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Grasping the 'teachable moment': time since diagnosis, symptom burden and health behaviors in breast, colorectal and prostate cancer survivors

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Abstract

***Background*: A cancer diagnosis may provide a 'teachable moment' in cancer recovery. To better understand factors influencing lifestyle choices following diagnosis, we examined associations between time since diagnosis and symptom burden with recommended dietary (e.g., five or more fruit/vegetable servings/day), physical activity (e.g., >150 active min, 3–5 times/week), and smoking behaviors (i.e., eliminate tobacco use) in cancer survivors.**

***Methods*: We analyzed cross-sectional survey data collected from breast ($n = 528$), colorectal ($n = 106$), and prostate ($n = 419$) cancer survivors following active treatment at The University of Texas MD Anderson Cancer Center. Four regression models were tested for behaviors of interest. Additionally, we assessed symptom burden as a potential moderator and/or mediator between time since diagnosis and behaviors.**

***Results*: Respondents were mostly female (55%) and non-Hispanic White (68%) with a mean age of 62.8 ± 11.4 years and mean time since diagnosis of 4.6 ± 3.1 years. In regression models, greater time since diagnosis predicted lower fruit and vegetable consumption ($B = -0.05$, $p = 0.02$) and more cigarette smoking ($B = 0.06$, $p = 0.105$). Greater symptom burden was a significant negative predictor for physical activity ($B = -0.08$, $p < .001$). We did not find evidence that symptom burden moderated or mediated the association between time since diagnosis and health behaviors.**

***Conclusion*: We assessed the prevalence of recommended behaviors in the context of other challenges that survivors face, including time since diagnosis and symptom burden. Our results provide indirect evidence that proximity to a cancer diagnosis may provide a teachable moment to improve dietary and smoking behaviors and that symptom burden may impede physical activity following diagnosis.**

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Introduction

Greater than 14 million Americans have survived cancer, and nearly 65% live ≥5 years beyond their initial diagnosis [1]. The longevity of cancer survivors has stimulated research targeting tertiary prevention, including energy balance [2] and tobacco control [3]. As part of survivorship care, it is recommended that survivors consume five or more fruit/vegetable servings per day; achieve at least 150 min of moderate-intensity to vigorous-intensity physical activity per week and bi-weekly strength training sessions, and that all survivors eliminate use of tobacco products, including cigarettes [4,5]. Improving lifestyle behaviors affords survivors a range of possible benefits, including reducing recurrence risk, mitigating comorbidities, managing symptoms and improving quality of life [6,7].

Surveillance data show that many survivors are not meeting recommendations for a healthy diet/weight, adequate physical activity (PA), and smoking cessation [8]. It has been suggested that cancer-related events may provide 'teachable moments' for behavior change in survivors [9]. The teachable moment concept has been applied to survivorship questions, positing that health events (e.g., cancer diagnosis) may 'cue' survivors to perform healthy behaviors [10], as suggested by the Health Belief Model [11]. Applying the teachable moment logic, it can be hypothesized that survivors closest to diagnosis would make healthier choices than longer-term survivors. However, optimal timing of behavioral interventions in the cancer continuum is not well understood [12]. To better understand the utility of teachable moments, a broader consideration of factors is required.

One major challenge for cancer survivors is symptoms, such as fatigue, pain, physical limitations, and health-related quality of life issues (HRQOL) [13,14], which may impact the ability of survivors to adhere to lifestyle

behaviors promoting long-term recovery. However, there is evidence that symptoms may change, becoming either better or worse over time [15]. Describing symptom burden relative to time since diagnosis may contextualize opportunities for lifestyle interventions at multiple stages of recovery. This may, in turn, bring us closer to understanding when teachable moments for cancer survivors may occur [16].

Using cross-sectional data, we explored the association between time since diagnosis, symptom burden, and health behaviors (i.e., dietary habits, PA, and smoking) in cancer survivors treated at The University of Texas MD Anderson Cancer Center (MDACC). The specific aims were as follows: (1) characterize cancer survivors' health behaviors relative to time since diagnosis and symptom burden; (2) test whether symptom burden moderates the association between time since diagnosis and behaviors; and (3) test whether symptom burden mediates the association between time since diagnosis and health behaviors.

