Significant changes in dietary intake and supplement use after breast cancer diagnosis in a UK multicentre study

EPIDEMIOLOGY

Significant changes in dietary intake and supplement use after breast cancer diagnosis in a UK multicentre study

Louiza S. Velentzis · Mohammed R. Keshtgar · Jayne V. Woodside ·
Anthony J. Leathem · Ann Titcomb · Katherine Anne Perkins · Monika Mazurowska ·
Victoria Anderson · Kayleigh Wardell · Marie M. Cantwell

Abstract The diagnosis of cancer can motivate survivors to alter their lifestyle habits. Healthcare providers need to be aware of what changes patients are likely to make in order to derive more pertinent recommendations; however, few studies have reported pre- and post-diagnostic lifestyle behaviours. Semi-quantitative food frequency questionnaires (FFQs) completed approximately 1 year after diagnosis were used to evaluate dietary intake and supplement use before and after diagnosis in a cohort of 1,560 breast cancer patients participating in the UK, prospective Diet-CompLyf study. Intake of fruit and vegetables, wholegrains and lean sources of protein increased significantly post-diagnosis ($P < 0.05$, each). Conversely, after diagnosis consumption of high-fat, high-sugar products, red meat, coffee, some alcoholic drinks and refined grains significantly decreased ($P < 0.05$, each). Post-diagnostic changes in diet were accompanied by changes in the intake of macronutrients and a number of vitamins and minerals. Supplement use was highly prevalent (56.1%) pre-diagnosis, increasing to 62.8% after diagnosis ($P = 0.001$). Fish oils, multivitamin and minerals, and evening primrose oil were most often used and the proportion of users significantly increased ($P < 0.05$, each) after diagnosis. The percentage of women using oestrogenic botanical supplements (OBSs) was small but more than doubled to 8.4% after diagnosis ($P < 0.05$). British women participating in the DietCompLyf study reported significant changes in dietary intake and supplement use after their breast cancer diagnosis. These findings contribute to our understanding of female cancer survivors' dietary behaviours which is crucial for developing and implementing recommendations.

Keywords Dietary changes · Supplements ·
Oestrogenic supplements · Breast cancer

L. S. Velentzis (✉)
Cancer Epidemiology Research Unit, Cancer Council NSW,
PO Box 572, KINGS CROSS, NSW 1340, Australia
e-mail: louizav@nswcc.org.au

A. J. Leathem · A. Titcomb · K. A. Perkins · M. Mazurowska ·
V. Anderson · K. Wardell
Breast Cancer Research Group, Institute for Women's Health,
University College London, 1st Floor Maple House,
149 Tottenham Court Road, W1T 7DN London, UK

M. R. Keshtgar
Department of Surgery, Royal Free Hospital, Pond St,
London NW3 2QG, UK

J. V. Woodside · M. M. Cantwell
Centre for Public Health, Queen's University Belfast Institute
for Clinical Science B, Grosvenor Road, Belfast BT12 6BJ, UK

Introduction

Diet, exercise and other beneficial lifestyle changes are initiated by many following a diagnosis of cancer [1]. A desire to be cured of cancer, prevent disease progression, maintain and improve health in preparation for treatment with significant side-effects are among the main reasons stated by cancer survivors for adopting positive lifestyle habits [2–5]. The diagnosis of cancer has been referred to as a "teachable moment" when people are motivated to make changes [6]. Healthcare providers can therefore inform their patients of current recommendations and motivate them to adopt healthier lifestyle behaviours. This is of great importance as cancer survivors are at an increased risk of developing secondary cancers as well as other chronic diseases, such as diabetes, osteoporosis and cardiovascular disease [1].

There is evidence to suggest that diet plays a role in breast cancer progression and overall mortality [7–11] and

the assessment of survivors' dietary habits at the time of diagnosis and afterwards is of importance. Cancer studies based on self-reported statements of change indicate that 30–48% of breast cancer patients make dietary changes following diagnosis including an increase in fruit and vegetable consumption and a decrease in meat, fat and sugar intake [2, 3, 5, 12]. Only one study to date, however, has provided limited quantitative data for both pre- and post-diagnostic periods and it included only 260 patients [13].

Changing supplement use is another lifestyle factor considered by many survivors. A systematic review of studies reported that use of vitamin, mineral and multivitamins by breast cancer patients ranged from 57–87% [14] and is considered to be higher than supplement use by the general population [15–17]. Only a few studies have investigated supplement use before and after breast cancer diagnosis [2, 18–21], and oestrogenic botanical supplements sometimes marketed as "natural" remedies for the relief of menopausal symptoms have usually not been enumerated. Investigating their use by breast cancer patients would, however, be of particular interest because of the potential effects of oestrogenic constituents on the progression of breast cancer.

We have therefore evaluated dietary intake and supplement use in the DietCompLyf study, an ongoing prospective cohort of patients with invasive breast cancer recruited from multiple centres within the UK. We have used validated self-administered food frequency questionnaires (FFQs), for quantitative assessment of diet pre- and post-diagnosis to compare intakes of foods and nutrients during this important period. Both FFQs were completed at study entry, with one FFQ reporting dietary intake prior to diagnosis and the other FFQ for after diagnosis. Use of dietary supplements including OBSs was also investigated for the same time period.

Methods

Study cohort

Subjects were part of a larger, ongoing prospective cohort study of breast cancer patients called DietCompLyf. The study will investigate the associations between phytoestrogens status as well as other dietary and lifestyle factors and breast cancer survival. Patients were invited to enter the study 9–15 months after diagnosis of invasive primary breast cancer. After obtaining ethical approval, recruitment was carried out in two waves; one between February 1998 and December 2004 and the second from January 2005 to August 2010. Fifty six collaborating hospital centres within the UK National Health Service (NHS) were involved.

