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Predictors of Fatigue 30 Days After Completing Anthracycline Plus Taxane Adjuvant Chemotherapy for Breast Cancer

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Breast cancer is the most common type of cancer in women in the United States (Jemal et al., 2008). Women treated with adjuvant chemotherapy for breast cancer of all stages have an 89% five-year survival rate (Jemal et al.). Taxane chemotherapy increasingly is used to improve survival (Ferguson, Wilcken, Vagg, Ghersi, & Nowak, 2007); however, chemotherapy can result in distressful, debilitating fatigue in approximately a third of survivors that persists for years after completing treatment (Bower et al., 2006; National Comprehensive Cancer Network [NCCN], 2008). As the number of breast cancer survivors who have received adjuvant chemotherapy increases, improving fatigue and other symptoms becomes increasingly important to optimize quality of life (Andrykowski, Schmidt, Salsman, Beacham, & Jacobsen, 2005; Janz et al., 2007; Lee, Cho, Miaskowski, & Dodd, 2004).

Fatigue is defined by NCCN (2008) as “a distressing, persistent, subjective sense of physical, emotional, and/or cognitive tiredness, or exhaustion related to cancer or cancer treatment that is not proportional to recent activity and interferes with usual functioning” (p. FT1). Cancer-related fatigue has been associated with disrupted circadian rhythms, disturbed sleep-wake, and activity rest (Ancoli-Israel et al., 2006; Berger & Farr, 1999). Gaps exist in knowledge regarding the predictability of these rhythms and patterns prior to and during the initial chemotherapy treatment as they affect fatigue after treatment.

The current study attempted to answer a clinically significant question: At the initiation of chemotherapy, can clinicians predict who will experience greater fatigue 30 days after completing chemotherapy? This knowledge is important for clinicians to identify women with breast cancer who are most in need of interventions to prevent persistent, debilitating fatigue. Currently, the strongest evidence-based intervention that has been recommended for practice by the Oncology Nursing Society’s (ONS’s) Putting Evidence into Practice® (PEP) card (Mitchell, Beck, Hood, Moore & Tanner, 2006) and NCCN (2008) to treat fatigue is exercise and activity en-

Purposes/Objectives: To identify the predictors of fatigue 30 days after completing adjuvant chemotherapy for breast cancer and whether differences are observed between a behavioral sleep intervention and a healthy-eating attention control group in predicting fatigue.

Design: Descriptive, exploratory, secondary analysis of a randomized clinical trial.

Setting: Outpatient oncology patients in a midwestern U.S. city.

Sample: 96 women, ages 29–83 years, 72% married, 95% white, diagnosed with stage I–IIIA breast cancer, receiving adjuvant anthracycline and taxane chemotherapy.

Methods: Participants were randomized to a behavioral sleep intervention group or an attention control group. Participants completed data collection prior to and during the peak and rebound days of the initial chemotherapy treatment cycle and after the last treatment.

Main Research Variables: Fatigue, circadian rhythms of activity, objective and subjective sleep-wake, and objective and subjective activity-rest.

Findings: Predictors of fatigue were less total sleep time prior to treatment, higher fatigue prior to treatment and at the peak, and less energy upon awakening on rebound days. In the control group, predictors of higher fatigue were higher fatigue prior to treatment, higher body mass index, higher number of positive lymph nodes, and less daytime dysfunction. For the intervention group, lower peak activity at the peak of initial treatment differentially predicted fatigue.

Conclusions: Results suggest the sleep intervention group participants who maintained activity balanced with sleep at the peak of the initial treatment benefited most from the intervention.

Implications for Nursing: Nurses should screen for fatigue prior to initial chemotherapy treatment and at regular intervals, further assess for poor sleep in patients who report fatigue of 4 or higher (on a 0–10 scale), and use evidence-based guidelines to select appropriate interventions.

hancement. Interventions to promote healthy circadian rhythms of activity, sleep-wake, activity-rest patterns potentially may reduce fatigue’s dramatic effect on

women's physical and social functioning, quality of life, and disability (NCCN; Prue, Rankin, Allen, Gracey, & Cramp, 2006). This randomized controlled trial (RCT) was developed after pilot testing the feasibility and outcomes and revision of a behavioral sleep intervention (Berger et al., 2002, 2003).

Conceptual Framework

The conceptual framework for the current study (see Figure 1) was derived from the Integrated Fatigue Model (IFM) (Piper et al., 1998; Piper, Lindsey, & Dodd, 1987). The components from the IFM that were proposed to influence fatigue were regulation and transmission (circadian rhythms of activity), sleep-wake, and activity-rest patterns.

The purposes of the study were to identify the predictors of fatigue 30 days after completing anthracycline plus taxane adjuvant chemotherapy for breast cancer using fatigue, circadian rhythms of activity, sleep-wake, activity-rest, and demographic and medical variables measured prior to and during the peak and rebound of the initial chemotherapy treatment and to determine whether differences exist between a behavioral sleep intervention group and a healthy eating attention control group in predicting fatigue 30 days after completing chemotherapy treatments.

