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Original Article

Psychosocial correlates of sleep quality and architecture in women with metastatic breast cancer

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ABSTRACT

Background: Sleep disturbance is prevalent among women with metastatic breast cancer (MBC). Our study examined the relationship of depression and marital status to sleep assessed over three nights of polysomnography (PSG).
Methods: Women with MBC ($N = 103$) were recruited; they were predominately white (88.2%) and 57.8 ± 7.7 years of age. Linear regression analyses assessed relationships among depression, marital status, and sleep parameters.
Results: Women with MBC who reported more depressive symptoms had lighter sleep (e.g., stage 1 sleep; $P < .05$), less slow-wave sleep (SWS) ($P < .05$), and less rapid eye movement (REM) sleep ($P < .05$). Single women had less total sleep time (TST) ($P < .01$), more wake after sleep onset (WASO) ($P < .05$), worse sleep efficiency (SE) ($P < .05$), lighter sleep (e.g., stage 1; $P < .05$), and less REM sleep ($P < .05$) than married women. Significant interactions indicated that depressed and single women had worse sleep quality than partnered women or those who were not depressed.
Conclusion: Women with MBC and greater symptoms of depression had increased light sleep and reduced SWS and REM sleep, and single women had worse sleep quality and greater light sleep than married counterparts. Marriage was related to improved sleep for women with more depressive symptoms.

1. Introduction

Women diagnosed with breast cancer have high rates of sleep disruption [1–5]. Sleep disturbance often begins before or during treatment and may continue long after treatment completion, often worsening for women with metastatic breast cancer (MBC) [6–8]. One recent study demonstrated that those with breast cancer had the highest number of sleep quality complaints among cancer patients [9]. The majority of studies examining sleep in women with breast cancer have relied on self-report or indirect measurement [10]. Relatively few studies have used polysomnography (PSG), the gold standard for objectively assessing sleep [10], to examine sleep patterns in individuals with breast cancer. Of the studies that utilized PSG, dysregulation of sleep architecture in cancer patients was evidenced by lower sleep efficiency (SE) [11], more time in lighter nonrapid eye movement (NREM) sleep (stages 1 and 2), and less time in deep NREM or slow-wave sleep (SWS) (stages 3 and 4), as well as less rapid eye movement (REM) sleep than experienced by the general population [12]. However, another study found little change in PSG-assessed sleep before and after completion of chemotherapy [13]. Evidence regarding objective changes in sleep architecture of women with MBC is inconclusive and further study is warranted.

There is a well-described correlation between depression and sleep disturbance in the general population [14,15]. Among women with breast cancer, nearly 20–30% experience depression [2,16,17], a higher prevalence than that seen in the general population. Depression further increases as breast cancer advances [18,19]. Palesh et al. [8] found that higher baseline and worsening depression among women with MBC predicted progressive sleep problems and that sleep disruption was associated with autonomic dysregulation during the day, particularly loss of vagal tone [20]. Although many precipitating factors may engender sleep disturbance and depression in MBC (e.g., stress, pain) the physiologic or psychological changes underlying these phenomena are unknown.

In addition, the relationship of marriage and sleep quality in women with breast cancer has been understudied, with investigations primarily focusing on healthy adults. Studies have demonstrated that divorced women have higher rates of sleep

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disturbance and insomnia [21]. Further there is evidence that marital happiness is related to improved sleep quality in women, relative to those experiencing marital discord [22]. Spousal sleep problems also negatively affect sleep and mood as well as the health of their partners [23]. Thus marriage appears to be an important variable affecting sleep quality in cancer patients. We aimed to examine the relationship of marital status to sleep among metastatic breast cancer patients. Our study examined the relationship of depression and marital status with sleep parameters assessed by two nights of consecutive at-home PSG and one night of laboratory PSG. Our a priori hypothesis was that higher depression scores among women with MBC would be related to significantly greater sleep disturbance. Exploratory aims were to examine the role of a potential moderator, marital status, in relation to sleep quality and architecture. We explored potential interactions between depression and marital status as they related to sleep in women with MBC.