Methods

We analyzed cross-sectional survey data collected in 2010 to inform the development of lifestyle interventions for cancer survivors. The survey assessed dietary habits, PA, cigarette smoking, and interest in behavioral intervention participation. All eligible survivors had loco-regional breast cancer, colorectal cancer or prostate cancer and were identified using MDACC tumor registry and departmental databases. These cancer sites were selected because they represent three of the largest survivor groups and are at increased risk for late effects of cancer and cancer treatment that may benefit from lifestyle interventions [17–19]. The survey was mailed to 1917 survivors who completed primary treatment at MDACC. Participants were selected according to the following criteria: cancer site (breast, colorectal, or prostate), gender, ethnicity, and time from diagnosis (i.e., 0–6 months post-diagnosis, 6–12 months post-diagnosis, 1–5 years post-diagnosis, and 5+ years post-diagnosis). Participants with more time since diagnosis were oversampled in anticipation of low response from this group. All participants completed treatment at MDACC within the past 20 years. Of the 1917 patients that were identified, 37 had incorrect addresses and nine were deceased, leaving a possible sample of 1871 patients.

All consenting participants also met the following criteria: (1) ≥18 years old; (2) able to read and speak English; (3) ≥3 months post-surgery (if required); (4) no history of other cancers (with the exception of non-melanoma skin cancer); (5) no metastatic disease at recruitment; and (6) permanent residents of Harris County and adjacent counties in Southeast Texas. This protocol was reviewed and approved by the Institutional Review Board (IRB) at MDACC. An additional IRB exemption was provided by the University of Texas Health Science Center at Houston.

Measures

Dietary habits were assessed using the National Cancer Institute Multifactor screener [20] that asks questions on nutritional intake of 16 food types, including frequency and servings of fruits, vegetables, fat, and fiber, consumed in the past 30 days. Daily servings of fruits and vegetables (excluding French fries) were used to assess fruit and vegetable (FV) consumption. Percent energy from fat was derived using published scoring algorithms (http://appliedresearch.cancer.gov/surveys/nhis/multifactor/scoring.html). Only aerobic PA behavior was measured using a three-item modified version of the Godin PA Questionnaire [21], which examines frequency and time spent in mild, moderate, and vigorous exercise. We used total minutes spent in moderate-intensity to vigorous-intensity physical activity (MVPA) per week in regression models. Smoking was determined by asking participants, 'How many cigarettes have you smoked in the last 7 days?' [22], calculated descriptively as mean cigarettes smoked per day and as total cigarettes in 7 days in regression models.

Symptom severity and interference were measured using the MD Anderson Symptom Inventory (MDASI), a validated, patient-reported outcome instrument developed specifically for use with cancer populations [23]. MDASI includes 13 items that measure the severity of commonly reported symptoms, such as pain, fatigue, appetite changes, sleep disturbances, and feelings of sadness or distress. Patients reported symptom severity at its worst in the last 24 h on a scale of 0 ('not present') to 10 ('as bad as you can imagine'). A composite score for patient assessment of severity was obtained by calculating the mean of these 13 items. If fewer items were reported, a mean was calculated based on the answers provided. The six symptom interference items are general activity, mood, work, relations with others, walking, and enjoyment of life. Interference is rated from 0 ('did not interfere') to 10 ('interfered completely'). The mean of these items can be used to represent overall symptom interference.

The MDASI developers conceptualized the construct of symptom burden as a combination of severity and interference [24]. To obtain an overall symptom burden score, a mean score from 19 items was calculated using previously described procedures. Other patient characteristics were reported via the survey or MDACC databases.

Analysis

All analyses were conducted using IBM SPSS (v21) and MPlus (v7.11) software. Descriptive statistics were used to summarize the study population by demographic and

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clinical characteristics. Standard quality and regression diagnostic procedures were followed, including assessment of linearity, normality, and homoscedasticity assumptions. Additionally, a correlation matrix was used to evaluate associations between independent variables of interest. Because the sample included large numbers of breast cancer and prostate cancer survivors, near perfect collinearity was observed between gender and cancer site variables ($r = 0.98$, $p < 0.001$). The cancer site variable was subsequently removed from the models but was evaluated descriptively and in bivariate analysis. Because race/ethnicity, education, and marital status had multiple categories, preliminary comparison was conducted with analysis of variance testing. Non-significant differences between categories supported the creation of dichotomous variables for several predictors (non-white versus white, married/stable union versus single, and college educated versus not).

Missing value analysis was conducted in SPSS. Cross-tabulations of categorical and indicator variables (e.g., demographic predictors and research variables) revealed that <5% of data were missing. However, a substantially larger proportion of data were missing for MVPA (9%) and cigarettes smoked (31%). Based on a significant result ($p = 0.045$) from Little's test for multivariable data [25], it was determined that data for these two variables were not missing completely at random. Because of large numbers of zero values and observed overdispersion, a zero-inflated negative binomial regression method was selected for these two outcomes [26].

