International Journal of Behavioral Medicine
2006, Vol. 13, No. 2, 163–172

Association Between Hot Flashes, Sleep Complaints, and Psychological Functioning Among Healthy Menopausal Women

Rebecca C. Thurston, James A. Blumenthal, Michael A. Babyak, and Andrew Sherwood

Self-report data suggest that sleep hot flashes among menopausal women are associated with sleep problems and in turn impaired psychological functioning. However, few studies have examined these relations with physiologic hot flash measures. A total of 41 perimenopausal and postmenopausal women with daily hot flashes underwent nighttime sternal skin conductance monitoring to quantify hot flashes. Participants completed sleep diaries; the Sleep-Wake Experience List (van Diest, 1990); and depression, anxiety, and daily stress measures. Participants experienced a median of 2 physiologically monitored and 1 reported sleep hot flash nightly. Although sleep complaints were significantly and positively associated with psychological functioning, neither sleep complaints nor psychological functioning was significantly related to frequency of physiologically monitored sleep hot flashes. Conversely, results indicate an association between reported sleep hot flashes and acute sleep problems. The frequency of physiologically monitored sleep hot flashes, as opposed to reported sleep hot flashes, may be independent of problems with sleep and mood among menopausal women.

Key words: hot flashes, menopause, mood, night sweats, sleep, vasomotor symptoms

One of the most common complaints among women transitioning through the menopause is sleep disturbance. Large population-based studies have estimated that 40% to 64% of perimenopausal or postmenopausal women report disturbed sleep (Kravitz et al., 2003; Kuh, Wadsworth, & Hardy, 1997; Ledesert, Ringa, & Breart, 1994; Owens & Matthews, 1998). According to a recent report from the Study of Women's Health Across the Nation (Kravitz et al., 2003), reported sleep difficulties were highest among perimenopausal and surgically menopausal women.

Both the causes and the impact of sleep problems during menopause are not well characterized. However, sleep problems are prevalent in women's lives in years when hot flashes, such as hot flashes and night sweats, peak (Dennerstein et al., 1993; Gold et al., 2000; S. M. McKinlay, Brambilla, & Posner, 1992; Neugarten & Kraines, 1965). Moreover, several studies have indicated increased sleep problems among menopausal women reporting hot flashes (Dennerstein, Dudley, Hopper, Guthrie, & Burger, 2000; Hollander et al., 2001; Kravitz et al., 2003). Therefore, menopausal sleep problems may be due, at least in part, to the occurrence of hot flashes at night.

Sleep disturbance related to menopausal hot flashes may have an important impact on mood. Menopausal women often attribute daytime irritability to nighttime awakenings (Kronenberg, 1990). Moreover, evidence has suggested a rise in mood disturbance among some perimenopausal women (Avis, Brambilla, McKinlay, & Vass, 1994; Bromberger et al., 2003, 2001; Hunter, 1990) and women reporting menopausal symptoms (Bromberger et al., 2003, 2001; Collins & Landgren, 1994). Thus, it has been asserted that mood symptoms among menopausal women are due to disturbed sleep secondary to sleep hot flashes.

Evidence connecting sleep, mood, and hot flashes have been largely derived from studies of self-reported hot flashes. However, self-report measures for sleep hot flashes have important limitations. The accurate reporting of hot flashes during sleep, and particularly their frequency, is very limited. Moreover, comparisons of women with and without reported sleep hot flashes may differ in other important physiological and psychological ways (Moe, 1999). Furthermore, relations between sleep disturbance and hot flashes may be

Rebecca C. Thurston, James A. Blumenthal, Michael A. Babyak, and Andrew Sherwood, Duke University Medical Center, Department of Psychiatry and Behavioral Sciences, Durham, North Carolina.

Rebecca C. Thurston is currently Assistant Professor of Psychiatry at the University of Pittsburgh School of Medicine. We thank Ginger Henshall for her help with preparation of this article. This research was conducted in partial fulfillment of the requirements for a doctoral degree in clinical health psychology at Duke University.