2. Methods

2.1. Participants

Predominately white women (88.2%) with MBC (N = 103) were recruited and consented to participate (Fig. 1). The women were postmenopausal and were between the ages of 45–75 years (mean age, 57.8 ± 7.7 years) (Table 1). They also had documented metastatic or recurrent breast cancer, with Karnofsky Performance Status Scale ratings of at least 70% (physical ability measure for medically ill patients) [24]. Participants were at least 2 months postchemotherapy or hormonal treatment. Women were excluded if they had (1) previous bilateral lymph nodes removal; (2) had active cancers (other than breast cancer) within the past 10 years; (3) had taken corticosteroids, glucocorticoids, or benzodiazepines within the week preceding and during their in-laboratory sleep study; (4) had a history of major psychiatric illness that required

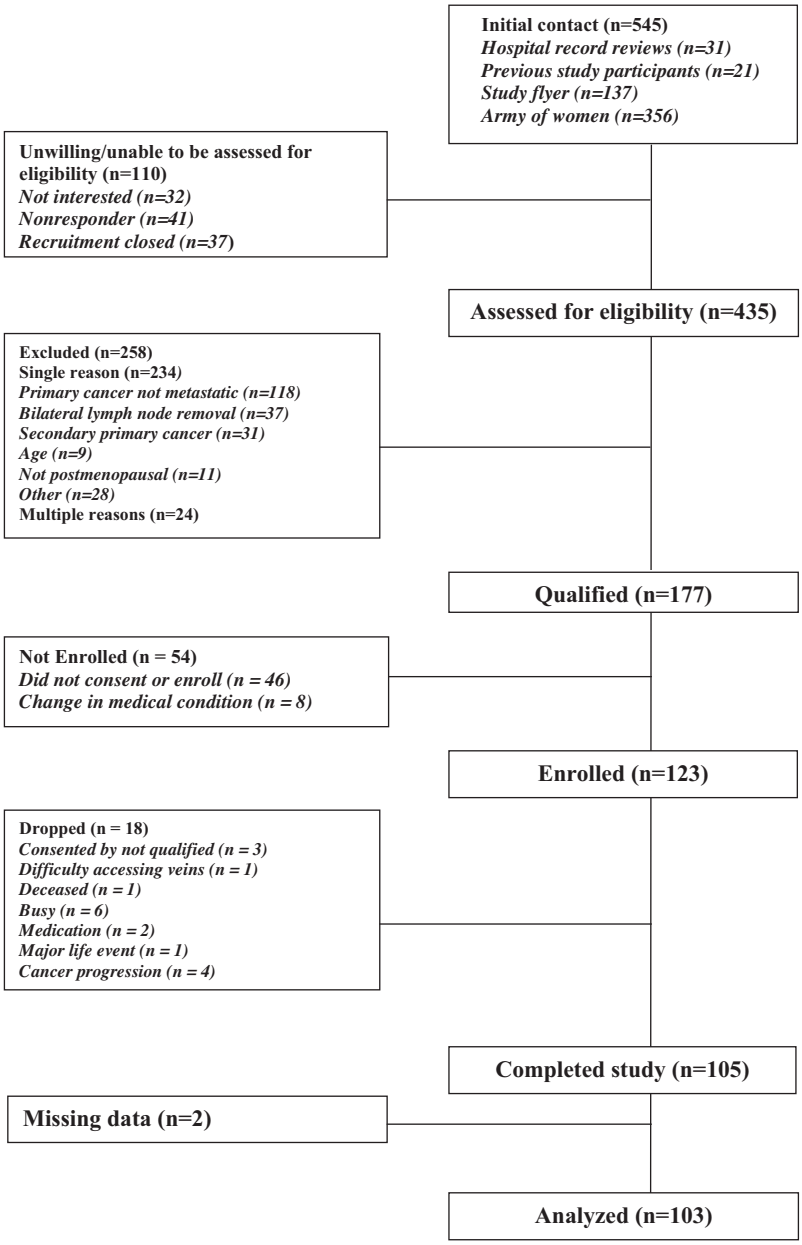

Fig. 1. Patient flow diagram.

hospitalization in the preceding year; (5) had substance abuse or dependence; or (6) had engaged in regular travel involving two or more time zones or shift work (e.g., working 4:00 pm–midnight or 10:00 pm–6:00 am) during the 3 months before the beginning of the study. Participants were recruited by letter of request through breast cancer clinics at Stanford University, by breast surgeons and oncologists at Stanford and University of California San Francisco (UCSF), through Army of Women mailing list, and through advertisements in the local newspapers and the Internet.