Methods

The current descriptive, exploratory study was a secondary analysis of data from an RCT that tested a behavioral sleep intervention compared to a healthy eating attention control in women with stages I–III breast cancer at initiation of chemotherapy. For the secondary analysis,

participants completed data collection prior to (days –2 to –1) and during the peak (days 2–4) and rebound (days 5–7) of the initial chemotherapy treatment and for 7 days and 30 days after the last chemotherapy treatment.

Setting and Sample

The RCT recruited participants (N = 219) from outpatient oncology clinics in a large midwestern city. Inclusion criteria for the RCT were women ages 19 and older who were diagnosed for the first time with stage I, II, or IIIA breast cancer; were post-breast cancer surgery (lumpectomy or mastectomy with or without reconstruction); were scheduled to begin adjuvant anthracycline-based IV chemotherapy for breast cancer; were English-speaking; and had a Karnofsky Performance Scale (KPS) score of greater than or equal to 60. Exclusion criteria were unstable comorbidities and an erratic sleep schedule (rotating shift worker).

Only findings from the participants who received anthracyclines plus taxanes are reported in the secondary analysis. Of the 103 eligible participants, 96 who provided data prior to and at peak and rebound days of the initial chemotherapy treatments, are included in the analysis.

As an exploratory study, choice of predictors was driven by the data as well as by theory. Probability values (and significance tests) are not accurate in this situation, but power still was estimated to help identify a reasonable model size. A model with 28 predictors (up to 14 predictors and their product variables) that explains 40% of the variance will have power of 0.80 to test individual predictors that uniquely explain at least 3% of the variance if using a liberal alpha level of 0.20.

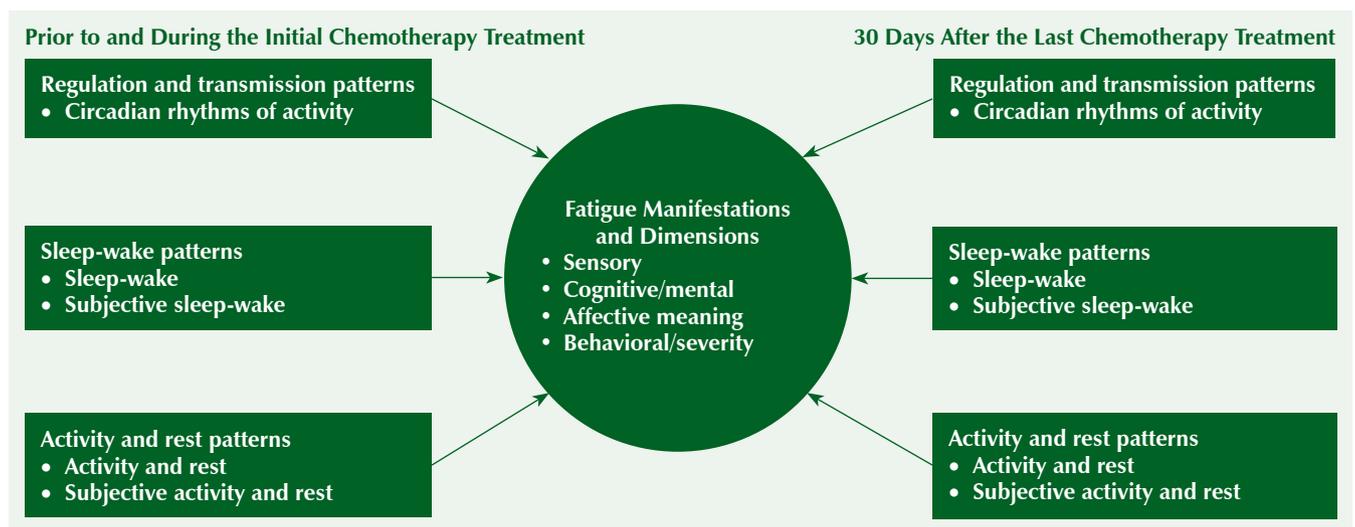


Figure 1. Conceptual Model of Factors Influencing Fatigue Experienced by Women With Stage I, II, or IIIA Breast Cancer

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Measurement of Variables

Measurements and timing of the key variables used in the current study are shown in Table 1.

Fatigue: Fatigue was measured using the 22-item multidimensional revised **Piper Fatigue Scale (PFS)** (Piper et al., 1998). The 22 numerically scaled (0–10) items with word anchors measure four dimensions of subjective fatigue (behavioral/severity, sensory, cognitive/mood, and affective meaning). Excellent validity and reliability have been reported (Fu, LeMone, McDaniel, & Bausler, 2001; Piper et al., 1998). High estimates of internal consistency reliability (Cronbach alpha) have been reported for the subscales and total PFS scores in women with early-stage breast cancer (Berger, 1998; Berger et al., 2002). Cronbach alpha in the study for the total PFS score ranged from 0.97–0.98.

