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Breast Cancer Collaborative Registry informs understanding of factors predicting sleep quality

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Abstract

Significance Poor sleep quality is a common and persistent problem reported by women with breast cancer (BC). Empirical evidence identifies many risk factors for self-reported sleep deficiency, but inconsistencies limit translation to practice.

Purpose To increase understanding of risk factors predicting self-reported poor sleep quality in women with BC who completed the Breast Cancer Collaborative Registry (BCCR) questionnaire.

Methods This cross-sectional study recruited women with a first diagnosis of BC ($n = 1302$) at five sites in Nebraska and South Dakota. Women completed the BCCR that includes numerous variables as well as the Pittsburgh Sleep Quality Index (PSQI) and SF36v2 ($n = 1260$). Descriptive statistics and non-parametric correlations were used to determine associations and create predictive models of sleep quality with BCCR variables and SF36v2 subscales.

Results Most women were white (93.7%) and married (71.5%); mean age was 60.1 (21–90) years. Poor sleep was self-reported by 53% of women. Seven variables were highly associated with sleep quality ($p \leq 0.001$). The first model found younger age, lower physical activity, and higher fatigue were the strongest combined and independent variables predicting poor sleep quality ($F = 23.0$ ($p < .001$), $R^2 = 0.103$). Participants self-reported lower health status on most SF36v2 subscales [$Z = 44.9$ (11.6) to 49.1 (10.1)]. A second model found that all subscales were predictors of poor sleep; vitality, mental health, bodily pain, and general health were the strongest predictors ($F = 101.3$ ($p < .001$), $R^2 = 0.26$).

Conclusions Results confirm previously identified risk factors and reveal inconsistencies in other variables. Clinicians need to routinely screen for the identified risk factors of self-reported poor sleep quality.

Keywords Sleep quality · Sleep deficiency · Symptoms · Physical health · Mental health · Quality of life

Introduction

Despite receiving considerable attention during the last decade, breast cancer (BC) survivors are at increased risk for sleep deficiency [1, 2], defined as the discrepancy in sleep duration and/or quality obtained compared to the amount needed for optimal health [3]. Women who report poor sleep quality prior to chemotherapy often remain poor sleepers afterwards, and a percentage of good sleepers become poor sleepers, with 30–60% of patients affected [4]. Different BC treatments increase the risk of impaired sleep quality, thus contributing to the global disability associated with cancer treatments [5]. When poor sleep occurs with depression in patients with cancer, epidemiological observations link these symptoms to cancer morbidity and mortality risk [6]. In addition, until there is routine screening, assessment, and treatment of sleep deficiency, an increasing number of BC survivors are likely to experience lower quality of life (QOL) [5, 7].

Several measurements are available to screen and assess sleep quality/deficiency in the general population, in patients with chronic insomnia without comorbid disease (s), and in patients with cancer. The Pittsburgh Sleep Quality Index (PSQI) is the gold standard and most widely used measurement for assessment of sleep quality in various populations in research studies. The PSQI was designed to assess sleep

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quality, sleep duration, and frequency and severity of sleep disturbances [8]. A global score > 5 indicates poor sleep quality and a score of ≤ 5 indicates good sleep [8, 9].

Clinicians and researchers rely on data from healthy controls to determine if a sample/population meets criteria for good or poor sleep. In initial research by Buysse and team, individuals identified as healthy controls had a mean PSQI global score of 2.67 with a standard deviation (SD) of 1.7 [8]. Buysse next reported on sleep in both healthy young and older adults. The mean PSQI global score in young adults was 3.1 (1.6) for males and 1.9 (1.4) for females. In older adults, the mean score was 4.4 (2.8) for males and 5.1 (3.2) for females [9]. Ten years later, a study examining PSQI in patients with primary insomnia reported that the mean global scores for healthy controls were 3.3 (1.8) and 12.5 (3.8) for patients with primary insomnia [10]. Bush et al. examined older primary care patients referred for treatment of worry or anxiety. At baseline, mean PSQI global score of individuals who were diagnosed was 8.74 (4.05) compared to 6.65 (3.7) in those not diagnosed with generalized anxiety disorder [11].

Beck et al. was the first to examine PSQI scores in patients with cancer and reported a high mean global score of 8.15 (4.7) in several types of cancer and 7.31 (4.03) in BC patients [12]. A second study also reported a high mean score of 7.98 (4.12) in multiple types of cancer and 6.80 (3.64) in BC patients [13]. These results indicate that poor sleep is often associated with age, anxiety disorder, and cancer diagnosis.