These are evenly distributed throughout England, with Scotland, Northern Ireland and Wales having 2–3 hospitals each. Participants have been recruited mainly from small cities, with less than a third living in large cities. Eligibility criteria include: age up to 75 years; histologically confirmed invasive breast cancer grades I–III; good understanding of English. Exclusion criteria include previous history of cancer other than basal-cell carcinoma; concomitant primary cancer; bilateral breast cancer; cognitive impairment and severe psychological conditions. Written informed consent was obtained from all women. The present analyses are based on data from participants recruited between 1 February 1998 and 31 December 2007.

Baseline data collection and assessment

Following consent at hospital, two FFQs, lifestyle and quality of life questionnaires were given to participants by research nurses who explained how these had to be completed and returned by post within 4 weeks. Participants were asked to complete both FFQs, starting with information on their habitual average dietary intake before learning about their diagnosis (1st FFQ) and then proceeding to the 2nd FFQ with information since being diagnosed. The FFQ is a self-administered, validated, semi-quantitative questionnaire developed by the UK study arm of the European Prospective Investigation into Cancer and Nutrition (EPIC) study [22]. It consists of two sections: the first is a list of 130 food and beverage items, each with an assigned standard portion size. Fruit and vegetable portion sizes were either natural units, e.g. one apple or a medium serving. All items were associated with nine options for frequency of consumption ranging from never/less than once a month to more than six portions per day. The second part consists of 15 questions to determine further information on: consumption of milk (food item 131), types of breakfast cereal eaten and other cooking and eating habits.

To evaluate the entire diet, food items were combined to form food groups based on a previously reported classification of foods [23] and similarity in nutrient content and culinary use. Daily intake of kilocalories, macronutrients and common micronutrients were derived using the nutritional software program, Compositional Analyses from Frequency Estimates (CAFE) (MRC Centre for Nutritional Epidemiology in Cancer Prevention and Survival, University of Cambridge) developed specifically to analyse the UK version of the EPIC questionnaire. Participants whose FFQs corresponded to a daily intake either below 600 kcals or above 4,800 kcals were excluded from further analyses leaving 1,560 patients. Dietary intakes of nutrients and food items were adjusted for energy intake, using the nutrient density model, before further analyses were carried out.

The FFQ also includes a section which asks: "have you taken any vitamins, minerals, fish oils, fibre or other food supplements during the past year" followed by a request for provision of the name, brand, strength, dose and frequency of use. Only data on supplement types taken at least once a month have been included in the present analyses. Supplements were reviewed for individual ingredients but if information provided was too generic, only recognisable vitamins, minerals or botanical terms provided in the name were considered. For the purpose of this analysis, multivitamins and products with two or more minerals and/or two or more vitamins were combined to form the multivitamin and mineral (MVM) category because the majority of formulations had a combination of both vitamins and minerals. Oestrogenic supplements were also evaluated. A search was conducted in MEDLINE for cell culture or animal studies investigating the oestrogenicity of each ingredient to determine which supplements were potentially oestrogenic. A product was defined as an oestrogenic botanical supplement if it contained at least one ingredient of plant origin contained in a comparable amount to other constituents, for which there was evidence of oestrogenicity.

Clinical details (grade, nodal status, tumour histology information, past medical history, current medication), and treatment details (including surgery type and use of chemotherapy, radiotherapy, adjuvant hormonal therapy and other treatments) were collected from medical notes and patients' weight and height were measured at study entry. Additional information including socio-demographic characteristics was collected from a self-administered lifestyle questionnaire also completed at study entry.

Statistical analyses

Mean and standard deviations of energy adjusted nutrient and food intakes were estimated. Paired t tests were used to determine whether the changes between pre-diagnostic and post-diagnostic dietary intakes were significantly different from zero. Chi-squared (χ^2) tests were used to compare the proportion of supplement users before and after diagnosis. Statistical analyses were performed using SPSS version 14.0 for Windows (SPSS Inc, Chicago, IL, USA). A significance level of $P < 0.05$ was considered statistically significant.

Results

Participants and clinical characteristics

This sample of 1,560 patients consisted mainly of Caucasian (90%), postmenopausal (67.7%) women. In terms of body size, 33.3% were overweight (BMI 25–29.9) and 21.1% were obese (BMI $\geq$ 30) at study entry. Fifty three percent of participants were diagnosed with T1 tumours (less than 2 cm) and 40.3% with T2 tumours (2–5 cm). In terms of nodal status, 60.6% were node negative and 85.3% of patients were taking adjuvant hormonal therapy as part of their treatment. Table 1 summarises the main demographic and clinical characteristics of participants.

Table 1 Demographic, clinical and lifestyle characteristics of 1560 participants

Characteristic	Number ($n = 1560$)	%
Age (year), diagnosis		
<50	528	33.8
50–59	512	32.8
60–69	427	27.7
70+	93	6.0
Ethnicity		
Caucasian	1404	90.0
Others	94	6.0
Unknown	62	4.0
Menopausal status		
Pre/Peri-menopausal	504	32.3
Postmenopausal	1056	67.7
BMI (study entry)		
Underweight (<18.5)	15	0.9
Normal (18.5–24.9)	521	33.4
Overweight (25.0–29.9)	519	33.3
Obese ($\geq$30)	329	21.1
Unknown	176	11.3
Grade		
I	273	17.5
II	676	43.3
III	583	37.3
Not assessable/unknown	28	1.8
Tumour size (mm)		
$\leq$1–19	830	53.2
$\geq$20–49	629	40.3
Not assessable/unknown	101	6.5
Nodes affected		
No	945	60.6
Yes	615	39.4
Treatment		
Surgery only	136	8.7
Surgery and Rx	615	39.4
Surgery, Cx and Rx	720	46.2
Other combinations	89	5.7
Adjuvant hormonal therapy		
Yes	1331	85.3
No	229	14.7