Four separate models with four continuous response variables were created for percent energy from fat, FV intake, MVPA, and cigarette smoking. Model testing used $p < 0.05$ as the threshold to evaluate statistical significance. Covariates included time since diagnosis (reported in years) and symptom burden as well as statistically significant demographic variables (e.g., age, marital status, education, and ethnicity) and BMI. Because percent energy from fat and FV consumption met the assumptions for linear regression, a hierarchical linear regression procedure was followed for these two response variables, in which control variables were entered in the first block, followed by time since diagnosis and symptom burden in the second block. A third block tested the addition of the interaction term for time since diagnosis and symptom burden. Scores for time since diagnosis and symptom burden were centered by subtracting the sample mean from scores on each predictor.

For PA and smoking outcomes, two models were created using zero-inflated negative binomial regression, with full-information maximum likelihood estimation to address missing data issues. Additionally, to understand the potential role of symptom burden as a moderator between time since diagnosis and behaviors, time since diagnosis and symptom burden was added as an interaction term and included in the third block of testing for these two models.

Finally, symptom burden was tested for possible mediation between time since diagnosis and behaviors. The product of the coefficients method was used to estimate the mediated effect [27]. Statistical significance was tested using bootstrapped confidence intervals, which have been shown to have increased power over other methods [28].

Results

A total of 1053/1871 breast cancer ($n = 528$), colorectal cancer ($n = 106$), and prostate cancer ($n = 419$) survivors responded to the survey (response rate = 56%) (Table 1). Based on registry data, participant race/ethnicity was identified as white (68%), African American (12%), Hispanic (19%), or other racial/ethnic groups (2%). The mean age of participants was 62.8 ± 11.4 years. The mean reported time since primary cancer diagnosis was 4.6 ± 3.1 years, with approximately 54% of survivors reporting <5 years since diagnosis and 46% reporting ≥5 years since diagnosis with similar distributions of time since diagnosis for participants when stratified by cancer site (Table 1). Additional information about categories of time since diagnosis and comparability to recommended health behaviors among all survivors is presented in Table 2.

When comparing health status and behaviors by disease site, breast cancer survivors reported the fewest minutes of MVPA (108 min/week), and prostate cancer survivors reported the greatest minutes of MVPA (125 min/week), although all survivors reported less than the recommended 150 min of MVPA/week. Excess weight was a common issue, 772 (64%) survivors reporting BMI levels considered overweight or obese. Dietary habits appeared similar across all three cancer groups, with all reporting approximately 5 mean daily FV servings (the minimum recommended amount) and similar levels of energy consumed from fat (33%) over 30 days. Overall, participants reported low symptom scores (mean: 1.38/10). However, there was some site-specific variation on this factor. Breast cancer survivors reported the highest symptom burden score of 1.7 ± 1.98, whereas prostate cancer survivors reported the lowest score of 0.94 ± 1.39.

For dietary habits (percent energy from fat and FV consumption) (Table 3), both models explained 3% of shared variance but had several significant individual predictors. For example, higher BMI was negatively associated with FV intake, women consumed more FV than men, and college-educated survivors were more likely to report higher FV consumption than others. Time since diagnosis had a significant negative association with FV consumption, indicating that survivors who were further from diagnosis consumed fewer FV servings than those who were more proximal to diagnosis. Higher BMI was positively associated with percent energy from fat, with men consuming more energy from fat than women. Time since diagnosis was not significant for percent energy from fat,

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Table 1. Participant characteristics[a]