The literature identifies several risk factors that are associated with poor sleep quality among patients with BC: age, higher body mass index (BMI), hot flashes, pain, and cancer-related fatigue, as well as lower physical functioning and mental health (depression and anxiety). However, empirical data are limited and inconsistencies in findings limit translation to practice. Both younger age [1] and older age [14] have been associated with poor sleep measured by the PSQI in patients with BC, whereas another study found no significant correlations between age and sleep in patients with BC 5 years after completion of treatment [15]. Higher BMI has been associated with poor sleep quality in BC during chemotherapy [16] and in survivors [17] but was not associated with either short sleep (< 6 h) or excessive daytime sleepiness in another large sample (N = 861) of survivors [18]. Hot flashes/vasomotor symptoms [2, 15] and pain [2] have been associated with poor sleep using PSQI.

The relationship between cancer-related fatigue and poor sleep in women with BC often is considered reciprocal. Higher cancer-related fatigue was associated with poor sleep quality in a large, mixed sample (N = 1938) of Chinese cancer patients [19], in patients with BC [20–22], and in a mixed sample during chemotherapy [16]. However, reviewed studies were inconsistent in reporting cancer-related fatigue as a risk factor for poor sleep.

Poor physical functioning has been a consistent predictor of poor sleep among patients with BC [14–17]. Empirical evidence recently has established that adult patients with cancer who engage in physical activity/exercise report better sleep quality [23, 24]. A recent systematic review concluded that aerobic exercise positively affects sleep outcomes in women with BC [25]. Lower mental health is the most consistent risk factor for poor sleep on PSQI. Depressive symptoms and anxiety significantly influence both the baseline and the trajectory of subjective sleep disturbances [5, 26].

Based on this knowledge, we sought to increase understanding of risk factors predicting self-reported poor sleep quality in patients with BC who completed the Breast Cancer Collaborative Registry (BCCR) questionnaire. Specific aims were to analyze associations between sleep quality with demographic, medical, tumor, lifestyle, and environmental variables and quality of life subscales and create predictive models using these variables and subscales to identify factors that predict self-reported sleep quality. We hypothesized that sleep quality would be associated with demographic, medical, tumor, lifestyle, and environmental variables and quality of life subscales and that our models would confirm factors previously identified and explicate the inconsistencies among predictors.

Methods

Study design

A cross-sectional study design used data from women who participated in the BCCR.

Sample and setting

The BCCR database was used to locate all cases in five registries from January 2008 to January 2017. Registries included UNMC/Nebraska Medicine, Omaha, NE; Saint Francis Medical Center, Grand Island, NE; Good Samaritan Hospital, Kearney, NE; Avera, Aberdeen SD; and Avera Cancer Institute, Sioux Falls, SD. Inclusion criteria were (1) women with a first BC diagnosis and (2) at any phase of the cancer trajectory. Exclusion criteria were (1) diagnosed with recurrent BC and (2) males.

Procedures

The Institutional Review Board (IRB) of the University of Nebraska Medical Center approved the study. At enrollment, patients provided informed consent for use of the data in clinical studies. All participants completed the BCCR questionnaire either at a clinic appointment or at home and returned it by US Postal Service.

BCCR questionnaire/study variables

The BCCR was developed in collaboration with BC experts, and research questions were standardized to satisfy the needs of all the centers [27]. The questionnaire contains standard data to provide a comprehensive review of the patient's demographic, medical, tumor, lifestyle, environmental, quality of life, and sleep quality that could influence BC cancer diagnosis and survivorship. Demographic data include variables such as participant's age, race/ethnicity, marital status, and educational status. Medical data include height/weight/BMI and a list of chronic conditions but no comorbidity index; gynecologic data such as menstrual status, pregnancy, breast feeding, and birth control; and BC data such as therapies received, functional changes, and symptoms since surgery or completing therapy. Tumor data include stage and receptor status. Lifestyle data include history of smoking, alcohol consumption, and physical activity. Environmental factors include annual household income and history of night or rotating shiftwork. Measures of physical and mental health status and subjective sleep quality complete the questionnaire.

Physical and mental health statuses were measured using the SF36v2 Health Survey [28]. The tool includes 36 items measuring eight aspects of physical and mental health in the last 4 weeks (standard form), including physical function, role function, role emotional, social functioning, bodily pain, mental health, vitality, and general health. Higher scores indicate higher functioning. Physical and mental health component scores were calculated according to standard procedures. Reliability and validity of the SF36 are well established. Reliability scores for the eight aspects/subscales ranged from 0.80 to 0.96 in this sample.

Subjective sleep quality during the previous month was measured using the PSQI, a 19-item tool [8, 9]. A global score includes seven components: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleeping medication use, and daytime dysfunction. Components are scored on a 0–3 scale and combined with equal weights to yield a global score (0–21). Higher scores indicate more severe complaints and poorer sleep quality. The PSQI takes 5–10 min to complete. The psychometrics of the PSQI have been established in cancer patients; Cronbach's alpha for the global PSQI was reported as 0.80 and was 0.71 in this study. A global PSQI score > 5 has a sensitivity of 89.6% and a specificity of 86.5% in identifying poor sleepers. Optional questions 10–11 were not included in the BCCR questionnaire.