Circadian rhythms of activity and objective sleep-wake and activity-rest: **Octagonal Motionlogger™ actigraphs** (Ambulatory Monitoring, Inc.) were used to quantify the movements of the wrist to yield circadian rhythms of activity, sleep-wake, and activity-rest indicators (Mormont et al., 2000). They determine sleep versus

activity based on the assumption that individuals move less when asleep and more when awake (Ambulatory Monitoring, Inc., 2005; Ancoli-Israel et al., 2003). The device is the size of a man's wristwatch and is worn on the nondominant wrist. The actigraphs recorded activity counts in one-minute epochs (intervals) per recent guidelines (Littner et al., 2003). Actigraphs have been reported to have 88% accuracy at distinguishing wakefulness from sleep when compared to the gold standard of polysomnography (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992; Mullaney, Kripke, & Messin, 1980). The definitions of specific actigraphy variables are shown in Figure 2.

Subjective sleep-wake: An item from the daily diary, measuring "energy upon awakening," was used to measure subjective sleep-wake. The item asked the participants to rate from 1–5 "When I got up this morning, I felt ___" (1 = exhausted, 5 = refreshed). Each morning of data collection, information about the prior night's bed time and morning wake time also were recorded in the daily diary, and the times were used to distinguish day and night intervals in actigraphy files (Littner et al., 2003).

Table 1. Data Collection Timetable

Variable Group	Measurement	Prior ^a	Peak ^b	Rebound ^c	Completion ^d
Fatigue	PFS	Day –2	Day 3	–	Day 1
Circadian rhythms of activity Peak activity 24-hour autocorrelation	Actigraphy ^e	48 hours	72 hours	72 hours	168 hours
Objective sleep-wake Total sleep time	Actigraphy ^e	48 hours	72 hours	72 hours	168 hours
Subjective sleep-wake Energy upon awakening	Daily diary	Two days from daily diary ^f	Three days from daily diary ^f	Three days from daily diary ^f	Seven days from diary ^f
Daily dysfunction	PSQI	Day –2	–	–	Day 1
Objective activity-rest Sleep percent (day)	Actigraphy ^e	48 hours	72 hours	72 hours	168 hours
Subjective activity-rest PCS	PCS	Day –2	–	–	Day 1
Demographic or medical characteristics					
Body mass index	Medical record	Day 0	–	–	–
Hemoglobin	Medical record	Day 0	–	–	–
Lymph node status	Medical record	Day 0	–	–	–
KPS	KPS	Day –2	–	–	–

^a Two-day measurement period prior to receiving the initial chemotherapy treatment

^b Three-day measurement period during days 2–4 of the initial chemotherapy treatment; PFS measured on day 3

^c Three-day measurement period during days 5–7 of the initial chemotherapy treatment

^d Seven-day measurement period 30 days following completion of the last chemotherapy treatment

^e Wrist actigraphy—worn continuously

^f Mean of daily values

KPS—Karnofsky Performance Scale; PCS—Physical Component Summary of the SF-36®, version 2; PFS—Piper Fatigue Scale; PSQI—Pittsburgh Sleep Quality Index

24-Hour Autocorrelation

The extent to which activity levels within 24 hours correlate with levels of another 24 hours (Lentz, 1990); this serves as an index of robustness of the circadian rhythm (Ambulatory Monitor, Inc., 2005; Rich et al., 2005).

Peak Activity

Mean activity level plus the highest activity level of an individual's circadian rhythm of activity (Lentz, 1990)

Sleep Percent (Day)

The total number of minutes of sleep during the day divided by the total wake time (Young-McCaughan et al., 2003).

Total Sleep Time

The number of minutes asleep while in bed (Berger et al., 2005)

Figure 2. Definitions of Variables Obtained by Actigraphy

Subjective sleep-wake during the prior month was measured using the **Pittsburgh Sleep Quality Index (PSQI)** (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). A 19-item questionnaire, the PSQI yields a global score and seven component scores, one of which is daytime dysfunction. Each item is rated on a 0–3 scale with global scores ranging from 0–21. Higher scores indicate poorer sleep quality. Excellent internal reliability consistency (Cronbach alpha range 0.73–0.94) and construct validity (convergent, discriminant, and divergent) have been reported for a sample that included women with early-stage breast cancer (Berger et al., 2002; Carpenter & Andrykowski, 1998).

Subjective activity-rest: The Physical Component Summary (PCS) of the SF-36®, version 2 (Ware, Kosinski, & Dewey, 2000) was used to measure subjective activity-rest. Internal consistency (Cronbach alpha) was calculated for each of the SF-36 subscales because it is inappropriate to calculate internal consistency on the PCS with its positive and negative weighting. In the sample, Cronbach alpha for the subscales ranged from 0.69–0.93.

