in USA ( $OR=0.50$ ,  $95\%CI=0.27-0.95$ )- a case-control study conducted in Mexico has shown that high omega-3/omega-6 ratio is associated with lower risk in obese women ( $p=0.01$ ) (33). Whereas there are other studies that have not shown such a correlation (34, 35). A prospective study conducted in Singapore that included 35298 women aged 45-74 years showed an inverse relationship between high intake of fatty acids and incidence of breast cancer (relative risk (RR)=0.74,  $95\%CI=0.58-0.94$ ). Similar to our study, several of the previously performed analyses have not shown a statistically significant relationship between dietary

Table III. Results of univariate and multivariate logistic regression analysis assessing the association between risk factors and breast cancer.

	Univariate OR (95% CI)	p-Value	Multivariate OR (95%CI)	p-Value
Alcohol intake $\geq 12$ g/day	1.54 (0.67-3.51)	0.3	1.18 (0.44-3.17)	0.74
Physical activity (yes/no)	1.17 (0.71-1.93)	0.53	1.12 (0.64-1.96)	0.69
Smoking (yes or former)	1.1 (0.75-1.64)	0.6	1.23 (0.79-1.93)	0.36
Ionising radiation in childhood	2.75 (0.96-7.88)	0.06	2.39 (0.75-7.59)	0.14
Mononucleosis in childhood	1.33 (0.76-2.35)	0.32	1.19 (0.62-2.3)	0.6
Age at menarche (years) $>12$	1.03 (0.63-1.69)	0.9	1.3 (0.73-2.24)	0.39
Resignation from breastfeeding	1.67 (1.06-2.49)	0.02	1.47 (0.9-2.4)	0.12
Miscarriage	1.12 (0.7-1.8)	0.63	1.16 (0.68-1.99)	0.58
HRT (Hormon Replacement Therapy)	1.6 (0.98-2.52)	0.06	1.63 (0.95-2.79)	0.07
Family history of breast cancer	1.2 (0.76-1.91)	0.41	1.03 (0.53-1.97)	0.94
Family history of breast cancer at $<55$ years old	1.5 (0.83-2.73)	0.18	1.47 (0.62-3.48)	0.38
Menopause	0.98 (0.66-1.45)	0.92	0.84 (0.53-1.32)	0.44
Living in the rural aera	1.94 (1.17-3.2)	0.009	1.85 (1.03-3.33)	0.04
Energy request $>30$ kcal/kg body mass	1.13 (0.73-1.74)	0.58	0.94 (0.48-1.83)	0.86
Protein intake $>1$ g/kg body mass	1.14 (0.73-1.79)	0.56	1.015 (0.43-2.4)	0.97
Fibre intake $<20$ g/day	1.35 (0.91-2.0)	0.13	1.31 (0.71-2.41)	0.38
Calcium intake $<1200$ mg/day	0.95 (0.63-1.45)	0.83	1.01 (0.55-1.83)	0.98
Iron intake $<8$ mg/day	0.78 (0.48-1.27)	0.32	0.69 (0.3-1.59)	0.39
Zinc intake $<8$ mg/day	0.94 (0.59-1.5)	0.81	1.84 (0.76-4.42)	0.17
Manganese intake $>2.5$ mg/day	1.15 (0.68-1.92)	0.6	0.94 (0.46-1.89)	0.86
Vitamin A intake $>600$ $\mu$ g/day	1.55 (0.83-2.88)	0.16	1.54 (0.7-3.42)	0.28
Vitamin D intake $<10$ $\mu$ g/day	0.65 (0.3-1.34)	0.26	0.78 (0.33-1.85)	0.57
Vitamin E intake $<8$ mg/day	0.81 (0.54-1.21)	0.3	0.88 (0.5-1.53)	0.65
Folate intake $<320$ $\mu$ g/day	0.74 (0.5-1.11)	0.15	0.98 (0.51-1.91)	0.96
Vitamin B12 intake $>2$ $\mu$ g/day	1.7 (1.04-2.8)	0.03	2.13 (0.99-4.56)	0.05
Saturated fat $\geq 6\%$ of total energy intake	1.06 (0.66-1.68)	0.81	1.02 (0.51-2.03)	0.95
Omega 3 $<1$ g/day	0.64 (0.35-1.16)	0.14	1.05 (0.48-2.31)	0.9
Omega 6 $>4\%$ of total energy intake	1.08 (0.69-1.68)	0.73	1.06 (0.62-1.81)	0.84
Cholesterol $\leq 350$ mg/day	0.94 (0.63-1.4)	0.76	0.6 (0.34-1.04)	0.07
BMI $\geq 30$	2.06 (1.3-3.24)	0.002	2.27 (1.36-3.79)	0.002
Omega-3/omega-6 $<0.2$	1.02 (0.68-1.51)	0.92	1.72 (0.74-3.79)	0.17
PUFA $\geq 10\%$ total energy intake	0.7 (0.48-1.1)	0.14	0.42 (0.18-0.98)	0.04
Eliminating fish from the diet	3.48 (1.66-7.32)	0.001	3.58 (1.59-8.08)	0.002