Data analysis

All BCCR data were entered and verified by trained research assistants. Descriptive statistics (frequency distributions, means, and SD) were used to analyze BCCR questionnaire data. Scores were calculated according to established

procedures for the PSQI total score and the eight SF36 subscales as well as physical and mental component scores. Nonparametric correlations were calculated to determine associations between BCCR variables, SF36 scores, and PSQI global score. Stepwise multiple regression was used to build predictive models of sleep quality. Due to positive skew in PSQI scores, a natural log transformation was applied prior to performing the regression models, which normalized the distribution. Variables were considered for inclusion using the common practice of a significance level of less than 0.20 on the bivariate correlations with PSQI scores. Two separate stepwise regression models were performed. One was for significant demographic, medical, tumor, lifestyle, and environmental variables and the second one for physical and mental health status subscales. Pairwise deletion was used, as opposed to listwise deletion, so all available data were utilized in building the models. IBM SPSS version 24 was used for all analyses.

Results

Table 1 presents demographic data using the number and percent of the sample who completed the BCCR questionnaire. Only questionnaires with the PSQI data were included in this analysis (n = 1260). An additional 42 women's data were not included because they did not complete the PSQI. No records were kept of the number of patients approached.

The sample was predominately Caucasian, non-Hispanic, and married. The mean age was 60.1 years (range 21–90; SD = 12.1), and the average length of time since BC diagnosis was 3.1 (0 to 33) years. Almost 80% of participants were diagnosed as stage I or II. Almost 50% received chemotherapy (30% in the last month), about 40% received radiation therapy, and 36% took estrogen-blocking therapy.

The sample's mean PSQI global scores are shown in Fig. 1. There was a full range of scores (0–19) with a mean of 6.51 (3.64), with 47.1% of scores reflecting good sleepers and 52.9% of scores indicating poor sleepers in the last month.

The range, mean, and SD of the eight SF36 subscale scores appear on Table 2. Mean scores were generally higher for the mental than physical subscales.

Table 3 displays non-parametric BCCR questionnaire variable correlates with global sleep quality. Many demographic, medical, tumor, lifestyle, and environmental variables and QOL subscales correlated with sleep quality. Several variables had a correlation of .10 or higher and p < .001, including age, race, cognitive problems, hot flashes, and urinary problems; BMI did not meet this criteria. The only variables with stronger correlations of .20 or higher and p < .001 were fatigue and physical activity. Poor sleep quality was strongly related to all QOL subscales at .25 and higher, especially lower vitality and mental health. All variables with a superscript met inclusion criteria and were entered in the models.

Table 1 Descriptive data of the sample (*n* = 1260)

Variable	Yes (% of sample)	No (% of sample)
Race: Caucasian/White	1181 (93.7)	79 (6.3)
Ethnicity: Hispanic/non-Hispanic	17 (1.3)	1243 (98.7)
Married/partnered*	893 (71.5)	356 (28.5)
Education: college degree or higher*	434 (36.4)	758 (63.6)
Income 75 k or higher*	383 (34.9)	715 (63.6)
Post-menopausal status*	490 (49.4)	502 (50.6)
Chemotherapy in past 30 days*	398 (31.6)	821 (65.2)
Chemotherapy	612 (48.6)	648 (51.4)
Radiation therapy	505 (40.1)	755 (59.9)
Estrogen-blocking therapy	458 (36.3)	802 (63.7)
Stages I-II*	721 (78.6)	198 (21.4)
Estrogen receptor (ER) positive*	972 (77.9)	275 (22.1)
Progesterone receptor (PR) positive*	793 (63.8)	450 (36.2)
HER2 positive*	218 (18.3)	972 (81.7)
Smoking: current smoker*	87 (7.0)	1148 (93.0)
Alcohol: currently drinks*	672 (55.2)	545 (44.8)
Employment: full time*	599 (47.9)	652 (52.1)
Ever worked the night shift*	307 (36.5)	534 (63.5)

HER-2 human epidermal growth factor receptor 2

*Missing data

A stepwise method entered all included variables in the regression model displayed in Table 4. Demographic, medical, tumor, lifestyle, and environmental variables were represented. A model that included age, fatigue, and physical activity was the strongest in predicting risk factors influencing sleep quality, and all were significant independent variables as well with moderate bivariate correlations. The model accounted for approximately 10% of the overall variance in sleep quality (overall $F = 23.005$ ($p < .001$); $R^2 = 0.103$, adjusted $R^2 = 0.099$).

