Original Article

Unhealthy Behaviors After Breast Cancer: Capitalizing on a Teachable Moment to Promote Lifestyle Improvements

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BACKGROUND: This study assessed the prevalence and risk factors of unhealthy behaviors among survivors of early-stage breast cancer. **METHODS:** Women (n = 9556) from the CANcer TOxicity cohort (NCT01993498) were included. Physical activity (PA), tobacco and alcohol consumption, and body mass index were assessed at diagnosis and at years 1 and 2 after diagnosis. A behavior was defined as unhealthy if patients failed to meet PA recommendations (≥10 metabolic equivalent task hours per week), reduce/quit tobacco, or decrease alcohol consumption to less than daily, or if they gained substantial weight over time. Multivariable-adjusted generalized estimating equations explored associations with unhealthy behaviors. **RESULTS:** At diagnosis, 41.7% of patients were inactive, 18.2% currently used tobacco, 14.6% consumed alcohol daily, and 48.9% were overweight or obese. At years 1 and 2, unhealthy PA behavior was reported among 37.0% and 35.6% of patients, respectively, unhealthy tobacco use behavior was reported among 11.4% and 9.5%, respectively, and unhealthy alcohol behavior was reported among 13.1% and 12.6%, respectively. In comparison with the previous assessment, 9.4% and 5.9% of underweight and normal-weight patients had transitioned to the overweight or obese category at years 1 and 2, respectively, and 15.4% and 16.2% of overweight and obese patients had gained ≥5% of their weight at years 1 and 2, respectively. One in 3 current tobacco smokers and 1 in 10 daily alcohol users reported improved behaviors after diagnosis. Older women (5-year increment) were more likely to be inactive (adjusted odds ratio [aOR], 1.03; 95% confidence interval [CI], 1.01-1.05) and report unhealthy alcohol behavior (aOR, 1.28; 95% CI, 1.23-1.33) but were less likely to engage in unhealthy tobacco use (aOR, 0.81; 95% CI, 0.78-0.85). Being at risk for depression (vs not being at risk for depression) was associated with reduced odds of unhealthy tobacco use (aOR, 0.67; 95% CI, 0.46-0.97) and with a higher likelihood of unhealthy alcohol behavior (aOR, 1.58; 95% CI, 1.14-2.19). Women with a college education (vs a primary school education) less frequently reported an unhealthy PA behavior (aOR, 0.61; 95% CI, 0.51-0.73) and were more likely to report unhealthy alcohol behavior (aOR, 1.85; 95% CI, 1.37-2.49). Receipt of chemotherapy (vs not receiving chemotherapy) was associated with higher odds of gaining weight (aOR, 1.51; 95% CI, 1.23-1.87) among those who were overweight or obese at diagnosis. **CONCLUSIONS:** The majority of women were adherent to healthy lifestyle behaviors at the time of their breast cancer diagnosis, but a significant subset was nonadherent. Unhealthy behaviors tended to persist after the breast cancer diagnosis, having varying clinical, psychological, sociodemographic, and treatment-related determinants. This study will inform more targeted interventions to promote optimal health. ***Cancer* 2021;0:1-14**.

KEYWORDS: breast cancer, physical activity, tobacco use, alcohol consumption, body mass index, health behaviors.

INTRODUCTION

Breast cancer is the most common cancer in women worldwide, with the number of survivors of early-stage cancers progressively increasing each year.[1] Evidence suggests multiple benefits for survivors pursuing a healthy lifestyle, including improved breast cancer–specific outcomes.[2] However, unhealthy lifestyle habits remain prevalent among women diagnosed with early-stage breast cancer.[3,4]

Receiving a diagnosis of breast cancer may have a substantial psychological impact and represent a catalyst to adopt healthier behaviors. The teachable moment after a diagnosis of cancer is documented in the literature, with some women motivated to seek information about lifestyle modifications to change certain behaviors or to pursue techniques to manage stress, improve well-being, and maintain quality of life.[5]

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Nevertheless, for many women, additional support through lifestyle interventions is required to facilitate and maintain these positive changes. Some studies also suggest that many cancer survivors are unsuccessful in improving their lifestyle behaviors and that they are no healthier than individuals without a history of cancer.[5]

Characterizing vulnerable patient populations that are less likely to achieve a healthy lifestyle after a breast cancer diagnosis is essential for building targeted interventions. However, prior research has not been fully informative in identifying these subgroups of at-risk patients.[5] Limitations to these studies have included a small sample size, nondetailed characterization, and limited generalizability. Using the CANcer TOxicity (CANTO) cohort, we sought to describe patterns of and factors associated with unhealthy behaviors and to identify women at higher risk of not attainting/maintaining healthy lifestyle changes. This large, longitudinal clinical study offers robust and comprehensive clinical, tumor-related, treatment, and behavioral data.[6]

MATERIALS AND METHODS

Data Source

CANTO (NCT01993498) is a prospective, multicenter cohort that enrolled patients with stage I, II, or III breast cancer.[6] Clinic-collected anthropometric measures (including body mass index [BMI]), self-reported physical activity (PA), tobacco use, and alcohol intake were collected by trained study nurses. Longitudinal data assessed at the time of the breast cancer diagnosis (the baseline) and at years 1 and 2 after the diagnosis were used. Per the CANTO study protocol, for patients experiencing progression of disease, including nodal or distant recurrence of breast cancer (ie, other than local breast cancer recurrence), second primary cancers, or fatal comorbidities, the study was terminated at the time of the event. Data from cases that experienced these events during follow-up were censored from analyses. All participants provided informed written consent. The study was approved by the ethics committee (ID-RCB:2011-A01095-36,11-039).

Variables of Interest

Outcome variables: definitions of lifestyle behaviors

PA

The Global Physical Activity Questionnaire 16 (World Health Organization [WHO]) was used to assess the duration and intensity of work, transportation, and leisure-time PA in metabolic equivalent task [MET] hours per week as well as sedentary behavior (hours per day). Ten or more MET hours per week defined patients as sufficiently active (vs insufficiently active according to WHO recommendations: 150 minutes of moderate intensity per week, 75 minutes of vigorous intensity per week, or an equivalent combination).[7] The categories for changes were maintained activity (ie, sufficiently active before and after), increased activity (ie, insufficiently active before and sufficiently active after), decreased activity (ie, sufficiently active before and insufficiently active after), and persistently insufficient activity (ie, insufficiently active before and after) in comparison with the previous assessment.

Tobacco and alcohol use

At diagnosis, patients were defined as current tobacco users or former or never tobacco users. The frequency of alcohol intake was defined as daily or less than daily. At years 1 and 2 after diagnosis, patients were asked whether their use had remained unchanged, increased, or decreased in comparison with the previous assessment. The number of pack-years and the tobacco use duration were also collected.

