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Sedentary behavior after breast cancer: motivational, demographic, disease, and health status correlates of sitting time in breast cancer survivors

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Abstract

Purpose—Sedentary behavior is associated with poor health outcomes including obesity, lower quality of life, and mortality in breast cancer survivors. This study sought to identify motivational, demographic, and disease characteristics of breast cancer survivors who engage in greater amounts of sedentary behavior.

Methods—Multivariate linear regression models estimated associations between demographic, disease, and health characteristics with reported sitting in breast cancer survivors (n = 279; M_{age} = 60.7 (± 9.7) years). Regression models estimated associations between motivational factors and reported sitting adjusted for demographic and disease and health covariates.

Results—Working at least part-time and marital status were associated various sitting domains including weekday and non-leisure sitting. Higher BMI was associated with more average daily, weekend, and weekday sitting. High income was additionally associated with less non-leisure sitting. The belief that sedentary behavior is bad for health, physical function, and self-evaluative OE, and lifestyle self-efficacy were associated with multiple sitting domains in both univariate and covariate-adjusted models.

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Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards (IRB Approval Number: STU00201007).

Informed consent Informed consent was obtained from all individual participants included in the study.

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Conflict of interest The authors declare that they have no conflicts of interest.

Conclusions—Future work should examine the relationships between motivational, demographic, and disease predictors and objectively measured sedentary behavior over time and across different sedentary behavior domains. Understanding activity changes during and after treatment is needed to identify intervention targets and develop effective interventions.

Keywords

Sedentary behavior; Breast cancer survivors; Motivational factors

Introduction

Breast cancer survivors are at higher risk for diabetes [1], cardiovascular disease [2], and poor quality of life [3] compared to non-cancer controls, and they experience numerous persistent side effects of treatment including lymphedema, fatigue, and neuropathy [4]. Higher levels of sedentary behavior, defined here as activities done in a seated position with ≤ 1.5 metabolic equivalents [5, 6], are associated with worse outcomes including higher waist circumference [7, 8] increased fatigue [9], pain [10], functional decline [11], and all-cause mortality [12], even when controlling for moderate-to-vigorous physical activity (MVPA) in this population. Post-treatment, survivors are estimated to be more sedentary than the general population, spending an average of 9 h per day (up to 66% of waking hours) sedentary [7, 13]. Although there are a number of interventions that have successfully increased MVPA for breast cancer survivors [14, 15], evidence suggests that sedentary behavior is different from MVPA [16]. Thus, targeting MVPA alone will not necessarily result in decreased sedentary behavior [17]. Work is beginning to be done in both breast cancer [18] as well as other tumor groups, including endometrial [19] and colon-cancer [20] survivors, to design interventions that specifically target reducing sedentary behavior beyond increasing MVPA. However, to our knowledge, no published outcomes from trials specifically focused on reducing sedentary behaviors among breast cancer survivors exist. This study was designed to identify motivational, demographic, and disease factors that could be used to target interventions for survivors who are most sedentary.

Factors at multiple levels may influence sedentary behavior including home and work environments and demographic and motivational characteristics [21]. In the general population, employment status and body mass index (BMI) have been associated with increased sedentary time [21] as well as positive beliefs and cognitions about sitting behaviors [22]. Among breast cancer survivors, number of comorbidities, disease stage at diagnosis, BMI, employment status, and treatment type have been associated with sedentary time [23]. However, there is limited understanding of variables that impact sedentary behavior beyond demographic and disease factors in the general population and more specifically in breast cancer survivors. Exploring relations between motivational factors (e.g., motivations, beliefs, self-efficacy, outcome expectation, habit strength) and sedentary behavior offers the opportunity to inform future intervention development.

Motivational factors have previously been linked to MVPA [24, 25] and other health behaviors in the general population [26, 27]. Research examining sedentary behavior has primarily focused on motivational processes as a potential pathway to produce behavior

change resulting in less sedentary time [28]. Studies using the theory of planned behavior as a framework have explored attitudes, intentions, and social norms as influencers of sedentary behavior [29]. Prapavessis et al. found that social norms and intentions to be less sedentary were the most consistent predictors of behavior, while perceived behavioral control was less consistent. Attitudes about sitting were also significantly associated with sedentary time [29]. Finally, factors including habits, beliefs, outcome expectations, and self-efficacy have been targeted in interventions that have successfully reduced sedentary behavior among adults in the general population [22]. However, this literature exploring potential motivational determinants of sedentary behavior has focused primarily on healthy adult populations. Knowing how these relations may differ in survivors who may experience additional barriers to reducing sedentary behavior due to comorbidities and treatment side effects will help to develop effective sedentary behavior interventions.

