Cancer Causes Control (2009) 20:1955–1966
DOI 10.1007/s10552-009-9390-3

ORIGINAL PAPER

Dietary change among breast and colorectal cancer survivors and cancer-free women in the Norwegian Women and Cancer cohort study

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Received: 19 November 2008 / Accepted: 18 June 2009 / Published online: 30 June 2009

Abstract
Objective To study diet before and after diagnosis of breast and colorectal cancers compared with diet in cancer-free women in the Norwegian Women and Cancer study.
Methods This paper reports dietary changes from a data collection in 1996–1999 to another in 2002–2005. A total of 43,847 cancer-free women aged 41–70 years answered the baseline questionnaire on diet and lifestyle, 130 women developed colorectal cancer and 563 breast cancer. Dietary change in the three groups was compared, for breast cancer a comparison was made according to stage and time since diagnosis.
Results Breast cancer survivors increased fruit and vegetable consumption with 81 g compared to 42 g in colorectal cancer survivors and 50 g in cancer-free women (p difference in change <0.001). Milk consumption decreased among cancer-free women, but not among colorectal cancer survivors ($p = 0.007$). Significantly more cancer survivors quit smoking ($p < 0.001$). There were no differences in change of alcohol consumption or BMI. In breast cancer survivors, differences increased with time since diagnosis, and stage II survivors made larger changes than stage I survivors.
Conclusions Cancer survivors showed little change toward cancer-preventive guidelines, although more advanced stage and being more than 2.4 years post diagnosis was associated with greater change in diet and smoking behaviors.

Keywords Breast cancer · Colorectal cancer · Cohort study · Dietary change · Survivors

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Introduction

Several studies have shown that cancer survivors change their diets after diagnosis, most frequently in a healthier direction, cutting down on fat consumption and increasing the intake of fruits and vegetables [1]. However, most of these studies have been done in U.S. populations, have a retrospective or cross-sectional design, did not use validated methods for measuring diet, or did not have a comparison group of cancer-free persons. It is not known how persistent the behavioral changes are, and some recent large-scale studies suggest that health behaviors do not differ much between cancer survivors and healthy populations or non-cancer controls [2–4]. Few studies have examined dietary change according to time since diagnosis or stage of disease [5].

Much of the knowledge on cancer survivors and diet/lifestyle has come from studies of breast cancer survivors and studies of childhood cancer survivors [5]. Compared to breast cancer survivors, colorectal cancer survivors have been an understudied group, and not much research exists on colorectal cancer and dietary changes [5, 6]. Some recent studies of colorectal cancer survivors show results similar to those found among breast cancer survivors [6–9].

Two large U.S. prospective intervention studies of dietary change in breast cancer survivors have been carried out. Although the interim results from the Women's Intervention Nutrition Study (WINS) showed a lower risk

of recurrence with a low-fat diet, the intervention group had more mastectomies and lost weight, which might account for the effect, and the effect was more beneficial in women with tumors with negative hormonal receptor status [10]. In the Women's Healthy Eating and Lifestyle (WHEL) study, fruit and vegetable consumption above five servings a day, combined with lower fat intakes did not affect prognosis, neither did it lead to changes in body weight between the intervention group and the control group [11]. However, results from the control arm of the WHEL study indicated that women with higher serum carotenoid content at diagnosis had greater likelihood for recurrence-free survival [12]. Similarly, a cohort analysis of the WHEL study found that women with medium/high serum carotenoid levels (averaged over enrollment and follow-up values from year 1, 2, 3, 4, and 6) had a lower recurrence risk [13]. The 2007 WCRF/AICR expert report stated that no conclusions could be derived from the results of these and other studies on 'healthy diets' for cancer survivors [14]. The panel's advice for cancer survivors is therefore to follow the dietary recommendations for cancer prevention: to eat mostly plant foods, limit intake of red meat, alcoholic drinks, energy-dense foods and salt, and avoid processed meat and sugary drinks. In addition: be as lean as possible within the normal range and be physically active as part of daily life.

The aim of our study was to compare change in diet and selected lifestyle variables in Norwegian women who were diagnosed with breast cancer or colorectal cancer and cancer-free women, using a prospective design. A second aim was to examine dietary change according to time since diagnosis and stage of disease in breast cancer survivors.

Materials and methods

The Norwegian Women and Cancer study was initiated in 1991 and is a national, population-based cohort study. The study design, population, and procedures have been described elsewhere, together with aspects of external validity [15, 16]. The regional ethical committee for northern Norway and the Norwegian Data Inspectorate approved the study, and all the participants provided informed written consent. This paper reports dietary and other lifestyle changes in a cohort of women with one wave of data collection in 1996–1999 and a second wave in 2002–2005. The first wave of data collection and the dietary data and calculations were described in an earlier paper [17]. In short, the first data collection included 67,932 women aged 41–70 years who filled in a self-administered questionnaire including questions on health and lifestyle variables and a semi-quantitative food-frequency questionnaire (FFQ). The FFQ covered the habitual diet in the previous year, with special attention to the consumption of fish and fish products [18].

The second questionnaire was filled in by 50,800 women. Between the first and the second questionnaire 1,065 women had been selected for a case–control study and were ineligible for this study, 1,085 women had died, 268 women had emigrated, and 318 women could not be contacted due to missing addresses or other reasons (Fig. 1). Among those who were eligible, 5,286 women refused to participate and 9,110 did not reply, giving a response rate of 80.5%.