BMI and weight status

Weight and BMI were assessed at diagnosis and at years 1 and 2 after diagnosis. The BMI categories were defined as underweight (BMI < 18.5 kg/m^2), normal weight (BMI $= 18.5$-24.9 kg/m^2), overweight (BMI $= 25.0$-29.9 kg/m^2), and obese (BMI ≥ 30.0 kg/m^2) according to WHO definitions.[8] The categories of weight change were as follows: lost weight ($\geq$5%), stable weight ($\pm$5%), or gained weight ($\geq$5%) in comparison with the previous assessment. Cutoffs to define the weight status were based on evidence that a weight change as low as 5% of the initial weight could be clinically meaningful; this included associations with cardiovascular and metabolic disease risk factors and outcomes[9] and with health-related functional parameters, symptoms, and quality of life among early-stage breast cancer survivors.[10,11]

To identify patients who were more prone to negative changes, we focused on 1) unhealthy PA behavior (ie, decreased or persistently insufficient activity); 2) unhealthy tobacco use or 3) unhealthy alcohol intake behavior (ie, unchanged use if the patients were previously current tobacco users or daily alcohol users or increased use [eg, resumed use] in comparison with the previous assessment); and 4) unhealthy weight status (defined as transitioning to being overweight or obese among patients who were underweight or normal weight and as gaining additional

TABLE 1. Baseline Cohort Characteristics (n = 9556)

Age, mean (SD), years	56.3 (11.4)
Body mass index, kg/m^2	
Mean (SD)	25.9 (5.4)
Missing	57
Body mass index, No. (%)	
<18.5 kg/m^2, underweight	225 (2.4)
18.5-24.9 kg/m^2, normal-weight	4633 (48.8)
25.0-29.9 kg/m^2, overweight	2773 (29.2)
≥30.0 kg/m^2, obese	1868 (19.7)
Missing	57
Menopausal status, No. (%)	
Premenopausal	3486 (37.2)
Postmenopausal	5891 (62.8)
Missing	179
Charlson comorbidity score, No. (%)	
0	7077 (80.8)
≥1	1684 (19.2)
Missing	795
Anxiety, No. (%)	
Not at risk	3446 (39.5)
Doubtful risk	2340 (26.8)
At risk	2929 (33.6)
Missing	841
Depression, No. (%)	
Not at risk	7107 (81.5)
Doubtful risk	996 (11.4)
At risk	617 (7.1)
Missing	836
Patient-reported quality of life: EORTC QLQ-C30 summary score[a]	
Mean (SD)	82.7 (12.8)
Missing	1139
Highest education level, No. (%)	
Primary school	1298 (15.0)
High school	4045 (46.6)
College degree or higher	3332 (38.4)
Missing	881
Marital status, No. (%)	
Partnered	6169 (72.0)
Not partnered	2398 (28.0)
Missing	989
Monthly household income, No. (%)[b]	
<€3000	4503 (56.2)
≥€3000	3513 (43.8)
Missing	1540
Center volume, No. (%)	
High (>1000 patients enrolled in CANTO)	2314 (24.2)
Low/intermediate (≤1000 patients enrolled in CANTO)	7242 (75.8)
Stage, No. (%)	
I	4706 (49.5)
II	3868 (40.7)
III	923 (9.7)
Missing	59
Breast cancer surgery, No. (%)	
Mastectomy	2516 (26.4)
Partial breast surgery[c]	6997 (73.6)
Missing	43
Axillary surgery, No. (%)	
Axillary dissection	3589 (37.7)
Sentinel node or none	5924 (62.3)
Missing	43
Chemotherapy, No. (%)	
Yes	5037 (53.0)
No	4471 (47.0)
Missing	48
Radiation therapy, No. (%)	
Yes	8665 (91.3)
No	827 (8.7)
Missing	64
Endocrine therapy, No. (%)	
Yes	7677 (81.1)
No	1788 (18.9)
Missing	91
Anti-HER2 therapy, No. (%)	
Yes	1152 (12.1)
No	8343 (87.9)
Missing	61
Physical activity behavior: WHO recommendations, No. (%)	
Insufficiently active	3658 (41.7)
Sufficiently active	5105 (58.3)
Missing	793
Tobacco use behavior, No. (%)	
Current user	1709 (18.2)
Former/never user	7689 (81.8)
Missing	158
Alcohol intake behavior, No. (%)	
Daily	1351 (14.6)
Less than daily	7904 (85.4)
Missing	301

Abbreviations: EORTC QLQ-C30, European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire C-30; HER2, human epidermal growth factor receptor 2; SD, standard deviation; WHO, World Health Organization.

[a]The summary score is a composite score that includes 13 of the 15 domains of the EORTC QLQ-C30: Physical Function, Emotional Function, Social Function, Cognitive Function, Role Function, Fatigue, Pain, Insomnia, Nausea/Vomit, Dyspnea, Appetite Loss, Constipation, and Diarrhea.

[b]Threshold closest to the median value in this cohort and defining most individuals belonging to the middle-to-upper class in France.

[c]Includes 30 patients who did not undergo breast surgery.

weight [≥5%] among patients who were overweight or obese at the first assessment).

Covariates

Socioeconomic, clinical, tumor, and treatment characteristics were categorized according to Table 1. Anxiety and depression were explored with the Hospital Anxiety and Depression Scale, and each was categorized as "not at risk" (score = 0-7), "doubtful risk" (score = 8-10), or "at risk" (score = 11-21).[12] Quality of life was assessed with the European Organisation for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaire (QLQ) C-30.[13,14]

Statistical Analysis

First, descriptive statistics were used to summarize cohort characteristics and the evolution of behaviors from diagnosis to years 1 and 2.

We then evaluated exposure variables (Table 2) in relation to changes in lifestyle behaviors. We fit models to correlated responses by generalized estimating equations to explore the association between exposure variables and the outcome of engaging in an unhealthy PA, tobacco use, or alcohol intake behavior or that of gaining weight