Correspondence concerning this article should be addressed to Rebecca C. Thurston, 3811 O'Hara Street, Pittsburgh, PA 15213. E-mail: thurstonrc@upmc.edu

more indicative of the tendency to awaken from hot flashes among poor sleepers. Thus, physiologic measurement of hot flashes is crucial to accurately assess relations between sleep and hot flashes. It may be particularly important in studies of mood, which may impact symptom perception and reporting (Barsky, Goodson, Lane, & Cleary, 1988; Brantley, Waggoner, Jones, & Rappaport, 1987; Craig, 1994; Thurston, Blumenthal, Babyak, & Sherwood, 2005).

Only three published studies to date of sleep among healthy menopausal women have measured hot flashes physiologically. One study (Erlik et al., 1981) showed waking episodes to be significantly correlated with the occurrence of hot flashes among eight out of nine women with severe and frequent hot flashes. Another study (Woodward & Freedman, 1994) found that women with hot flashes had altered sleep, although in positive and negative directions. Finally, a recent investigation (Freedman & Roehrs, 2004) found no relationships between any aspect of objective or subjective acute sleep indexes and physiologically measured sleep hot flashes. Thus, studies utilizing physiologic hot flash measures have shown mixed relations between hot flashes and sleep. The nature of these relations, including their impact on mood, remains unclear.

In this study, we used ambulatory skin conductance monitoring, a validated physiologic measure of hot flashes (Carpenter, Andrykowski, Freedman, & Munn, 1999; Freedman, 1989), to evaluate the relation between physiologic sleep hot flashes, reported sleep disturbance, and negative mood. We evaluated the following hypotheses: (a) women with more frequent overnight physiologic hot flashes would report increased sleep problems, (b) women with more frequent overnight physiologic hot flashes would report elevated negative mood and daily stress, (c) women with more sleep problems would report increased negative mood and daily stress, and (d) the relation between physiologic sleep flashes and psychological functioning would be mediated by sleep complaints. We examined self-reported hot flashes, sleep, and mood in an exploratory fashion.

Methods

Study Participants

We recruited 52 perimenopausal and postmenopausal women from the Research Triangle community (Raleigh, Durham, and Chapel Hill, NC) via fliers, public service announcements, and newspaper advertisements. The following criteria were required for participants to enter the study: (a) female, (b) age 40 to 60 years, (c) reporting daily hot flashes, and (d) perimenopausal or postmenopausal status (amenorrhea ≥ 3 months or a menstrual period within 3 months with irregularity in menstrual cycle length and/or frequency ≥ 6 months).

The following factors rendered women ineligible for the study: (a) taking the following medications:birth control pills, hormone replacement therapy (HRT), clonidine, tamoxifen, raloxifene, bellargal, tibolone; (b) hysterectomy without bilateral oophorectomy due to inability to establish menopausal status based on menstrual cycle characteristics; (c) history of menstrual cycle irregularities in peak reproductive years, and (d) history medical or psychiatric conditions associated with hot-flash-like sensations (panic disorder, pheochromocytoma, leukemia, pancreatic tumor).

Study Procedures

Participants underwent a telephone and in-person screening, including an assessment of reproductive and medical history, medication use, and menopausal symptoms. We equipped eligible participants with an ambulatory skin conductance monitor between 7:30 a.m. and 10:00 a.m. on a typical workday. They wore the monitor during their workday and overnight at home, removed the monitor on waking the following morning, and returned to the laboratory. Participants repeated this protocol on a second workday within 2 weeks. We originally designed the protocol to include overnight monitoring only on the first monitoring day to reduce participant burden. However, participants reported tolerating the sleep monitoring well (e.g., with no subjective sleep disruption), and therefore, we changed the study protocol to incorporate sleep monitoring on the second monitoring day. Therefore, two nights of sleep monitoring were obtained on a subset of participants. Of the final sample of 41 participants, 28 underwent two monitoring nights, and 13 underwent one monitoring night. Participants completed a structured diary during monitoring including information regarding sleep. All participants completed a battery of questionnaires during the first monitoring day. Participants were compensated $50 for participation.