A second regression model shown in Table 5 entered all eight physical and mental health subscales. All were significant bivariate predictors of sleep quality. A model that included subscales of vitality, mental health, bodily pain, and general health was the strongest in predicting risk factors influencing sleep quality. The quality of life model accounted for
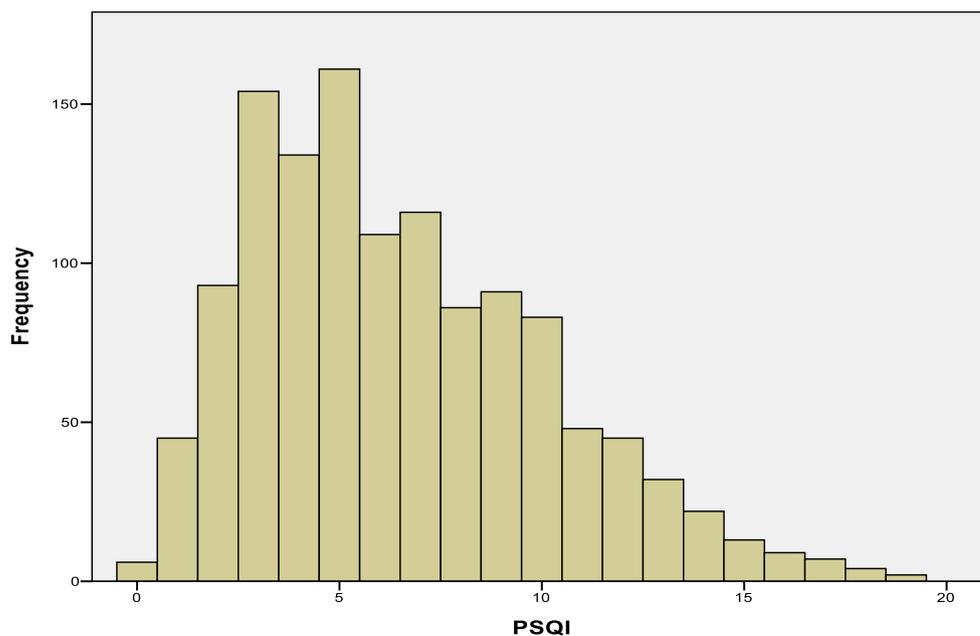

Fig. 1 Distribution of global Pittsburgh Sleep Quality Index (PSQI) scores (*n* = 1260) [8]

Table 2 Descriptive statistics for quality of life index

Tumor	Number	Minimum	Maximum	Mean	SD
SF36—physical functioning	1229	14.94	57.03	45.01	11.39
SF36—role physical	1230	17.67	56.85	44.39	11.59
SF36—bodily pain	1251	19.86	62.12	49.06	10.14
SF36—general health	1237	16.23	63.90	47.50	10.16
SF36—vitality	1248	20.87	70.82	48.64	10.58
SF36—social functioning	1217	13.22	56.85	46.90	10.99
SF36—role emotional	1219	9.23	55.88	47.27	11.84
SF36—mental health	1245	10.58	64.09	50.29	9.59
SF36—physical component score	1147	15.85	67.73	45.78	10.24
SF36—mental component score	1147	6.70	73.60	49.84	10.48

Short Form-36 v2 T-Scores [28]

approximately 26% of the overall variance in sleep quality (overall $F = 101.33$ ($p < .001$); $R^2 = 0.256$, adjusted $R^2 = 0.253$).

Discussion

Our purpose was to increase understanding of risk factors predicting self-reported poor sleep quality (deficiency) in a large sample of women with BC who completed the BCCR questionnaire. Our examination increases understanding of associations between self-reported sleep quality with demographic, medical, tumor, lifestyle, and environmental variables and quality of life subscales. The main findings were that younger age, self-reported co-occurring symptoms of higher cancer-related fatigue (and its' reverse expression as lower vitality), lower mental health (anxiety and depression), higher pain, lower general health, and lower physical activity were the risk factors for poor sleep quality. Our results confirm several previously identified risk factors and explicate inconsistencies among predictors of self-reported poor sleep quality in women with BC. We now discuss these findings.

More than 50% of our large sample of women with a mean time of over 3 years since BC diagnosis self-reported poor sleep within the past month. This finding is consistent with extant literature reports of 30–60% of patients being affected [1, 4]. One explanation is that about 30% of the women in our sample received chemotherapy within the last month [4, 13]. These figures confirm reports that sleep deficiency is a common and persistent symptom after BC treatment [29].

Most of the demographic, medical, tumor, lifestyle, and environment variables and quality of life subscales associated with sleep quality in this study are identified in the literature. Variables of younger age, BMI, race, cognitive problems, and urinary problems are inconsistent in prior literature. White women reported poorer sleep than a small percentage (1.3%) of minority women, a finding inconsistent from a prior report [30]. Cognitive problems were supported by one recent study

[31]. Urinary problems/symptoms are understudied areas in women with BC. A systematic review of urinary problems/symptoms reported that this symptom has been included as one of several menopausal symptoms in women with BC [32]. Although urinary symptoms were suggested as having a negative effect on quality of life, the effect on sleep was not included in the review.