BMI body mass index (kg/m^2), *Cx* chemotherapy, *Rx* radiotherapy

Dietary changes

Changes in the intakes of the most common food groups are shown in Table 2. Participants reported a significant increase following diagnosis in mean fruit intake from 1.84 to 2.3 servings/1000 kcals/day, and vegetable intake from 3.26 to 3.74 servings/1000 kcals/day. The mean daily servings of combined fruit, 100% pure fruit juice and vegetables consumed also rose from 5.40 to 6.43 per 1000 kcals (or from 9.7 to 10.6 servings per day). Significant increases in intake were also noted for wholegrain foods, cereals, poultry, fish and seafood, legumes, soya meat substitutes, nuts, tea and milk. Significant decreases in

intake were observed for full-fat dairy foods, red and processed meats, chips, pizza, desserts, chocolate, butter, wine and alcoholic beverages other than beer, high energy drinks, coffee and foods made of refined grains such as white bread and pasta.

Table 3 compares pre- and post-diagnostic nutrient intake per 1000 kcals/day. Women reported consuming around 173 kilocalories less per day after their breast cancer diagnosis. This was accompanied by a decrease in reported consumption of all macronutrients and total alcohol while fibre intake increased. Reported post-diagnostic intakes of most vitamins related to fruit and vegetable consumption (α- and β-carotene, folate, vitamin C)

Table 2 Comparison of energy adjusted mean intake pre-diagnosis and 1 year post-diagnosis of common food groups ($n = 1560$)

Food group	Pre-diagnosis, mean (SD) (servings/1000 kcals/day)	Post-diagnosis mean (SD) (servings/1000 kcals/day)	P value	Type of change
Fruit[a]	1.84 (1.43)	2.30 (1.60)	<0.0001	Increase
Vegetables[a]	3.26 (1.44)	3.74 (1.71)	<0.0001	Increase
Fruit/veg/pure fruit juice[a]	5.40 (2.39)	6.43 (2.78)	<0.0001	Increase
Legumes	0.38 (0.25)	0.44 (0.28)	<0.0001	Increase
Red meat	0.26 (0.16)	0.25 (0.16)	0.016	Decrease
Poultry	0.15 (0.12)	0.16 (0.13)	0.0001	Increase
Processed meat	0.26 (0.20)	0.25 (0.21)	0.02	Decrease
Soy Meat	0.030 (0.06)	0.033 (0.07)	<0.0001	Increase
White fish/shellfish	0.16 (0.09)	0.18 (0.01)	<0.0001	Increase
Oily fish/fish roe	0.10 (0.09)	0.14 (0.12)	<0.0001	Increase
Refined grains	0.78 (0.66)	0.72 (0.64)	<0.0001	Decrease
Whole grains	0.41 (0.41)	0.45 (0.42)	<0.0001	Increase
Cold breakfast cereal	0.28 (0.27)	0.31 (0.28)	<0.0001	Increase
Potatoes	0.37 (0.22)	0.38 (0.23)	0.015	Increase
Chips	0.06 (0.06)	0.05 (0.05)	<0.0001	Decrease
Pizza	0.032 (0.03)	0.030 (0.02)	0.008	Decrease
Milk (ml)	135.8 (77.3)	141.8 (82.7)	<0.0001	Increase
Low-fat dairy	0.25 (0.28)	0.25 (0.30)	0.97	None
Full-fat dairy	0.33 (0.23)	0.28 (0.21)	<0.0001	Decrease
Eggs	0.174 (0.15)	0.179 (0.15)	0.08	None
Butter	0.31 (0.47)	0.26 (0.44)	<0.0001	Decrease
Processed fat	0.56 (0.57)	0.56 (0.59)	0.59	None
Desserts	0.92 (0.58)	0.80 (0.52)	<0.0001	Decrease
Chocolate	0.37 (0.46)	0.34 (0.42)	0.0002	Decrease
Nuts	0.13 (0.20)	0.16 (0.25)	<0.0001	Increase
Coffee	1.05 (1.07)	0.96 (1.08)	<0.0001	Decrease
Tea	1.55 (1.23)	1.61 (1.31)	0.0002	Increase
Wine	0.33 (0.49)	0.31 (0.47)	0.002	Decrease
Beer	0.06 (0.18)	0.06 (0.16)	0.23	None
Other alcohol	0.125 (0.29)	0.116 (0.26)	0.03	Decrease
High energy drinks	0.074 (0.22)	0.065 (0.20)	0.04	Decrease

SD standard deviation

[a] Unadjusted values and SD for fruit, vegetables and combination of these plus pure fruit juice were

Fruit: 3.32 (2.72) before diagnosis and 3.81 (2.87) after diagnosis

Vegetables: 5.83 (2.45) before diagnosis and 6.13 (2.72) after diagnosis

Fruit, vegetables and pure fruit juice: 9.70 (4.34) before diagnosis and 10.58 (4.79) after diagnosis

Table 3 Comparison of energy adjusted mean nutrient intake pre-diagnosis and 1 year post-diagnosis (n = 1560)