Among the participants, there were 659 women with incident breast cancer (International Classification of Diseases, version 7, code 1700–1709) and 155 with incident colorectal cancer (ICD-7, code 1530–1549) as their primary diagnosis in Cancer registry of Norway in the period between the two questionnaires. They are hereafter called BCS (breast cancer survivors) and CRCS (colorectal cancer survivors). Participants were excluded if they did not answer any dietary questions, or had missing values on weight or height, reported implausible energy intakes (were in the upper or lower percentile of energy intake divided by basal metabolic rate [19]) for any questionnaire (Fig. 1). In

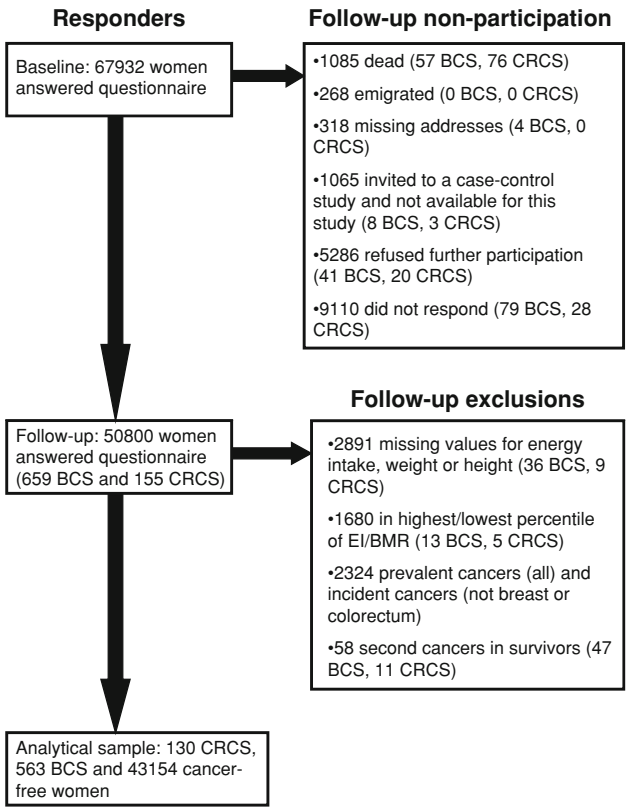

Fig. 1 Overview over baseline and follow-up participants with reasons for non-participation and exclusion. *BCS* breast cancer survivors, *CRCS* colorectal cancer survivors, *EI* energy intake, *BMR* basal metabolic rate

the comparison group, women with a prevalent cancer diagnosis (any site) or incident cancer diagnosis other than breast or colorectal were excluded. Likewise survivors with second cancers between the questionnaires were excluded. Finally, 563 women with incident breast cancer, 130 women with incident colorectal cancer, and 43,154 cancer-free women were included. Due to missing values these numbers vary a little from variable to variable, larger variations are noted in the table footnotes. In order to evaluate the representativeness of the analytical sample, we compared baseline characteristics of all who answered the baseline questionnaire and the analytical sample.

There were 58.4% BCS with stage I of the disease, 38.0% stage II, 1.8% stage III, 1.4% stage IV, and 0.4% had Paget's disease. Among CRCS, 26.2% had non-invasive tumors and 73.8% had invasive tumors.

Endpoints

Information about death and emigration was obtained by linkage to the Norwegian Population Registry [20], using the individually unique national identity numbers. Likewise, information on cancer diagnoses was obtained by linkage to the Cancer registry of Norway [21].

Dietary variables

Daily intake of nutrients and energy was calculated using values from the Norwegian Food Composition table, the 2001 version, for the first wave of questionnaires [22], and the 2006 version for the second wave of questionnaires [23]. This table includes data on liquid cod liver oil, but not on other dietary supplements. Liquid cod liver oil (not capsules) is therefore the only dietary supplement included in the nutrient calculations. Missing frequency values were imputed as 0, missing portion sizes as the smallest portion, as imputation with the median value only minimally affected the energy intake [18]. A more detailed description of the core dietary questions and their validation is published elsewhere [18, 24–26]. For the second wave, some dietary questions had been added, due to new products available on the market, improvements of the questionnaire and specific hypotheses.

Since our aim was to compare dietary change, we concentrated on the food/food group data, and only on those nutrients possibly related to breast or colorectal cancer incidence according to the first WCRF/AICR report: alcohol, total fat, saturated fat, refined sugars, fiber, starch, and carotenoids [27]. This way we could evaluate whether the changes were science based. We present data on β-carotene, not total carotenoids, as this was the only carotenoid available from the food composition table. In addition, we present data on folate intake, since folate modifies the association between alcohol consumption and cancer.

Even if changes in individual foods or food groups may confer a positive effect, more comprehensive dietary changes may be even more helpful. We therefore checked how many of four quantified dietary recommendations the women followed, and whether this changed between baseline and follow-up. The selected recommendations were low fat (30% or less of the energy from fat), low refined sugar (10% or less of the energy from refined sugar), high fiber (25 g or more per day), and high fruit and vegetables (400 g or more per day) [28, 29].