To date, almost all of the research studies in the cancer survivor population exploring determinants of sedentary behavior have focused exclusively on total volume of sedentary time. For example, recent analyses of sedentary behavior correlates in colorectal and breast cancer survivors [30] have measured sedentary behavior in daily minutes of sitting, total sitting time, or long sitting bouts and neglected the different domains within which sedentary behavior occurs [31] (i.e., weekend vs. weekday, leisure vs. non-leisure). However, time spent sitting may vary by domain; some domains may be more amenable and responsive to behavioral interventions than others and different domains may require different intervention strategies. This proposition was supported by a recent study by Lynch et al., who found that survivors tended to be more sedentary during weekdays and less sedentary on Saturdays; however, associations with motivational determinants were not examined. This work was completed in male and female colorectal cancer survivors [20] so it may not capture adequately the experience of breast cancer survivors due to differing treatments and comorbidities associated with each disease. Thus, there is a gap in the current body of research examining sedentary behavior determinants within different contexts among breast cancer survivors. In order to develop effective interventions that successfully reduce sedentary behavior in this population, understanding how motivational, demographic, and disease characteristics are related to sedentary behavior, overall, and within different contexts is critical to identify candidate intervention targets. Knowledge of how these variables differ in their associations with reported sitting in various domains must be explored in order to appropriately tailor interventions around these domains. The primary aim of this study is to identify motivational, demographic, and disease factors that can be used to guide future sedentary behavior reduction interventions for breast cancer survivors.

Methods

Participants and procedures

Participants were recruited to complete a 25–30 min online survey via REDCap (Research Electronic Data Capture) system [32] concerning their MVPA and sedentary behaviors, demographic information, and preferences regarding a technology-supported intervention as part of a project to examine preferences for MVPA promotion and sedentary behavior reduction interventions [33, 34]. Recruitment methods and eligibility criteria have been

published previously [33]. Briefly, participants were a nationwide sample of women who had participated in a prior study examining MVPA and quality of life and agreed to be contacted regarding future research opportunities (n = 1,366) in July 2015. Inclusion criteria included 18 years of age or older, able to read and write in English, a prior history of breast cancer, and access to the internet. Eligible survivors completed informed consent and the online questionnaire. This work was reviewed and approved by the University internal review board (IRB Approval Number: STU00201007).

Sedentary behavior—Sedentary behavior was measured as sitting time using the Marshall sitting time questionnaire, a valid and reliable measure of sitting time [35]. This survey assessed respondents reported time in hours, spent sitting on an average weekday and weekend during each of the following activities: while traveling, working, watching television, using the computer at home, and other leisure activities excluding television. In total, 10 activities were assessed across the weekend and weekday categories. Scores from this questionnaire have previously been validated in breast cancer survivors [36].

Five sitting domains were defined from the responses to each of the 10 activities. Average daily sitting was defined as a weighted average of all time spent in all weekday and weekend activities over a 7-day week. Weekday sitting was created by summing the five activity items specifying weekdays. Weekend sitting was created by summing the five activity items specifying weekends. Leisure sitting was defined by creating a weighted average of time spent watching television, using the computer at home, and other leisure activities during the weekday and weekend. Non-leisure sitting was defined using a weighted daily average of time spent traveling and working during the weekday and weekend.

Physical activity—Physical activity participation was measured using the Godin Leisure-Time Exercise Questionnaire [35]. Participants reported the frequency and average amount of leisure time spent engaging in strenuous, moderate, and mild exercise over the previous 7 days. This measure has shown sufficient reliability in cancer populations [37]. Reported time spent in each intensity was multiplied by the respective number of reported times per week to obtain total number of weekly minutes in each activity. These values were summed and divided across 7 days to calculate average time spent in total leisure time physical activity. Total physical activity was included as a predictor in the disease and health characteristics multivariate linear regression and adjusted for as a covariate in the models in examining motivational factors.

Demographics and disease characteristics—Participants reported age, race, educational attainment, household income, and employment status. BMI was calculated from self-reported height and weight. Additionally, survivors reported date of cancer diagnosis, and treatment received. Finally, participants indicated whether they had experienced any of the 18 different comorbidities (e.g., arthritis, asthma, angina, congestive heart failure, diabetes, depression, obesity, hearing impairment).

Health beliefs about sedentary behavior—Single-item questions assessed whether individuals agreed or disagreed (yes/no) that “sitting and/or lying down for extended periods of time is harmful” for health. An additional question assessed whether individuals believed

that reducing time spent “sitting and/or lying down for extended periods” would improve health.

Self-efficacy—The 12-item Barriers to Reducing Sedentary Behavior Self-Efficacy Scale was adapted from a physical activity questionnaire [38]. Participants responded to each item on a scale ranging from 0% (not at all confident) to 100% (highly confident) in 10% increments. Higher scores represented stronger beliefs in their ability to “reduce the amount of time you spend sitting and/or lying down” by at least 60 min each day if faced with commonly experienced barriers. The internal consistency of responses was high (α = 0.93) in this sample.

The 6-item Reduction in Sedentary Behavior Self-Efficacy scale was adapted from the Exercise Self-efficacy scale [38]. Participants rated each item on a scale ranging from 0% (not at all confident) to 100% (highly confident) in 10% increments. Higher scores represented greater confidence in their ability to reduce sedentary behavior by 60 min over the next one to six months. The internal consistency of responses was high (α = 0.99) in this sample.