Measures

Hot flashes. We objectively measured hot flashes during sleep at participants' homes via ambulatory sternal skin conductance (SCL) monitoring, a validated physiologic measure of hot flashes (Carpenter et al., 1999; Freedman, 1989). The Biolog ambulatory skin conductance monitor (UFI, Model 399/1–SCL, Morro Bay, CA) is a lightweight, portable, unobtrusive single channel device that allows the measurement of SCL during daily life and sleep. It contains 64 KB of memory, is powered by one 9-Volt battery, and samples skin conductance at 1 Hz (once per second) via two Medi-trace silver/silver chloride electrodes (Kendall,

Syracuse, NY) filled with 0.05 M potassium chloride Unibase/glycol paste affixed to the sternum. We instructed participants to avoid rigorous physical activities or showering while wearing the monitor.

We downloaded data into a personal computer and scanned for hot flashes visually and using DPS Software Support Package (UFI, Morro Bay, CA). Criteria for hot flashes were a ≥ 2 μmho increase within 30 sec, with a minimum interflash scoring interval of 20 min after flash onset during which no flashes were scored (Carpenter et al., 1999; Freedman, 1989). Hot flashes meeting criteria were electronically flagged and subsequently visually inspected by a trained analyst in 5-min, 1-min, or 30-sec intervals to distinguish a hot flash from artifact following established procedures (Carpenter et al., 1999; Freedman, 1989).

Sleep. Participants completed the Sleep Wake Experience List (SWEL; van Diest, 1990), a structured 15-item sleep measure assessing sleep over the past 3 months. Severity ranging from 1 (*not at all*) to 5 (*very severe*) or frequency ranging from 1 (*never*) to 5 (*always*) ratings were provided on a 5-point scale and combined into six dichotomous measures of sleep disturbance (initiating sleep, maintaining sleep, early morning wakening, difficulty in waking up, tiredness on waking up, daytime sleepiness). For example, individuals answering *quite, severe,* or *very severe* to the question "Do you have trouble waking up easily in the morning?" and answering *often* or *always* to the question "How often is it difficult for you to wake up?" were classified as having difficulty waking up. Scale classifications have been validated by both clinical diagnosis and polysomnography (van Diest & Snel, 1990).

Participants completed a structured sleep diary on waking after each night of monitoring. The diary assessed time of sleep onset, time of final waking, frequency of nighttime waking, number of sleep hot flashes, and a rating of sleep as compared to an average night ranging from 1 (*much worse*) to 5 (*much better than usual*).

Demographic and psychological. Participants completed a battery of the following measures:

1. The demographic and health questionnaire contained questions about demographic characteristics (age, ethnicity, income, education, employment status, marital status), health behaviors (engaging in regular aerobic exercise, current use of tobacco or alcohol), and medical history (current and past medical conditions, reproductive history, surgical history, current medication use).

2. The Beck Depression Inventory (2nd ed. [BDI–II]; Beck, Steer, & Brown, 1996) is a recent revision of the widely used BDI (Beck, Steer, & Garbin, 1988), a preferred scale for assessing depressive symptoms among symptomatic menopausal women (Gath, 1998). It assesses the presence and severity of 21 depressive symptoms experienced within the previous 2 weeks.

3. The Daily Stress Inventory (DSI; Brantley et al., 1987) assesses the occurrence and perceived stressfulness of 58 events experienced over the past 24 hr.

4. The State–Trait Anxiety Inventory (STAI; Spielberger, 1983) is a widely used 40-item scale assessing anxious feelings at the time of completion, or state anxiety, as well as a general propensity toward anxiety, or trait anxiety.

Statistical Analysis

We assessed hot flashes by ambulatory skin conductance monitoring. We included only flashes occurring during reported sleeping hours in analyses. Reliability of hot flash coding (coding of both flash and nonflash periods) was established by independent coding of 10% of the SCL files by expert Carpenter and colleagues (see Carpenter et al., 1999; Carpenter, Gautam, Freedman, & Andrykowski, 2001) using the same coding method we described earlier. $\kappa = 0.74$ indicated adequate interrater reliability.