2.2. Design and procedures

All study procedures were approved by the Stanford University Institutional Review Board and conformed to the principles outlined in the Declaration of Helsinki. Participants underwent two nights of at-home PSG and one night of laboratory PSG, which consisted of a reduced montage (LOC/ROC, C3/C4, Fz/Cz, electrocardiogram 1/2, and electromyogram 1/2). The laboratory study was conducted for 28 h at Stanford Hospital's Clinical Translational Research Unit or at the Stanford Sleep Medicine Center during which participants were scheduled to sleep at their habitual sleep time for 8 h. For participants who did not live near the clinics, the at-home protocol was conducted at a hotel before or after the 28-h laboratory study. Computerized psychosocial measures were administered during the second night of at-home PSG.

2.3. Measures

2.3.1. Sleep measures

Our study utilized three nights of PSG-measured sleep (two at-home and one laboratory PSG), with home sleep measured approximately 2 weeks before laboratory sleep. Surface electrodes (Grass Instruments Co, Braintree, MA) were taped to standard (International 10–20 System) locations on the face (bilateral electrooculogram, above and below the outer canthi; electromyogram, chin) and to the scalp (electroencephalogram, C3, C4, Fz, Oz) using Quik-Cap (Neuroscan, Charlotte, NC). Signals were collected by a Siesta system (Compumedics, El Paso, TX) onto compact flash memory cards. Data were analyzed using Pro Fusion PSG software (Compumedics, El Paso, TX) and scored in 30-s epochs after the method of Rechtschaffen and Kales [25]. Sleep scoring yielded both total amount and percentage of stages 1, 2, 3, and 4 of NREM sleep, REM sleep, and wake. Other calculated metrics include time available for sleep, total sleep time (TST), SE, sleep- or REM-onset latency, and wake after sleep onset (WASO).

2.3.2. Depression

To examine depressive symptoms among women with MBC, we administered the Center for Epidemiologic Studies Depression scale (CES-D) [26,27] and the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders (SCID) [28], and also assessed the participants' use of antidepressant medication. The CES-D was selected because the items of the scale minimize medical illness symptoms; it also has high internal consistency ($\alpha = 0.89$) and adequate test–retest reliability in individuals with cancer ($r = 0.57$; $P < .001$) [26,29]. For between-group analyses involving the presence or absence of depression, we first used a median split (8.0) on the CES-D to separate those with less or more depressive symptoms for clinical relevance. Studies among nondepressed nonpatient and community samples have demonstrated that CES-D scores below 8 indicate no depression, thus supporting our use of the median split to differentiate depression in our sample [30–32]. Second, we utilized the SCID to determine lifetime or current depression. Lastly, we included a third variable that combined women who had a positive screening for clinical depression on the CES-D (e.g., a score $\geqslant$16 was considered the clinical cutoff point for high depressive symptoms) [27] or on the SCID, or those who were taking antidepressant medication. Fifteen women met criteria for depression on the CES-D and six women on the SCID; additionally, 21 women were taking selective serotonin reuptake inhibitors or other antidepressants for mood disturbance. A total of 33 women met criteria for depression on either the CES-D (score $\geqslant$16) or the SCID, or were taking antidepressants. Therefore, we captured a clinical range of women who reported subthreshold depressive symptoms (e.g., score $\geqslant$8), who met full criteria for depression, or who were being treated for depression.

2.3.3. Marital status

The role of marriage as a moderator was assessed through the marital status item collected in the demographic data. This variable was recorded and women were dichotomized into two groups of either married or single (e.g., single, divorced, widowed).

2.4. Data analysis

At-home PSG data were averaged over two nights and the means were used in the analyses. Laboratory PSG data were separately analyzed. To assess if sleep differed between home and laboratory environments, we examined these associations. Only approximately 3% of at-home PSG and laboratory PSG variables were moderately or less correlated (0.40 < Spearman rho < 0.60), thus indicating differences between at-home vs in-laboratory sleep. Although we were not surprised that women had greater sleep disturbance in the laboratory, significant findings that emerged in the laboratory environment suggest the relationships between psychosocial and sleep variables are robust outside of their habitual sleep environments. We corrected for multiple comparisons equivalent to other studies using PSG in cancer populations (e.g., Bonferroni correction) [33]. Our between-group rather than continuous analysis of depression was designed to be clinically relevant and address the floor effect of our sample, as the majority of women with MBC did not meet full criteria for depression. To examine the effects of depression and marriage and their interaction on sleep, linear regression analysis was employed. Scheffé tests ($\alpha = 0.05$) were conducted to follow-up on significant interactions. Medical variables (e.g., treatment type, disease status, hormone receptor status, medications) (Table 1) did not show any significant or sizable ($r > 0.30$) association with the predictor or outcome variables in our hypotheses, and therefore were not included in our main regression analyses. Analyses were conducted using SPSS 19.0. Data are presented as mean ± standard deviation.