The 6-item Leisure Time Lifestyle Activity Self-Efficacy Scale assessed participants’ beliefs in their ability to accumulate 150 min of physical activity over the following month for the next 1–6 months [39]. Participants rated each item on a scale ranging from 0% (not at all confident) to 100% (highly confident) in 10% increments. Higher scores represented greater self-efficacy in participating in leisure time physical active. The internal consistency for responses was high (α = 0.99) in this sample.

Outcome expectations—The 15-item outcome expectations for reducing sedentary behavior measure was adapted from the Multidimensional Outcome Expectations for Exercise Scale [40]. Participants rated social, self-evaluative, and physical outcome expectations for reducing “the time you spend sitting and/or lying down by at least 60 min per day” on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Items from each subscale were averaged to obtain a subscale score. Higher scores represented stronger beliefs that reducing sedentary behavior would produce desirable outcomes. Responses to each subscale demonstrated high internal consistency (α = 0.94 for physical, α = 0.89 for social, and α = 0.91 for self-evaluative) in the present study.

Habit strength—Habit strength was measured using the 4-item automaticity subscale of the Self-Report Habit Index [41] modified by Conroy and colleagues to address sedentary behaviors [42]. Participants rated each item using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher average scores represented stronger habits for sedentary behavior. Responses exhibited high internal consistency (α = 0.87) in this sample.

Intentions and plans—Intentions to reduce sedentary time were assessed using a 4-item questionnaire assessing behavior on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree), whether participants had plans to reduce their sedentary time over the next 2 months. This scale was adapted from measures used to assess physical activity behavior change motivations and intentions [43, 44]. Higher scores indicate stronger plans and intentions to

reduce sedentary behaviors. These questions showed good internal consistency (α = 0.95) in this sample.

Data analysis

Analyses were performed in SAS version 9.4 (Cary, NC). Separate multivariate linear models examined the associations between five sedentary behavior domains (average daily sitting, weekday, weekend, leisure, and non-leisure sitting) and demographic variables (age, race, education, income, employment status, and marital status). Age was treated as a continuous measure while, race (white vs. nonwhite), education (< 4 year college degree vs. ≥ 4 year college degree), household income (< $60,000 vs. ≥ $60,000), employment status (< working less than part-time vs. ≥ working at least part-time), and marital status (married vs. not married) were examined as binary variables.

A second set of multivariate models examined relationships for each of the sedentary behavior domains and disease and health factors (treatment received, time since diagnosis, BMI, number of chronic conditions, and physical activity). Type of treatment received, chemotherapy, radiation, and surgery were treated as binary variables. BMI, number of chronic conditions, and time since diagnosis and physical activity were calculated and treated as continuous.

Separate univariate linear models examined the associations between each sedentary domain and each potential motivational variable (Model 1). Statistically significant relationships were, then, examined further in separate multivariate linear models controlling for demographic factors (Model 2) and disease and health characteristics (Model 3). Finally, models adjusting for all demographic and disease and health characteristics were examined (Model 4). This method has been used previously to examine predictors of sedentary behavior domains in older adults [45].

Results

Participants

A total of 279 women completed the survey after the planned sample size of participants was achieved within 24–48 h of sending the recruitment email. Sedentary behavior, motivational, demographic, disease, and health characteristics are reported in Table 1. Briefly, survivors (mean age = 60.6 (± 9.7) years old) were primarily white (97.1%) and possessed a 4-year college degree (71.7%) and had a household income of ≥ $60,000 (73.7%).

Sitting time and physical activity

Survivors reported sitting an average of 10.1 (± 4.3) h/day. Survivors reported sitting more on weekdays than on weekends (10.5 (± 4.7) h/day and 9.1 (± 4.5) h/day $p < 0.01$, respectively). Additionally, on average, women reported participating in 43.2 (± 33.9) minutes of physical activity per day.

Correlates of sitting time

Results of multivariate regression models are presented in Tables 2 and 3.

Demographic variables—Women who worked at least part-time self-reported more 3.27 (95% CI 2.03, 4.52; $p < 0.001$) more hours of average daily sitting, 3.99 (CI 2.67, 5.31; $p < 0.001$) more hours of weekday sitting hours, and 3.60 (CI 2.90, 4.29; $p < 0.001$) more hours of non-leisure sitting hours than those who did not work. Additionally, women who were married reported 1.55 (CI – 2.98, – 0.13; $p = 0.03$) fewer hours of weekday sitting and 1.11 (CI – 1.86, – 0.35; $p = 0.004$) fewer hours of non-leisure sitting than those who were not married while lower income women reported 0.90 (CI – 1.68, – 0.12; $p = 0.02$) fewer hours of non-leisure sitting.

Disease and health status variables—Women with a higher BMI self-reported 0.12 (CI 0.02, 0.22; $p = 0.02$), more hours or 7.2 min of average daily sitting, 0.11 (CI 0.01, 0.21; $p = 0.04$) more hours or 6.6 min of weekend sitting, and 0.13 (CI 0.02, 0.24; $p = 0.03$) more hours or 7.98 min of weekday sitting. Those who had radiation treatment reported 1.70 (CI 0.63, 2.76; $p = 0.002$) more hours of leisure time sitting. Finally, women who reported more chronic conditions reported 0.32 (CI – 0.57, – 0.07; $p = 0.01$) fewer hours of non-leisure sitting.