Adjustment variables

Body weight and height were self-reported, and body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m). BMI was further categorized in three groups, low (20 or lower), normal (20.1–25), and overweight (above 25). Only about 1% of the participants had a BMI under 18.5, so a lower of cut-point 20 was chosen in order to get a larger group. Education was asked in years and categorized as low (0–9 years), medium (10–12 years), and high (more than 12 years) [30]. A global scale asking for total physical activity (in home, at work, and exercise, walking, etc.) graded from 1 to 10 was categorized into low (1–3), medium (4–7), and high (8–10) [31]. This is a subjective measure that cannot yet be translated into METS or physical activity recommendations. Smoking was assessed with several questions [32]; in the main analyses, baseline smokers were compared to check whether quitting rates differed by cancer status. The participants were also categorized according to smoking cessation: "never smokers", who reported to be never smokers at both questionnaires, were compared with "quitters", who smoked daily at the first questionnaire, but not at the second questionnaire, and "current smokers", who reported daily smoking at both occasions. Participants were also asked whether they were teetotalers, or not.

Statistical analyses

All analyses were performed using SAS release 9.1 (SAS Institute, Inc., Cary, NC, USA). Changes were calculated as values from the second measurement minus values from the first measurement. The subjects were ranked on the baseline food and nutrient variables in order to divide the sample in tertiles for a check of linearity. In the final models, only energy was included as a categorical adjustment variable in tertiles based on the entire sample, while the baseline foods and nutrients were used as continuous

adjustment variables in analyses of change. Additional adjustment variables were categories of baseline BMI, baseline type of questionnaire (four types, grouped according to mean energy intake and year of mailing), and age at study entry (continuous). It was decided a priori to use a model with as few adjustment variables as possible, partly to avoid loss of statistical power (e.g., more missing values for physical activity) and partly due to the large number of outcomes, since it was unlikely that all outcomes would be related to a large set of adjustment variables.

Still, in order to check the robustness of the findings, we reran the analyses with selected variables, which we assumed could affect the results. Education and physical activity are related both to diet and health behaviors and were therefore added separately to the basic model. Smoking cessation is related to health and affects weight gain, and the basic model was therefore adjusted for it, to check whether it affected the associations and estimates.

Baseline mean values, mean change values, and standard errors of the changes were obtained in analyses of variance using a general linear model [33] where all variables were mutually adjusted for each other. The Bonferroni method was used to adjust for multiple comparisons and with adjusted p values for each of the least-squares means one could tell whether any of the compared groups differed from the others [33]. Due to the large number of participants, and the large number of comparisons, the significance level was set to $p < 0.01$.

We repeated the main analyses excluding simultaneously all cases diagnosed less than a year after answering the baseline questionnaire and all cancer-free women diagnosed with breast or colorectal cancer within 1 year after answering the follow-up questionnaire, to see whether latent disease affected the baseline results in cancer survivors or the changes in the cancer-free women.

Breast cancer survivors were ranked on time since diagnosis to obtain two groups of equal size for comparison. In a separate analysis, we compared dietary change in BCS in stage I of the disease and BCS in stage II. There were too few BCS with more advanced stage to include them in this analysis.

Results

Those who answered both questionnaires (Fig. 1—analytical sample) were younger than the baseline sample (0.5 years) and had slightly higher education (0.2 years), but the number of children and BMI was not significantly different, and baseline physical activity showed only a negligible difference (5.5 vs. 5.4; results not shown). The participation rate for the follow-up questionnaire did not differ between those who were diagnosed with cancer between the questionnaires and those who stayed cancer free (74.2 and 76.4%, respectively).

The characteristics of BCS, CRCS, and cancer-free women differed somewhat at baseline. CRCS were older than the other two groups (Table 1). There was no difference in the percentage of postmenopausal women at baseline, but at follow-up significantly more BCS than cancer-free women were postmenopausal. Hormone therapy (HT) use at baseline was more common among BCS (32.6% users) than among cancer-free women (21.8% users), but at follow-up only 1.2% of BCS were current HT users, significantly fewer than in cancer-free women (22.5%) and CRCS (24.4%). Among BCS, there were a higher percentage of women who had mothers with breast cancer than among cancer-free women. The percentage of women who reported good/excellent health was significantly higher among the cancer-free women (92.0%) than the CRCS (84.8%). Mean time since diagnosis for BCS was 2.6 years (range 0.0–7.2) and 2.4 years (range 0.0–6.9) for CRCS. Mean age at diagnosis was 55.0 for BCS and 58.9 for CRCS.

The baseline food intake was similar between the three groups (Table 2), except that those who later developed breast cancer drank more wine (22.7 vs. 16.4 g per day) and ate less cheese than the cancer-free women.

In the period between the questionnaires, the dietary change differed somewhat between the groups. BCS increased their intake of fruits with 51 g (Table 2), or about a third of a fruit per day [28]. This increase was significantly higher than the increase among cancer-free women (33 g, $p = 0.003$). They also increased the intake of vegetables more than cancer-free women did (31 vs. 17 g, $p < 0.001$). Analyses of the intake of specific fruits and vegetables (details not shown) indicated that BCS increased their consumption of "other fruits" significantly more than the cancer-free women. The change in carrot intake was borderline different among groups, and BCS increased their intake while cancer-free women decreased their intake. All groups increased their consumption of cauliflower/broccoli, BCS significantly more than cancer-free women did.