Variables	Overall ($n = 1053$)	Breast ($n = 528$)	Colorectal ($n = 106$)	Prostate ($n = 419$)
Mean age in years (sd); range	62.8 (11.4); 27–94	58.92 (11.62); 27–94	65.24 (12.49); 29–94	67.11 (8.83); 44–90
Gender (% female)	55.3	100	50.9	0
Race/ethnicity				
White	715 (67.9%)	338 (64%)	83 (78.3%)	294 (70.2%)
African American	124 (11.8%)	63 (11.9%)	9 (8.5%)	52 (12.4%)
Hispanic	196 (18.6%)	116 (22%)	13 (12.3%)	67 (16%)
Other	18 (1.7%)	11 (2.1%)	1 (.9%)	6 (1.4%)
Education				
<High school	76 (7.6%)	34 (6.4%)	12 (11.8%)	30 (70.6%)
High school graduate	147 (14.6%)	90 (17.8%)	14 (13.7%)	43 (10.8%)
Some college/vocational school	241 (24%)	141 (27.9%)	26 (25.5%)	74 (18.6%)
College/post graduate	540 (53.8%)	240 (47.5%)	50 (49%)	250 (63%)
Marital status				
Single	69 (6.8%)	46 (9%)	8 (7.8%)	15 (3.7%)
Married/stable union	752 (73.6%)	337 (65.7%)	68 (66%)	347 (85.5%)
Separated or divorced	101 (9.9%)	70 (13.6%)	12 (11.7%)	19 (4.7%)
Widowed	100 (9.8%)	60 (11.7%)	15 (14.6%)	25 (6.2%)
Physical activity (min/week)				
Vigorous	43.8 (122.8)	41 (145.9)	30.6 (57)	49.8 (102.77)
Moderate	73.09 (127.5)	67.4 (111.7)	85.3 (198.9)	74.95 (120.9)
Mild	98.3 (330.4)	77.5 (173.88)	83.17 (285.4)	129.28 (467)
Dietary habits				
Fruits and vegetables (mean daily servings)	5.22 (2.18)	4.99 (2.18)	4.56 (1.7)	5.2 (2.07)
Percent energy from fat	33.5 (4.67)	33.25 (5.39)	33.73 (3.7)	33.79 (3.84)
Smoking				
Mean daily cigarettes smoked in last 7 days (sd)	6.81 (28.4)	5.69 (22.9)	6.9 (34.5)	8.3 (33.04)
Smoked cigarettes in last 7 days	78 (7.4%)	45 (8.5%)	5 (5%)	28 (6.7%)
BMI				
Underweight or normal (<24.9)	334 (33%)	211 (40%)	28 (26.4%)	95 (22.7%)
Overweight (25–29.9)	395 (39.3%)	189 (35.7%)	49 (46.2%)	205 (49%)
Obese (>30)	277 (27.5%)	128 (24%)	29 (27.3%)	119 (28.4%)
Time from diagnosis (in years)				
Mean (sd); range	4.6 (3.08); 0.5–20	4.5 (3.05); 0.46–10.19	4.88 (3.19); 0.46–20.12	4.57 (3.08); 0.46–10.27
0 ≤ 1 year	168 (16%)	96 (18%)	8 (8%)	64 (15.3%)
1 year–< 3 years	245 (23.3%)	113 (21.4%)	25 (24%)	107 (25.5%)
3 years–< 5 years	152 (14.4%)	70 (13.2%)	27 (25.5%)	55 (13.1%)
5 years or more	488 (46.3%)	249 (47%)	46 (43.3%)	193 (46%)
Symptom burden				
Mean (sd); range	1.38 (1.78); 0–10	1.69 (1.98); 0–10	1.5 (1.76); 0–8.6	0.95 (1.39); 0–9

sd, standard deviation.

[a]Table descriptors use *n* (%) reported for categorical and mean (standard deviation) for continuous variables.

and symptom burden was not significant for either response variable.

Taking advantage of the two-part, zero-inflated model structure for MVPA and smoking outcomes, we simultaneously assessed the probability of zero values for each behavior (using logistic regression) and the estimated amount of behavior (using count regression) within each model. The estimates for both logistic and count portions of the models are reported in raw and exponentiated betas for ease of interpretation (Table 4). For the logistic portion of PA, older age, female gender, greater BMI, and greater symptom burden significantly predicted zero PA among survivors. For the count portion of the model, PA was significantly associated with gender, BMI, and symptom burden. Notably, PA reported in 7 days was 19% higher in women than men, adjusting for excess zeroes and all other covariates in the model. We also observed that for each one-unit increase in BMI, PA decreased by 2% and for each one-unit increase in symptom burden, PA decreased by 7%.

Zero values for cigarettes smoked also had several significant predictors, including older age, female gender, and non-white ethnicity (Table 4). We also observed that college-educated survivors were three times more likely to report zero smoking in the past 7 days than non-college educated survivors. In addition, survivors who were closer to diagnosis ($B = -0.09$, $p = 0.02$) and those with higher symptom burden ($B = -0.17$, $p = 0.01$) were significantly less likely to report smoking zero cigarettes in the past 7 days. Similarly, a one-point increase in BMI was associated with a 4% increase in the number of cigarettes smoked, adjusting for other variables in the model.

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Table 2. Percent of survivors meeting health behavior recommendations[a] by time since diagnosis

Health behavior	0–12 months (%) (*n* = 159)	>12 months – 5 years (%) (*n* = 370)	>5 years (%) (*n* = 471)
Physical activity (% achieving ≥150 MVPA per week)	23.5	34.9	29.3
Energy from fat (consumed <35% of calories from fat)	64.5	70.8	70.9
Fruit and vegetable consumption (more than or equal to five daily servings)	51	51	41.7
Reported not smoking in past 7 days	96	89.5	88.9

MVPA, moderate-intensity to vigorous-intensity physical activity.
[a]Based on the National Comprehensive Cancer Network Guidelines for Survivorship.