TABLE 2. Multivariable Models of Factors Associated With Unhealthy Behaviors

	Model 1: Unhealthy Physical Activity Behavior				Model 2: Unhealthy Tobacco Use Behavior				Model 3: Unhealthy Alcohol Intake Behavior				Model 4: Unhealthy Weight Status (Among Underweight and Normal-Weight Patients)				Model 5: Unhealthy Weight Status (Among Overweight and Obese Patients)			
Prevalence	Year 1, 37.0%/Year 2, 35.6%				Year 1, 11.4%/Year 2, 9.5%				Year 1, 13.1%/Year 2, 12.6%				Year 1, 9.4%/Year 2, 5.9%				Year 1, 15.4%/Year 2, 16.2%			
		95% CI				95% CI				95% CI				95% CI				95% CI		
Variable	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*
Age, continuous (5-year increase)	1.03	1.01	1.05	**.045**	0.81	0.78	0.85	**<.0001**	1.28	1.23	1.33	**<.0001**	0.77	0.74	0.81	**<.0001**	0.90	0.86	0.95	**<.001**
BMI, continuous (1-unit increase)	1.06	1.05	1.07	**<.0001**	0.96	0.94	0.98	**<.0001**	0.96	0.95	0.98	**<.0001**	3.33	2.95	3.77	**<.0001**	0.98	0.96	0.99	**.020**
Comorbidities, Charlson comorbidity score ≥ 1 vs 0	1.03	0.91	1.17	.611	1.11	0.89	1.38	.350	1.14	0.94	1.39	.187	0.80	0.57	1.14	.219	1.16	0.96	1.41	.126
Anxiety, doubtful risk vs not at risk	0.90	0.79	1.02	.094	1.04	0.84	1.29	.703	0.89	0.73	1.08	.245	1.13	0.84	1.52	.408	1.18	0.97	1.43	.089
Anxiety, at risk vs not at risk	0.85	0.74	0.97	**.016**	1.09	0.87	1.35	.464	0.81	0.65	1.00	.055	0.90	0.66	1.24	.532	1.00	0.81	1.24	.947
Depression, doubtful risk vs not at risk	1.21	1.03	1.43	**.023**	1.02	0.78	1.33	.907	1.08	0.82	1.44	.570	1.26	0.86	1.86	.242	1.33	1.04	1.71	**.026**
Depression, at risk vs not at risk	1.14	0.91	1.42	.248	0.67	0.46	0.97	**.035**	1.58	1.14	2.19	**.006**	1.52	0.97	2.38	.065	1.23	0.89	1.67	.200
Overall QOL, C30 summary score, continuous (10-unit increase)	0.95	0.91	0.99	**.033**	0.87	0.81	0.94	**.001**	0.97	0.91	1.05	.500	0.99	0.98	1.01	.317	0.99	0.99	1.00	.880
Education, high school vs primary school	0.81	0.69	0.95	**.010**	1.14	0.84	1.54	.400	1.33	1.01	1.74	**.043**	0.80	0.51	1.24	.314	0.99	0.79	1.23	.912
Education, college vs primary school	0.61	0.51	0.73	**<.0001**	0.80	0.57	1.13	.206	1.85	1.37	2.49	**<.0001**	0.52	0.32	0.83	**.006**	0.82	0.63	1.07	.141
Marital status, partnered vs not partnered	1.29	1.14	1.47	**<.0001**	0.71	0.58	0.88	**.001**	1.34	1.09	1.64	**.005**	1.03	0.76	1.39	.843	1.08	0.89	1.30	.423
Household income, ≥€3000/month vs <€3000/month	0.93	0.83	1.05	.230	0.89	0.72	1.09	.261	0.97	0.80	1.17	.741	0.91	0.69	1.20	.490	0.89	0.74	1.06	.195
Center volume, low/intermediate vs high	1.01	0.90	1.14	.854	0.99	0.81	1.20	.918	1.13	0.93	1.37	.212	1.30	0.96	1.75	.087	1.11	0.93	1.33	.225
Stage, II vs I	1.11	0.98	1.26	.102	1.10	0.89	1.35	.384	1.16	0.95	1.42	.134	1.38	1.03	1.84	**.031**	1.03	0.84	1.26	.760
Stage, III vs I	0.98	0.79	1.21	.829	1.16	0.80	1.67	.437	1.24	0.87	1.76	.234	1.41	0.88	2.26	.153	1.14	0.85	1.56	.380
Breast surgery, partial vs mastectomy	0.95	0.82	1.08	.422	1.08	0.86	1.36	.515	0.96	0.76	1.20	.715	1.26	0.92	1.72	.158	0.93	0.76	1.14	.479
Axillary surgery, dissection vs none or sentinel	1.03	0.90	1.18	.658	0.92	0.74	1.14	.446	0.97	0.79	1.20	.786	0.76	0.56	1.03	.073	1.18	0.96	1.46	.106
Chemotherapy, yes vs no	0.98	0.86	1.12	.776	0.76	0.61	0.94	**.012**	1.16	0.94	1.42	.171	1.09	0.81	1.45	.578	1.51	1.23	1.87	**.0001**
Radiotherapy, yes vs no	0.89	0.72	1.09	.263	1.54	1.07	2.20	**.019**	0.80	0.58	1.10	.174	0.80	0.51	1.27	.342	1.15	0.83	1.60	.392
Endocrine therapy, yes vs no	0.99	0.87	1.12	.844	0.93	0.75	1.15	.502	1.11	0.89	1.37	.352	0.83	0.62	1.11	.208	0.93	0.77	1.13	.477

TABLE 2. *Continued*

Variable	Model 1: Unhealthy Physical Activity Behavior				Model 2: Unhealthy Tobacco Use Behavior				Model 3: Unhealthy Alcohol Intake Behavior				Model 4: Unhealthy Weight Status (Among Underweight and Normal-Weight Patients)				Model 5: Unhealthy Weight Status (Among Overweight and Obese Patients)			
Prevalence	Year 1, 37.0%/Year 2, 35.6%				Year 1, 11.4%/Year 2, 9.5%				Year 1, 13.1%/Year 2, 12.6%				Year 1, 9.4%/Year 2, 5.9%				Year 1, 15.4%/Year 2, 16.2%			
		95% CI				95% CI				95% CI				95% CI				95% CI		
Variable	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*	OR[a]	Low	High	*P*
Anti-HER2 therapy, yes vs no	0.99	0.85	1.16	.934	1.02	0.79	1.33	.865	0.83	0.64	1.09	.184	1.00	0.72	1.39	.991	1.13	0.90	1.42	.272
Physical activity behavior, sufficiently vs insufficiently active	—	—	—	—	0.73	0.62	0.87	**.0001**	0.99	0.84	1.16	.898	1.04	0.83	1.32	.713	1.15	0.98	1.34	.079
Tobacco use behavior, current vs former/never	1.43	1.25	1.63	**<.0001**	—	—	—	—	2.19	1.81	2.64	**<.0001**	1.56	1.19	2.05	**.001**	1.43	1.16	1.75	**.0006**
Alcohol intake behavior, daily vs less than daily	0.99	0.86	1.14	.901	2.24	1.82	2.75	**<.0001**	—	—	—	—	1.03	0.75	1.42	.852	0.96	0.76	1.22	.743

Abbreviations: BMI, body mass index; CI, confidence interval; HER2, human epidermal growth factor receptor 2; OR, odds ratio; QOL, quality of life.

Estimates were obtained with a multivariable-adjusted generalized estimating equation model correcting for all factors included in the table. The probability modeled is "unhealthy" behavior at any time point (year 1 or year 2).

[a]Adjusted for all variables in the table. Associations with a *P* value < .05 are bolded.

at years 1 and 2 after diagnosis. Separate models were constructed for each outcome. For each behavior outcome, models were also adjusted for other health behaviors. An exchangeable working correlation matrix structure was specified to account for within-subject correlations. The variance function for the binomial distribution and the logit-link function were used (binary response data). To assess relative differences between levels of explanatory variables, model-based multivariable-adjusted odds ratios (aORs) and respective 95% confidence intervals (CIs) were obtained.

Changes in sedentary behavior (continuous) were evaluated with multivariable random-effect mixed models, which were adjusted for covariates, time, and covariate-by-time interactions, as appropriate, and model-based means were obtained (a 95% CI not crossing 0 represented a significant change).