Breast cancer survivors reduced fat spread on bread more than the other groups, but the difference was only borderline significant. CRCS had a non-significant decrease in milk consumption (−13 g/day), while cancer-free women decreased their consumption by 43 g ($p = 0.01$). Further analyses indicated that decrease in the consumption of low-fat milk (not skimmed or whole milk), was most important for this difference, though there was a decrease for all subtypes (results not shown). BCS decreased their coffee consumption with almost a deciliter per day, significantly more than cancer-free

Table 1 Age-adjusted demographic and lifestyle factors among breast cancer survivors (BCS), colorectal cancer survivors (CRCS), and cancer-free women

	Breast cancer survivors ($n = 563$)		Colorectal cancer survivors ($n = 130$)		Cancer-free women ($n = 43{,}154$)		p value
	Mean	SE	Mean	SE	Mean	SE	
Age at baseline, years	51.4	0.3	55.3	0.6	50.8	0.03	<0.001[a]
Age at follow-up, years	57.5	0.3	61.2	0.6	56.8	0.03	<0.001[a]
No. of children, baseline	2.3	0.1	2.1	0.1	2.3	0.01	0.06
Years of education, baseline	12.2	0.1	11.6	0.3	11.9	0.02	0.06
Postmenopausal at baseline (%)[b]	53.4	1.7	59.5	3.5	56.0	0.2	0.2
Postmenopausal at follow-up (%)[c]	93.8	1.3	89.6	2.5	88.8	0.1	<0.001[d]
Hormone therapy users at baseline (%)[e]	32.6	1.8	27.8	3.7	21.8	0.2	<0.001[d]
Hormone therapy users at follow-up (%)	1.2	1.7	24.4	3.6	22.5	0.2	<0.001[f]
Mother with breast cancer at follow-up (%)	10.7	1.0	5.0	2.1	6.0	0.1	<0.001[d]
Good/excellent self-reported health at follow-up (%)	88.9	1.2	84.8	2.5	92.0	0.1	0.001[g]
Length of cancer diagnosis, years	2.6	0.07	2.4	0.2			0.2
Time between questionnaires, years	5.9	0.03	5.9	0.6	5.8	0.003	0.004[h]

All variables are age-adjusted, except the age-variables

SE standard error

[a] CRCS were older than the two other groups, $p < 0.001$ in Bonferroni adjusted tests

[b] 8,025 women in perimenopause or with uncertain menopausal status were excluded from this analysis

[c] 4,063 women in perimenopause, hysterectomized and aged less than 53, or with uncertain menopausal status was excluded from this analysis

[d] BCS differed from cancer-free women, $p < 0.001$ in Bonferroni adjusted tests

[e] 1,002 women were not asked about current use at baseline

[f] BCS differed from both other groups, $p < 0.001$ in Bonferroni adjusted tests

[g] CRCS differed from cancer-free women, $p = 0.01$ in Bonferroni adjusted tests

[h] BCS differed from cancer-free women, $p = 0.004$ in Bonferroni adjusted tests

women did, and the CRCS followed the same trend as the BCS. When analyzed by type of coffee (boiled, filtered, or instant), the CRCS decreased their consumption of filtered coffee significantly more than cancer-free women did ($p < 0.01$ in Bonferroni adjusted tests). For the rest of the foods, the change or lack of change seemed to be similar across the three groups.

At baseline, nutrient intakes were the same in the three groups (Table 3), except that BCS had a higher intake of alcohol (based on contributions from wine, beer, and hard liquors). CRCS (6.1 g) increased their refined sugar intake more than the other groups (both <3 g), $p = 0.01$. BCS did not decrease their β-carotene intake, while cancer-free women did, this difference was significant, $p = 0.007$. Cancer survivors increased their folate intake more than cancer-free women did ($p = 0.01$). There were also borderline differences in change in energy intake, total fat intake, and saturated fat intake where CRCS tended to increase or not change their intake between questionnaires, while the cancer-free women decreased their intake significantly. BCS decreased saturated and total fat, but not energy. No differences were found in the number of teetotalers between questionnaires.

In order to check if more comprehensive dietary changes had taken place, we studied compliance with dietary recommendations pertaining to fruit and vegetables, fat, added sugar, and fiber. Mean number of recommendations followed at baseline did not differ; 1.67, 1.62, and 1.79 among cancer-free women, BCS, and CRCS, respectively. At follow-up, the numbers had increased with 0.16, 0.27, and 0.10, respectively, which was borderline significant, $p = 0.02$ (results not shown).

All groups increased their weight with about one unit of BMI from baseline to follow-up (Table 4). The increase was largest in the BCS (1.0 kg/m^2), but not significantly different from the cancer-free women (0.8 kg/m^2). At baseline, 32% of the study population smoked, and there were no significant differences among the groups. The quitting rate was significantly higher among baseline smoking cancer survivors (54% of CRCS smoking at baseline, 33% of BCS) than among cancer-free women (20%). The level of physical activity was similar between the groups, and did not change over time.

Addition of either education level or physical activity to the model changed many of the change estimates, but all significant associations from Tables 2, 3, and 4 remained

Table 2 Adjusted baseline food intake ± change from baseline among breast cancer survivors (BCS), colorectal cancer survivors (CRCS), and cancer-free women