Both SF36 physical and mental component scores indicate functioning lower than US population norms. Mental health was the only subscale score at the US population norm of 50.0 or higher with the remaining seven subscale scores below population norms [28]. Several subscales were predictors of poor sleep. These findings are consistent with reports from BC survivors [33, 34]. Patients with BC who reported significant anxiety and depression at baseline were more likely to have a trajectory of poor sleep quality during the first 3 years after BC diagnosis [29]. A national cohort of Danish women ($n = 3344$) identified seven predictors of poor sleep 3 to 4 months post-BC surgery [14]. In order of strength, they were depressive symptoms, poor physical functioning, older age, higher levels of trait anxiety, cigarette smoking, post-lumpectomy, and lower levels of physical activity. The strongest of these predictors were depressive symptoms and poor physical functioning. The current study's results agree with several of the above findings; however, we found younger (not older) age, no relation with cigarette smoking, and were unable to examine if type of surgery was a predictor.

Our first model supports younger age [1, 35], higher cancer-related fatigue [19–21], and lower physical activity [14, 23] as the strongest combined and independent variables in predicting sleep quality. The second model supports lower vitality and mental health as the strongest mental health predictors and higher bodily pain and lower general health as the strongest physical health predictors of sleep quality. Sustained sleep duration changes over time have been related to higher fatigue and lower vitality in women with BC, but self-reported sleep quality was not measured [36]. Lower mental health,

Table 3 Non-parametric correlates of study variables with sleep quality (PSQI)

Factor	BCCR variable	Correlation	p value	Number
Demographic	Age	− .146*	< .001	1260
	White vs non-White	.102*	< .001	1260
	Marital status	− .031	.276	1249
	Education	− .007	.796	1192
Medical	Arm swelling	.063*	.026	1260
	Arthritis	.092*	.001	1260
	BMI	.087*	.002	1244
	Chemotherapy	.068*	.015	1260
	Cognitive problems	.163*	< .001	1260
	Fatigue	.229*	< .001	1260
	Heart problems	.031	.265	1260
	Hot flashes	.104*	< .001	1260
	Hypothyroidism	.054*	.057	1260
	Infertility	.038*	.180	1260
	Osteoporosis	− .013	.642	1260
	Peripheral neuropathy	.071*	.012	1260
	Post-menopausal	− .094*	.003	992
	Scleroderma	.011	.700	1260
	Urinary problem	.116*	< .001	1260
Tumor	Estrogen receptor (ER) +	− .038*	.184	1247
	Progesterone receptor (PR) +	− .017	.560	1243
	HER2	− .008	.779	1190
	Stage	.101*	.002	924
Environment	Income	− .081*	.007	1098
	Employment	.041*	.143	1251
	Ever worked night shift	.052*	.135	841
Lifestyle	Current smoker	.073*	.126	1235
	Smoking—pack years	.099*	.112	259
	Current drinker	− .033	.246	1217
	Drinks per week	− .008	.778	1213
	Physical activity	− .228*	< .001	1256
Quality of life	SF36—physical functioning (PF)—T-score	− .257*	< .001	1229
	SF36—role physical (RP)—T-score	− .321*	< .001	1230
	SF36—bodily pain (BP)—T-score	− .362*	< .001	1251
	SF36—general health (GH)—T-score	− .351*	< .001	1237
	SF36—vitality (VT)—T-score	− .450*	< .001	1248
	SF36—social functioning (SF)—T-score	− .384*	< .001	1217
	SF36—role emotional (RE)—T-score	− .385*	< .001	1219
	SF36—mental health (MH)—T-score	− .450*	< .001	1245
	SF36—physical component score**	− .281	< .001	1147
	SF36—mental component score**	− .449	< .001	1147

*Non-parametric correlates included in regression model

**Physical component score calculated from PF, RP, BP, and GH; mental component score calculated from VT, SF, RE, and MH

reported as depressive symptoms and trait anxiety, has been identified as a predictor of poor sleep previously in patients with cancer [14, 29, 37, 38] and in healthy populations.

Early identification and treatment of anxiety and depression may lead to reduced rates of sleep deficiency. However, one study reported only 29% of the patients with clinically

Table 4 Regression coefficients for sleep quality regressed on influencing factors in women who completed the BCCR

Variables	Beta	t	p	Simple r
Fatigue	0.190	4.83	<.001	.229
Physical activity	− 0.199	− 5.09	<.001	− .228
Age	− 0.125	− 3.20	.001	− .146

Overall $F = 23.005$ ($p < .001$); $R^2 = .103$; adjusted $R^2 = .099$. Sleep quality measured by Pittsburgh Sleep Quality Index [8]

significant anxiety and depression sought help [38]. Poor sleep in patients with BC also has been linked to pain during adjuvant treatment [2] and in advanced cancer [39]. Literature of healthy adults links good general health with good sleep quality. BC survivors who return to good general health are more likely to regain higher vitality and mental health and lower pain, fatigue, and sleep deficiency.