OR: Odds ratio; CI: confidence interval.

fat, saturated and unsaturated fatty acids, and breast cancer (27, 36-40). However, in a study conducted in Poland in the Pomorskie Voivodeship between 1999-2006, a positive relationship was found between high total saturated fatty acids intake and breast cancer (OR=1.66, 95%CI=1.07-3.59) (41). A similar result was obtained in a case-control study conducted in Taiwan – OR=2.6, 95%CI=1.4-5.0 (42). Other results were provided by a study conducted in New York, where it was estimated that high consumption of PUFA, omega-3, and omega-6 is associated with an increased risk of breast cancer (OR=1.25); on the other hand, no relationship was found between omega-3/omega-6 ratio alone and breast cancer (43). Interestingly, a reduced risk was estimated in the case of low supply of omega-3 and omega-6 in total (OR=0.83, 95%CI=0.63-1.09). In a study conducted in Shanghai, high intake of omega-6 with a simultaneous low intake of omega-3 was associated with a two-fold higher risk

Table IV. Odds ratios (ORs) of breast cancer for different types of fats.

	Multivariate OR (95%CI)	p-Value
omega-3/omega-6 $<0.2$	2.04 (0.99-4.17)	0.05
PUFA $\geq 10\%$ total energy intake	0.4 (0.19-0.85)	0.02
Eliminating fish from the diet	3.37 (1.57-7.23)	0.002

OR: Odds ratio; CI: confidence interval.

of disease (25). The EPIC study showed a small but significant relationship between the total consumption of saturated fatty acids and an increased risk of breast cancer (5). The results of the Women's Health Initiative Dietary Modification Trial suggested that reducing the total dietary fat may reduce the risk by 9% (but this comparison did not show any statistical significance) (44). Some additional

prospective studies have not shown a relation between dietary fat and risk of breast cancer (35); however, a meta-analysis of 45 case-control studies has shown an increased risk with dietary total fat and saturated fatty acids (45).

Summing up, the results from this study suggest that a high omega-3/omega-6 ratio, optimal body weight, and fish as part of the diet can be a first step towards breast cancer prevention in Poland. In addition, consumption of PUFA  $\geq 10\%$  of the total daily energy can decrease the risk. Several sources of information suggest that people have evolved on a diet with a ratio of omega-3/omega-6 fatty acids of  $\sim 1$ , while today in western diets (also in Poland) this ratio is 1/15 -1/30. The average diet in developed countries is characterised by low supply of omega-3 fatty acids (found in fish) and excessive amounts of omega-6 fatty acids (found in vegetable oils, *i.e.* sunflower, as well as in corn, eggs and meat) in comparison to the ancestral diet, on which human genetic patterns were established (12). Many studies indicate that polyunsaturated fatty acids from the omega-6 family can stimulate the process of cancer, while omega-3 fatty acids can contribute to the reduction of the incidence of malignant tumours, including breast cancer (46). Excess of vegetable oils in the diet with a simultaneous low supply of fish may lead to an abnormal omega-3/omega-6 indicator (12). Breast cancer nutritional prophylaxis should be based largely on a high inclusion of fish in the diet, especially seawater fish, such as mackerel, tuna, salmon, or herring (47). The protective influence is induced by consumption of at least two portions per week, although in this studied population it turned out that supplementing the menu with fish once a month compared to total exclusion from the menu plays a significant role towards the prevention of breast cancer. Unfortunately, in Poland, the consumption of sea fish is decreasing every year (48). This is probably related to the relatively high price of fish compared to meat and the lack of public awareness on the health benefits from fish. Possibly associated with low fish consumption may also be the fact that there is fear of pollution in the sea; however, many studies have shown that the health benefits of eating fish to a large extent outweigh the risks (49).