3. Results

3.1. Depression and sleep

3.1.1. Home PSG

Consistent with our hypothesis regarding depression and sleep disruption, significant effects of depression emerged for REM sleep. Women who reported more symptoms of depression on the CES-D (score of $\geqslant$8) spent less time in REM sleep (i.e., minutes of REM sleep divided by minutes of TST) and had fewer minutes of REM sleep than those reporting fewer symptoms of depression. Table 2 presents the CES-D means and standard deviations, and Table 3 shows the standardized regression coefficients and effect sizes for at-home and laboratory PSG sleep by depression severity and marital status.

Table 1
Baseline means and standard deviations of demographic variables by condition.

Demographic characteristics (N = 103)	Mean/%/N ± SD	Medical characteristics (N = 103)	Mean/%/N ± SD
Age, y	57.8 ± 7.7	*Age at diagnosis, y*	47.3 ± 8.3
BMI	27.3 ± 5.5	*Stage at initial diagnosis*	
		0/I	32.1%
Education		II	35.9%
HS/GED/trade school	8.7%	III	15.5%
Some college/Graduate school	91.3%	IV	16.5%
Employment		*Site of metastatic spread*	
Unemployed/retired	52.4%	Soft tissue or chest wall	33
Part time	20.4%	Bone	28
Fulltime	27.2%	Organs	16
		Multiple sites	26
Total gross income			
<$20,000–$59,900	42.2%	*Disease-free interval (mo)*	70.5 ± 64.1
$60,000–$99,900	36.2%	*Treatment type*	
⩾$100,000	33.3%	Radiation	1
D/K or refused	2.0%	Chemotherapy	16
		Hormonal therapy	66
Ethnicity		Monoclonal antibody	18
Non-Hispanic	97.1%		
Hispanic/Latino	2.9%	*Hormone receptor status*	
		ER+	82.5%
Race		ER−	16.5%
Asian	3.9%	PR+	67.0%
Black	6.9%	PR−	28.2%
White	88.2%	HER2+	23.2%
Black/white	1.0%	HER2−	67.0%
Marital status		*Medications*	
Married/partnered	57.3%	Pain	53.4%
Single/NM	8.7%	Sleep	39.8%
Separated	3.9%	Antidepressants	29.1%
Divorced	24.3%	Steroids	16.5%
Widowed	4.9%	Benzodiazepines	12.6%
Other	1.0%		

Abbreviations: N, number of patients; SD, standard deviation; y, years; BMI, body mass index; HS, high school; GED, general equivalency diploma; mo, months; D/K, do not know; NM, not married; ER, estrogen receptor; PR, progesterone receptor.

3.1.2. Laboratory PSG

In the high depression group, women spent significantly more time in light sleep, including more time in stage 1 sleep and less time in minutes and percentage in stage 2 sleep.

3.1.3. Clinical depression

Similar to our findings above, women with clinical depression had significant sleep disturbance including reduced REM sleep and spent significantly more time in the lighter stages of sleep. Table 3 highlights the standardized regression coefficients that demonstrated significant relationships between depression severity and sleep, both at home and in the laboratory.

3.2. Post hoc analyses: marital status

3.2.1. Home PSG

Participants who were single with MBC had less TST, more WASO, and worse SE than married women. Single women also had fewer minutes of stage 2 sleep and a lower percentage of REM sleep (Table 3).

3.2.2. Laboratory PSG

Similarly sleep architecture measured in the laboratory revealed that single women spent a greater percentage of sleep in stage 1 and fewer minutes in stage 2 sleep than married women with MBC. Overall, depressed and single women with MBC who slept in the laboratory had worse sleep quality and spent more time in lighter NREM sleep than depressed and married or not depressed and single or married counterparts. Significant interactions emerged between depression (CES-D) and marital status for laboratory-measured TST ($\beta = 0.47$, $P < .01$; $R^2_{adj} = 0.08$, $P < .05$), WASO ($\beta = -0.45$, $P < .01$; $R^2_{adj} = 0.07$, $P < .05$), stage 1 sleep percentage ($\beta = -0.38$, $P < .05$; $R^2_{adj} = 0.14$, $P \leqslant .001$), and stage 2 sleep in minutes ($\beta = 0.46$, $P < .01$; $R^2_{adj} = 0.17$, $P < .001$). Scheffé tests using analysis of variance were conducted to follow-up on the significant interactions. Significant comparisons are represented in Fig. 2 and depict differences in sleep among groups in relation to those who were depressed and single.