Strengths of the study were the sample size and the finding that mean physical and mental component scores from SF36v2 indicated that many, but not all, of the women had QOL similar to healthy US women. Limitations include the cross-sectional design, the quality of some questionnaire items, the wide range of time since diagnosis, missing data, measurement of mental health but no specific measurements of anxiety and depression, and use of a single item to measure physical activity level and cancer-related fatigue. Variables that may explain poor sleep quality in this sample represent the breadth of the data collected but lack a depth of details.

Implications for research include the need to develop methods to identify and analyze individual symptoms, symptom clusters, and mental and physical health status. Interventions are needed that are designed to improve symptom clusters with an emphasis on a "driving" symptom [40]. Researchers can use current knowledge to test evidence-based interventions to change lifestyle behaviors and modify medical and environmental factors identified in this and other studies to reduce risk factors of poor sleep.

Implications for practice include the urgent need to screen and assess for risk factors for poor sleep using measures that rate several symptoms and their impact on functioning. Screening and assessment need to begin at BC diagnosis, a time when a risk-based assessment for distress is performed routinely [41]. Policy regulators currently mandate regular screening and assessment of pain, emotional distress, performance status, and QOL in BC survivors, but not sleep deficiency and/or fatigue. Clinicians can implement routine screening measures such as PROMIS-29 [42] or the M.D. Anderson Symptom Inventory (MDASI) [43] to identify patients with poor sleep and co-occurring symptoms.

Interventions to improve poor sleep in BC patients have been developed and tested for use when sleep is the primary or only symptom [25]. Meta-analysis results provide a strong quality of evidence and large effect sizes for the use of cognitive behavior therapy (CBT) in cancer survivors [44]. Evidence also suggests that physical activity/exercise interventions favorably affect both fatigue and sleep quality. The National Comprehensive Cancer Network (NCCN) Guidelines for Cancer-Related Fatigue [45] and Survivorship [46] recommend a personalized physical activity/exercise program for patients during and after treatment. Likewise, the Oncology Nursing Society Putting Evidence into Practice (ONS-PEP) resource rates CBT as "recommended for practice" and physical activity/exercise as "likely to be effective" to reduce poor sleep [25].

When the screen is positive for moderate to severe co-occurring symptoms, clinicians need to focus their assessment on modifiable risk factors identified as predictors of poor sleep in BC survivors. Treatment to reduce co-occurring symptoms is paramount to improving sleep quality. Treatment is needed for distress, worries, anxiety, and depression. Evidence-based strategies can be initiated for cancer-related fatigue and pain. Strategies can be taught to increase physical activity and vitality. These treatments are likely to result in improved sleep quality, lower fatigue, enhanced daytime vitality, and gradual improvement in physical, mental, and general health.

Compliance with ethical standards

The Institutional Review Board (IRB) of the University of Nebraska Medical Center approved the study. At enrollment, patients provided informed consent for use of the data in clinical studies.

Conflict of interest The authors declare they have no conflict of interest.

Table 5 Regression coefficients for sleep quality regressed on physical and mental health factors in women who completed the BCCR

Variables	Beta	t	p	Simple r
Vitality	− 0.184	− 4.805	<.001	− .450
Mental health	− 0.237	− 7.152	<.001	− .450
Bodily pain	− 0.124	− 4.062	<.001	− .362
General health	− 0.071	− 2.210	.027	− .351

Overall $F = 101.33$ ($p < .001$); $R^2 = 0.256$, adjusted $R^2 = 0.253$. Sleep quality measured by Pittsburgh Sleep Quality Index [8]. Physical and mental health measured by SF36v2 [28]

References

1. Palesh O, Roscoe J, Mustian KM et al (2010) Prevalence, demographics, and psychological associations of sleep disruption in patients with cancer: University of Rochester Cancer Center-Community Clinical Oncology Program. J Clin Oncol 28:292–298

2. Sanford SD, Wagner LI, Beaumont JL, Butt Z, Sweet JJ, Cella D (2013) Longitudinal prospective assessment of sleep quality: before, during, and after adjuvant chemotherapy for breast cancer. Support Care Cancer 21:959–967

3. National Institute of Health (2011) National Institutes of Health Sleep Disorders Research Plan. https://www.nhlbi.nih.gov/health-pro/resources/sleep/nih-sleep-disorders-research-plan-2011