Demographic and medical characteristics: This form included the demographic and medical characteristics of the sample. Medical charts were reviewed by research nurses to obtain height, weight, and hemoglobin.

Procedure for Data Collection

The study was approved by a university institutional review board. Participants were randomized to the behavioral sleep intervention group or the healthy-eating, attention control group. Group randomization was stratified by number of planned chemotherapy treatments (4 or > 4) and self-identified type of sleeper (good or poor), using item number 6 from the PSQI. Data collection procedures were identical for the two groups with the exception of the forms used for delivery of the intervention. The intervention group received the behavioral sleep intervention from a trained research nurse. The behavioral sleep interven-

tion involved developing an Individualized Sleep Promotion Plan (ISPP) that consisted of sleep restriction, stimulus control, relaxation therapy, and sleep hygiene counseling. The intervention was implemented at the first visit, reinforced on day 8 of each treatment, and revised 2 days prior to each subsequent treatment and at 30, 60, and 90 days after completing chemotherapy. Additional intervention details are described in the pilot study reports (Berger et al., 2002; 2003). Participants in the control group were given equal time and attention and new information about healthy eating and general conversation at each visit.

Statistical Analysis

SPSS® 13.0 for Microsoft® Windows® was used to perform the statistical analysis. To address the first purpose of the study, zero-order correlations were used to evaluate predictors for inclusion. Hierarchical multiple regression was used for exploratory model building to predict the levels of fatigue 30 days after completing chemotherapy treatment from predictors chosen from the study variables and sample characteristics.

To address the second purpose of the study, the regression model was extended by adding calculated product variables for each of the continuous predictors. To reduce the multicollinearity likely to occur with inclusion of product variables, predictors were centered by subtracting the mean of a variable from the variable's value (Cohen, Cohen, West, & Aiken, 2002) prior to multiplication by the dummy-coded grouping variable.

Results

The 96 women included in the sample ranged in age from 29–83. The typical participant was married, living with someone who was not a dependent, and White non-Hispanic. All received anthracycline-based (doxorubicin) adjuvant chemotherapy regimens for breast cancer plus a taxane; some received standard dosing (every three weeks) and others received dose dense (every two weeks) chemotherapy. Demographic characteristics of the sample are shown in Table 2. The two groups did not significantly differ prior to starting chemotherapy treatment.

The correlation of each study variable with total PFS score at treatment completion was evaluated to select predictors. A significance level of $p \leq 0.20$ for the correlation was used as a cutoff for inclusion, following a model-building strategy outlined by Hosmer and Lemeshow (2000). Attention was given to selecting variables from each variable group included in the study. As indicated in the power analysis, the sample size of the secondary analysis constrained the number of predictors that could be included in the model. Multicollinearity among available variables presented an additional limitation. When

Table 2. Demographic and Medical Characteristics of Sample

Characteristic	Intervention (n = 53)			Control (n = 43)			Total (N = 96)		
	\bar{X}	SD	Range	\bar{X}	SD	Range	\bar{X}	SD	Range
Age (years)	49.3	9.1	29–71	52.4	11.4	35–83	50.7	10.3	29–83
Body mass index	27.9	6.9	16–49	29.4	5.0	20–39	28.6	6.2	16–49
Hemoglobin day 1 ^a	13.0	1.2	10.3–15.2	12.9	1.2	10.3–15.1	12.9	1.2	10.3–15.2
Characteristic	n	%	n	%	n	%			
Race									
Black	2	4	3	7	5	5			
White	51	96	40	93	91	95			
Ethnicity									
Hispanic	1	2	2	5	3	3			
Non-Hispanic	52	98	41	95	93	97			
Marital status									
Single or never married	6	11	4	9	10	10			
Married	37	70	32	74	69	72			
Separated or divorced	9	17	4	9	13	14			
Widowed	1	2	3	7	4	4			
Employment									
Professional	25	47	16	37	41	43			
Service	13	25	16	37	29	30			
Homemaker	8	15	2	5	10	10			
Retired	5	9	7	16	12	13			
Unemployed	2	4	1	2	3	3			
Student	–	–	1	2	1	1			
Karnofsky Performance Scale score									
60	1	2	–	–	1	1			
70	2	4	2	5	4	4			
80	5	9	5	12	10	10			
90	17	32	15	35	32	33			
100	28	53	21	49	49	51			
Cancer stage									
I	3	6	5	12	8	8			
II	39	74	27	63	66	69			
IIIA	11	21	11	26	22	23			
Lymph node status									
Negative	12	23	13	30	25	26			
Positive 1–3	32	60	20	47	52	54			
Positive 4–9	9	17	10	23	19	20			
Surgical procedure									
Lumpectomy	20	38	18	42	38	40			
Modified mastectomy	13	25	12	28	25	26			
Modified mastectomy with reconstruction	20	38	13	30	33	34			
Chemotherapy protocol									
Adriamycin and cytoxan times four followed by taxane times four every two weeks	33	62	26	61	59	62			
Adriamycin and cytoxan times four followed by taxane times four every three weeks	13	25	9	21	22	23			
Adriamycin and cytoxan times four every three weeks followed by taxane every week times 12	4	8	4	9	8	8			
Adriamycin and cytoxan times four every two weeks followed by taxane every week times 12	2	4	3	7	5	5			
Adriamycin and cytoxan times six followed by taxane times four every two weeks	1	2	–	–	1	1			
Adriamycin and cytoxan times four every two weeks followed by taxane times four every three weeks	–	–	1	2	1	1			