To evaluate the first hypothesis that women with more frequent overnight hot flashes would report increased sleep problems, we utilized a generalized linear model. Generalized linear models allow for modeling of outcomes with distributions from any of the exponential family. Given the distribution of the outcome sleep hot flashes, their count nature, and their sensitivity to monitoring duration, we modeled number of sleep hot flashes with a Poisson distribution and a log link function offset by sleep monitoring duration. We included a dispersion parameter estimated based on Pearson's chi-square in the specification of the variance to allow for overdispersion. Main predictor variables were individual SWEL sleep indexes (individual sleep problems as well as sum of sleep problems), and the main outcome variable was SCL-monitored sleep hot flash frequency. However, we also estimated models with predictor diary-rated sleep and outcome subjectively reported sleep hot flashes. When we examined diary reported characteristics of a specific night in relation to sleep hot flashes for that night, we implemented the Poisson regression analysis in a repeated measures framework (generalized estimating equations) given the repeated nights for a subset of participants. We adopted an unstructured covariance matrix in these analyses. We determined goodness of model fit from examination of deviance and log likelihood values.

We evaluated the second hypothesis that women with more frequent overnight hot flashes would report elevated negative mood and daily stress similarly in the

Poisson model, although modeling mood and daily stress sum scores as predictors. We averaged the DSI score over two monitoring days, and we evaluated each psychological variable in a separate model. We examined analyses of reported hot flashes similarly, substituting reported sleep hot flashes as the outcome variable.

To evaluate the third hypothesis that individuals with more sleep problems would show increased negative mood and daily stress, we examined relations between SWEL-assessed sleep problems and psychological variables via univariate analysis of variance (ANOVA), with predictors sleep problems and outcomes psychological variables. We estimated separate models for each sleep problem, the sum number of sleep problems, and each psychological variable. We calculated the sum sleep problems score based on the number of sleep problems. We estimated relations between the sum sleep score and psychological, demographic, and medical variables via linear regression, ANOVA, and analysis of covariance (ANCOVA). For participants with two monitoring nights, we used an average of diary-reported occurrences of times waking or getting out of bed; otherwise, we used one night's ratings. We evaluated associations between diary-rated sleep and psychological variables within multiple linear regression.

We evaluated the fourth hypothesis that the relation between sleep flashes and psychological functioning would be mediated by sleep problems. In the Poisson regression model, sleep indexes were entered as covariates in the models with predictors mood variables and outcomes reported or physiologic sleep hot flash frequency.

Finally, to examine whether the predictor hot flashes were related to the outcome sleep disturbance, we divided the sleep hot flash rate (the number of sleep hot flashes divided by sleep monitoring duration) into tertiles and examined them in relation to sleep disturbance via chi-square models for individual sleep problems and ANCOVA with the log transformed (after addition of a constant) sleep sum score given its skewed distribution. We evaluated antidepressant use as a main effect and in interaction with psychological or sleep variables in all models. We evaluated interactions with ethnicity in all models and reported any significant differences by ethnicity. We estimated models with and without adjustment for relevant covariates or significant univariate predictors of the outcome variable. We conducted all statistical analyses using SAS Version 8.0 (SAS Institute, Cary, NC).

Results

Sample Characteristics

Of the women we recruited for the sample, we obtained at least one night of sleep monitoring and the sleep questionnaire on 43 participants. Two had had a hysterectomy without oophorectomy, and we eliminated them from analyses. Therefore, the final sample included 41 participants.