Table 3. Results from linear regression models for dietary habits

Variables	B	SE	*p*-value
Percent energy from fat (in 30 days)			
BMI	0.076	0.028	0.007
Gender (female/male)	0.78	0.313	0.013
Education (college/no college)	−0.467	0.317	0.141
Marital status (yes/no)	−0.459	0.356	0.197
Time since diagnosis (years)	0.027	0.048	0.584
Symptom burden	0.12	0.09	0.183
R = 0.18			
R-sq = 0.033			
R-sq change = 0.002[a]			
Daily servings of fruits and vegetables (except French fries)			
Age (years)	−0.011	0.006	0.094
BMI	−0.034	0.012	0.006
Gender (female/male)	0.345	0.15	0.018
Education (college/no college)	0.296	0.14	0.035
Non-white (yes/no)	0.23	0.15	0.115
Time since diagnosis (years)	−0.053	0.02	0.017
Symptom burden	0.018	0.04	0.655
R = 0.168			
R-sq = 0.028[b]			

SE, standard error.
[a]Change when time since diagnosis and symptom burden added to the model.
[b]No change when time since diagnosis and symptom burden added to the model.

Comparing groups of survivors, women reported almost twice as much smoking as men. The amount of cigarettes smoked in 7 days was 55% less in non-white survivors compared with white survivors. In the count portion of the model, which reflected adjustments for excess zeroes, the estimate for time since diagnosis and amount of cigarettes smoked was positive but approached significance (B = 0.06, $p = 0.105$).

Although time since diagnosis was negatively correlated with symptom burden ($r = -0.04$), we did not find evidence that symptom burden moderated or mediated the association between time since diagnosis and health behaviors.

Table 4. Zero-inflated models for moderate-intensity to vigorous-intensity physical activity and cigarette smoking

Total MVPA (in last 7 days)

Logistic portion of the model

Variable	B	SE B	*p*-value	OR	CI (95%)
Age (years)	0.05	0.008	<0.001	1.05	(0.034, 0.064)
College (yes/no)	−0.41	0.152	0.008	0.667	(−0.703,−0.108)
Gender (female/male)	−0.36	0.162	0.027	0.698	(−0.678,−0.041)
BMI	0.05	0.014	<0.001	1.052	(0.024, 0.078)
Marital status (yes/no)	−0.21	0.169	0.221	0.813	(−0.539, 0.125)
Time since diagnosis (years)	−0.04	0.02	0.071	0.958	(−0.090, 0.004)
Symptom burden	0.136	0.04	0.002	1.146	(0.05, 0.222)

Count portion of the model

Variable	B	SE B	*p*-value	IRR	CI (95%)
Age (years)	−0.004	0.003	0.144	0.996	(−0.010, 0.001)
Gender (female/male)	0.18	0.07	0.006	1.19	(0.050, 0.304)
BMI	−0.02	0.007	0.006	0.98	(−0.033,−0.006)
Time since diagnosis (years)	−0.008	0.01	0.395	0.99	(−0.028, 0.011)
Symptom burden	−0.08	0.02	<.001	0.93	(−0.121,−0.034)

Cigarette smoking (in last 7 days)

Logistic portion of the model

Variable	B	SE B	*p*-value	OR	CI (95%)
Age (years)	0.04	0.01	<0.001	1.04	(0.03, 0.06)
College (yes/no)	1.14	0.29	<0.001	3.11	(0.57, 1.7)
Gender (female/male)	−0.7	0.31	0.023	1.04	(−1.3,−0.09)
Non-white (yes/no)	0.71	0.29	0.016	1.06	(0.13, 1.3)
Marital status (yes/no)	0.40	0.28	0.179	1.49	(−0.18, 0.99)
Time since diagnosis (years)	−0.09	0.04	0.021	0.91	(−0.17,−0.014)
Symptom burden	−0.17	0.07	0.011	0.84	(−0.31,−0.04)

Count portion of the model

Variable	B	SE B	*p*-value	IRR	CI (95%)
Non-white (yes/no)	−0.79	0.25	0.002	0.454	(−1.28,−0.3)
Gender (female/male)	0.65	0.20	0.001	1.908	(0.25, 1.04)
BMI	0.04	0.01	0.007	1.036	(0.01, 0.06)
Time since diagnosis (years)	0.06	0.04	0.105	1.06	(−0.01, 0.13)
Symptom burden	−0.04	0.04	0.322	0.96	(−0.12, 0.04)

MVPA, moderate-intensity to vigorous-intensity physical activity; SE, standard error; OR, odds ratio; IRR, incidence rate ratio.