^aN = 82 because of missing data.

Note. Because of rounding, not all percentages total 100.

Note. No significant differences between groups on any variable at alpha = 0.05

predictors within a variable group and measured at the same time were highly correlated with each other, the one with the strongest correlation with fatigue 30 days after completing treatment was selected.

A total of 13 predictors were included in the prediction model along with a dummy-coded variable representing the RCT group assignment (0 = intervention). Predictor variables measured prior to chemotherapy were fatigue (PFS), body mass index (BMI), hemoglobin, lymph node status, daytime dysfunction (PSQI), PCS, KPS score, and total sleep time at night (actigraph). Variables measured at the peak were fatigue (PFS) and peak activity (actigraph). Variables measured at the rebound were 24-hour autocorrelation (actigraph), energy upon awakening (daily diary), and sleep percent during the day (actigraph). Table 3 details the descriptive statistics of the 13 predictors as well as the zero-order correlations of the predictors with the outcome of fatigue 30 days after completing treatment.

Of the 96 participants included in the secondary analysis, 60 had complete data; 35 cases were missing a few values, usually on 1 or 2 variables. One case had missing values on multiple variables and, therefore, was excluded. Those with missing data differed ($p < 0.20$) from those with complete data on day 1 hemoglobin ($p = 0.03$), PCS prior to treatment ($p = 0.13$), and amount of energy upon awakening at rebound ($p = 0.11$). Missing values were imputed using the expectation

maximization in SPSS Missing Values Analysis 13.0 module, which assumes data are missing at random. To strengthen the imputation model, a small number of additional variables correlated with the predictors having incomplete data were included in calculation of missing values (Collins, Schafer, & Kam, 2001). To preserve possible interactions of the intervention group with other predictors, imputation was conducted for each group independently and then combined into a single dataset.

The list of predictors was organized temporally into four groups for entry into the hierarchical regression model, with the intervention group added at a fifth step. This allowed evaluation of whether factors occurring at later points added significantly to what could be explained by previously existing characteristics.

Multiple Regression Results of Fatigue Regressed on Selected Predictors: Model 1

Because of the exploratory nature of the analysis, a liberal significance level of $p \leq 0.20$ was used to evaluate individual regression coefficients as well as changes in R^2 as sets of variables were added. Table 4 presents the model summary for each step of the model. Change in R^2 as sets of variables were added was significant only at step 1 ($p < 0.001$), in which variables measured prior to treatment were entered, and at step 3 ($p = 0.05$), in which fatigue and peak activity at the peak (days 2–4) were

Table 3. Descriptive Statistics and Pairwise Correlations of 13 Predictors With Fatigue Measured 30 Days Following Completion of Chemotherapy Treatment by Groups

Measurement Time	Key Variables and Measurements	Study Groups								
		Total ^a			Intervention ^b			Control ^c		
		\bar{X}	SD	r	\bar{X}	SD	r	\bar{X}	SD	r
Prior	Fatigue (PFS total score)	2.73	1.99	0.39***	2.89	2.01	0.35*	2.53	1.98	0.46**
	Body mass index	28.59	6.16	0.15	27.92	6.92	0.08	29.42	5.01	0.27
	Day 1 hemoglobin	12.94	1.18	-0.19	12.96	1.21	-0.21	12.93	1.15	-0.15
	Lymph node status			0.10			-0.04			0.23
	Daytime (PSQI) dysfunction	0.58	1.02	0.23*	0.90	0.63	0.36*	0.98	0.74	0.10
	Physical component summary	43.58	9.58	-0.28*	43.56	9.73	-0.22	43.60	9.51	-0.35*
	KPS score	–	–	-0.21*	–	–	-0.23	–	–	-0.20
	Total sleep time	421.39	9.03	-0.24*	430.26	83.66	-0.17	410.30	95.22	-0.30
Peak	Fatigue (PFS total score)	4.85	2.23	0.33**	5.00	2.24	0.39**	4.68	2.22	0.27
	Peak activity	176.46	46.17	-0.13	176.94	49.34	-0.31*	175.90	42.86	0.08
Rebound	24-hour autocorrelation	0.43	0.16	-0.24*	0.43	0.17	-0.32*	0.41	0.15	-0.16
	Energy upon awakening	3.41	0.92	-0.35***	3.31	0.93	-0.44**	3.54	0.91	-0.26
	Sleep percent (day)	11.47	8.77	0.18	12.24	10.01	0.39**	10.58	7.08	-0.11

^a Total sample (N = 96) range of sample sizes for correlations was 77–89.