Nutrient	Pre-diagnosis, mean (SD) (nutrient/1000kcals/day)	Post-diagnosis, mean (SD) (nutrient/1000kcals/day)	P value	Type of change
Macronutrients				
Kcals	1892.78 (625.15)	1720.06 (558.45)	<0.0001	Decrease
Total fat (g)	37.18 (6.88)	33.27 (10.49)	<0.0001	Decrease
Saturated fat (g)	13.74 (3.69)	11.67 (4.69)	<0.0001	Decrease
Monounsaturated fat (g)	13.00 (2.86)	11.80 (4.30)	<0.0001	Decrease
Polyunsaturated fat (g)	7.09 (2.08)	6.77 (2.60)	<0.0001	Decrease
Protein (g)	44.02 (8.36)	42.23 (11.17)	<0.0001	Decrease
Carbohydrate (g)	121.88 (18.88)	116.5 (31.48)	<0.0001	Decrease
Fibre-Englyst method (g)	9.57 (3.25)	10.10 (3.71)	<0.0001	Increase
Alcohol (g)	4.83 (6.53)	4.15 (5.96)	<0.0001	Decrease
Vitamins				
Alpha-carotene (µg)	286.9 (278.04)	327.2 (314.79)	<0.0001	Increase
Beta-carotene (µg)	1811.1 (1141.89)	2026.2 (1286.08)	<0.0001	Increase
Total carotene (µg)	2132.2 (1306.67)	2392.6 (1476.71)	<0.0001	Increase
Folate (µg)	170.9 (49.54)	174.2 (55.86)	0.0006	Increase
Niacin (mg)	12.30 (3.19)	12.10 (3.73)	0.002	Decrease
Retinol (µg)	351.61 (413.57)	304.46 (378.53)	<0.0001	Decrease
Riboflavin (mg)	1.12 (0.31)	1.07 (0.36)	<0.0001	Decrease
Thiamine (mg)	0.84(0.19)	0.84 (0.24)	0.95	None
Vitamin B12 (µg)	3.88 (1.95)	3.83 (2.05)	0.24	None
Vitamin B6 (mg)	1.23 (0.27)	1.23 (0.34)	0.71	None
Vitamin C (mg)	76.82 (40.56)	92.75 (47.02)	<0.0001	Increase
Vitamin D (µg)	1.74 (0.90)	1.80 (1.10)	0.006	Increase
Vitamin E (mg)	6.60 (1.96)	6.41 (2.35)	0.0001	Decrease
Minerals				
Calcium (mg)	509.91 (132.57)	471.2 (162.84)	<0.0001	Decrease
Copper (mg)	0.676 (0.24)	0.672 (0.26)	0.51	None
Iodine (µg)	80.79 (23.77)	77.90 (28.68)	<0.0001	Decrease
Iron (mg)	6.28 (1.58)	6.19 (1.82)	0.015	Decrease
Magnesium (mg)	176.11 (36.61)	175.21 (48.17)	0.29	None
Phosphorus (mg)	762.33 (128.76)	730.15 (183.92)	<0.0001	Decrease
Potassium (mg)	2055.9 (432.95)	2040.8 (539.48)	0.096	None
Selenium (mg)	34.54 (9.36)	34.55 (11.60)	0.95	None
Sodium (mg)	1422.58 (283.72)	1343.00 (375.65)	<0.0001	Decrease
Zinc (mg)	4.92 (0.97)	4.71 (1.27)	<0.0001	Decrease

increased while others such as niacin and retinol decreased. Intakes of some minerals were found to remain the same but sodium, calcium, iron, iodine and zinc decreased significantly after diagnosis.

Supplement use

Nearly half the subjects within this cohort (47.4%) used supplements before and after diagnosis, while 25.8% never took any supplements. A change in behaviour was observed in 23.3% of the study sample with 10.3%

stopping all supplement usage after diagnosis and 15.3% starting to use supplements after diagnosis. Overall, supplement use increased by 5.2% from 56.1% before diagnosis to 64.8% after diagnosis. Overall, cod liver oil/fish oils, MVMs, evening primrose oil, vitamin C, glucosamine and calcium supplements were most popular with increases after diagnosis being statistically significantly (Table 4). Fifty six different types of OBSs were identified according to the definition described in the methods. A specific reference to the use of a supplement both before or during the menopause was made by manufacturers of six of the 29

Table 4 Use of supplements among patients before and 1 year after diagnosis ($n = 1560$)

Supplement	Pre-diagnosis (%)	Post-diagnosis (%)	P value
Supplement users	876 (56.1)	980 (62.8)	0.001
Fish oils	377 (21.6)	451 (28.9)	<0.0001
MVM	320 (20.5)	526 (33.7)	<0.0001
Evening primrose oil	151 (9.7)	238 (15.3)	<0.0001
Vitamin C	142 (9.1)	227 (14.6)	<0.0001
Glucosamine	113 (7.2)	186 (11.9)	<0.0001
Calcium	66 (4.2)	166 (10.6)	<0.0001
OBS	58 (3.7)	131 (8.4)	<0.0001

OBS oestrogen botanical supplements, *MVM* multivitamins and minerals

named products with an additional 3 products referring to "oestrogen metabolism", "hormonal changes" or "menstrual support". Overall, the number of OBS users was small but increased significantly after diagnosis from 3.7 to 8.4%. The most commonly used OBSs were flaxseed, soy/isoflavone containing supplements, ginseng, and red clover followed by a range of other botanical supplements.

Discussion

This study is a quantitative comparison of self-reported dietary intake prior to diagnosis and approximately 1 year after diagnosis in a large sample of British women with invasive breast cancer participating in the prospective DietCompLyf study. A diagnosis of cancer is often referred to as a teachable moment for health behaviour change [1]. We observed statistically significant changes in reported dietary habits, characterised by increased consumption of fruit, vegetables, wholegrain foods and lean sources of protein as well as decreased consumption of high-fat, high sugar products, red/processed meat, coffee, alcoholic drinks and refined grain products. Reported pre-diagnostic supplement use was highly prevalent among this cohort (56.1%) and the number of supplements used following diagnosis increased substantially. Although supplements containing potentially oestrogenic ingredients were only used by a small number of women, their use increased significantly after diagnosis.