Food/food group (g/day)	Breast cancer survivors ($n = 563$)			Colorectal cancer survivors ($n = 130$)			Cancer-free women ($n = 43{,}154$)			p value change
	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	
Fruit	173.7	*50.8*	5.6	183.9	21.6	11.4	178.1	*32.7*	1.4	0.003[b]
Vegetables	122.2	*30.6*	3.4	133.2	*20.8*	7.0	121.9	*17.4*	0.8	<0.001[c]
Potato	111.1	*−18.4*	2.1	121.3	*−16.7*	4.2	111.3	*−15.8*	0.5	0.4
Bread and crispbread	141.2	*−17.6*	2.3	136.6	*−16.7*	4.7	139.6	*−14.6*	0.6	0.4
Fat spread on bread	15.5	*−2.3*	0.4	14.3	−0.4	0.9	15.0	*−1.4*	0.1	0.03
Pasta	17.2	−1.0	0.6	16.9	−1.3	1.2	17.7	*−1.4*	0.1	0.8
Rice	15.8	*1.3*	0.5	14.9	1.2	1.1	15.3	*1.0*	0.1	0.7
Milk	175.2	*−35.8*	5.1	138.7	−13.4	10.5	170.4	*−42.9*	1.3	0.007[d]
Cheese[e]	29.5	*−5.5*	0.9	30.1	−3.8	1.9	32.8	*−4.0*	0.2	0.3
Wine[f]	22.7	*5.1*	1.1	17.6	5.5	2.3	16.4	*4.5*	0.3	0.8
Coffee	434.3	*−90.6*	8.2	432.1	*−93.0*	16.7	447.7	*−61.3*	2.0	<0.001[d]
Fish	101.6	−4.6	2.0	114.6	−0.03	4.1	104.2	*−5.8*	0.5	0.3
Cod liver oil (liquid)	1.8	0.1	0.1	1.4	0.3	0.2	1.8	*−0.2*	0.03	0.03
Red meat	15.3	−0.1	0.4	14.7	−0.3	0.9	15.0	*−0.5*	0.1	0.5
Meat products	71.1	*−7.0*	1.5	73.1	*−11.6*	3.0	70.0	*−7.8*	0.4	0.4
Chicken	11.2	*3.7*	0.5	11.3	*2.7*	1.0	10.6	*3.3*	0.1	0.5
Chocolate	6.5	−0.3	0.3	6.1	0.7	0.7	6.0	−0.001	0.1	0.4
Soft drinks with sugar[g]	38.5	*−21.4*	2.9				40.8	*−19.2*	0.5	0.4
Soft drinks without sugar[g]	40.9	*−14.5*	4.6				39.0	*−7.3*	0.7	0.1
Orange juice[g]	55.3	−3.4	3.7				56.3	*−9.8*	0.6	0.08
Baked goods[g]	32.1	*−3.5*	1.4				35.5	*−3.1*	0.2	0.8
Salty snacks[g]	4.6	0.8	0.4				4.3	*1.5*	0.1	0.05

All analyses are adjusted for age (years at baseline), baseline type of questionnaire, baseline energy intake in tertiles, baseline BMI groups (≤20, 20.1–25, >25). The analyses of changes are additionally adjusted for baseline intake of the food (g/day)

[a] Change estimates in italic are significantly different from 0 ($p = 0.01$)

[b] BCS differed from cancer-free women, $p = 0.003$ in Bonferroni adjusted analyses

[c] BCS differed from cancer-free women, $p < 0.001$ in Bonferroni adjusted analyses

[d] CRCS differed from cancer-free women, $p = 0.01$ in Bonferroni adjusted analyses

[e] Baseline intake among BCS differed from cancer-free women, $p = 0.002$ in Bonferroni adjusted analyses

[f] Baseline intake among BCS differed from cancer-free women, $p < 0.001$ in Bonferroni adjusted analyses

[g] Question not asked to all at baseline, $n = 23{,}722$ cancer-free women, 308 BCS, and 52 CRCS, so CRCS were excluded from these analyses

significant (<0.01). Due to a low number of smoking CRCS at follow-up ($n = 17$ quitters, $n = 13$ continuing smoking), CRCS were not included in the analysis of how quitting smoking affected the results. Also in this analysis many of the estimates changed, but most associations between cancer status and change in diet/lifestyle remained significant. The exceptions were the associations between cancer status and milk and refined sugars, which not were significant anymore.

Comparing differences in food intake change in BCS stage I and II showed that stage II survivors made larger changes than cancer-free women, and stage I survivors usually made more intermediate changes (Table 5). For fruit and vegetables, the differences between the stage II survivors and cancer-free women were significant, $p < 0.001$. For coffee, the decreased intake in stage II survivors was significantly larger than decrease in the two other groups, $p = 0.001$.

When the BCS were divided in two equal groups according to time since diagnosis, and compared to the cancer-free women, the largest differences were found between the group diagnosed more than 2.36 years (2.37–7.15 years) before the second questionnaire and the cancer-free women (results not shown). This group increased the

Table 3 Adjusted baseline nutrient intake ± change from baseline among breast cancer survivors (BCS), colorectal cancer survivors (CRCS), and cancer-free women

Nutrient	Breast cancer survivors ($n = 563$)			Colorectal cancer survivors ($n = 130$)			Cancer-free women ($n = 43{,}154$)			p value change
	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	
Energy (kJ/day)	6,623	−27	64	6,746	268	131	6,781	*−77.1*	15.8	0.02
Total fat (g/day)	63.2	−1.7	0.7	62.4	2.6	1.5	63.4	*−1.3*	0.2	0.03
Saturated fat (g/day)	25.4	*−1.3*	0.3	24.9	0.5	0.7	25.6	*−1.0*	0.1	0.05
Alcohol (g/day)[b]	4.0	0.2	0.1	3.2	0.2	0.3	3.1	*0.2*	0.04	0.9
Starch (g/day)	102.5	*−7.8*	1.1	102.4	−5.4	2.3	103.1	*−6.8*	0.3	0.5
Refined sugar (g/day)	19.6	*2.6*	0.5	19.3	*6.1*	1.1	20.5	*2.6*	0.1	0.005[c]
Fiber (g/day)	21.0	0.2	0.2	21.4	−0.2	0.5	21.2	*−0.3*	0.1	0.1
β-Carotene (ug/day)	3,479	−28	82	3,885	−317	167	3,599	*−271*	20	0.01[d]
Folate	164	*22*	2.0	168	*27*	4.1	165	*15*	0.5	<0.001[e]