Statistical analyses were performed with SAS statistical software (version 9.4; SAS Institute, Inc). Statistical significance was defined with a 2-sided P value < .05.

RESULTS

Cohort Characteristics

We included 9556 women who had been diagnosed with breast cancer from 2012 to 2017 and had follow-up data until year 2 after diagnosis. Responders to behavior assessments at each time point are reported in Figure 1. Responders to PA questionnaires were younger and leaner, had lower depression scores and a higher socioeconomic status (SES), and were more frequently former or never smokers. Comparisons between patients providing and not providing data on behavior assessments are shown in Supporting Table 1.

The mean age at inclusion was 56.3 years; 2929 patients (33.6%) and 617 patients (7.1%) were categorized as being at risk for anxiety and depression at diagnosis, respectively; 3332 patients (38.4%) had a college degree; and 5037 patients (53.0%) received adjuvant chemotherapy (Table 1).

PA Behavior

At diagnosis, 41.7% of the patients (n = 3658) did not meet recommendations for PA (Fig. 2Ai), and this proportion slightly decreased over time (37.1% at year 1 [n = 2901] and 36.0% at year 2 [n = 2400]; $P_{trend} < .0001$). Fewer patients reported no engagement in any PA (0 MET hours per week; 26.8% [n = 2345] at diagnosis, 21.9% [n = 1716] at year 1, and 21.0% [n = 1398] at year 2; $P_{trend} < .0001$).

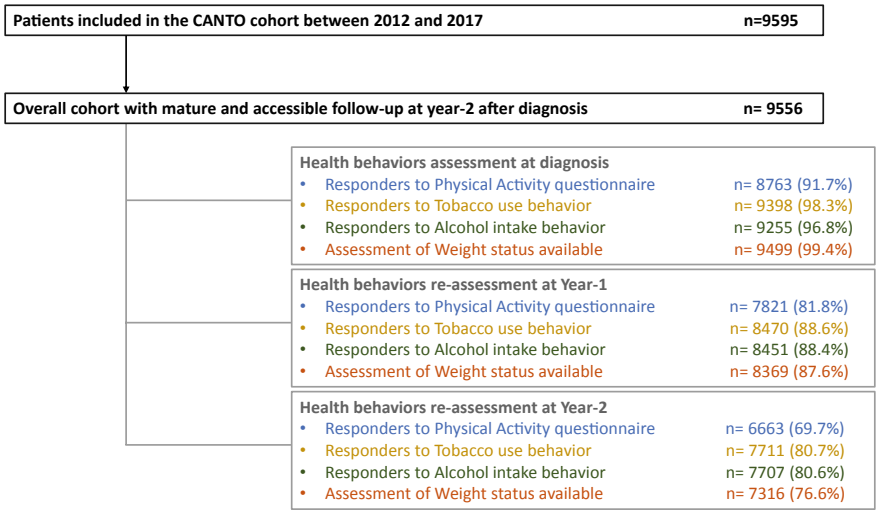


Figure 1. Flow-chart of the study patient population. CANTO enrolled a total of 12012 patients overall. This analysis included 9556 patients for whom mature follow-up until year 2 after diagnosis was available. CANTO indicates CANcer TOxicity.

Overall, at year 1 and year 2, 37.0% and 35.6% of patients, respectively, reported decreased or persistently insufficient PA in comparison with the previous assessment (Fig. 2Aii). Among patients insufficiently active at diagnosis, 41.8% had increased their activity at year 1, whereas 27.2% had maintained their activity and 17.7% had increased their activity at year 2 in comparison with year 1 (Fig. 2Aiii).

The mean sedentary time at diagnosis was 6.40 hours per day (95% CI, 6.13-6.65 hours per day). There was a global tendency toward reducing sedentary time after diagnosis, with larger reductions reported over year 1 in comparison with year 2 (mean change at year 1, –0.27 hours per day; 95% CI, –0.37 to –0.17 hours per day; adjusted $P < .0001$; mean change at year 2, –0.14 hours per day; 95% CI, –0.25 to –0.03 hours per day; adjusted $P = .012$).

Older age (5-year increment in age; aOR, 1.03; 95% CI, 1.01-1.05), higher BMI (1-unit increment; aOR, 1.06; 95% CI, 1.05-1.07), partnered status (vs not partnered; aOR, 1.29; 95% CI, 1.14-1.47), and current smoker status (vs former/never smoker; aOR, 1.43; 95% CI, 1.25-1.63) were risk factors for an unhealthy PA behavior. Conversely, women reporting higher anxiety scores (at risk vs not at risk for anxiety; aOR, 0.85; 95% CI, 0.74-0.97) and those with higher education (college vs primary school; aOR, 0.61; 95% CI, 0.51-0.73) were less likely to engage in an unhealthy PA behavior (Table 2).

Tobacco Use Behavior

Current tobacco use was prevalent among 18.2% of patients (n = 1709) at diagnosis (Fig. 2Bi), with a reported median of 19 pack-years (quartile 1 to quartile 3, 10-30 pack-years) and with a mean average of 32 years (quartile 1 to quartile 3, 25-39 years) since smoking initiation.

Unhealthy tobacco use behavior was reported by 11.4% of patients at year 1 and by 9.5% of patients at year 2, who either resumed/increased use or continued using (Fig. 2Bii).

For those who were current tobacco users at diagnosis, reduction/cessation was reported by 37.5% of patients at year 1 and by 30.2% of patients at year 2 (Fig. 2Biii).