4. Discussion

Women with MBC who had more depressive symptoms had more disturbed sleep at home and in the laboratory. Single women with MBC had worse sleep quality at home and worse SE than married women. We also found that marriage was protective of sleep quality in women with high depressive symptoms. At home women with MBC averaged 6.5 h of sleep and had low SE of 74.0% (i.e., normal efficiency ⩾85%) [34,35]. Our sample had considerably longer sleep-onset latency [34,36], extended REM sleep latency, and reduced percentage of REM sleep relative to other advanced-cancer patients and healthy adults [33,35]. The number of nocturnal awakenings and WASO were considerably higher than that among healthy adults [34]. The poor sleep quality of the overall sample made sleep differences among the depressed and single patients more notable. Sleep architecture differences included increased stage 1 sleep, reduced stage 2 sleep, and lower than average SWS relative to other advanced-cancer patients. Although sleep quality and architecture were significantly more disturbed in the laboratory than at home for TST, WASO, SE, NREM sleep stages 1 and 2, SWS, and REM sleep as might have been expected (*P* values ranged from $P < .001$ to $P < .05$), the findings linking depression and unmarried women were consistent across measurement settings.

Table 2
Means, standard deviations, and significant differences of home and laboratory polysomnography–measured sleep by Center for Epidemiologic Studies Depression scale depressive symptom severity.

	Low depression Mean ± SD	High depression Mean ± SD
Home PSG	(n = 54)	(n = 48)
Sleep quality		
Time available for sleep (min)	522.5 ± 67.5	518.0 ± 82.6
TST (min)	394.9 ± 58.0	382.5 ± 77.2
Sleep efficiency (%)	75.8 ± 8.4	73.7 ± 11.5
Sleep-onset latency (min)	44.0 ± 28.6	47.5 ± 37.4
REM sleep latency (min)	110.0 ± 51.2	131.5 ± 62.8
WASO (min)	70.0 ± 37.0	70.5 ± 37.2
Sleep stages		
Stage 1 (%)	39.6 ± 8.8	41.5 ± 9.9
Stage 2 (%)	39.8 ± 8.6	39.0 ± 9.0
SWS (%)	6.9 ± 5.4	8.0 ± 6.1
REM (%)	13.3 ± 4.5	11.5** ± 5.4
Stage 1 (min)	155.9 ± 39.0	158.8 ± 47.7
Stage 2 (min)	156.7 ± 39.9	148.0 ± 44.6
SWS (min)	27.3 ± 21.7	29.7 ± 21.7
REM (min)	53.5 ± 20.5	45.8* ± 24.8
Laboratory PSG		
Sleep quality		
Time available for sleep (min)	515.7 ± 52.2	506.3 ± 49.2
TST (min)	339.8 ± 73.2	323.9 ± 71.4
Sleep efficiency (%)	66.1 ± 14.1	64.3 ± 14.1
Sleep-onset latency (min)	51.4 ± 42.1	47.1 ± 37.3
REM sleep latency (min)	141.3 ± 77.5	149.5 ± 82.3
WASO (min)	105.8 ± 47.1	116.6 ± 53.8
Sleep stages		
Stage 1 (%)	43.0 ± 12.4	51.6** ± 17.9
Stage 2 (%)	40.2 ± 9.7	34.3* ± 12.9
SWS (%)	5.2 ± 5.8	4.3 ± 5.0
REM (%)	11.6 ± 4.8	9.9 ± 7.3
Stage 1 (min)	143.4 ± 45.0	164.3 ± 61.5
Stage 2 (min)	137.5 ± 45.1	110.5** ± 48.1
SWS (min)	18.7 ± 21.0	14.6 ± 18.4
REM (min)	40.2 ± 20.4	34.4 ± 27.5

Abbreviations: SD, standard deviation; min, minutes; TST, total sleep time; REM, rapid eye movement sleep; WASO, wake after sleep onset; SWS, slow-wave sleep; PSG, polysomnography.
Reference group is low depression.
Median split = high depression: Center for Epidemiologic Studies Depression scale (CES-D) score of ⩾8.1 (mean, 14.92 ± 5.94).
Low depression: CES-D score of ⩽8 (mean, 2.97 ± 2.57).
* Significant at $P < .05$.
** Significant at $P < .01$.