Research indicates that compared with individuals who do not have a history of cancer; cancer survivors are more likely to develop secondary cancers and co-morbid chronic conditions and are at greater risk of dying from non-cancer causes [1]. The changes in dietary intake seen within this study are therefore likely to have an important impact in terms of not only cancer recurrence but also other co-

morbid conditions in this patient group. Previous studies of breast cancer patients have reported qualitative dietary changes which are similar to our study including post-diagnostic increases in fruit and vegetable consumption and decreases in red meat, desserts and foods containing high amounts of fat [3–5, 12, 24]. The Healthy, Eating, Activity and Lifestyle (HEAL) study [13] has also reported quantitative changes in diet, but in a much smaller study of just 260 breast cancer patients. To our knowledge, the DietCompLyf study is the first to provide a comprehensive quantitative analysis of pre- and post-diagnostic dietary intake in a large cohort of breast cancer patients.

The mean reported fruit and vegetable intakes of women in the DietCompLyf study prior to diagnosis was 5.4 servings/1000 kcals/day or 9.7 servings/day indicating that they were already meeting the UK's Department of Health recommendation of five portions per day. This is higher than the average UK reported intake for women (2.9 servings/day) [25] and higher than the 3.5 servings/day reported in the HEAL study [13]. Following their diagnosis, in this study, women increased their fruit and vegetable intake nearly one extra serving to 10.6 servings/day. Breast cancer patients in the control arm of the Women's Healthy Eating and Living (WHEL) study [26] reported eating 7.2 portions/day, while six portions/day were consumed before the initiation of an intervention diet in the Women's Intervention Nutrition (WINS) study [27]. A lower daily intake of 4.1 servings was reported by participants in the Life After Cancer Epidemiology (LACE) study [28]. The variation in fruit and vegetable intake observed between these studies may be due to actual differences in intakes between populations, but could also be due to measurement error resulting from differences in dietary assessment methods and in serving size definitions, or reflect variation in the ethnic or socio-cultural background of the different populations studied. The impact of a change in fruit and vegetable intake on breast cancer recurrence remains equivocal and results from the WHEL [26] and WINS [29] studies are not consistent. Follow-up of the women in the DietCompLyf study will help to elucidate the role of fruit and vegetable consumption on breast cancer recurrence and mortality.

The participants also reported a decrease in their mean energy intake from 1,893 to 1,720 kilocalories/day after their diagnosis which is comparable to reported intake by both the WHEL [26] and WINS [30] studies. This energy decrease was accompanied by a significant reduction of all subtypes of dietary fats. A significant increase in reported mean fibre intake from 9.6 g/1000 kcals/day pre-diagnosis to 10.1 g/1000 kcals/day post-diagnosis was also observed. This is consistent with a previously reported increase in consumption of high-fibre foods following a breast cancer diagnosis [24]. However, it is difficult to make a direct

comparison between studies due to methodological and geographical variation [25], and because of possible differences in the length of time between diagnosis and dietary assessment. Overall, changes in dietary intake, similar to those reported above, have so far not been associated with improvements in disease-free survival and breast cancer mortality [26]. The association between dietary changes made by the DietCompLyf cohort and breast cancer outcomes will be investigated in the future.

Reported intake of vitamins associated with fruit and vegetables increased post-diagnosis, whereas intake of retinol, niacin and riboflavin decreased, probably due to lower consumption of meat and dairy products. This would also explain the decreased intake of certain minerals such as iron, zinc, phosphorus and calcium. However, the possibility of observed changes in reported nutrient and mineral intakes being a statistical artefact due to multiple analyses cannot be ruled out. Furthermore, these values are based on dietary intake from food alone and do not take into account any dietary supplements taken. Analysis of supplement use by participants post-diagnosis reveals a significant increase in the number of formulations taken and it is likely that total intake of nutrients is higher than those estimated from food alone.

Supplement use before and after diagnosis

Dietary supplement use was highly prevalent among this cohort of women with 56% taking one or more supplements before breast cancer diagnosis. This figure is higher than the 40–43% of British adult supplement users according to two previous national UK surveys [31, 32], but similar to recent findings by the Pathways study [18] reporting frequent use of botanical and other natural products by 41–58% of a cohort of 1,000 women within 5 years of their breast cancer diagnosis. In comparison to these findings earlier reports found lower pre-diagnostic supplement use by breast cancer patients which ranged from 24–33% [21, 33]. Following diagnosis, there was a small overall increase of 5.2% in patients taking supplements accompanied by a significant increase in the use of the most common supplement types suggesting that supplement users pre-diagnosis took new individual supplements after their diagnosis. There have been few reports to date regarding behaviour changes in terms of supplement use. Holmes et al. [20] found supplement users increased by 7% post-diagnosis while reports of new dietary supplement use since diagnosis range from 34–64% [2, 18]. Overall, both pre- and post-diagnostic supplement use in the DietCompLyf cohort was substantial and higher than previous reports from the UK of between 33.2 and 53% for women with breast cancer [34–36]. The higher prevalence presented here could be due to increased use of

supplements over time, a trend that has been reported previously for complementary and alternative medicine use [37]. The most commonly consumed supplements after diagnosis by this cohort were MVMs (34%) and fish oils (29%), similar to previous reports from the UK [31, 34]. Prevalence of multivitamin use by UK breast cancer survivors was much lower than findings from US studies which ranged from 57–62% [14].