Demographic, medical, and reproductive. All participants reported daily hot flashes. No participants had medical or psychiatric conditions producing hot flash sensations. However, participants reported other medical conditions, most commonly hypertension (26.8%, n = 11), arthritis (17.1%, n = 7), and hyperlipidemia (14.6%, n = 6). Most participants were postmenopausal (58.5%, n = 24), with no menstrual period within 12 months. The remaining women were perimenopausal, with 19.5% (n = 8) having menstruated in the past 12 but not 3 months, and 22.0% (n = 9) having menstruated in the past 3 months. Among menstruating women, the average duration of menstrual irregularities was 16.4 (SD = 9.0) months, none had had irregularities for less than 6 months, and none had a history of menstrual irregularities during peak reproductive years. Most women (90.2%, n = 37) retained both their ovaries and uterus, although one woman (2.4%) had undergone a hysterectomy with bilateral oophorectomy, and three (7.4%) had a unilateral oophorectomy without hysterectomy.

All women reported no use of exogenous estrogen or progesterone (e.g., HRT, birth control pills) in the month before the study. No women reported ever having taken tamoxifen, raloxifene, clonidine, tibolone, or bellargal. Two (4.9%) women reported taking soy supplements and four (9.8%) reported taking Vitamin E. No participants reported taking black cohosh. Nine (21.9%) women reported taking antidepressants. Demographic and medical characteristics are presented in Table 1.

Psychological. The mean BDI–II score was 10.0 (SD = 9.9; range = 0–50), indicating levels of depressive symptoms within normal range (Beck et al., 1996). However, 19.5% (n = 8) of participants had a BDI–II score consistent with mild (14–19) or moderate depression (20–28), and an additional 4.8% (n = 2) reported severe levels of depressive symptoms (> 28). Participants exhibited typical levels of state (M = 34.8, SD = 11.7; range = 20–66) and trait (M = 37.5, SD = 9.8; range = 23–67) anxiety for a nonclinical population (Spielberger, 1983). DSI scores (M = 41.3, SD = 34.3; range = 4–144) indicated relatively low levels of stress compared to normative data on females (Brantley et al., 1987; see Table 2).

Among medical, racial, socioeconomic, demographic, and behavioral characteristics, only alcohol use was related to psychological characteristics. More frequent alcohol consumption was associated with increased depressive symptoms (r = .38, p = .01).

Table 1. *Demographic Characteristics of Study Participants*

Characteristic	*n*	%[a]
Ethnicity		
White	23	56.1
African American	15	36.6
Hispanic	2	4.9
Native American	1	2.4
Education		
High school	4	9.7
Some college	15	36.6
College	12	29.3
Graduate/professional degree	10	24.4
Employment status		
Full-time	28	68.3
Part-time	9	22.0
Unemployed/retired/disabled	4	9.8
Marital status (%)		
Married/live-in relationship	23	56.1
Single	4	9.8
Divorced	13	31.7
Widowed	1	2.4
Number of children		
0	7	17.1
1	12	29.3
2	18	43.9
3	4	9.7
Menopausal status		
Amennorhea 12+ months	23	56.1
Amennorhea 3–12 months	8	19.5
Menstrual irregularities 6+ months	9	22.0
Surgically postmenopausal[b]	1	2.4
Current smoker	4	9.8
Regular aerobic exercise[c]	23	56.1
Antidepressant use[d]		
Tricyclic	2	4.9
SSRI	6	14.6
Other	1	2.4

Note. Age (years) $M = 50.9$ ($SD = 4.5$). Household income mediam = $45,000 to $59,999 (two participants declined to answer this question).
[a]$N = 41$. [b]Hysterectomy with bilateral oophorectomy. [c]Reporting engaging in regular aerobic exercise.[d]One participant is represented in more than one category.

Sleep. Participants reported sleeping approximately 7.3 hr (SD = 1.2), waking a median of two times, and getting out of bed a median of one time each monitoring night. Participants on average rated sleep during monitoring nights as *same as usual* (median [Mdn] = 3, $M = 3.3$, $SD = 1.3$). Thus, sleep during monitoring nights was considered representative of a typical night.