4.1. Depression and sleep architecture

We found that women with high depressive symptoms obtained less REM sleep at home, both in percent and minutes of REM. In studies with depressed adults, REM percentage of sleep generally is found to increase relative to the other sleep stages [36]; however, this increase generally is related to a deficiency in SWS [37–40]. In our sample, REM sleep was reduced compared to other studies with healthy adults who averaged 17–25% of REM sleep [35]. Our findings reflect those of a study that found that advanced-cancer patients spent 15% of their sleep in REM sleep [33], and another study of breast cancer patients who spent 18% of sleep in REM sleep [11]. Our sample had reductions in REM sleep beyond that previously observed; thus, it was striking that depressed women had reductions in REM sleep beyond their non-depressed counterparts. Women who met all three criteria for depression (SCID, CES-D, or use of antidepressant agents) had increased REM sleep latency, which may be a feature of antidepressant use. Studies have found that antidepressant agents typically suppress REM sleep [41] and the use of selective serotonin reuptake inhibitors by advanced-cancer patients increases REM sleep latency [33], which is congruent with our observations.

Women with MBC who were more depressed also spent more of their TST in stage 1 sleep (in the laboratory) and spent less time sleeping in stage 2 sleep (at home and in the laboratory) or in SWS (in the laboratory). These findings are different from other studies with advanced-cancer patients (e.g., stage 1, 10.9%; stage 2, 73.8%; SWS, 0.3%) [33], breast cancer patients (e.g., stage 1, 15%; stage 2, 61%; SWS, 4%) [11], and healthy adults (e.g., stage 1, 3–12%; stage 2, 51–72%; SWS, 0–17%) [34]. However, Parker et al. [33] and Silberfarb et al. [11] observed small samples of breast cancer patients (N = 32 and N = 15, respectively) and patients varied on level of cancer progression. Consistent with our findings, Fiorentino et al. [12] found that breast cancer patients spent more time in the light stages of sleep, with reductions in SWS and REM sleep. Studies on depression have shown reductions in SWS [42] and also that increases in SWS may improve mood [43]. SWS also is known as restorative sleep and is linked to decreased cortisol secretion [44], reduced insulin sensitivity and sympathetic nervous system arousal [42,43], and lower nocturnal blood pressure [45,46]. The reductions in SWS found among depressed women in our sample may be associated with worsened immune and cardiovascular functioning. The significant distur-

Table 3
Standardized regression coefficients and effect sizes for home and laboratory polysomnography–measured sleep by depression severity and family structure.

	β	R^2_{adj}	P value	Cohen d
Depression severity				
Home PSG				
High depression(CES-D) vs low depression				
REM (%)	−0.26	0.057	$P < .01$	−0.37
REM (min)	−0.23	0.044	$P < .05$	−0.34
High depression (SCID) vs low depression				
REM (%)	−0.20	0.031	$P < .05$	−0.88
REM (min)	−0.20	0.029	$P < .05$	−0.85
Stage 2 (min)	−0.26	0.055	$P < .01$	−1.12
High depression (combined) vs low depression				
REM latency (min)	0.32	0.090	$P < .001$	−0.71
Laboratory PSG				
High depression (CES-D) vs low depression				
Stage 1 (%)	0.28	0.065	$P < .01$	0.41
Stage 2 (%)	−0.25	0.053	$P < .05$	−0.35
Stage 2 (min)	−0.28	0.068	$P \leqslant .01$	−0.43
High depression (SCID) vs low depression				
REM latency (min)	0.23	0.042	$P < .05$	−1.13
High depression (combined) vs low depression				
SWS (min)	−0.22	0.039	$P < .05$	−0.49
Marital status				
Home PSG				
Single/no partner vs married				
TST (min)	−0.30	0.081	$P < .01$	−0.64
WASO (min)	0.20	0.029	$P < .05$	0.40
Sleep efficiency (min)	−0.28	0.068	$P < .01$	−0.58
Stage 2 (min)	−0.27	0.063	$P < .01$	−0.56
REM (%)	−0.23	0.043	$P < .05$	−0.48
Laboratory PSG				
Single vs married				
Stage 1 (%)	0.27	0.060	$P < .05$	0.55
Stage 2 (min)	−0.28	0.067	$P < .01$	−0.59