Consumers of OBSs were few among this cohort but more than doubled after diagnosis to 8.4%. There are few reports of OBS use by breast cancer patients. In a case–control study [38], 17.2% of breast cancer cases were found to use hormone-related supplements, while as part of the HEAL study 34.7% of 502 postmenopausal women with in situ and invasive breast cancers reported taking at least one oestrogenic supplement since diagnosis [39]. Direct comparison between studies is, however, difficult due to differences in characterisation and grouping of supplements. The effects of OBSs on recurrence are still unknown. Being weakly oestrogenic, it is possible such supplements could affect the prognosis of women treated for oestrogen receptor positive tumours. Contrary to this hypothesis, a significant association between the use of OBSs and lower levels of serum oestrogens has been reported [39], although this was a cross sectional study. Concurrent use of supplements during breast cancer therapy may impact on treatment effectiveness. Dietary genistein for example, has been shown to counteract the antiproliferative effect of the aromatase inhibitor letrozole on MCF-7 tumours implanted in ovariectomized mice [40]. Most botanical extracts, however, have not been tested thoroughly for oestrogenic activity. Furthermore, seasonal variation in compounds within plants [41] can contribute to misclassification as the chemical content and biological activity of botanical supplements is often not standardised [42].

Only a third of branded OBS products were being promoted for hormone/menopausal-related problems suggesting that women were taking the rest for other indications and most probably were not aware that the oestrogenic constituents could have potentially adverse effects in terms of recurrence. This finding highlights the need to educate patients about the harmful effects of such products, providing guidance for supplements to avoid. As patients may not readily disclose information about supplement consumption to their clinician [43] and their habits may change periodically, it may be advisable for clinicians to regularly ask patients about their supplement use and suggest caution due to a lack of evidence of any beneficial effects [44]. At the same time, more research on the effects of oestrogenic and other supplements in breast cancer patients and tighter regulations on labelling are needed.

Strengths and limitations

Results presented in this study should be considered in light of certain limitations. Participants were asked to recall information about their diet approximately 1 year before their breast cancer was diagnosed and data is therefore subject to recall error. However, events such as cancer diagnosis can be a turning point for adopting new lifestyle changes [1, 6] and significant dietary changes may be more clearly remembered. Although the FFQ used in this study has been shown to produce similar macronutrient intakes and average intakes of foods to those identified by the more robust assessment method of a 7-day food diary [45]. In addition, factors including age, education, race, obesity and social desirability could have resulted in under and over-reporting as previously demonstrated [46–49]. In terms of assessment of dietary supplement use, it is likely that some women were misclassified in terms of supplement type due to insufficient information provided, while objective characterisation of supplements as oestrogenic was difficult when inadequate data was provided on labels. It is also possible that women participating in the Diet-CompLyf study were more interested in health-related behaviours than those who declined participation, and to be healthier than those who were excluded from participating because of disease progression before reaching the recruitment timeframe. These findings can therefore not be generalised to the whole UK breast cancer population. The findings reported here are an intermediate analysis not based on the full study cohort ($n = 3381$). It is possible that findings may differ in the full cohort, once recruitment and data collection has been completed.

The strength of the analyses presented here is based on the use of data from a large cohort of breast cancer patients and has been obtained from semi-quantitative FFQs validated for a UK population. Results from this cohort demonstrate that, after their breast cancer diagnosis, British women reported making significant changes to their diet, adopting healthier food choices in addition to increasing the number of new supplements taken. Such dietary changes may benefit survivors by potentially decreasing their risk of breast cancer recurrence and reducing the risk of developing other co-morbidities including diabetes and heart disease.

Follow-up of this cohort is essential to determine the impact of not only pre-diagnostic dietary intake, but also the impact of change in dietary intake on disease free survival and overall mortality. It is encouraging, however, that these women made changes to their diets that are likely to have a beneficial effect on other co-morbidities. These findings contribute to our understanding of breast cancer patients' dietary behaviours and the changes they make following their diagnosis. Further analysis of the data within this study will help to elucidate the predictors of dietary changes at diagnosis, and their impact on breast cancer recurrence and mortality.

References

1. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM (2005) Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. J Clin Oncol 23: 5814–5830
2. Patterson RE, Neuhouser ML, Hedderson MM, Schwartz SM, Standish LJ, Bowen DJ (2003) Changes in diet, physical activity, and supplement use among adults diagnosed with cancer. J Am Diet Assoc 103:323–328
3. Salminen E, Bishop M, Poussa T, Drummond R, Salminen S (2004) Dietary attitudes and changes as well as use of supplements and complementary therapies by Australian and Finnish women following the diagnosis of breast cancer. Eur J Clin Nutr 58:137–144
4. Maskarinec G, Murphy S, Shumay DM, Kakai H (2001) Dietary changes among cancer survivors. Eur J Cancer Care (Engl) 10:12–20
5. Salminen EK, Lagström HK, Heikkilä S, Salminen S (2000) Does breast cancer change patients' dietary habits? Eur J Clin Nutr 54:844–848
6. McBride CM, Clipp E, Peterson BL, Lipkus IM, Demark-Wahnefried W (2000) Psychological impact of diagnosis and risk reduction among cancer survivors. Psychooncology 9:418–427
7. Chlebowski RT, Blackburn GL, Thomson CA, Nixon DW, Shapiro A, Hoy MK, Goodman MT, Giuliano AE, Karanja N, McAndrew P, Hudis C, Butler J, Merkel D, Kristal A, Caan B, Michaelson R, Vinciguerra V, Del Prete S, Winkler M, Hall R, Simon M, Winters BL, Elashoff RM (2006) Dietary fat reduction and breast cancer outcome: interim efficacy results from the Women's Intervention Nutrition Study. J Natl Cancer Inst 98:1767–1776
8. Rock CL, Flatt SW, Natarajan L, Thomson CA, Bardwell WA, Newman VA, Hollenbach KA, Jones L, Caan BJ, Pierce JP (2005) Plasma carotenoids and recurrence-free survival in women with a history of breast cancer. J.Clin Oncol 23:6631–6638
9. McEligot AJ, Largent J, Ziogas A, Peel D, Anton-Culver H (2006) Dietary fat, fiber, vegetable, and micronutrients are

associated with overall survival in postmenopausal women diagnosed with breast cancer. Nutr Cancer 55:132–140