^b Intervention group (n = 53) range of sample sizes for correlations was 40–48.

^c Control group (n = 43) range of sample sizes for correlations was 38–41.

* $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

KPS—Karnofsky Performance Scale; PFS—Piper Fatigue Scale; PSQI—Pittsburgh Sleep Quality Index

Table 4. Model 1: Summary of Multiple Regression Results for Fatigue Regressed on Selected Predictors at Treatment Completion

Step	R ²	Adjusted R ²	R ² Change	p (R ² change)
1	0.206	0.171	0.206	< 0.001
2	0.256	0.187	0.050	0.227
3	0.306	0.224	0.050	0.053
4	0.335	0.228	0.029	0.323
5	0.339	0.223	0.004	0.510

N = 95

entered. In some cases, individual predictors were significant even when the test of the set of variables added was not.

Coefficients for Model 1 with all 14 predictors are presented in Table 5. Four variables were significant predictors of fatigue at treatment completion: fatigue prior to treatment ($p = 0.007$), total sleep time prior to treatment ($p = 0.13$), fatigue at the peak ($p = 0.12$), and amount of energy upon awakening at rebound ($p = 0.09$). Each of these variables also had been a significant predictor at the step in which it entered the model and remained so as other variables were added. The remaining variables were not significant at any step, with the exception of BMI. BMI was not significant in the final model ($p = 0.59$), but was significant ($p < 0.12$) when it entered the model in the first step. It no longer made a unique contribution once step 2 variables were added.

Multiple Regression Results of Fatigue Regressed on Selected Predictors and Product Variables: Model 2

To evaluate whether relationships of the predictors and fatigue 30 days after completing chemotherapy varied by group, product variables were added in a sixth step. This resulted in large variance inflation factors (VIF), indicating high multicollinearity. Removing product variables with p values greater than 0.20 reduced VIF values with little effect on the regression coefficients of the remaining predictors. The reduced model is presented as Model 2 in Table 6.

Adding the five product variables significantly increased the R^2 by 0.10 ($p = 0.03$) to 0.440 (adjusted $R^2 = 0.299$, $p < 0.001$), suggesting significant differences between the groups in the relationships of some of the predictors with fatigue 30 days after completing treatment, controlling for other predictors in the model.

The only variable in the reduced model from the earlier steps that was significant independently was the amount of energy upon awakening at rebound ($p < 0.02$). Those with less energy upon awakening at rebound (days 5–7) had higher fatigue at treatment completion with no difference between groups. Although peak activity at the

peak (days 2–4) was significant ($p < 0.07$), it was not interpreted because of its significant interaction with the group.

To interpret the group differences in prediction, separate regression coefficients for each predictor were calculated. The unstandardized coefficient for the original variable represents the relationship of that variable to fatigue 30 days after completing treatment for the intervention group (coded 0). The regression coefficient for the associated product variable indicates the amount that the control group's coefficient differs from that of the intervention group. Adding the two values yields the coefficient for the control group (coded 1). By running the model again with the coding reversed, a p value for the coefficient for the control group was obtained.

Higher fatigue prior to treatment was related significantly to higher fatigue 30 days after completing treatment in the control group (0.484, $p < 0.001$) but not in the intervention group (0.123, $p = 0.46$). A similar pattern was observed for BMI prior to treatment, with a significant positive relationship for the control group (0.097, $p = 0.19$) but not for the intervention group (-0.016 , $p = 0.72$). More positive lymph nodes predicted higher fatigue at treatment completion in the control group (0.935, $p = 0.04$), but not in the intervention group (-0.441 , $p = 0.34$). Lower daytime dysfunction (PSQI) prior to treatment predicted higher fatigue in the control group (-0.744 , $p = 0.11$), but not in the intervention group (0.492, $p = 0.39$). Peak activity at the peak of treatment in the intervention group had a coefficient of -0.012 ($p = 0.07$), indicating that in the group, lower peak activity during the peak of the initial treatment predicted higher fatigue at treatment completion. The coefficient in the control group was not significant (0.008, $p = 0.31$).

Discussion

This secondary analysis was able to identify the predictors of fatigue 30 days after completing anthracycline-based plus taxane adjuvant chemotherapy for breast cancer. Four predictors of higher fatigue 30 days after completing treatment were identified. These predictors were less total sleep time prior to treatment, higher fatigue prior to and at the peak of treatment, and less energy upon awakening at rebound from the initial treatment. Fatigue prior to treatment was the strongest predictor of later fatigue.