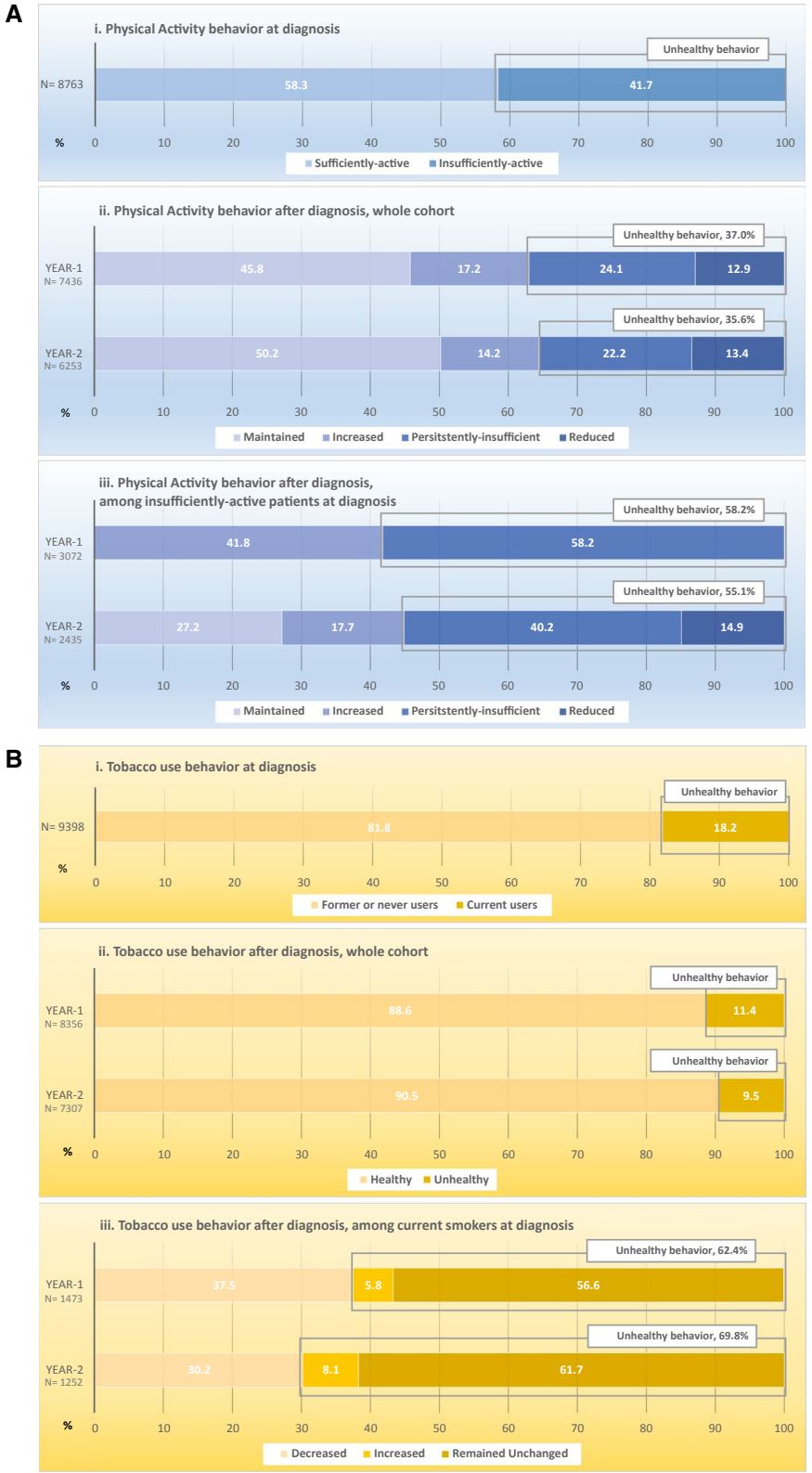
Odds of unhealthy tobacco use behavior were lower among women who were older (5-year increment in age; aOR, 0.81; 95% CI, 0.78-0.85), were heavier (1-unit BMI increment; aOR, 0.96; 95% CI, 0.94-0.98), were partnered (vs not partnered; aOR, 0.71; 95% CI, 0.58-0.88), received chemotherapy (vs not receiving chemotherapy; aOR, 0.76; 95% CI, 0.61-0.94), and were sufficiently physically active (vs insufficiently active; aOR, 0.73; 95% CI, 0.62-0.87; Table 2).

Alcohol Behavior

Daily alcohol use was prevalent among 14.6% of participants (n = 1351) at diagnosis (Fig. 2Ci). An unhealthy alcohol behavior was present in 13.1% of patients at year 1 and in 12.6% of patients at year 2 (Fig.

2Cii). The vast majority of patients did not change their alcohol behavior, although a minority of daily alcohol users at diagnosis reported reductions in use over time, namely 10.4% at year 1 and 7.9% at year 2 (Fig. 2Ciii).

Older age (5-year increment in age; aOR, 1.28; 95% CI, 1.23-1.33), higher depression scores (at risk vs not at risk for depression; aOR, 1.58; 95% CI, 1.14-2.19), higher education (college vs primary school; aOR, 1.85;