All analyses of changes are adjusted for age (years at baseline), baseline type of questionnaire, baseline energy intake in tertiles, baseline BMI groups (≤20, 20.1–25, >25), and baseline intake of the nutrient (continuous), except for change in energy intake which was adjusted for energy as a continuous variable, and not in tertiles. Baseline values are analysed for the same variables, except baseline intakes

[a] Change estimates in italic are significantly different from 0 ($p = 0.01$)

[b] Baseline intake among BCS differed from cancer-free women, $p < 0.001$ in Bonferroni adjusted analyses

[c] CRCS differed from both other groups, $p = 0.01$ in Bonferroni adjusted analyses

[d] BCS differed from cancer-free women, $p = 0.007$ in Bonferroni adjusted analyses

[e] Cancer survivors differed from cancer-free women, $p = 0.01$ in Bonferroni adjusted analyses

Table 4 Adjusted baseline lifestyle variables ± change from baseline among breast cancer survivors (BCS), colorectal cancer survivors (CRCS), and cancer-free women

	Breast cancer survivors ($n = 563$)			Colorectal cancer survivors ($n = 130$)			Cancer-free women ($n = 43{,}154$)			p value change
	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	Mean baseline	Mean change[a]	SE change	
BMI (kg/m^2)	24.3	*1.0*	0.1	24.5	*0.9*	0.2	24.5	*0.8*	0.02	0.06
Physical activity[b]	5.4	−0.1	0.1	5.6	−0.2	0.2	5.5	0.04	0.02	0.1
Quit smoking between questionnaires, % of baseline smokers		*33.4*	3.5		*53.6*	7.8		*20.1*	0.9	<0.001[c]

All analyses are adjusted for age (years at baseline), baseline type of questionnaire, baseline energy intake in tertiles, baseline BMI groups (≤20, 20.1–25, >25), except for BMI change, which was adjusted for BMI as a continuous variable, and physical activity change which was additionally adjusted for baseline physical activity (continuous). BMI analyses were additionally adjusted for current hormone therapy use (yes/no)

[a] Change estimates in italics are significantly different from 0 ($p = 0.01$)

[b] $N = 36{,}641$ cancer-free women, 485 BCS, and 100 CRCS

[c] Cancer-free women differed from the survivors, $p < 0.001$ in Bonferroni adjusted analyses. $N = 12{,}161$ cancer-free women, 155 BCS, and 30 CRCS

consumption of fruits more than cancer-free women did (62 vs. 33 g, $p < 0.001$), and increased vegetable consumption more than both cancer-free women and those with a shorter time since diagnosis (40 vs. 17 vs. 21 g, $p = 0.01$). On the other hand, the decrease in coffee consumption was largest in the group with the shortest time since diagnosis, 97 versus 62 g in cancer-free women, $p = 0.006$. For the other foods/food groups, no significant differences in changes were found. The number of cases was too low to allow analyses by time since diagnosis for colorectal cancer.

Table 5 Adjusted change in food intake (99% CI) among stage I and II BCS, compared with cancer-free women

Food/food group (g/day)	Stage I breast cancer survivors ($n = 329$)		Stage II breast cancer survivors ($n = 214$)		Cancer-free women ($n = 43{,}154$)		p value
	Mean[a]	SE	Mean[a]	SE	Mean[a]	SE	
Fruit	*41.2*	7.2	*65.9*	8.9	*32.5*	1.4	<0.001[b]
Vegetables	*26.5*	4.4	*37.3*	5.5	*17.4*	0.9	<0.001[b]
Potato	*−16.9*	2.7	*−20.7*	3.3	*−15.8*	0.5	0.3
Bread and crispbread	*−14.5*	3.0	*−22.4*	3.7	*−14.6*	0.6	0.1
Fat spread on bread	*−2.4*	0.5	*−2.3*	0.7	*−1.4*	0.1	0.08
Pasta	−1.0	0.7	−0.8	0.9	*−1.4*	0.1	0.7
Rice	*1.9*	0.7	0.5	0.8	*0.9*	0.1	0.3
Milk	*−40.0*	6.7	*−32.7*	8.2	*−43.1*	1.3	0.4
Cheese	*−5.0*	1.2	*−6.4*	1.5	*−4.1*	0.2	0.2
Wine	*7.3*	1.5	1.8	1.8	*4.5*	0.3	0.05
Coffee	*−68.2*	10.6	*−126.9*	13.1	*−61.6*	2.0	<0.001[c]
Fish	−2.8	2.6	−5.5	3.2	*−5.8*	0.5	0.5
Cod liver oil (liquid)	−0.1	0.2	0.2	0.2	*−0.2*	0.03	0.09
Red meat	−0.7	0.5	0.5	0.7	*−0.5*	0.1	0.3
Meat products	*−4.8*	1.9	*−10.3*	2.3	*−7.8*	0.4	0.2
Chicken	*4.1*	0.6	*3.1*	0.8	*3.3*	0.1	0.4
Chocolate	−0.5	0.4	−0.1	0.6	−0.01	0.1	0.5
Soft drinks with sugar[d]	*−21.6*	3.7	*−20.0*	4.5	*−19.2*	0.5	0.8
Soft drinks without sugar[d]	−11.5	6.0	*−18.1*	7.3	*−7.3*	0.7	0.3
Orange juice[d]	0.3	4.8	−9.7	5.8	*−9.7*	0.6	0.1
Baked goods[d]	−3.1	1.8	−4.4	2.2	*−3.1*	0.2	0.8
Salty snacks[d]	0.6	0.5	1.2	0.6	*1.5*	0.1	0.1