This is the first report that identifies predictors of fatigue 30 days after completing chemotherapy from measurements collected prior to and during the initial week of treatment.

Previous descriptive studies have reported associations between fatigue and other variables selected for inclusion in the secondary analysis. Ancoli-Israel et al. (2006) described patterns of fatigue, sleep, and circadian rhythms in 85 women with breast cancer prior to the

Table 5. Model 1^a: Multiple Regression Results of Fatigue Regressed on Selected Predictors 30 Days After Completing Chemotherapy Treatment

Step	Variable	Coefficient			
		B	SE	Beta	p
Prior ^b	Fatigue (PFS Total)	0.331	0.120	0.307	0.007**
	Body mass index	0.021	0.038	0.058	0.587
	Hemoglobin	-0.030	0.184	-0.016	0.870
	Lymph node status	0.183	0.324	0.057	0.574
Prior ^b	Daytime dysfunction (PSQI)	-0.120	0.353	-0.037	0.735
	PCS	-0.002	0.028	-0.007	0.951
	Karnofsky Performance Scale	-0.080	0.278	-0.033	0.773
	Total Sleep Time	-0.004	0.003	-0.171	0.128*
Peak ^c	Fatigue (PFS Total)	0.164	0.104	0.167	0.120*
	Peak activity	-0.004	0.005	-0.087	0.423
Rebound ^d	24-hour autocorrelation	-1.009	1.852	-0.071	0.587
	Amount of energy upon awakening	-0.454	0.262	-0.191	0.087*
	Sleep percent (day)	-0.007	0.034	-0.028	0.832
Grouping variable	Grouping variable	0.272	0.412	0.062	0.510

N = 95

*p < 0.20; **p < 0.05

^aR²_(14,80) = 0.339, p = 0.001 (adjusted R² = 0.223)

^bTwo-day measurement period prior to receiving the initial chemotherapy treatment

^cThree-day measurement period during days 2–4 of the initial chemotherapy treatment

^dThree-day measurement period during day 5–7 of the initial chemotherapy treatment

PCS—Physical Component Summary of the SF-36®, version 2; PFS—Piper Fatigue Scale; PSQI—Pittsburgh Sleep Quality Index

Note. Table presents results for all predictors in model simultaneously in step 5.

initial chemotherapy treatment. Although no relationships were found between fatigue and circadian rhythms of activity and objective sleep-wake prior to initial treatment, significant relationships exist between fatigue and subjective sleep-wake and activity-rest measures. Berger (1998) described patterns of lower circadian rhythms of activity that were associated with higher fatigue during the first four days after the initial treatment. The current study is important because it adds to the understanding of the variables related to fatigue prior to and during initial chemotherapy that are predictive of fatigue after completion of chemotherapy treatment. This is an important area of study because receiving adjuvant chemotherapy, compared to radiation, has been shown to significantly predict higher fatigue at treatment completion (Andrykowski et al., 2005), and fatigue is the most common symptom reported by survivors (Janz et al., 2007).

The secondary analysis also determined the differences between a behavioral sleep intervention and a healthy-eating, attention control group in predicting fatigue 30 days after completing chemotherapy treatments. When group assignment was added to the key variables, five of the variables predicted higher fatigue based on the group. For control group participants, values prior to treatment of higher fatigue and daytime

dysfunction, higher BMI, and more positive lymph nodes predicted higher fatigue 30 days after completing treatment. Individual factors prior to initiation of chemotherapy, such as fatigue levels, BMI, and lymph node status, appear to play a role above and beyond that contributed by the chemotherapy regimen in women's perceptions of fatigue after completing treatment.

For sleep intervention participants, lower peak activity (less activity during the day and more at night as measured by actigraphy) was the only predictor of higher fatigue 30 days after completing treatment. The result suggests that those in the sleep intervention group who were able to maintain day activity balanced with night sleep at the peak of the initial treatment benefited most from the intervention. In addition, these results suggest that the sleep intervention was able to decrease the effects of the factors that predicted higher fatigue in the control group at treatment completion. No other studies have used a behavioral sleep intervention to reduce fatigue in women with breast cancer; therefore, the findings cannot be compared. A limited number of small studies have used a behavioral sleep intervention to relieve fatigue in patients with cancer (Berger et al., 2002, 2003; Mitchell et al., 2007).