Motivational factors—Results of the models examining the relationships between motivational factors and sedentary domains are reported in Table 3. Those factors with statistically significant ($p < 0.05$) univariate associations are described below.

Average daily sitting—In unadjusted models, the belief that sedentary behavior is bad for health was associated with 2.25 (CI – 3.77, –0.73; $p = 0.003$) fewer hours of daily sitting. Incrementally higher physical was associated with 0.12 (CI – 0.23, – 0.02; $p = 0.02$) fewer hours or 7.2 min of daily sitting. Incrementally higher self-evaluative outcome expectations were associated with 0.14 (CI – 0.26, – 0.01; $p = 0.03$) fewer hours or 8.4 min of daily sitting, while higher lifestyle activity self-efficacy was associated with 0.03 (CI – 0.05, – 0.01; $p = 0.02$) fewer hours or 1.8 min of average daily sitting. These relationships remained after controlling for demographic, disease, and health status characteristics.

Weekend sitting—The belief that sedentary behavior is bad for health was associated with 1.99 (CI – 3.56, – 0.42; $p = 0.01$) fewer reported hours of sitting time on the weekends. Incrementally higher physical and self-evaluative outcome expectations were associated with 0.13 (CI – 0.24, – 0.03; $p = 0.02$) fewer hours or 7.8 min and 0.14 (CI – 0.27, – 0.02; $p = 0.03$) fewer hours or 8.4 min of sitting on a weekend day, respectively. Higher lifestyle activity self-efficacy was associated with 0.03 (CI – 0.05, – 0.01; $p = 0.004$) fewer hours or 1.8 min of daily weekend sitting. In the fully adjusted model, all relationships remained significant except the belief that sedentary behavior is bad for health.

Weekday sitting—In unadjusted models, the belief that sedentary behavior is bad for health was associated with 2.37 (CI – 4.04, – 0.71; $p = 0.005$) fewer hours of week day sitting. Increased physical outcome expectations were associated with 0.12 (CI –0.23, – 0.005; $p = 0.04$) fewer hours or 7.2 min of weekday sitting, while an incrementally higher lifestyle activity self-efficacy scores were associated with 0.02 (CI – 0.05, –0.001; $p = 0.04$) fewer hours or 1.2 min of weekday sitting. All relationships remained statistically significant in the fully adjusted models.

Leisure sitting—The belief that sedentary behavior is bad for health was associated with 2.40 (CI – 3.66, – 1.14; $p < 0.001$) fewer hours of sitting. The belief that reducing sitting is beneficial for health was associated with 1.41 (CI – 2.78, –0.04; $p = 0.04$) fewer hours of sitting, while incrementally higher self-evaluative outcome expectations were associated with 0.11 (CI – 0.21, – 0.01; $p = 0.04$) fewer hours or 6.6 min of leisure time sitting in unadjusted models. Relationships remained significant in the fully adjusted model for all factors except the belief that reducing sitting is beneficial for health.

Non-leisure sitting—Higher motivation scores were associated with 0.08 (CI 0.02, 0.15; $p = 0.01$) more hours or 4.8 min of non-leisure sitting in the unadjusted model. However, after full covariate adjustment, this association was no longer significant.

Discussion

Although researchers have identified sedentary behavior as a target for behavioral interventions to improve health in breast cancer survivors [7, 23], little is known about how to identify survivors who would benefit most from interventions. The present study identified a variety of motivational, demographic, and disease characteristics that can be used to target interventions for high-risk participants. This sample self-reported similar or higher sitting time to previous samples of breast cancer survivors [36, 46], further supporting the need for effective interventions to reduce sedentary behavior in this population. Overall, demographic and disease and health factors varied in their associations across the different sitting domains. Working at least part-time was associated with higher reported non-leisure and weekday sitting, while BMI was associated with more weekend and weekday sitting. Additionally, statistically significant putative motivational factors that were associated with various domains of sedentary behavior included beliefs, outcome expectations, and lifestyle self-efficacy. These results suggest that domain-specific sitting time was associated with the different variables suggesting the context in which sitting occurs should be considered when developing interventions.

Employment status was associated with over an hour of reported weekday sitting, and non-leisure sitting, suggesting that individuals in this sample are likely sitting a great deal at work and that this may be more predictable on weekdays and in non-leisure domains. Similarly, two of the variables associated with non-leisure sitting were job related (i.e., income, employment status). Collectively, these results suggest that non-leisure sitting may be best targeted in the workplace. This finding in this relatively high-income and educated population is consistent with findings from general populations suggesting that high-income individuals participate in more sedentary time [47]. Future work should examine whether this relationship holds in more demographically diverse survivor populations.