Results of the SWEL indicated the most common sleep problem to be tiredness on waking, with 19.5% ($n = 8$) of participants in the clinical range on this problem (see Table 3). The number of sleep problems were relatively low in the sample as a whole ($M = 0.89$, Mdn = 0; range = 0–6). However, over a third (34.2%, n = 14) had one or more clinically significant sleep problems, and 14.6% ($n = 6$) had three or more. The number of sleep problems was unrelated to ethnicity, employment status, demographic characteristics, medical characteristics, health behaviors, and medications, with the exception of income ($b = –0.16$, $p = .009$) and smoking, $F(1, 39) = 18.1$, $p = .0001$), with sleep problems fewer among nonsmokers ($M = 0.5$, $SD = 1.0$) relative to smokers ($M = 3.5$, $SD = 2.1$) and increased as income decreased.

SCL-monitored hot flashes during sleep. An average of 2.2 sleep hot flashes per woman per night (SD = 2.2, Mdn = 2; range = 0–8.0) were observed on SCL monitoring. We examined factors related to physiologic sleep hot flashes in a Poisson regression analysis offset by monitoring duration. Physiologic sleep hot flashes were unrelated to menopausal or surgical status, age, ethnicity, employment status, family income, smoking, or supplement use. However, women with more children had more frequent physiologic sleep hot flashes (rate ratio [RR] = 1.44, 95% confidence interval [CI] 1.05–1.96, $p = .02$). Compared to women with a graduate degree, those with high school (RR = 3.57, 95% CI 1.22–10.41, $p = .02$) or some college (RR = 2.32, 95% CI 0.86–6.28, $p = .09$) education had more frequent physiologic sleep hot flashes. Antidepressant use was associated with a lower physiologic sleep hot flash frequency (RR = 0.32, 95% CI 0.12–0.81, $p = .02$).

Reported hot flashes during sleep. Participants reported a median of one sleep hot flash per night in their diaries ($M = 1.7$, $SD = 1.7$; range = 0–6). The number of reported sleep hot flashes was not significantly related to ethnicity, income, education, menopausal status, surgical status, age, most health behaviors, and psychologi-

Table 2. *Psychological Characteristics of Study Participants*

Characteristic	*M*	*SD*	Range
Depression (BDI–II)	10.0	9.9	0–50
Anxiety (STAI)			
State	34.8	11.7	20–66
Trait	37.5	9.8	23–67
Daily stress (DSI; *M* across 2 days)	41.3	34.3	4–144
Attitudes towards menopause	16.5	2.9	10–24

Note. $N = 41$. BDI–II = Beck Depression Inventory (2nd ed.); STAI = State–Trait Anxiety Inventory; DSI = Daily Stress Inventory.

Table 3. *Sleep Problems Among Study Participants*

Sleep Problems (SWEL)	*n*	%
Initiating sleep	6	14.6
Maintaining sleep	5	12.2
Early morning wakening	5	12.2
Difficulty waking up	4	9.8
Tiredness upon waking	8	19.5
Daytime sleepiness	6	14.6

Note. SWEL = Sleep Wake Experience List.

cal characteristics. However, employed women reported fewer (RR = 0.55, 95% CI 0.18–0.98, $p = .04$) and smokers reported more (RR = 1.42, 95% CI 1.26–4.95, $p = .02$) sleep hot flashes relative to not employed and nonsmoking women, respectively.

Notably, the number of diary-reported sleep hot flashes was not significantly related to the number of physiologically monitored flashes. In fact, an average of 2.0 ($SD = 2.2$, range = 0–7) SCL-monitored hot flashes occurred on nights when women reported no sleep hot flashes. Of these nights, 58% were associated with one or more SCL-monitored hot flashes (23% of all monitoring nights). Conversely, women reported an average of 1.25 ($SD = 1.6$; range = 0–5) sleep hot flashes on nights when none were observed on SCL monitoring. Of these nights, 45% were associated with one or more diary-reported hot flashes (14% of all nights).