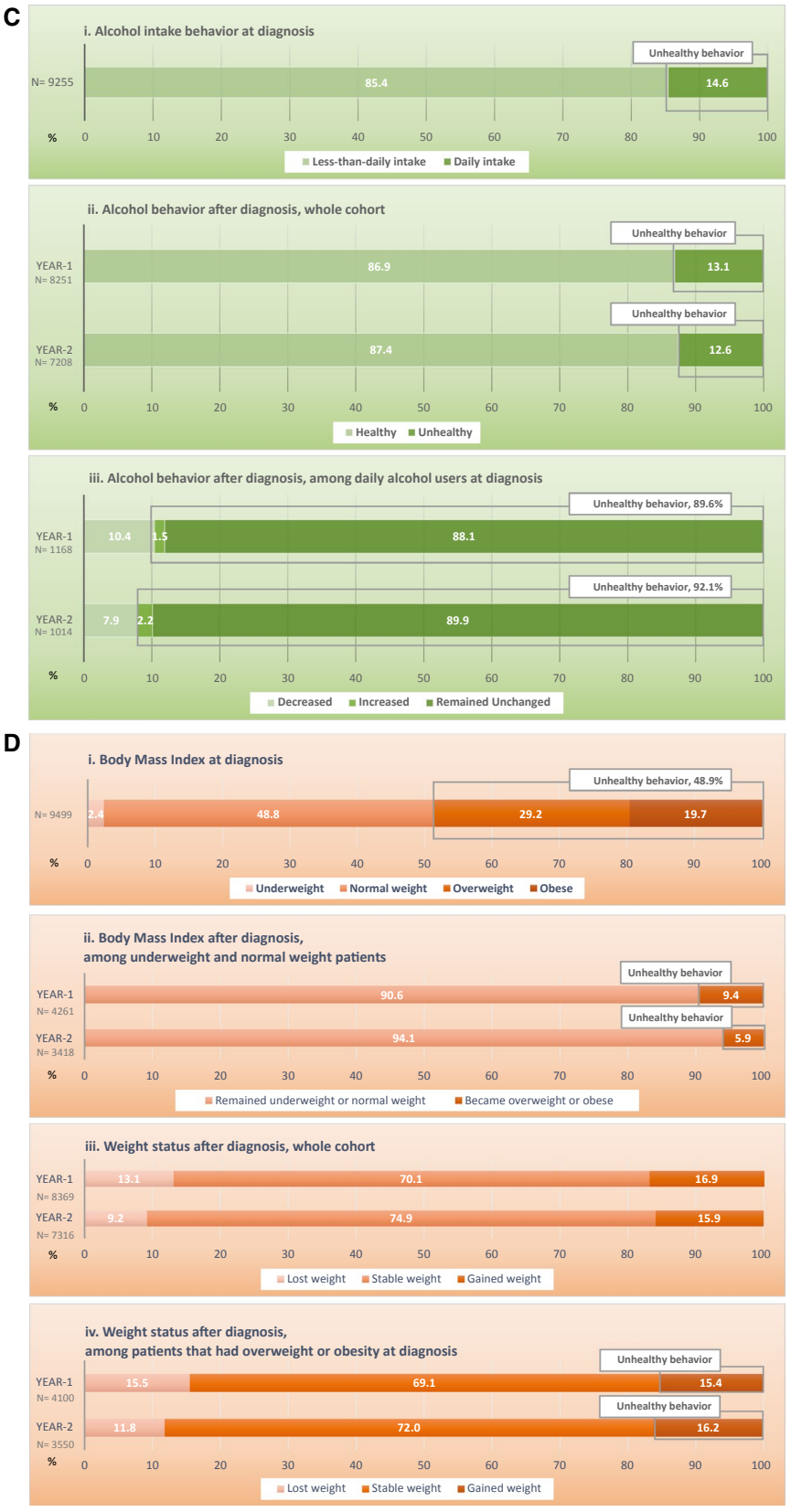

C
i. Alcohol intake behavior at diagnosis
N= 9255
85.4
14.6
Unhealthy behavior
%
0 10 20 30 40 50 60 70 80 90 100
Less-than-daily intake
Daily intake
ii. Alcohol behavior after diagnosis, whole cohort
YEAR-1
N= 8251
86.9
13.1
Unhealthy behavior
YEAR-2
N= 7208
87.4
12.6
Unhealthy behavior
%
0 10 20 30 40 50 60 70 80 90 100
Healthy
Unhealthy
iii. Alcohol behavior after diagnosis, among daily alcohol users at diagnosis
YEAR-1
N= 1168
10.4
1.5
88.1
Unhealthy behavior, 89.6%
YEAR-2
N= 1014
7.9
2.2
89.9
Unhealthy behavior, 92.1%
%
0 10 20 30 40 50 60 70 80 90 100
Decreased
Increased
Remained Unchanged
D
i. Body Mass Index at diagnosis
N= 9499
2.4
48.8
29.2
19.7
Unhealthy behavior, 48.9%
%
0 10 20 30 40 50 60 70 80 90 100
Underweight
Normal weight
Overweight
Obese
ii. Body Mass Index after diagnosis,
among underweight and normal weight patients
YEAR-1
N= 4261
90.6
9.4
Unhealthy behavior
YEAR-2
N= 3418
94.1
5.9
Unhealthy behavior
%
0 10 20 30 40 50 60 70 80 90 100
Remained underweight or normal weight
Became overweight or obese
iii. Weight status after diagnosis, whole cohort
YEAR-1
N= 8369
13.1
70.1
16.9
YEAR-2
N= 7316
9.2
74.9
15.9
%
0 10 20 30 40 50 60 70 80 90 100
Lost weight
Stable weight
Gained weight
iv. Weight status after diagnosis,
among patients that had overweight or obesity at diagnosis
YEAR-1
N= 4100
15.5
69.1
15.4
Unhealthy behavior
YEAR-2
N= 3550
11.8
72.0
16.2
Unhealthy behavior
%
0 10 20 30 40 50 60 70 80 90 100
Lost weight
Stable weight
Gained weight

Figure 2. Lifestyle behaviors at diagnosis and after diagnosis. (A) Physical activity behavior: (A_i) at diagnosis, (A_{ii}) after diagnosis (whole cohort), and (A_{iii}) after diagnosis (patients insufficiently active at diagnosis). At diagnosis, patients were sufficiently active if they reported ≥10 MET hours per week and insufficiently active if they reported <10 MET hours per week. After diagnosis, the categories for changes in activity were as follows: maintained activity (ie, sufficiently active before and after), increased activity (ie, insufficiently active before and sufficiently active after), decreased activity (ie, sufficiently active before and insufficiently active after), and persistently insufficient activity (ie, insufficiently active before and after) in comparison with the previous assessment (ie, year 1 vs the baseline and year 2 vs year 1). (B) Tobacco use behavior: (B_i) behavior at diagnosis, (B_{ii}) behavior after diagnosis (whole cohort), and (B_{iii}) behavior after diagnosis (current tobacco users at diagnosis). After diagnosis, behavior was classified as follows: remained unchanged, increased, or decreased in comparison with the previous assessment (ie, year 1 vs the baseline and year 2 vs year 1). (C) Alcohol intake behavior: (C_i) behavior at diagnosis, (C_{ii}) behavior after diagnosis (whole cohort), and (C_{iii}) (behavior after diagnosis (daily alcohol users at diagnosis). After diagnosis, behavior was classified as remained unchanged, increased, or decreased in comparison with the previous assessment (ie, year 1 vs the baseline and year 2 vs year 1). (D) BMI and weight status: (D_i) BMI at diagnosis, (D_{ii}) BMI after diagnosis (underweight and normal-weight patients), (D_{iii}) weight status after diagnosis (whole cohort), and (D_{iv}) weight status after diagnosis (patients who were overweight or obesity at diagnosis). At diagnosis, patients were defined as underweight (BMI < 18.5 kg/m^2), normal-weight (BMI = 18.5-24.9 kg/m^2), overweight (BMI = 25.0-29.9 kg/m^2), or obese (BMI ≥ 30.0 kg/m^2). At year 1 and year 2 after diagnosis, the categories of weight change were defined as lost weight (≥5%), stable weight (±5%), or gained weight (≥5%) in comparison with the previous assessment. BMI indicates body mass index; MET, metabolic equivalent task.

95% CI, 1.37-2.49), and partnered status (vs not partnered; aOR, 1.34; 95% CI, 1.09-1.64) were significantly associated with an increased risk of unhealthy alcohol behavior. Women with higher BMIs were less likely to have an unhealthy alcohol behavior (1-unit increment; aOR, 0.96; 95% CI, 0.95-0.98; Table 2).

BMI and Weight Status

The proportion of patients who were overweight or obese was 48.9% (n = 4641) at diagnosis (Fig. 2Di), 50.3% (n = 4211) at year 1, and 51.0% (n = 3903) at year 2 (P_{trend} = .005). Among underweight or normal-weight patients, 9.4% and 5.9% transitioned to being overweight or obese at year 1 and year 2, respectively (Fig. 2Dii). In the whole cohort, at year 1 and year 2, 16.9% and 15.9% of patients, respectively, had a weight gain of 5% or more in comparison with the previous assessment (Fig. 2Diii). Similarly, among patients who were overweight or obese at diagnosis, 15.4% had gained weight at year 1 in comparison with their weight at diagnosis, and 16.2% had gained weight at year 2 in comparison with year 1 (Fig. 2Div).

Among underweight and normal-weight patients, higher odds of becoming overweight or obese were found for those who were younger (5-year increment in age; aOR, 0.77; 95% CI, 0.74-0.81), less educated (college vs primary school; aOR, 0.52; 95% CI, 0.32-0.83), and current smokers at diagnosis (vs former/never smokers; aOR, 1.56; 95% CI, 1.19-2.05). Analogously, among patients who were overweight or obese at diagnosis, younger women (5-year increment in age; aOR, 0.90; 95% CI, 0.86-0.95) and those who were current smokers at diagnosis (vs former/never smokers; aOR, 1.43; 95% CI, 1.16-1.75) were significantly more likely to have a weight gain ≥ 5%. Furthermore, among overweight and obese patients, we found a significant association between the receipt of chemotherapy and a weight gain ≥ 5% (vs not receiving chemotherapy ; aOR, 1.51; 95% CI, 1.23-1.87; Table 2).