BMI was positively associated with average daily, weekend, week day, and non-leisure sitting, so that survivors with higher BMIs reported more sitting. This is consistent with previous findings in colorectal cancer [20] and lung cancer [48] survivors and suggests BMI may be an important factor for tailoring interventions. Indeed, work examining health outcomes of sedentary breaks and light intensity activity interventions has shown that individuals who experienced particular health improvement were individuals who were more

sedentary and weighed more [49]. Therefore, because BMI is associated with lower MVPA participation in breast cancer survivors [50], sedentary behavior reduction interventions may be particularly beneficial for overweight/obese survivors who are both sedentary and not meeting MVPA guidelines and may be overwhelmed or discouraged by current MVPA goals of 150 min per week [51].

Additionally, while survivors who had radiation therapy reported more leisure sitting than survivors who did not, increases in total number of comorbidities were associated with decreased non-leisure sitting. However, the majority of disease and health characteristics (e.g., time since diagnosis, comorbidities, treatment received, physical activity) were not associated with reported sitting. This result differs slightly from previous findings that more advanced disease stage and treatment of chemotherapy were associated with increased accelerometer-measured total sedentary behavior [23]. This discrepancy may be partially due to self-reported sitting in our sample and objectively collected physical activity in the previous sample [23], but more work is needed to understand the short and long-term effects of cancer treatment on sedentary behavior.

With respect to motivational factors, results indicate that believing that sedentary behavior is bad for health was associated with decreased average daily, weekday, and leisure time sitting when controlling for other potential covariates. This was one of the most consistent predictors across all the domains, along with both physical function and self- evaluative outcome expectations, and suggests improving knowledge of the physical and health benefits of reducing sedentary behavior beyond increasing MVPA may be one important piece for emerging interventions to consider. While behavioral counseling which includes some educational elements is beginning to be utilized in sedentary behavior reduction interventions [18], the type of educational components to include and how to deliver this information will be important to consider in future interventions. Strategies that increase perceived benefits of reducing sedentary behavior possibly through education should be pursued.

The association between higher lifestyle activity self-efficacy and lower average daily sitting, weekend and weekday sedentary time was somewhat unexpected. This measure assesses confidence in accumulating 150 min of MVPA; this may suggest an overall confidence with being physically active, which may be related to sitting less. However, more work is needed to understand this finding as data suggest that many people who are highly active are also highly sedentary [47].

Future research is warranted to understand weekend sitting behavior and how it may differ from weekday sitting as well as differences between leisure and non-leisure sitting to determine appropriate intervention strategies. Work into understanding objectively measured sedentary time in colon-cancer survivors suggests that individuals engaged in less sedentary time on Saturday’s compared to other days of the week [20]. However, colon-cancer survivors had less sedentary time than breast cancer survivors (526 min/day in colorectal cancer survivors vs. 660 min/day in breast cancer survivors). Additionally, this work did not capture leisure and non-leisure sitting. While self-reported surveys used in this analysis may not accurately capture specific sitting behaviors and may introduce some bias, our work

suggests interventions that are highly tailored, contextually adaptive, and delivered in real time (i.e., just in time adaptive interventions [52]) may be appropriate to detect a threshold of sitting and the contextual domain in which it occurs to intervene appropriately to encourage light activity or sitting breaks.

Findings should be considered within the context of their limitations. First, we used self-reported sitting as our measure of sedentary behavior. Although this measure has been significantly associated with accelerometer-measured sedentary behavior in breast cancer survivors [36], it may introduce bias and potential misclassification of sitting time within each of the domains explored. Ultimately, because the built environment encourages more automatic and, therefore, habitual sedentary behavior, it may be difficult for individuals to estimate how much they sit. Second, our motivational measures all assessed motivation for reducing overall sedentary behavior including sitting and lying down. However, we only examined sitting time in this study which could influence the relationships observed. Future work should also assess relationships between both self-reported and objectively measured time spent lying down.

The broad assessment of motivational variables cross-sectionally also may oversimplify how these variables may change over time and limits what inferences can be made about what characteristics are associated with sedentary behavior changes across time. Specifically, these findings only suggest relative sub-groups at greatest risk and may not reflect causal determinants. In addition, we adapted many of these measures from MVPA measures and the chosen anchors (i.e., reducing sitting time by a total of an hour per day) could have also influenced responses. Future work is warranted to explicitly explore measurement of these constructs as they pertain to sedentary behavior. Ecological momentary assessment [53, 54] may be particularly useful in this context to establish temporality among the motivational factors explored and better characterize the ways in which these variables may change over time and in different contexts (e.g., watching television, using the computer, transportation) and locations (e.g., at work, at home). Similarly, in order to clarify the role of multi-level factors that may contribute to the individual factors in this analysis, an expansive look at behavioral theories that may inform sedentary behavior and the use of mixed methods incorporating qualitative research are other necessary next steps for behavioral research and intervention development. Finally, this sample was demographically homogenous and only included longer-term breast cancer survivors who completed treatment. Thus findings may not be generalizable to all breast cancer survivors. Explorations of the relationship between motivational factors and sedentary behavior in more diverse samples should be conducted.