Sleep Hot Flashes and Sleep Complaints

In the Poisson regression model offset by monitoring duration, sleep disturbance was not significantly related to the number of SCL-recorded sleep hot flashes. Specifically, problems initiating sleep, sleep maintenance, daytime sleepiness, difficultly waking up, early morning wakening, and the sleep problem sum were unrelated to physiologic sleep hot flash frequency. Increasing number of sleep problems were not significantly related to physiologic sleep hot flashes, nor was there any suggestion of a relation (RR = 0.95, 95% CI 0.77–1.18, $p = .66$). Comparison of women in highest versus lowest sleep hot flash frequency tertile indicated no evidence of a high physiologic sleep hot flash rate associated with increased sleep problems. Moreover, no aspect of diary-rated sleep was significantly related to physiologic sleep hot flash frequency. Addition of antidepressant use, income, education, and smoking to these models did not alter any of these relations.

Analyses of reported sleep hot flashes revealed SWEL-assessed sleep problems were marginally positively related to reported hot flashes (RR = 1.16, 95% CI 0.98–1.38, $p = .10$). Diary-reported number of times waking up (RR = 1.47, 95% CI 1.29–1.67, $p = .0002$) and the number of times getting out of bed (RR = 1.35, 95% CI 1.08–1.46, $p = .03$) were significantly and positively related to reported sleep hot flashes. Results were largely unchanged controlling for smoking, employment status, or the number of SCL-monitored sleep hot flashes.

Sleep Hot Flashes and Psychological Functioning

In the Poisson regression model offset by sleep monitoring duration, neither depression (RR = 1.00, 95% CI 0.98–1.03, $p = ns$), trait anxiety (RR = 0.98, 95% CI 0.95–1.02, $p = ns$), nor daily stress (RR = 1.00, 95% CI 0.99–1.00, $p = ns$) were significantly related to physiologic sleep hot flash frequency. Results were similar with and without adjustment for antidepressant use, education, and number of children. In fact, for every 1 unit increase in state anxiety, the physiologic sleep hot flash rate marginally decreased by 0.98 (95% CI 0.95–1.01, $p = .08$), controlling for duration of physiologic sleep monitoring, antidepressant use, education, and the number of children. This inverse relation between state anxiety and physiologic sleep hot flashes varied by ethnicity (interaction; $p = .01$), occurring primarily among minority ethnic participants (RR = 0.91, 95% CI 0.86–0.95, $p < .0001$; White participants RR = 1.00, 95% CI 0.97–1.03, $p = ns$). Psychological characteristics were not significantly related to reported sleep hot flashes.

Sleep Complaints and Psychological Functioning

In linear regression analyses, individual sleep problems were strongly related to state anxiety, trait anxiety, and depression and to a lesser extent daily stress (see Table 4). The sum of sleep problems was related to increased depression ($b = 4.18$, $p < .0001$), state anxiety ($b = 3.9$, $p = .0013$), trait anxiety ($b = 4.3$, $p < .0001$), and daily stress ($b = 9.19$, $p = .009$). Addition of antidepressant use, alcohol use, number of children, income, and smoking did not sizably alter these relations, nor did they vary by ethnicity. Finally, diary-reported waking episodes were marginally related to increased depression ($b = 2.0$, $p = .07$), and instances of getting out of bed were marginally associated with increased trait anxiety ($b = 2.8$, $p = .06$). Results were similar after elimination of sleep disturbance item from the BDI–II.

Hot Flashes, Psychological Functioning, and Sleep Complaints

The final model tested sleep complaints, sleep hot flashes, and psychological functioning in the Poisson

Table 4. *Mean Levels of Psychological Characteristics by Reported Sleep Problem*

Characteristic	Depression	State Anxiety	Trait Anxiety	Daily Stress
Initiating sleep				
Yes	17.5**	44.5**	45.7**	62.8*
No	8.8	33.1	36.1	37.6
Maintaining sleep				
Yes	17.6*	41.6	45.8**	56.5
No	9.0	33.9	36.3	39.2
Early morning wakening				
Yes	17.6*	41.6	45.8**	56.5
No	9.0	33.9	36.3	39.2
Difficulty waking up				
Yes	29.5****	49.5***	53.8****	80.5**
No	7.9	33.2	35.7	37.0
Tiredness on waking				
Yes	21.0****	45.8***	49.4****	68.1**
No	7.4	32.3	34.6	34.8
Daytime sleepiness				
Yes	20.8***	44.0**	49.0***	60.8
No	8.2	33.2	35.5	37.9