Discussion

Our finding that survivors closer to diagnosis had higher FV intake and smoked fewer cigarettes than long-term survivors is consistent with the view that diagnosis provides a teachable moment for these behaviors, a theme that has been identified in previous studies. In a study of 7903 survivors, >40% of participants reported making positive dietary changes following diagnosis [18]. Two smaller studies found similar changes to FV consumption in newly diagnosed breast cancer survivors [29] and longer-term survivors of several cancer types [30]. Other researchers have found similar links between smoking cessation and cancer-related events, including diagnosis [31]. However, two studies using National Health Interview Survey data found that health behaviors (especially related to diet and exercise) in survivors were largely similar to healthy controls when controlling for other factors, suggesting that lifestyle changes made post-diagnosis, while feasible, may

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not predict sustainability [32,33]. Studies on trajectories of psychosocial distress in survivors indicate that distress post-diagnosis may be highly variable but still valuable in finding and framing opportunities for physical activity and other necessary health interventions [34,35].

Our most notable result for symptom burden was its negative association with PA, suggesting that symptom burden impeded an active lifestyle. This is consistent with other PA studies, particularly for breast cancer and prostate cancer survivors [36]. The presence of age-related symptoms (e.g., bone or muscle loss) has a negative association with PA [37], a relevant consideration for older survivors. Although more research is needed to understand how PA can be targeted to ameliorate cancer-related symptoms, a meta-analysis of 40 trials found substantial evidence favoring PA interventions to address HRQOL outcomes in cancer survivors and older populations [38].

For breast cancer, colorectal cancer, and prostate cancer survivors, there is mounting evidence that supports positive outcomes related to diet and PA; the most important of which is healthy weight management [39]. Excess weight is associated with diminished survival outcomes in breast cancer survivors [40], but may also be important for prostate cancer, colon cancer, and other survivor groups [41]. Because 64% of our participants reported excess weight (BMI $>$ 25), our findings support the need for ongoing weight management in survivorship. An energy balance approach, incorporating both diet and PA, may be more effective in producing weight loss than targeting diet or PA alone [42,43]. Recent reviews of physical activity behavior interventions in survivors emphasize that program effectiveness is related to appropriate support and use of behavior change strategies, in accordance with the needs and preferences of survivors in adopting lifestyle changes [44–46].

This large study was strong in several ways. It offered important insights on health behaviors for the growing population of cancer survivors, especially post-treatment. Assessing multiple behaviors across disease sites and ethnic groups also provided a broader perspective on lifestyle choices in survivors. Studying time since diagnosis and symptom burden also helped contextualize these factors in the recovery process, enhancing knowledge about potentially teachable moments for behaviors. Additionally, the large sample size permitted use of advanced statistical methods not frequently used in survivorship studies. In particular, our use of the zero-inflated models permitted a deeper understanding of zero values in assessing MVPA and smoking [47]. Furthermore, maximum likelihood methods to estimate missing values strengthened our estimates over other types of missing data procedures.

A limitation of this study is its cross-sectional design because it does not provide information about changes over time. A longitudinal study with additional objective measures would be valuable to further investigate the role of time since diagnosis in long-term recovery and accuracy/consistency of behavioral trends. Additionally, most behavior measures were assessed by self-report. These measures did not include an assessment of resistance training frequency, although this could be beneficial in future studies. Additionally, it is possible that survivors closer to diagnosis had more interactions with healthcare providers or support resources at MDACC, which potentially influenced health behaviors after treatment, but almost half of survivors were 5 years or more beyond diagnosis, diminishing this potential influence. There was a break between time of initial data collection and submission of this paper, although we believe these results are still timely and relevant to current survivors. Although symptom burden was measured using a validated instrument, the low scores suggest that further study of symptom measures may be useful in differentiating site-specific symptom experiences. Also, MDASI was validated primarily with cancer patients undergoing active treatment and thus may not be as sensitive to the symptom experience of survivors that are further along in recovery. However, the significant negative association between symptom burden and PA is an important finding and may support the need for research on the role of symptom burden and PA.

Conclusion

This study sought to understand prevalence of multiple behaviors in the context of other challenges that survivors face. Our results provide indirect but pertinent evidence that cancer diagnosis may provide a teachable moment to influence health behaviors, especially those related to dietary habits and smoking. However, optimal timing of interventions based on the intersection of time since diagnosis, symptom burden, and behaviors requires further exploration, especially to better understand how to sustain positive lifestyle changes following diagnosis. Additionally, the role of symptom burden may be especially relevant for future PA research.