Notwithstanding these limitations, to the best of our knowledge, this study was the first study to explore potential motivational correlates of sedentary behavior in breast cancer survivors. It represents an important initial step in better understanding which survivors may benefit most from sedentary behavior reduction. Results highlighted the importance of examining different contexts of sitting and the need to target interventions differently depending on when and in which contexts sedentary behavior occurs.

Conclusion

This work is important in highlighting characteristics of breast cancer survivors who engage in the greatest amounts of sedentary behavior. The present study emphasizes the importance of considering the domain of sedentary behavior (weekend vs. weekday, discretionary vs. non-discretionary). Health beliefs, outcome expectations, and lifestyle self-efficacy were most commonly associated with sitting. Other characteristics, including BMI and comorbidities, unique to survivors could be used to target interventions. Future work should examine the relationships between objectively measured sedentary behavior, motivational correlates, and other potential correlates of sedentary behavior across time and in different sedentary behavior domains in order to better design effective interventions to reduce sedentary behavior, and ultimately, improve survivors health and disease outcomes.

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Table 1

Sample descriptive statistics (n = 279)

	Mean (SD)
Sedentary behavior	
Average daily sitting (h/day)	10.1 (4.3)
Average discretionary sitting (h/day)	6.6 (3.6)
Average non-discretionary sitting (h/day)	3.7 (3.0)
Total sit weekend (h/day)	9.1 (4.5)
Total sit week day (h/day)	10.5 (4.7)
Motivational characteristics	
Habit strength (range 1–5)	3.36 (0.86)
Sedentary barriers self-efficacy (range 0–100)	52.8 (22.3)
Reduce sitting self-efficacy (range 0–100)	60.0 (27.4)
Leisure time self-efficacy for physical activity (range 0–100)	80.3 (25.3)
Plans to reduce sedentary behavior (range 4–28)	17.4 (6.3)
Social OE[a] (range 5–25)	10.6 (13.1)
Physical OE (range 6–30)	24.9 (5.1)
Self-evaluative outcome expectation (range 4–20)	19.6 (4.3)
Motivation to reduce sitting (range 7–35)	25.2 (5.7)
Belief that sedentary behavior is bad for health (yes, %)	87.0
Belief reducing sitting is beneficial for health (yes, %)	90.0
Demographic covariates	
Age (years)	60.6 (9.7)
Race (white, %)	97.1
Education (college degree %)	71.7
Income (≥ $60,000)	73.7
Employment status (employed at least part-time, %)	53.8
Marital status (married, %)	75.3
Physical activity, health, and disease covariates	
Treatment ever received	
Chemotherapy (%)	58.8
Radiation (%)	72.0
Surgery (%)	89.6
Time since diagnosis (years)	11.6 (5.9)
BMI[b] (kg/m^2)	26.5 (5.7)
Number of chronic conditions	1.7 (1.5)
Total physical activity (min/day)	43.2 (33.9)

Demographics and disease characteristics have been reported previously: Lloyd et al. [33]

[a] Outcome expectation (OE)

[b] Body mass index (BMI)

Table 2

Relationships between demographic and disease and health status covariates and sedentary behavior domains

Demographics[a]	Average daily sitting β (95% Confidence interval)	Weekend sitting β (95% Confidence interval)	Weekday sitting β (95% Confidence interval)	Leisure sitting β (95% Confidence interval)	Non-leisure sitting β (95% Confidence interval)
Age	0.03 (– 0.03, 0.10)	0.04 (– 0.03, 0.11)	0.03 (– 0.04, 0.10)	0.04 (– 0.01, 0.10)	– 0.01 (– 0.04, 0.03)
Employment status (employed at least part-time vs. working less than parttime)	**3.27 (2.03, 4.52)****	1.35 (– 0.06, 2.77)	**3.99 (2.67, 5.31)****	– 0.05 (– 1.18, 1.08)	**3.60 (2.90, 4.29)****
Race (white vs. non-white)	–2.42 (– 6.35, 1.51)	– 2.61 (– 7.07, 1.84)	– 2.36 (– 6.53, 1.81)	– 0.18 (– 3.76, 3.41)	– 2.04 (– 4.24, 0.16)
Education (< collage degree vs. ≥ college degree)	0.66 (– 0.54, 1.86)	0.50 (– 0.86, 1.86)	0.74 (– 0.53, 2.02)	0.60 (– 0.49, 1.69)	– 0.14 (– 0.81, 0.53)
Income (< $60,000 vs. ≥ $60,000)	– 0.48 (– 1.87, 0.90)	0.03 (–1.55, 1.60)	–0.68 (–2.16, 0.79)	0.43 (–0.83, 1.70)	**–0.90 (–1.68, –0.12)***
Marital status (married vs. other)	– 1.23 (– 2.58, 0.11)	– 0.50 (– 2.03, 1.02)	**–1.55 (–2.98, –0.13)***	–0.11 (–1.33, 1.12)	**–1.11 (–1.86, –0.35)****
Disease and health status facto[b]	**β (95% Confidence interval)**	**β (95% Confidence interval)**	**β (95% Confidence interval)**	**β (95% Confidence interval)**	**β (95% Confidence interval)**
Treatment ever received					
Chemotherapy	– 0.48 (–1.63, 0.67)	–0.41 (–1.59, 0.76)	–0.51 (–1.78, 0.76)	–0.07 (–1.03, 0.90)	–0.37 (–1.14, 0.41)
Radiation	1.06 (–0.21, 2.32)	1.14 (–0.16, 2.43)	1.03 (–0.37, 2.42)	**1.70 (0.63, 2.76)****	–0.40 (–1.25, 0.46)
Surgery	–0.57 (–2.52, 1.38)	–1.02 (–3.01, 0.98)	–0.39 (–2.54, 1.76)	–0.72 (–2.32, 0.89)	–0.26 (–1.58, 1.07)
Time since diagnosis	–0.05 (–0.14, 0.04)	–0.02 (–0.11, 0.07)	–0.06 (–0.16, 0.04)	0.02 (–0.06, 0.09)	–0.06 (–0.12, 0.003)
Body mass index[c]	**0.12 (0.02, 0.22)***	**0.11 (0.01, 0.21)***	**0.13 (0.02, 0.24)***	0.07 (–0.01, 0.16)	0.06 (–0.01, 0.13)
Number of chronic conditions	–0.18 (–0.54, 0.19)	0.14 (–0.24, 0.51)	–0.30 (–0.70, 0.10)	0.09 (–0.22, 0.40)	**–0.32 (–0.57, –0.07)***
Total physical activity	–0.01 (–0.02, 0.01)	0.00 (–0.02, 0.02)	–0.01 (–0.03, 0.01)	0.01 (–0.01, 0.02)	–0.01 (–0.02, 0.002)