Abbreviations: PSG, polysomnography; CES-D, Center for Epidemiologic Studies Depression scale; REM, rapid eye movement sleep; min, minutes; SCID, Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders; SWS, slow-wave sleep; TST, total sleep time; WASO, wake after sleep onset.
High depression: CES-D score of $\geqslant 8.1$ ($n = 48$).
High depression: SCID ($n = 6$).
High depression: combined ($n = 33$), CES-D score of $\geqslant 16$ + SCID + antidepressant users.

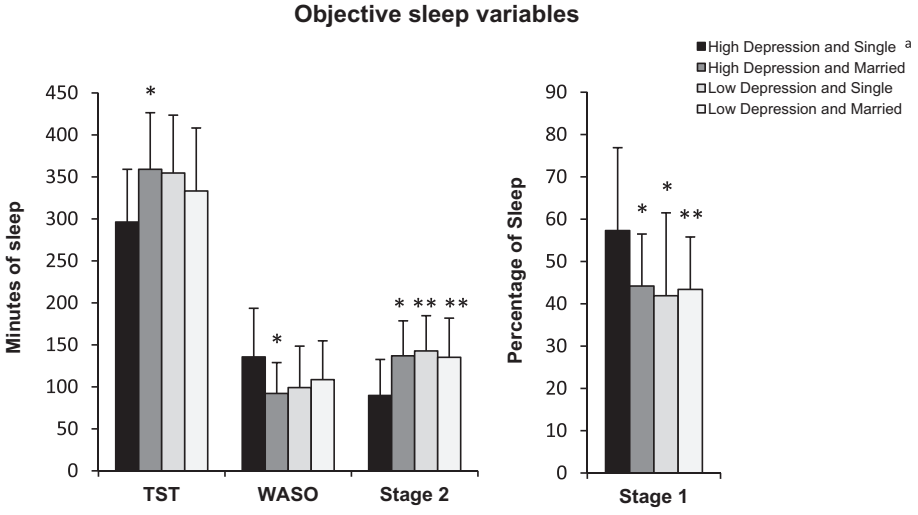

Fig. 2. Significant Scheffé group comparisons for polysomnographic in-laboratory sleep quality and architecture among women with metastatic breast cancer. *Abbreviations:* TST, total sleep time; WASO, wake after sleep onset. *Significant at $P < .05$. **Significant at $P < .01$. [a]All significant group comparisons are between the high depression Center for Epidemiologic Studies Depression scale score $\geqslant 8.1$ (mean, 4.92 ± 5.94) and single group.

bances in NREM and REM sleep found among more depressed women with MBC in our study suggest a negative and synergistic effect of advanced disease and worsened mood on sleep architecture.

4.2. Marital status, sleep quality, and sleep architecture

Single women with MBC had significantly worse sleep quality than married women. Further our findings demonstrate that single women have less TST, more WASO, and worse SE than married counterparts, which is consistent with studies on sleep quality in marriage [21–23]. Sleep architecture also significantly differed, with single women having reduced REM sleep and stage 2 sleep at home. These findings demonstrate a link between marriage and improved sleep and suggest that having a stable partner also may stabilize sleep, which also is consistent with studies that have examined the role of social rhythms in entraining biologic rhythms and sleep [20,47–49].

Breast cancer and its treatment often create lasting problems with sleep including insomnia [9]. Although biologic changes that can affect sleep have been reported in women with breast cancer (e.g., diurnal cortisol disruption, menopause) [50–53], it might be that marriage provides both psychological and social benefits that support regular sleep habits and improve sleep quality [48]. In contrast, a negative relationship emerged in a study on the role of spousal sleep problems and partner health, indicating that worse health and well-being of the partner are associated with greater spousal sleep problems (e.g., depressed mood, unhappiness) [23]. Although we were not able to measure our participants' spousal sleep problems, it is promising to see a positive association with marriage and improved sleep quality. However, more research is needed to examine the role of marriage as it relates to objective and subjective sleep quality in women with MBC. To our knowledge, our study was the first study to examine the relationship of depression and marital status on objective sleep quality and architecture.