4. Savard J, Ivers H, Savard MH, Morin CM (2015) Cancer treatments and their side effects are associated with aggravation of insomnia: results of a longitudinal study. Cancer 121:1703–1711

5. Fontes F, Pereira S, Costa AR, Gonçalves M, Lunet N (2017) The impact of breast cancer treatments on sleep quality 1 year after cancer diagnosis. Support Care Cancer 25:3529–3536

6. Irwin MR (2013) Depression and insomnia in cancer: prevalence, risk factors, and effects on cancer outcomes. Curr Psychiatry Rep 15:404–404

7. Liu L, Fiorentino L, Rissling M, Natarajan L, Parker BA, Dimsdale JE, Mills PJ, Sadler GR, Ancoli-Israel S (2013) Decreased health-related quality of life in women with breast cancer is associated with poor sleep. Behav Sleep Med 11:189–206

8. Buysse D, Reynolds CF 3rd, Monk TH et al (1989) The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 28:193–213

9. Buysse D, Reynolds CF 3rd, Monk TH et al (1991) Quantification of subjective sleep quality in healthy elderly men and women using the Pittsburgh Sleep Quality Index (PSQI). Sleep 14:331–338

10. Backhaus J, Junghanns K, Broocks A, Riemann D, Hohagen F (2002) Test–retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. J Psychosom Res 53:737–740

11. Bush AL, Armento ME, Weiss BJ et al (2012) The Pittsburgh Sleep Quality Index in older primary care patients with generalized anxiety disorder: psychometrics and outcomes following cognitive behavioral therapy. Psychiatry Res 199:24–30

12. Beck SL, Schwartz AL, Towsley G, Dudley W, Barsevick A (2004) Psychometric evaluation of the Pittsburgh Sleep Quality Index in cancer patients. J Pain Symptom Manag 27:140–148

13. Beck SL, Berger A, Barsevick A et al (2010) Sleep quality after initial chemotherapy for breast cancer. Support Care Cancer 18:679–689

14. Colagiuri B, Christensen S, Jensen AB, Price MA, Butow PN, Zachariae R (2011) Prevalence and predictors of sleep difficulty in a national cohort of women with primary breast cancer three to four months postsurgery. J Pain Symptom Manag 42:710–720

15. Otte JL, Carpenter JS, Russell KM, Bigatti S, Champion VL (2010) Prevalence, severity, and correlates of sleep-wake disturbances in long-term breast cancer survivors. J Pain Symptom Manag 39:535–547

16. Mark S, Cataldo J, Dhruva A, Paul SM, Chen LM, Hammer MJ, Levine JD, Wright F, Melisko M, Lee K, Conley YP, Miaskowski C (2017) Modifiable and non-modifiable characteristics associated with sleep disturbance in oncology outpatients during chemotherapy. Support Care Cancer 25:2485–2494

17. Visovsky C, Berger A, Hertzog M et al (2014) Breast cancer collaborative registry: comparison of physical and mental health and sleep in breast cancer survivors. JONS 5:29–38

18. Klyushnenkova EN, Sorkin JD, Gallicchio L (2015) Association of obesity and sleep problems among breast cancer survivors: results from a registry-based survey study. Support Care Cancer 23:3437–3445

19. Tian L, Lin L, Li HL, Chen KJ, Zhang XJ, Qian SJ, Hu Y (2016) Prevalence and associated factors of cancer-related fatigue among cancer patients in Eastern China. Oncologist 21:1349–1354

20. Vargas S, Wohlgemuth WK, Antoni MH et al (2010) Sleep dysfunction and psychosocial adaptation among women undergoing treatment for non-metastatic breast cancer. Psycho-Oncol 19:669–673

21. Bower J, Ganz PA, Irwin MR et al (2011) Inflammation and behavioral symptoms after breast cancer treatment: do fatigue, depression, and sleep disturbance share a common underlying mechanism? J Clin Oncol 29:3517–3522

22. Overcash J, Tan A, Patel K, Noonan A (2018) Factors associated with poor sleep in older women diagnosed with breast cancer. Oncol Nurs Forum 45:359–371

23. Chiu HY, Huang HC, Chen PY, Hou WH, Tsai PS (2015) Walking improves sleep in individuals with cancer: a meta-analysis of randomized, controlled trials. Oncol Nurs Forum 42:E54–E62

24. Rogers LQ, Fogleman A, Trammell R, Hopkins-Price P, Spenner A, Vicari S, Rao K, Courneya KS, Hoelzer K, Robbs R, Verhulst S (2015) Inflammation and psychosocial factors mediate exercise effects on sleep quality in breast cancer survivors: pilot randomized controlled trial. Psycho-Oncol 24:302–310

25. Matthews E, Carter P, Page M, Dean G, Berger A (2018) Sleep-wake disturbance: a systematic review of evidence-based interventions for management in patients with cancer. Clin J Oncol Nurs 22:37–52