10. Kwan ML, Weltzien E, Kushi LH, Castillo A, Slattery ML, Caan BJ (2009) Dietary patterns and breast cancer recurrence and survival among women with early-stage breast cancer. J Clin Oncol 27:919–926

11. Kroenke CH, Fung TT, Hu FB, Holmes MD (2005) Dietary patterns and survival after breast cancer diagnosis. J Clin Oncol 23:9295–9303

12. Maunsell E, Drolet M, Brisson J, Robert J, Deschênes L (2002) Dietary change after breast cancer: extent, predictors, and relation with psychological distress. J Clin Oncol 20:1017–1025

13. Wayne SJ, Lopez ST, Butler LM, Baumgartner KB, Ballard-Barbash R (2004) Changes in dietary intake after diagnosis of breast cancer. J Am Diet Assoc 104:1561–1568

14. Velicer CM, Ulrich CM (2008) Vitamin and mineral supplement use among US adults after cancer diagnosis: a systematic review. J Clin Oncol 26:665–673

15. Radimer K, Bindewald B, Hughes J, Ervin B, Swanson C, Picciano MF (2004) Dietary supplement use by US adults: data from the National Health and Nutrition Examination Survey, 1999–2000. Am J Epidemiol 160:339–349

16. Rock CL, Newman VA, Neuhouser ML, Major J, Barnett MJ (2004) Antioxidant supplement use in cancer survivors and the general population. J Nutr 134:3194S–3195S

17. Van de Creek L, Rogers E, Lester J (1999) Use of alternative therapies among breast cancer outpatients compared with the general population. Altern Ther Health Med 5:71–76

18. Greenlee H, Kwan ML, Ergas IJ, Sherman KJ, Krathwohl SE, Bonnell C, Lee MM, Kushi LH (2009) Complementary and alternative therapy use before and after breast cancer diagnosis: the Pathways Study. Breast Cancer Res Treat 117:653–665

19. Molassiotis A, Scott JA, Kearney N, Pud D, Magri M, Selvekerova S, Bruyns I, Fernadez-Ortega P, Panteli V, Margulies A, Gudmundsdottir G, Milovics L, Ozden G, Platin N, Patiraki E (2006) Complementary and alternative medicine use in breast cancer patients in Europe. Support Care Cancer 14:260–267

20. Holmes MD, Stampfer MJ, Colditz GA, Rosner B, Hunter DJ, Willett WC (1999) Dietary factors and the survival of women with breast carcinoma. Cancer 86:826–835

21. Burstein HJ, Gelber S, Guadagnoli E, Weeks JC (1999) Use of alternative medicine by women with early-stage breast cancer. N Engl J Med 340:1733–1739

22. Bingham SA, Gill C, Welch A, Cassidy A, Runswick SA, Oakes S, Lubin R, Thurnham DI, Key TJ, Roe L, Khaw KT, Day NE (1997) Validation of dietary assessment methods in the UK arm of EPIC using weighed records, and 24-hour urinary nitrogen and potassium and serum vitamin C and carotenoids as biomarkers. Int J Epidemiol 26 Suppl 1:S137–S151

23. Bamia C, Orfanos P, Ferrari P, Overvad K, Hundborg HH, Tjønneland A, Olsen A, Kesse E, Boutron-Ruault MC, Clavel-Chapelon F, Nagel G, Boffetta P, Boeing H, Hoffmann K, Trichopoulos D, Baibas N, Psaltopoulou T, Norat T, Slimani N, Palli D, Krogh V, Panico S, Tumino R, Sacerdote C, Bueno-de-Mesquita HB, Ocké MC, Peeters PH, van Rossum CT, Quirós JR, Sánchez MJ, Navarro C, Barricarte A, Dorronsoro M, Berglund G, Wirfält E, Hallmans G, Johansson I, Bingham S, Khaw KT, Spencer EA, Roddam AW, Riboli E, Trichopoulou A (2005) Dietary patterns among older Europeans: the EPIC-Elderly study. Br J Nutr 94:100–113

24. Thomson CA, Flatt SW, Rock CL, Ritenbaugh C, Newman V, Pierce JP (2002) Increased fruit, vegetable and fiber intake and lower fat intake reported among women previously treated for invasive breast cancer. J Am Diet Assoc 102:801–808

25. Henderson L, Gregory J, Swan G (2003) The National Diet and Nutrition Survey: adults aged 19–64 years, vol 1. Types and quantities of foods consumed. HMSO, London http://www.statistics.gov.uk/statbase/Product.asp?vlnk=9761&More=N

26. Pierce JP, Natarajan L, Caan BJ, Parker BA, Greenberg ER, Flatt SW, Rock CL, Kealey S, Al-Delaimy WK, Bardwell WA, Carlson RW, Emond JA, Faerber S, Gold EB, Hajek RA, Hollenbach K, Jones LA, Karanja N, Madlensky L, Marshall J, Newman VA, Ritenbaugh C, Thomson CA, Wasserman L, Stefanick ML (2007) Influence of a diet very high in vegetables, fruit, and fiber and low in fat on prognosis following treatment for breast cancer: the Women's Healthy Eating and Living (WHEL) randomized trial. JAMA 298:289–298

27. Winters BL, Mitchell DC, Smicklas-Wright H, Grosvenor MB, Liu W, Blackburn GL (2004) Dietary patterns in women treated for breast cancer who successfully reduce fat intake: the Women's Intervention Nutrition Study (WINS). J Am Diet Assoc 104:551–559