Values in bold indicate statistical significance was observed;

* $p < 0.05$;

** $p < 0.01$;

β values are reported in hours

[a] Demographic covariates: age, race, education, employment status, household income

[b] Disease and health status covariates: total comorbidities, time since diagnosis, treatment received (radiation, chemotherapy, surgery), BMI, total physical activity

[c]Body mass index (BMI)

Table 3

Relationships between motivational factors and sedentary behavior domains

Motivational factor[a]	Model 1: unadjusted models β (95% Confidence interval)	Model 2: model 1 + demo-graphics[b] β (95% Confidence interval)	Model 3: model 1 + disease and health status factors[c] β (95% Confidence interval)	Model 4: model 1 + all covariates[b,c] β (95% Confidence interval)
Average daily sitting				
Belief that sedentary behavior is bad for health	**−2.25 (−3.77, −0.73)** **	−1.50 (−3.01, 0.01) *	**−2.57 (−4.17, −0.98)** **	**−1.77 (−3.32, −0.22)** *
Belief reducing sitting will improve health	−0.96 (−2.63, 0.71)			
Physical OE[d]	**−0.12 (−0.23, −0.02)** *	**−0.10 (−0.20, −0.0001)** *	**−0.14 (−0.26, −0.03)** *	**−0.17 (−0.28, −0.06)** **
Self-evaluative OE	**−0.14 (−0.26, −0.01)** *	**−0.14 (−0.25, −0.02)** *	**−0.15 (−0.28, −0.02)** *	**−0.18 (−0.30, −0.05)** **
Social OE	−0.02 (−0.19, 0.15)			
Lifestyle self-efficacy	**−0.03 (−0.05, −0.01)** *	**−0.03 (0.05, −0.01)** **	−0.02 (−0.04, 0.01)	**−0.03 (−0.06, −0.01)** *
Barriers to reducing sedentary behavior self Efficacy	−0.01 (−0.03, 0.01)			
Reduction in sedentary behavior self-efficacy Habits	−0.01 (−0.02, 0.01)			
Habits	0.30 (−0.35, 0.95)			
Plans and intentions	0.01 (−0.08, 0.09)			
Motivation	0.02 (−0.08, 0.11)			
Weekend sitting				
Belief that sedentary behavior is bad for health	**−1.99 (−3.56, −0.42)** *	−1.19 (− 2.91, 0.53)	**−2.08 (−3.72, −0.43)** *	−1.26 (−3.05, 0.54)
Belief reducing sitting will improve health	−1.32 (−3.03, 0.39)			
Physical OE	**−0.13 (−0.24, −0.03)** *	**−0.12 (−0.24, −0.01)** *	**−0.15 (−0.27, −0.03)** *	**−0.16 (−0.29, −0.03)** *
Self-evaluative OE	**− 0.14 (−0.27, −0.02)** *	−0.13 (− 0.27, 0.004)	**−0.15 (−0.29, −0.02)** *	**−0.15 (−0.29, −0.01** *
Social OE	0.03 (−0.14, 0.21)			
Lifestyle self-efficacy	**−0.03 (−0.05, −0.01)** *	**−0.03 (−0.06, −0.01)** **	**−0.03 (−0.06, −0.003)** *	**−0.04 (−0.07, −0.01)** *
Barriers to reducing sedentary behavior selfefficacy	−0.01 (−0.03, 0.02)			
Reduction in sedentary behavior self-efficacy	−0.01 (−0.03, 0.01)			
Habits	0.56 (−0.11, 1.23)			
Plans and intentions	−0.01 (−0.10, 0.08)			