26. Dhruva A, Paul SM, Cooper BA, Lee K, West C, Aouizerat BE, Dunn LB, Swift PS, Wara W, Miaskowski C (2012) A longitudinal study of measures of objective and subjective sleep disturbance in patients with breast cancer before, during, and after radiation therapy. J Pain Symptom Manag 44:215–228

27. Sherman S, Shats O, Fleissner E, Bascom G, Yiee K, Copur M, Crow K, Rooney J, Mateen Z, Ketcham MA, Feng J, Sherman A, Gleason M, Kinarsky L, Silva-Lopez E, Edney J, Reed E, Berger A, Cowan K (2011) Multicenter breast cancer collaborative registry. Cancer Inform 10:217–226

28. Ware JE, Kosinski M, Dewey JE (2000) How to score version 2 of the SF-36® Health Survey. QualityMetric Incorporated, Lincoln

29. Fontes F, Severo M, Goncalves M et al (2017) Trajectories of sleep quality during the first three years after breast cancer diagnosis. Sleep Med 34:193–199

30. Budhrani PH, Lengacher CA, Kip KE et al (2014) Minority breast cancer survivors: the association between race/ethnicity, objective sleep disturbances, and physical and psychological symptoms. Nurs Res Pract. https://doi.org/10.1155/2014/858403

31. Henneghan AM, Carter P, Stuifbergan A, Parmelee B, Kesler S (2018) Relationships between self-reported sleep quality components and cognitive functioning in breast cancer survivors up to 10 years following chemotherapy. Psycho-Oncol 27:1937–1943. https://doi.org/10.1002/pon.4745

32. Donovan KA, Boyington AR, Ismail-Khan R, Wyman JF (2012) Urinary symptoms in breast cancer: a systematic review. Cancer 118:582–593

33. Berger AM, Lockhart K, Agrawal S (2009) Variability of patterns of fatigue and quality of life over time based on different breast cancer adjuvant chemotherapy regimens. Oncol Nurs Forum 36:563–570

34. Tiezzi MF, da Mata B, de Andrade JM, Romão AP, Salata M et al (2016) Quality of life in women with breast cancer treated with or without chemotherapy. Cancer Nurs 40:108–116

35. Hofsø K, Rustøen T, Cooper BA, Bjordal K, Miaskowski C (2013) Changes over time in occurrence, severity, and distress of common symptoms during and after radiation therapy for breast cancer. J Pain Symptom Manag 45:980–1006

36. Alfano CM, Lichstein K, Vander Wal GS et al (2011) Sleep duration change across breast cancer survivorship: associations with

symptoms and health-related quality of life. Breast Cancer Res Treat 130:243–254

37. Mercadante S, Adile C, Ferrera P, Masedu F, Valenti M, Aielli F (2017) Sleep disturbances in advanced cancer patients admitted to a supportive/palliative care unit. Support Care Cancer 25:1301–1306

38. Mosher CE, DuHamel KN (2012) An examination of distress, sleep, and fatigue in metastatic breast cancer patients. Psycho-Oncol 21:100–107

39. Delgado-Guay M, Yennurajalingam S, Parsons H, Palmer JL, Bruera E (2011) Association between self-reported sleep disturbance and other symptoms in patients with advanced cancer. J Pain Symptom Manag 41:819–827

40. Miaskowski C, Barsevick A, Berger A et al (2017) Advancing symptom science through symptom cluster research: expert panel proceedings and recommendations. J Natl Cancer Inst 109:1–9

41. Syrowatka A, Motulsky A, Kurteva S, Hanley JA, Dixon WG, Meguerditchian AN, Tamblyn R (2017) Predictors of distress in

female breast cancer survivors: a systematic review. Breast Cancer Res Treat 165:229–245

42. Craig BM, Reeve BB, Brown PM, Cella D, Hays RD, Lipscomb J, Simon Pickard A, Revicki DA (2014) US valuation of health outcomes measured using the PROMIS-29. Value Health 17:846–853

43. Cleeland C, Mendoza TR, Wang XS et al (2000) Assessing symptom distress in cancer patients: the M.D. Anderson Symptom Inventory. Cancer 89:1634–1646

44. Johnson JA, Rash JA, Campbell TS et al (2016) A systematic review and meta-analysis of randomized controlled trials of cognitive behavior therapy for insomnia (CBT-I) in cancer survivors. Sleep Med Reviews 27:20–28

45. NCCN (2018) NCCN guidelines cancer-related fatigue, version 2.2018. https://www.nccn.org/professionals/physician_gls/pdf/fatigue.pdf 2018. Accessed 08/02 2018

46. NCCN (2018) NCCN guidelines survivorship, version 1.2018. https://www.nccn.org/professionals/physician_gls/pdf/survivorship.pdf. Accessed 08/02 2018