28. Caan B, Sternfeld B, Gunderson E, Coates A, Quesenberry C, Slattery ML (2005) Life After Cancer Epidemiology (LACE) Study: a cohort of early stage breast cancer survivors (United States). Cancer Causes Control 16:545–556

29. Chlebowski RT, Blackburn GL, Thomson CA, Nixon DW, Shapiro A, Hoy MK, Goodman MT, Giuliano AE, Karanja N, McAndrew P, Hudis C, Butler J, Merkel D, Kristal A, Caan B, Michaelson R, Vinciguerra V, Del Prete S, Winkler M, Hall R, Simon M, Winters BL, Elashoff RM (2006) Dietary fat reduction and breast cancer outcome: interim efficacy results from the Women's Intervention Nutrition Study. J Natl Cancer Inst 98(24):1767–1776

30. Chlebowski RT, Blackburn GL, Buzzard IM, Rose DP, Martino S, Khandekar JD, York RM, Jeffery RW, Elashoff RM, Wynder EL (1993) Adherence to a dietary fat intake reduction program in postmenopausal women receiving therapy for early breast cancer. The Women's Intervention Nutrition Study. J Clin Oncol 11:2072–2080

31. Food Standards Agency and Central Office of Information (2008) Consumer consumption of vitamin and mineral food supplement. Growth from Knowledge Social Research NOP, 2008. http://www.food.gov.uk/multimedia/pdfs/viminsupconsumer.pdf

32. Henderson L, Irving K, Gregory J, Bates CJ, Prentice A, Perks J, Swan G, Farron M (2003) the national diet and nutrition survey: adults aged 19 to 64 years, vol. 3: Vitamin and mineral intake and urinary analytes. The Stationery Office, London

33. Lengacher CA, Bennett MP, Kip KE, Keller R, LaVance MS, Smith LS, Cox CE (2002) Frequency of use of complementary and alternative medicine in women with breast cancer. Oncol Nurs Forum 29:1445–1452

34. Catt S, Fallowfield L, Langridge C (2006) What non-prescription treatments do UK women with breast cancer use? Eur J Cancer Care (Engl) 15:279–285

35. Rees RW, Feigel I, Vickers A, Zollman C, McGurk R, Smith C (2000) Prevalence of complementary therapy use by women with breast cancer. A population-based survey. Eur J Cancer 36:1359–1364

36. Harris P, Finlay IG, Cook A, Thomas KJ, Hood K (2003) Complementary and alternative medicine use by patients with cancer in Wales: a cross sectional survey. Complement Ther Med 11:249–253

37. Boon HS, Olatunde F, Zick SM (2007) Trends in complementary/alternative medicine use by breast cancer survivors: comparing survey data from 1998 and 2005. BMC Womens Health 7:4

38. Rebbeck TR, Troxel AB, Norman S, Bunin GR, DeMichele A, Baumgarten M, Berlin M, Schinnar R, Strom BL (2007) A retrospective case-control study of the use of hormone-related supplements and association with breast cancer. Int J Cancer 120:1523–1528

39. Wayne SJ, Neuhouser ML, Koprowski C, Ulrich CM, Wiggins C, Gilliland F, Baumgartner KB, Baumgartner RN, McTiernan A, Bernstein L, Ballard-Barbash R (2009) Breast cancer survivors who use estrogenic botanical supplements have lower serum estrogen levels than non users. Breast Cancer Res Treat 117: 111–119

40. Ju YH, Doerge DR, Woodling KP, Hartman JA, Kwak J, Helferich WG (2008) Dietary genistein negates the inhibitory effect of letrozole on the growth of aromatase-expressing estrogen-dependant human breast cancer cells (MCF-7Ca) in vivo. Carcinogenesis 29:2162–2168

41. Booth NL, Overk CR, Yao P, Totura S, Deng Y, Hedayat AS, Bolton JL, Pauli GF, Farnsworth NR (2006) Seasonal variation of red clover (Trifolium pratense L., Fabaceae) isoflavones and estrogenic activity. J Agric Food Chem 54:1277–1282

42. Van Breeman RB, Fong HH, Farnsworth NR (2007) The role of quality assurance and standardization in the safety of botanical dietary supplements. Chem Res Toxicol 20:577–582

43. Vickers KA, Jolly KB, Greenfield SM (2006) Herbal medicine: women's views, knowledge and interaction with doctors: a qualitative study. BMC Complement Altern Med 6:40

44. Velentzis LS, Woodside JV, Cantwell MM, Leathem AJ, Keshtgar MR (2008) Do phytoestrogens reduce the risk of breast cancer and breast cancer recurrence? What clinicians need to know. Eur J Cancer 44:1799–1806

45. Bingham SA, Welch AA, McTaggart A, Mulligan AA, Runswick SA, Luben R, Oakes S, Khaw KT, Wareham N, Day NE (2001) Nutritional methods in the European Prospective Investigation of Cancer in Norfolk. Public Health Nutr 4:847–858

46. Guenther PM, Dodd KW, Reedy J, Krebs-Smith SM (2006) Most Americans eat much less than recommended amounts of fruits and vegetables. J Am Diet Assoc 106:1371–1379

47. Kristal AR, Feng Z, Coates RJ, Oberman A, George V (1997) Associations of race/ethnicity, education, and dietary intervention with the validity and reliability of a food frequency questionnaire. Am J Epidemiol 146:856–869

48. Heitmann BL, Lissner L (1995) Dietary underreporting by obese individuals— is it specific or non-specific? BMJ 311:986–989

49. Johnson RK, Goran MI, Poehlman ET (1994) Correlates of over- and underreporting of energy intake in healthy older men and women. Am J Clin Nutr 59:1286–1290