All analyses are adjusted for age (years at baseline), baseline type of questionnaire, baseline energy intake in tertiles, baseline BMI groups (≤20, 20.1–25, >25), and baseline intake of the food (g/day)

[a] Change estimates in italics are significantly different from 0 ($p = 0.01$)

[b] BCS stage II differed from cancer-free women, $p < 0.001$ in Bonferroni adjusted tests

[c] BCS stage II differed from the two other groups, $p = 0.001$ in Bonferroni adjusted tests

[d] Question not asked to all at baseline, $n = 33{,}722$ cancer-free women, 179 BCS stage I, and 122 BCS stage II

The increase in BMI showed a borderline significant difference by time since diagnosis ($p = 0.02$). Cancer-free women gained 0.8 kg/m^2, BCS with shorter time since diagnosis 0.9 kg/m^2, while BCS with longer time since diagnosis gained 1.1 kg/m^2. There were no differences for physical activity. The percentage of smokers who quit smoking increased significantly by time since diagnosis, 20.1% of cancer-free women quit, 27.6% of those with a shorter time since diagnosis, and 39.7% of those with a longer time since diagnosis, $p < 0.001$.

Repeating the analyses of food intake change excluding survivors diagnosed less than a year after the baseline questionnaire and cancer-free women who were diagnosed with breast or colorectal cancer within a year after follow-up, had little effect on baseline estimates for survivors and change estimates for cancer-free women.

Discussion

In the Norwegian Women and Cancer cohort, all groups of participants made some dietary changes between the first and second wave of questionnaires. The changes went in the same direction for all groups, and seemed to be in line with general health and nutrition advice, and not particularly related to the cancer diagnoses. Many of the changes amounted to at least 10% of the baseline intake, e.g., for fruits, vegetables, potatoes, bread and crispbread, milk, soft drinks, chicken, coffee, and wine. In the Nurses' Health Study, it was found that the correlation between food consumption before and after breast cancer diagnosis ranged from 0.4 to 0.6, but dietary change for specific foods or food groups was not quantified [34]. In our study, not only diet changed between the questionnaires. All groups gained

weight, while quitting smoking was significantly more common in cancer survivors than in cancer-free women.

Mean total intakes of fruit, vegetables, and juice on the follow-up FFQ exceeded the World Health Organization's goal [29] of a minimum of 400 g per day for all three groups of participants, but not the Norwegian Health Directorate's goal [28] of 750 g per day (including potatoes). In our cohort, the BCS increased their fruit and vegetable consumption with 81 g, the CRCS with 42 g and the cancer-free women with 50 g. The fruit consumption increased more than the vegetable consumption, although the fruit questions have been unchanged, while new questions have been added for tomatoes and onion for parts of the follow-up. Increase in fruit and vegetable consumption is one of the most frequently observed dietary changes among cancer survivors, but few studies have quantified the change, and used a prospective design and a cancer-free control group [1].

Colorectal cancer survivors decreased their milk consumption less than the other groups, but had a lower baseline intake, so after diagnosis the consumption was similar between the groups. The decrease in total milk consumption was found despite that a new type of extra low fat vitamin D-fortified milk was introduced between the two questionnaires, and the follow-up questionnaires therefore had an extra question on milk. Some of the decrease, particularly in low-fat milk was a change to the new variety, but the new type could not compensate for the general decrease. The decrease in milk consumption is in line with what is observed from Norwegian food supply statistics [35]. Reduction of both whole-milk products and reduced-fat milk products has been reported among BCS, as well as changes to milk products with lower fat-content, but these studies did not quantify changes [36, 37]. Another study showed that 1.5% of Finnish BCS decreased their dairy consumption, and 1.5% increased the consumption, compared to 18.3% of Australian BCS who decreased their dairy consumption and 1.4% who increased their consumption [38]. At the time of our study, calcium was considered unrelated to colorectal cancer [27], since then conflicting results have been reported [14, 39, 40], and the association between milk/calcium and colorectal cancer remains unclear.

The decrease in coffee consumption could just be a spurious finding, but fits with our previous paper where in a cross-sectional analysis breast cancer survivors (particularly short term) had a lower intake of coffee than cancer-free women, though the trend was not significant on 0.01 level [17]. There is no recommendation regarding coffee drinking for cancer patients in Norway. Another paper has reported decreased caffeine intake after cancer diagnosis [41]. Unfortunately, tea was not assessed at baseline, and only in parts of the follow-up.

All groups increased their refined sugar intake, CRCS more than the others. The first mailings of the baseline questionnaire had few questions on sweet food items, so these foods have gradually got more focus in the FFQ. We therefore think that the baseline intakes were underestimated, and that in reality the increase has been lower than Table 3 suggests. Higher increase by CRCS could at least partly be explained by missing questions on sweetened soft drinks in some of the baseline questionnaires distributed to older sub-samples, which have higher colorectal cancer rates. Differences in change in β-carotene could be attributed to changes in carrot consumption.