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References

1. Siegel R, Naishadham D, Jemal A. Cancer statistics. *CA Cancer J Clin* 2013;**63**:11–30.
2. Ballard-Barbash R, Siddiqi SM, Berrigan DA, Ross SA, Nebeling LC, Dowling EC. Trends in research on energy balance supported by the National Cancer Institute. *Am J Prev Med* 2013;**44**:416–423.
3. Jemal A, Thun MJ, Ries LAG, *et al*. Annual report to the nation on the status of cancer, 1975–2005, featuring trends in lung cancer, tobacco use, and tobacco control. *J Natl Cancer Inst* 2008;**100**:1672–1694.
4. Rock CL, Doyle C, Demark-Wahnefried W, *et al*. Nutrition and physical activity guidelines for cancer survivors. 2012.
5. Campo RA, Rowland JH, Irwin ML, Nathan PC, Gritz ER, Kinney AY. Cancer prevention after cancer: changing the paradigm – a report from the American society of preventive oncology. *Cancer Epidemiol Biomarkers Prev* 2011;**20**:2317–2324.
6. Hewitt M, Greenfield S, Stovall E. From Cancer Patient to Cancer Survivor: Lost in Transition. National Academies Press: Washington, DC, 2005.
7. Sabiston CM, Brunet J. Reviewing the benefits of physical activity during cancer survivorship. *Am J Lifestyle Med* 2012;**6**:167–177.
8. Underwood JM, Townsend JS, Stewart SL, *et al.* Surveillance of demographic characteristics and health behaviors among adult cancer survivors: behavioral risk factor surveillance system, United States, 2009. US Department of Health and Human Services, Centers for Disease Control and Prevention, 2012.
9. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *J Clin Oncol* 2005;**23**:5814–5830.
10. Mcbride CM, Clipp E, Peterson BL, Lipkus IM, Demark-Wahnefried W. Psychological impact of diagnosis and risk reduction among cancer survivors. *Psycho-Oncology* 2000;**9**:418–427.
11. Rosenstock IM. The health belief model and preventive health behavior. *Health Educ Behav* 1974;**2**:354–386.
12. Williams K, Steptoe A, Wardle J. Is a cancer diagnosis a trigger for health behaviour change? Findings from a prospective, population-based study. *Br J Cancer* 2013; **108**(11):2407–2412.
13. Bellury L, Pett MA, Ellington L, Beck SL, Clark JC, Stein KD. The effect of aging and cancer on the symptom experience and physical function of elderly breast cancer survivors. *Cancer* 2012;**118**:6171–6178.
14. Basen-Engquist K, Hughes D, Perkins H, Shinn E, Taylor CC. Dimensions of physical activity and their relationship to physical and emotional symptoms in breast cancer survivors. *J Cancer Surviv* 2008;**2**:253–261.
15. Trudel-Fitzgerald C, Savard J, Ivers H. Evolution of cancer-related symptoms over an 18-month period. *J Pain Symptom Manage* 2013;**45**:1007–1018.
16. Rabin C. Promoting lifestyle change among cancer survivors: when is the teachable moment? *American Journal of Lifestyle Medicine* September/October 2009;**3**:369–378.
17. Ganz PA. Late effects of cancer and its treatment. *Semin Oncol Nurs* 2001;**17**:241–248.
18. Hawkins NA, Smith T, Zhao L, Rodriguez J, Berkowitz Z, Stein KD. Health-related behavior change after cancer: results of the American Cancer Society's studies of cancer survivors (SCS). *J Cancer Survivorship* 2010;**4**:20–32.
19. Carmack CL, Basen-Engquist K, Gritz ER. Survivors at higher risk for adverse late outcomes due to psychosocial and behavioral risk factors. *Cancer Epidemiol Biomarkers Prev* 2011;**20**:2068–2077.
20. Thompson FE, Midthune D, Subar AF, Kahle LL, Schatzkin A, Kipnis V. Performance of a short tool to assess dietary intakes of fruits and vegetables, percentage energy from fat and fibre. *Public Health Nutr-Cab International* 2004;**7**:1097–1106.
21. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci* 1985;**10**:141.
22. Wong SL, Shields M, Leatherdale S, Malaison E, Hammond D. Assessment of validity of self-reported smoking status. 2012.
23. Cleeland CS, Mendoza TR, Wang XS, *et al.* Assessing symptom distress in cancer patients: the M.D. Anderson Symptom Inventory. *Cancer* 2000;**89**:1634–1646.
24. Cleeland CS. Symptom burden: multiple symptoms and their impact as patient-reported outcomes. 2007; 2007: 16–21.