The results are useful for hypothesis generation and guiding future study. However, interpretation of the

Table 6. Model 2^a: Multiple Regression Results of Fatigue Regressed on Selected Predictors and Product Variables 30 Days After Completing Chemotherapy Treatment

Step	Variable	Coefficients			
		B	SE	Beta	p
Prior ^b	Fatigue (PFS Total)	0.123	0.165	0.114	0.459
	Body mass index	-0.016	0.044	-0.044	0.724
	Hemoglobin	-0.142	0.186	-0.075	0.448
	Lymph node status	-0.441	0.459	-0.138	0.340
Prior ^b	Daytime dysfunction (PSQI)	0.492	0.566	0.153	0.388
	PCS	-0.006	0.027	-0.024	0.835
	Karnofsky Performance Scale	-0.253	0.274	-0.104	0.360
	Total sleep time	-0.003	0.003	-0.111	0.327
Peak ^c	Fatigue (PFS total)	0.113	0.103	0.115	0.274
	Peak activity	-0.012	0.006	-0.250	0.065*
Rebound ^d	24-hour autocorrelation	-0.354	1.852	-0.025	0.849
	Amount of energy upon awakening	-0.638	0.261	-0.269	0.017**
	Sleep percent (day)	-0.033	0.036	-0.130	0.366
Grouping variable	Grouping variable	0.269	0.396	0.062	0.498
Product variables	Fatigue (PFS) prior times group	0.361	0.220	0.219	0.105*
	Body mass index times group	0.097	0.073	0.150	0.189*
	Lymph node status times group	1.376	0.626	0.310	0.031**
	Daytime dysfunction (PSQI) times group	-1.236	0.749	-0.280	0.103*
	Peak activity times group	0.019	0.010	0.254	0.051*

N = 95

*p < 0.20; **p < 0.05

^aR²_(19, 75) = 0.440, p < 0.001 (adjusted R² = 0.299)

^bTwo-day measurement period prior to receiving the initial chemotherapy treatment.

^cThree-day measurement period during days 2–4 of the initial chemotherapy treatment.

^dThree-day measurement period during day 5–7 of the initial chemotherapy treatment.

PCS—Physical Component Summary of the SF-36®, version 2; PFS—Piper Fatigue Scale; PSQI—Pittsburgh Sleep Quality Index

Note. Table presents results for all predictors and five product variables in model simultaneously in step 6. Variable name X group refers to the product variable. Model results including 13 product variables were R²_(27, 67) = 0.466, p = 0.006 (adjusted R² = 0.250). Product variables with p > 0.30 were removed. Model 2 represents the regression coefficients for the product variables retained.

model was limited by small sample size and multicollinearity. Another limitation is the lack of racial or ethnic diversity in the sample. A strength of the secondary analysis is that although missing data are inherent in studies of human subjects and present challenges, methods were used to maximize the use of available data for analysis.

Recommendations for Research

Using the entire data set of 219 participants, the prediction model could be reanalyzed with increased power to determine stability of the predictors with additional participants who received only anthracycline-based chemotherapy treatments. Also, data analysis from one or all chemotherapy treatments and at later times (60 and 90 days after treatment completion and one year after the initial treatment) may further explain the relationships between circadian rhythms of activ-

ity, sleep-wake, activity-rest, demographic or medical characteristics, and fatigue.

Implications for Practice

NCCN (2008) cancer-related fatigue guidelines recommended education and counseling regarding fatigue patterns as central to effective management. Results of the current study provided information regarding variables prior to treatment that predicted higher fatigue 30 days after completing treatment. The finding assists with identifying those most in need of early and intensive teaching on strategies to manage fatigue. The strongest predictor was the fatigue level of the individual prior to receiving the initial chemotherapy treatment. This supports the simple, and yet widely underused recommendation of the NCCN cancer-related fatigue guidelines to screen all patients for fatigue prior to treatment and at regular intervals.

NCCN (2008) suggested self-monitoring of fatigue levels. Because fatigue levels during the peak of treatment were found to be another strong predictor of fatigue at treatment completion, regular screening for fatigue should include an assessment of the patient's fatigue levels at the peak of treatment. The amount of energy upon awakening at rebound also predicted fatigue at treatment completion. A self-report diary could be completed for seven days after the initial treatment, including ratings of fatigue and an item assessing the energy upon awakening, to further focus teaching on promotion of quality sleep during the next visit to clinic as recommended by the NCCN guidelines.

Less total sleep time prior to treatment also predicted higher fatigue at treatment completion. An evidence-based intervention, such as the behavior sleep intervention tested in the current study, can be initiated in women who identify themselves as poor sleepers prior to treatment. Patient education to promote quality sleep for all women starting adjuvant chemotherapy for breast cancer is a first step. The ONS PEP card for sleep-wake disturbances provides the nurse clinician with information that can be taught to patients to improve their sleep quality (Page, Berger, & Johnson, 2006). Instruction at the initiation of chemotherapy may decrease the fatigue experienced at the peak, affect the amount of energy upon awakening at rebound, and encourage daytime activity (Mitchell et al., 2007).

Ongoing assessment of fatigue and sleep quality will identify individuals who develop these problems after the initial chemotherapy treatment. Intervening as early as possible in the course of chemotherapy offers the potential for lower fatigue at treatment completion, thereby possibly decreasing the disability and quality-of-life issues associated with this distressful symptom.

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