Most changes observed were healthy or neutral, with exception of the increase of alcohol intake. The increase could to some extent be explained by inclusion of a higher frequency option in the alcohol questions for the majority of the follow-up questionnaires. However, there has been an increase in alcohol sales in Norway in the period [42]. Still, the reported consumption is low, around a 1/3 of an alcohol unit per day. According to our validation study, alcohol is underreported with more than 50%. As alcohol intake is a risk factor for both breast and colorectal cancer (and other cancers and diseases), cancer survivors should limit their consumption [14]. Low intake of folate may increase the effect of alcohol on cancer. Folate intake increased relatively more than the alcohol intake, but was still below recommendations. No differences were found in the number of women who stopped drinking alcohol between questionnaires. Other studies have shown that cancer survivors were less likely to be current drinkers than cancer-free controls [4], or had similar levels of risky drinking behaviors [3].

Although some positive dietary changes were seen, and a trend toward more positive changes in BCS than in cancer-free women, generally few of the participants followed more than one or two of the selected four dietary recommendations.

Body fatness is a cancer risk factor, and possibly also affects survival [43]. Therefore, the higher increase in the BCS is worrying, even though it was not significantly higher than the increase the other groups. Physical activity is negatively associated with colorectal cancer incidence, and possibly also with breast cancer incidence [14, 27], despite this no differences in activity between the three groups were seen. A large difference was observed in the quitting smoking rate, from about half of the baseline smoking CRCS to one-fifth of the baseline cancer-free smokers. Lower smoking frequencies among cancer survivors have been found in other studies [44], though not among all groups of survivors [4, 45]. Some suggest that quitting smoking seems to be a health behavior easier to adopt after cancer diagnosis than following recommendations for physical activity and diet [44].

When the data were reanalyzed with education, physical activity, or smoking cessation status added to the model, the associations remained essentially the same, even though the estimates changed some. Also when excluding cases diagnosed the first year after baseline, it did not affect results appreciably.

Stage of disease could affect changes, and our results showing a tendency to larger changes with more advanced stages of breast cancer is in line with previous research [36], but not much literature exists in this field. We can only speculate that a more severe diagnosis is a stronger incentive to lifestyle change.

The timing of changes seems to be a complex issue. Based on our previous cross-sectional study, we assumed that women with a shorter time since diagnosis would differ more from cancer-free women than those with a longer time since diagnosis [17]. That was not the case here, but with the limited number of cases we could not use a more common grouping e.g., survivors of more than 5 years or less than 5 years. Actually, 86% of BCS in this paper were within 5 years from their date of diagnosis when they returned the follow-up questionnaire. A US study did not find significant differences in health behaviors according to time since diagnosis, but some interesting trends, e.g., for smoking, which was most prevalent in the first year after diagnosis, then lower, and more than 10 years after diagnosis again almost at the same level as the year after diagnosis [4]. This, together with findings of few differences in health behaviors compared to cancer-free controls have lead to speculations that the health changes seen might not generalize to all survivors or might be temporary [46]. Our results do not seem to support this, as improvements at least in diet and smoking cessation seem to increase with time since diagnosis, but since the time frame in our study is short more research is needed to confirm this.

Overall, the results obtained when adding other variables to the model, excluding early cases and analyzing sub-groups show that our findings are quite robust and not likely to be chance findings.

This study has several advantages; it reports prospective dietary changes measured with a validated semi-quantitative FFQ, and compares the changes in both breast and colorectal cancer survivors with those in the general population. The BCS group was large and allowed for analyses by stage and time since diagnosis.

The study also has some limitations: The number of CRCS was low, and therefore the results for this group must be taken with caution. The participants who died from their cancers naturally did not complete the follow-up questionnaire. Those who completed both questionnaires were younger than those who only completed the baseline questionnaire. However, 0.5 years is not a very large difference, and we do not think that this affected our results much. For all breast cancer cases diagnosed after the baseline study, we had information on stage of disease. The distribution of stages did not differ between non-responding BCS alive at the time of follow-up and those who responded ($p = 0.20$ in Fishers exact test), and participation rates were the same among cancer survivors and cancer-free women.

There were different versions of the dietary questionnaire both within and between the baseline study and the follow-up study. This complicates the interpretation of the data. However, changes were seen both for items with identical questions (fruits, coffee) and differences in questions (decrease in milk despite all had one extra question on milk on follow-up, and increase in vegetables despite only 43% of the cohort had an increased number of questions on follow-up). FFQs have measurement errors, and there has been a debate as to whether they are precise or specific enough to measure diet–disease relationships [47, 48]. Despite this, our study found differences in dietary changes between cancer survivors and cancer-free women. Given the problems with measurement errors, it is likely that changes are larger than what we have reported here. On the other hand, social desirability bias might have lead to over-reporting of fruit and vegetable intakes, but it is not likely that this should have affected the groups of participants differently. A further limitation with the study is the lack of validation studies for self-reported smoking, physical activity, height, and weight.

This study has shown that cancer survivors follow dietary trends that are common with the cancer-free female population, but tend to exaggerate them. No official Norwegian dietary advice aimed at cancer survivors exists, so we expect that the changes seen are results of individual choices rather than structured advice. Cancer survivors seem to be more ready to implement diet and lifestyle changes than cancer-free women, and the opportunity should be taken to give individualized, disease specific advice, which in addition to diet and smoking also should focus on alcohol and body weight [14]. Survivors, regardless of stage will benefit from a healthy lifestyle as they are at risk for recurrent disease, even with effective pharmaceutical approaches to long-term survival.

Acknowledgments Guri Skeie was supported by a Ph.D. grant from EXTRA funds from the Norwegian Foundation for Health and Rehabilitation and The Norwegian Cancer Society.

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