25. Little RJ. A test of missing completely at random for multivariate data with missing values. *J Am Stat Assoc* 1988;**83**:1198–1202.
26. Slymen DJ, Ayala GX, Arredondo EM, Elder JP. A demonstration of modeling count data with an application to physical activity. *Epidemiol Perspect Innov* 2006;**3**:3.
27. MacKinnon DP, Lockwood CM, Hoffman JM, West SG, Sheets V. A comparison of methods to test mediation and other intervening variable effects. *Psychol Methods* 2002;**7**:83.
28. Fritz MS, Mackinnon DP. Required sample size to detect the mediated effect. *Psychol Sci* 2007;**18**:233–239.
29. Maunsell E, Drolet M, Brisson J, Robert J, Deschenes L. Dietary change after breast cancer: extent, predictors, and relation with psychological distress. *J Clin Oncol* 2002; **20**:1017–1025.
30. Alfano CM, Day JM, Katz ML, *et al.* Exercise and dietary change after diagnosis and cancer-related symptoms in long-term survivors of breast cancer: CALGB 79804. *Psycho-Oncology* 2009;**18**:128–133.
31. Gritz ER, Fingeret MC, Vidrine DJ, Lazev AB, Mehta NV, Reece GP. Successes and failures of the teachable moment. *Cancer* 2006;**106**:17–27.
32. Coups EJ, Ostroff JS. A population-based estimate of the prevalence of behavioral risk factors among adult cancer survivors and noncancer controls. *Prev Med* 2005;**40**:702–711.
33. Bellizzi KM, Rowland JH, Jeffery DD, McNeel T. Health behaviors of cancer survivors: examining opportunities for cancer control intervention. *J Clin Oncol* 2005;**23**:8884–8893.
34. Chambers SK, Lynch BM, Aitken J, Baade P. Relationship over time between psychological distress and physical activity in colorectal cancer survivors. *J Clin Oncol* 2009; **27**:1600–1606.
35. Dunn J, Ng SK, Holland J, *et al.* Trajectories of psychological distress after colorectal cancer. *Psycho-Oncology* 2013;**22**:1759–1765.
36. Ottenbacher A, Sloane R, Snyder DC, Kraus W, Sprod L, Demark-Wahnefried W. Cancer-specific concerns and physical activity among recently diagnosed breast and prostate cancer survivors. *Integr Cancer Ther* 2013; **12**:206–212.
37. Courneya KS, Vallance JKH, McNeely ML, Karvinen KH, Peddle CJ, Mackey JR. Exercise issues in older cancer survivors. *Crit Rev Oncol* 2004;**51**:249–261.
38. Mishra S, Scherer R, Geigle P, *et al.* Exercise interventions on health-related quality of life for cancer survivors (Review) 2012.
39. Davies NJ, Batehup L, Thomas R. The role of diet and physical activity in breast, colorectal, and prostate cancer survivorship: a review of the literature. *Br J Cancer* 2011;**105**: S52–S73.
40. Protani M, Coory M, Martin JH. Effect of obesity on survival of women with breast cancer: systematic review and meta-analysis. *Breast Cancer Res Treat* 2010;**123**:627–635.
41. Ligibel J. Lifestyle factors in cancer survivorship. *J Clin Oncol* 2012;**30**(30):3697–3704.
42. Jones LW, Alfano CM. Exercise-oncology research: past, present, and future. *Acta Oncol* 2013;**52**:195–215.
43. Demark-Wahnefried W, Morey MC, Sloane R, *et al.* Reach out to enhance wellness home-based diet-exercise intervention promotes reproducible and sustainable long-term improvements in health behaviors, body weight, and physical functioning in older, overweight/obese cancer survivors. *J Clin Oncol* 2012;**30**:2354–2361.
44. Spark LC, Reeves MM, Fjeldsoe BS, Eakin EG. Physical activity and/or dietary interventions in breast cancer survivors: a systematic review of the maintenance of outcomes. *J Cancer Surviv* 2013;**7**:74–82.
45. Husebø A, Lunde M, Dyrstad SM, Søreide JA, Bru E. Predicting exercise adherence in cancer patients and survivors: a systematic

review and meta-analysis of motivational and behavioural factors. *J Clin Nurs* 2013;**22**: 4–21.
46. Bluethmann SM, Vernon SW, Gabriel KP, Murphy CC, Bartholomew LK. Taking the next step: a systematic review and meta-analysis of physical activity and behavior change interventions in recent post-treatment breast cancer survivors. *Breast Cancer Res Treat* 2015;1–12.
47. Atkins DC, Gallop RJ. Rethinking how family researchers model infrequent outcomes: a tutorial on count regression and zero-inflated models. *J Fam Psychol* 2007; **21**:726.

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