Motivational factor[a]	Model 1: unadjusted models	Model 2: model 1 + demo-graphics[b]	Model 3: model 1 + disease and health status factors[c]	Model 4: model 1 + all covariates[b,c]
	β (95% Confidence interval)	β (95% Confidence interval)	β (95% Confidence interval)	β (95% Confidence interval)
Motivation	−0.01 (−0.11, 0.08)			
Weekday sitting				
Belief that sedentary behavior is bad for health	**−2.37 (−4.04, −0.71)****	**−1.65 (−3.26, −0.05)***	**−2.77 (−4.52, −1.02)****	**−1.97 (−3.63, −0.32)***
Belief reducing sitting will improve health	−0.83, (−2.66, 1.00)			
Physical OE	**−0.12 (−0.23, −0.005)***	−0.10 (− 0.21, 0.01)	**−0.14 (−0.27, −0.01)***	**−0.17 (−0.29, −0.05)****
Self-evaluative OE	−0.13 (−0.27, 0.00)			
Social OE	−0.04 (−0.23, 0.15)			
Lifestyle self-efficacy	**−0.02 (−0.05, −0.001)***	**−0.03 (−0.05, −0.01)****	−0.01 (−0.04, 0.01)	**−0.03 (−0.06, −0.001)***
Barriers to reducing sedentary behavior selfefficacy	−0.01 (−0.04, 0.02)			
Reduction in sedentary behavior self-efficacy	−0.01 (−0.03, 0.02)			
Habits	0.20 (−0.51, 0.92)			
Plans and intentions	0.02 (−0.08, 0.11)			
Motivation	0.03 (−0.08, 0.13)			
Leisure sitting				
Belief that sedentary behavior is bad for Health	**−2.40 (−3.66, −1.14)****	**−1.99 (−3.35, −0.62)****	**−2.50 (−3.84, −1.17)****	**−2.18 (−3.61, −0.75)****
Belief reducing sitting will improve health	**−1.41 (−2.78, −0.04)***	−1.28 (−2.85, 0.29)	**−1.76 (−3.25, −0.28)***	1.53 (−3.18, 0.13)
Physical OE	−0.08 (−0.17, 0.01)			
Self-evaluative OE	**−0.11 (−0.21, −0.01)***	−0.10 (−0.21, 0.01)	**−0.12 (−0.23, −0.01)***	**−0.12 (−0.24, −0.004)***
Social OE	− 0.03 (− 0.18, 0.11)			
Lifestyle self-efficacy	− 0.01 (− 0.03, 0.01)			
Barriers to reducing sedentary behavior selfefficacy	0.00 (− 0.02, 0.02)			
Reduction in sedentary behavior self-efficacy	− 0.001 (− 0.02, 0.02)			
Habits	0.24 (− 0.30, 0.79)			
Plans and intentions	− 0.01 (− 0.08, 0.06)			
Motivation	− 0.05 (− 0.13, 0.03)			
Non-leisure sitting				

Motivational factor[a]	Model 1: unadjusted models	Model 2: model 1 + demo-graphics[b]	Model 3: model 1 + disease and health status factors[c]	Model 4: model 1 + all covariates[b,c]
	β (95% Confidence interval)	β (95% Confidence interval)	β (95% Confidence interval)	β (95% Confidence interval)
Belief that sedentary behavior is bad for health	0.14 (− 0.93, 1.21)			
Belief reducing sitting will improve health	0.41 (− 0.74, 1.57)			
Physical OE	− 0.03 (− 0.10, 0.05)			
Self-evaluative OE	0.001 (− 0.08, 0.09)			
Social OE	0.03 (− 0.09, 0.14)			
Lifestyle self-efficacy	− 0.01 (− 0.03, 0.00)			
Barriers to reducing sedentary behavior selfefficacy	− 0.01 (− 0.02, 0.01)			
Reduction in sedentary behavior self-efficacy	− 0.0002 (− 0.01, 0.01)			
Habits	0.01 (− 0.44, 0.45)			
Plans and intentions	0.03 (− 0.03, 0.09)			
Motivation	**0.08 (0.02, 0.15)** *	0.02 (− 0.04, 0.07)	**0.08 (0.01, 0.15)** *	0.01 (− 0.05, 0.07)
F (df)	1	7	8	14

Values in bold indicate statistical significance was observed;

* $p < 0.05$,

** $p < 0.01$;

β values are reported in hours

[a] Only predictors that were significant in Model 1 are included in Models 2−4

[b] Demographic covariates: age, race, education, employment status, household income

[c] Disease and health status covariates: total comorbidities, time since diagnosis, received (radiation, chemotherapy, surgery), body mass index (BMI), total physical activity

[d] Outcome expectation (OE)