It is also worth paying attention to vegetable sources of omega-3, *i.e.* linseed and chia seeds. An addition of 1 tbsp daily, for example to yogurt or porridge will supplement the daily demand for these fatty acids. Other sources of omega-3 fatty acids primarily include: walnuts, linseed and hemp oil, seafood, and soy products. Increasing the consumption of these products while limiting vegetable oils, full-fat milk products, and red meat should be the foundation of the diet of every woman who cares about her health (50). It is also worth noting that a diet taking into account an adequate supply of omega-3 fatty acids is also an element of prevention of obesity, which is not only a disease in itself, but is also an important risk factor for cancer - including breast cancer (51). Similar to many previous studies, the results of our analysis indicate a

protective (in relation to breast cancer) effect of normal body weight. Unfortunately, Polish society - including children - belongs to the infamous top countries in which the percentage of overweight and obese people is growing the fastest (52). There is mounting evidence that correct health behaviours in early childhood and adolescence may affect the incidence of breast cancer. Therefore, maintaining normal body weight should be one of the key elements of primary prevention (53).

The strengths of our study include the observation of the omega-3/omega-6 ratio, which, to our knowledge, has not yet been previously assessed in the Polish population. Our study also showed the relationship between body weight and fish consumption and a reduced risk of breast cancer.

The major limitation of this study was the recall bias, as in all case-control studies. However, effort was made to minimise this limitation by choosing newly diagnosed consecutive patients and collecting all necessary subjects during a short period of time. Unfortunately, as some of the cases were already undergoing chemotherapy, this largely influenced their diet. The applied FFQ method may have also constituted some limitations. Women who are aware of a beneficial diet can often give underestimated amounts and, based on their knowledge, choose products that have health-promoting effects. In addition, the evaluation of PUFAs with FFQ may differ on the actual acid content of the product, which may depend on different period of harvest of food products, storage time, or method of cooking (54). The analysis also includes omega-3 from supplementation, the absorption of which can be case-specific. Due to these restrictions, it seems reasonable to elaborate with larger studies to determine the content of individual fatty acids in the blood samples. However, biomarkers may reflect different time periods of exposure, ranging from a few days to 1 year (depending on the type of biomarker used) (55).

Another limitation is that the study was only carried out among Caucasian women who have a high rate of breast cancer. Therefore, it cannot be generalised with regards to the entire population. The questionnaire does not include questions about chemotherapy, which has a significant impact on the diet of patients, and might likely affect the ORs and 95% CIs.

The impact of modifiable diet components on the risk of breast cancer is still not fully understood. However, the results of our study shed light on the role of dietary fats and fatty acids in the aetiology of breast cancer. It is possible to create a dietary prevention program that would target the entire population. Replacing meat for fish twice a week minimum could be the first step towards improving breast cancer statistics in Poland. The results of the study can be a starting point for the construction of a primary breast cancer prophylaxis system in Poland.

### Conflicts of Interest

We have no conflicts of interest to disclose.

## Authors' Contributions

PZ designed the study and contributed in 20% of the paper. DDB was responsible for data collection and data analysis, wrote the paper with some input from PZ and contributed in 80% of the paper.

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