DISCUSSION

In this large study of women with nonmetastatic breast cancer, the majority were adherent to healthy lifestyle behaviors at the time of diagnosis, but there was a significant subset that was nonadherent. Over the first 2 years after diagnosis, some women improved their unhealthy behaviors. However, if patients had unhealthy behaviors at diagnosis, these were likely to persist, with a complex interplay among multiple risk factors.

Awareness about the importance of pursuing healthy behaviors has recently increased among cancer survivors, and lifestyle recommendations for patients living with and beyond breast cancer now exist.[15,16] However, changing behavior is complex and highly dependent on individual and community resources.[16,17] Our study identifies distinct patterns and risk factors of unhealthy behaviors.

First, despite a general trend showing increasingly higher adherence to recommendations, physical inactivity was still very common after diagnosis, particularly among CANTO women who were already insufficiently active at diagnosis. Inactivity was only slightly less frequent than the estimated prevalence of insufficient PA levels in France, with 35.2% of women overall at year 2 in CANTO and approximately 40% in the general population being nonadherent to PA guidelines according to WHO-Europe data.[18] There was also a relevant proportion of initially physically active patients who reduced their activity after their diagnosis, whereas reductions in sedentary time happened mostly in the early segment of follow-up. Similarly, an analysis from the American Cancer Society Study of Cancer Survivors II found that only 30% to 47% met PA

guidelines and that 31% of patients were completely inactive,[19] whereas the Health, Eating, Activity, and Lifestyle study reported significant downward trends in time spent exercising after a diagnosis of breast carcinoma.[20]

Second, in comparison with data from the general population, which indicate that up to 26.4% of individuals in the United States and 29.9% in France are current tobacco users,[21] the prevalence of current use among women with breast cancer in CANTO was slightly lower (18.2%), and only 1 in 10 women engaged in an unhealthy tobacco use behavior after their diagnosis. In addition, a readiness to pursue smoking reduction was evident in the approximately one-third of patients who reported reduction or cessation. This proportion was smaller than the cessation rates found for smoking-related cancers, including the rates among lung or head and neck cancer survivors (range, 53%-81%), although it was similar to the findings of previous studies of breast cancer survivors.[22,23] Taken together, these data suggest that current tobacco users may be successfully motivated to quit after a breast cancer diagnosis.[5] However, the vast majority (approximately 70%) continue to use tobacco over time. The National Cancer Institute recognizes this issue as a core gap in cancer care and defines smoking treatment as an often neglected element. In this context, efforts by the National Cancer Institute's Cancer Moonshot are underway to make tobacco cessation part of routine care at comprehensive cancer centers.[24]

Third, most of the CANTO patients reported less than daily alcohol intake, with little variation over time during follow-up. These data are consistent with alcohol use in the general French population, in which approximately 1 in 10 individuals has reported daily consumption of alcoholic beverages.[25] Alcohol abstinence rates have ranged from 8% to 16% in other reports of breast cancer survivors but have reached up to 57% in some studies.[5] This substantial variability across studies may derive from the way in which alcohol intake is assessed. From CANTO data, alcohol intake assessment was limited to whether consumption was daily or less frequent, with no information about the number of servings or drink equivalents per day. We must acknowledge that some guidelines for alcohol intake have, up until recently, supported limiting consumption to 1 drink per day or less. The 2015-2020 Dietary Guidelines for Americans recommend that "for adults who choose to drink alcohol, drinking should not exceed moderate intake"; this means up to 1 drink per day for women.[26] In a 2017 report from the French Public Health Authority and the National Cancer Institute of France, it was recommended that alcohol consumers "consume no more than 10 standard drinks per week and no more than two standard drinks per day."[25] Therefore, it is conceivable that CANTO women included in our analysis—and diagnosed with breast cancer from 2012 to 2017—who drank daily but consistently limited their intake to at most 1 to 2 drinks per day were in fact adherent to guidelines existing at that time. Notably, more recent French recommendations suggest avoiding alcohol consumption on a daily basis.[27] Moreover, alcohol intake in CANTO was assessed by nurses, and this may have influenced patients' propensity to overtly declare their drinking behavior.[28]

This analysis also informs about multiple risk factors that are associated with the uptake of these unhealthy lifestyle behaviors after a breast cancer diagnosis. Age, initial BMI, psychological distress, SES, and treatment-related factors were significantly associated with unhealthy lifestyle changes, but the direction of these associations varied by behavior.

The immediate postdiagnosis period and the beginning of treatment are thought to be critical for psychosocial adaptation, including attitudinal and behavioral changes. Maunsell et al[29] previously suggested that women facing a stressful experience such as cancer may adopt healthy behaviors as a strategy to cope with distress. In particular, women with higher levels of anxiety or depression were thought to be more concerned about recurrence or impact on quality of life; therefore, it was postulated that the uptake of healthy behaviors may provide a greater sense of control. This assumption has not been consistently confirmed because psychological distress may not always act as a motivating factor toward a generally healthier lifestyle. For example, Ligibel et al[30] found that women with anxiety were more likely to decrease PA, in contrast to CANTO, where higher anxiety scores were linked to reduced odds of a decline in PA. Here, we also found that higher depression scores at breast cancer diagnosis were associated with increased alcohol intake after diagnosis, and this suggests that the uptake of an unhealthy drinking behavior may serve as a coping mechanism. Finally, theoretical models of behavioral changes highlight powerful determinants of behavior improvements other than cancer-related psychological distress that need to be considered, including stage of readiness, intentions, and self-efficacy to change.[31]

Research assessing living situation and SES as determinants of adverse lifestyle changes after cancer is sparse despite its important clinical implications. Disparities in health determinants that correlate with modifiable behavioral factors may be responsible for variations in disease

outcomes and mediate part of the social inequalities related to breast cancer. There is evidence that women with lower social support in combination with lower SES are at higher risk of adverse health behavior changes and may benefit from interventions.[32] Khadanga et al[33] reported that women with higher SES may have better opportunities and flexibility to modulate their behaviors, whereas a lower degree level and financial discomfort have the potential to negatively influence behavior change. However, CANTO data suggest that, even among women with better SES and familial support, the risk of unhealthy behaviors persists.

Based on the notion that a worse cancer-related prognosis may motivate the adoption of healthier behaviors, an inverse relationship between higher tumor stage and odds of unhealthy behaviors has been proposed.[23] However, evidence from the literature is not compelling, and a higher stage did not represent a significant determinant of behavior uptake in our data. Nevertheless, we found an interesting association between receipt of chemotherapy and improved tobacco use behavior. This may suggest a greater awareness of smoking-related health risks and a willingness to pursue healthier behaviors among women receiving chemotherapy. Along these same lines, we recently reported a similar relationship between the receipt of chemotherapy and a lower risk of nonadherence to adjuvant endocrine treatment.[34] We hypothesize that women who are cognizant that higher disease severity may require more aggressive treatments may also be more receptive and sensitive to the potential impact of positive behavioral changes, including the impact of tobacco use cessation in mitigating treatment-related toxicities.