4.3. Depressed and single: adverse effects on sleep

The collective effect of being depressed and single with MBC revealed the most significant sleep quality and architecture disturbances. Although there is little research examining the role of marriage, sleep, and cancer, studies have demonstrated considerable psychological benefits of marriage on sleep [22], especially for individuals who reported premarital depression [54]. Another study that examined the effect of cancer and marital stability demonstrated that, while having cancer does not negatively impact marriage rates in women, individuals with breast cancer were notably less likely to be married [55]. It is unclear why women with breast cancer differ in marital status, but it may be that cancer-related stressors, age at onset, or the constellation of treatment side effects experienced by women with breast cancer (e.g., early menopause, sexual dysfunction) play a role [56,57]. Our findings are consistent with studies that have found that women who were separated or divorced had greater sleep disturbance [21]. Overall, married women in our sample had improved sleep even in the laboratory and away from their husbands, which suggests greater psychological effects of having a husband rather than physical effects on regulating sleep, especially among depressed women. Greater disturbances in sleep for depressed and single women with MBC suggest that these women also may be at greater risk for immune compromise [58]. Thus the benefit of marriage, especially for depressed women with metastatic breast cancer, appears to be central for improved sleep quality and architecture among women with MBC.

4.4. Comparisons of home PSG to laboratory PSG

Although the findings using at-home and laboratory PSG generally were consistent, they revealed greater disturbance in REM sleep associated with depression at home. Stage 2 sleep and REM sleep latency were equally disturbed in both environments, though differences in stage 1 sleep and SWS only emerged in the laboratory setting. For women who were single relative to married women, there were greater disturbances in their sleep in TST, WASO, SE, stage 2 sleep and REM sleep at home; however, laboratory findings revealed that the only differences in sleep disturbance emerged from stage 1 and 2 sleep.

Several studies have investigated the reliability and validity of objectively PSG measured sleep in both at-home and in-laboratory environments [59–61]. PSG-measured sleep at home is considered more reliable than laboratory-measured sleep when patients are fitted with the PSG device by a sleep technician, as in our study [59,62]. Thus it may be possible that substantive differences in sleep emerged in women based on assessment in their familiar home environment. For example, women with MBC may respond to the laboratory environment as a stressor, as many women with breast cancer experience anticipatory anxiety on returning to a hospital setting during treatment [63,64], and likely would experience this anxiety after treatment. In a study that investigated home-based and in-hospital PSG to measure obstructive sleep apnea, findings revealed improved sleep at home (e.g., improved SE, longer REM) compared to laboratory sleep [59]. Although greater sleep disturbances occurred in the laboratory for women overall, the differences that emerged among depressed or single women were robust and accounted for even greater discrepancies in sleep quality and architecture compared to nondepressed or married counterparts.

4.5. Study limitations

Our analyses were cross-sectional; however, the three nights of PSG-measured sleep strengthened our objective measurement of sleep in women with MBC. Analyses also were limited due to our sample size, and although we investigated a number of relationships with our sleep variables, at-home and in-laboratory PSG significantly differed, indicating that these two measures should be separately examined. Utilizing categorical rather than continuous analysis of measures of depression might have reduced our power to detect an effect of depression on sleep. Due to the low number of women in our sample with full clinical depression on the CES-D and SCID, we chose to compare groups with clinically meaningful elevation of scores on the CES-D in comparison to those who had few depressive symptoms. Further, sleep and pain medication use may have affected sleep architecture in our sample; however, the relationships between these medications and our sleep outcomes were not sizeable ($r < 0.30$). The generalizability of the study also was limited due to our sample of predominately non-Hispanic white women, with a relatively high education and socioeconomic status. Further, data were only collected on women with MBC, and thus we cannot generalize our results to women in earlier stages of breast cancer or to other individuals, including men with metastatic disease.

5. Conclusion

Our findings demonstrate that depressed or single women with MBC have disturbed sleep, including increased light NREM sleep, reduced SWS and REM sleep, and poor sleep quality. Marriage seemed to protect sleep quality and normalize sleep architecture in the presence of depression, even when women slept alone in

the laboratory. Depressed and single women with MBC appear to be at the highest risk for objective sleep disturbances and may derive greater benefit from clinical interventions. Future studies would be useful and should examine how mood, marriage, and sleep disturbance are related to endocrine and immune function. These studies are central to identifying potential treatment methods that may improve depression, sleep, and other aspects of quality of life among women with breast cancer.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2013.07.012.

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