Although perhaps not a lifestyle behavior per se, weight status represents an important modifiable risk factor that is for the most part dependent on other behaviors such as caloric intake and balance with energy expenditure. Excess body weight was common in our cohort, with almost 1 in 2 women being overweight or obese at diagnosis. These data are in keeping with the prevalence of overweight or obesity in the general population in Europe.[35] In addition, there were nonnegligible proportions of patients who transitioned to the overweight and obese BMI category over time and patients with excess weight at diagnosis who gained additional substantial weight after diagnosis. Among historical cohorts of patients with breast cancer such as those in the Life After Cancer Epidemiology[36] and Women's Healthy Eating and Living studies,[9] weight gain was reported by up to 40% of patients. Limited understanding of the consequences of weight gain was held up as a major contributor to these findings; better understanding might empower patients and physicians to engage in preventive actions.[37] Further studies confirmed that fewer than 1 in 3 survivors at that time reported concern about treatment-associated weight gain before therapy initiation.[38] In the last 10 years, knowledge has improved regarding excess weight, the risk of weight gain after breast cancer, and their link with general and cancer-specific outcomes,[3] including cardiovascular disease, deterioration of physical fitness, poor body image, diminished quality of life, and possibly a higher risk of breast cancer recurrence and poorer survival.[3,39] Several reports have also outlined great distress about unanticipated weight gain, with many women stating that they would want more information about how to prevent or minimize this outcome.[40] The American Society of Clinical Oncology supports prevention of weight gain with lifestyle therapy in any patient with a BMI $\geq$ 25 kg/m^2, even without comorbidities, and it suggests that combining a low-calorie diet, increased PA, and behavioral therapy provides the most successful intervention for weight loss and maintenance. Unfortunately, these aspects are often overlooked in common clinical practice.[41] For example, some breast cancer treatments may trigger metabolic and inflammatory alterations that, along with other lifestyle and behavioral changes, can lead to substantial weight gain after diagnosis.[42] Most pronounced weight gain was previously reported among patients undergoing older chemotherapy regimens (eg, involving the use of cyclophosphamide, methotrexate, and fluorouracil)[37]; however contemporary schemas used in CANTO were significantly associated with weight gain in our analysis, where the chemotherapy backbone was an anthracycline-taxane combination for the overwhelming majority of women.[6] Concomitant use of supportive drugs such as corticosteroids or changes in hormonal and proinflammatory stimuli may also factor in the risk of posttreatment weight gain, as suggested by the associations that we found with younger age and tobacco use; this is also consistent with prior data.[43,44]

Early education and physician emphasis on health-promoting initiatives are at the core of behavioral improvements among cancer survivors.[5,45] To facilitate change, lifestyle interventions should be made readily available throughout the cancer continuum, with an emphasis after the initial stage of diagnosis when patients may be more open to change and more likely to have frequent interactions with health care professionals.[23] In this context, oncologists are optimally positioned to capitalize on cancer as a teachable moment because they can act as a key determinant of change.[5] However, as suggested by Adams

et al,[46] the expectation of relying solely on oncologists is overburdening and unrealistic. Evidence shows that only approximately 20% of oncology care physicians provide assistance with healthy lifestyle behavior change, and patients report wanting their health care providers to advise and refer more to address these healthy lifestyles after a cancer diagnosis.[47] According to previous research, including a survey of the American Society of Clinical Oncology sent to oncology providers, the majority are conscious of being responsible for recommending increased PA, tobacco cessation, alcohol abstinence, and weight management.[47] However, barriers were reported, including a lack of time and content-specific expertise, and a need was cited for dedicated consultation time and specific training to adequately address these behavioral issues.[2,5] Larger cancer centers may have access to more resources and be able to offer better lifestyle programs; however, in our analysis, there was no suggestion of an impact of the size of the CANTO center on behavioral change.

Several strengths of our study include a large representative cohort of a routinely treated clinical population that was cancer-free at the time of the study with repeat assessments and few exclusion criteria for the analysis. We controlled for a number of patient-, context-, and tumor-related factors to reduce bias, and we used a large sample with adequate power. Limitations include the absence of a noncancer control group and some attrition over the course of follow-up. Baseline characteristics were overall homogeneous, although responders to behavior assessments may have been more likely to have healthier lifestyles or may have differed in other ways from nonresponders. However, it is unlikely that our findings are solely explained by a healthy-volunteer effect or by social desirability bias in light of their consistency with previous data.[33] We could not granularly describe alcohol intake behavior because the number of servings per day was not collected. Finally, the investigated behavioral items are forcedly influenced by the cultural and social environment of France, and results could potentially vary if the study were elsewhere conducted.

Healthy behavioral changes have the potential to decrease breast cancer risk and improve prognosis, ameliorate a wide array of health parameters, and modulate treatment-related side effects. We have found that an important subset of women are nonadherent to healthy lifestyle behaviors at the moment of their breast cancer diagnosis. Unfortunately, unhealthy behaviors also seem to tend to persist after diagnosis, and the implementation of behavioral interventions in cancer survivor populations has been limited to date.[2,48,49] Currently, there are no specific standardized strategies to support patients' choices to maintain or initiate healthy behaviors after a cancer diagnosis, and referrals to lifestyle behavior programs are not a usual standard of care. An integrated effort is strongly needed to develop tailored, patient-centered, and easily accessible programs for the promotion of a healthy lifestyle, which have the greatest potential for impact if they are targeted when women are most inclined to change their behaviors after a diagnosis of cancer.

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CONFLICT OF INTEREST DISCLOSURES

Antonio Di Meglio reports honoraria from Thermo Fisher Scientific. Elise Martin reports payments from the Fondation Arc Pour La Recherche Sur Le Cancer. Barbara Pistilli reports consulting/advising for Puma Biotechnology, Novartis, Myriad Genetics, and Pierre Fabre; meeting and/or travel support from Novartis, AstraZeneca, MSD Oncology, and Pfizer; and research funding from Daiichi, Puma Biotechnology, Novartis, Merus, Pfizer, and AstraZeneca. Charles Guenancia reports grants to his institution from Microport CRM, consulting fees from Microport CRM and Boston Scientific, and payments or honoraria from Medtronic. Ines Vaz-Luis reports payments or honoraria from Novartis, Kephren, AstraZeneca, and Amgen. Fabrice Andre reports grants or contracts with Novartis, Pfizer, Astra Zeneca, Eli Lilly, Daiichi, and Roche. The other authors made no disclosures.

AUTHOR CONTRIBUTIONS

Antonio Di Meglio: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing–original draft, and writing–review and editing. **Arnauld S. Gbenou:** Data curation and formal analysis. **Jennifer A. Ligibel:** Conceptualization, supervision, validation, and writing of the draft. **Tracy E. Crane:** Conceptualization, supervision, validation, and writing of the draft. **Ines Vaz-Luis:** Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing–original draft, and writing–review and editing. All the authors made substantial contributions to the interpretation of data, revised the manuscript for important intellectual content, contributed to the writing of the draft, and reviewed and approved the final version.

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