*$p < .10$. **$p < .05$. ***$p < .01$. ****$p < .001$.

regression model offset by monitoring duration. Results indicated that neither physiologic sleep hot flashes, antidepressant use, nor alcohol use had any significant impact on the relation between the psychological characteristics and sleep problems.

Discussion

The results of this study indicate that although sleep disturbance among perimenopausal and postmenopausal women with hot flashes was strongly related to psychological functioning, subjective sleep was not significantly related to physiologically measured sleep hot flashes. Moreover, physiologic sleep hot flashes were largely unrelated to psychological functioning. Conversely, exploratory analyses suggested that more self-reported sleep hot flashes may be associated with increased reported acute sleep problems. This study is notable for its physiologic and self-report sleep hot flash measures and its use of both sleep diaries and a validated sleep questionnaire. To our knowledge, it is currently the only study examining physiologic and self-reported sleep hot flashes, sleep, and psychological functioning among healthy perimenopausal and postmenopausal women.

Sleep disturbance was unrelated to physiologically monitored sleep hot flash frequency across questionnaire-rated sleep, diary-rated sleep, and among women with frequent hot flashes. This finding contrasts with women's reports that hot flashes disturb sleep (Kronenberg, 1990) and several epidemiologic studies that have shown self-reported sleep disturbance to be associated with self-reported hot flashes (Dennerstein et al., 2000; Hollander et al., 2001; Kravitz et al., 2003). It is notable, however, that more recent studies using objective sleep measures, including one that was particularly well designed (Young, Rabago, Zgierska, Austin, & Laurel, 2003), have generally shown null relations between objective sleep and reported sleep hot flashes (Polo-Kantola et al., 1999; Young et al., 2003).

The three studies using physiologic measures of sleep hot flashes and sleep among healthy menopausal women have produced mixed findings. One study (Erlik et al., 1981) found sleep hot flashes to be associated with waking episodes among nine women with both severe and frequent hot flashes, although the small sample and very high rate of sleep hot flashes limits the generalizability of these results. A second study (Woodward & Freedman, 1994) found no evidence of sleep changes coinciding with sleep hot flash occurrence. Women with sleep hot flashes did show altered sleep, but these alterations included increased deep sleep, consistent with another investigation (Young et al., 2003). Finally, a recent study (Freedman & Roehrs, 2004) of women free of chronic health problems, obesity, medication use, or drug use found no differences in subjective or objective sleep among premenopausal, asymptomatic postmenopausal, and postmenopausal women with physiologically monitored sleep hot flashes. No pattern of sleep changes was observed directly before, after, or during sleep hot flashes. Freedman and Roehrs concluded that sleep problems observed to be associated with menopause in other studies may be more due to anthropometric changes and the development of chronic diseases than to vasomotor symptoms. Thus, research utilizing objective hot flash measures has produced contradictory results, calling into question the role of hot flashes in sleep disturbance.

Studies assessing sleep hot flashes via self-report are vulnerable to reporting biases. Importantly, in this

study, the number of reported sleep hot flashes was unrelated to the number detected via physiologic monitoring. Evidence exists that factors such as mood and behaviors may impact the perception and reporting of waking hot flashes (Thurston et al., 2005). In the case of sleep hot flashes, these factors may be particularly salient. Individuals are recalling sleep hot flashes occurring overnight and during sleep, a recollection that may be confounded by fatigue, mood, or the number of arousals that occurred that night irrespective of their etiology. Comparing women with and without reported sleep hot flashes may be prone to error. It is notable that over half of the nights in which women reported no hot flashes, one or more physiologic sleep hot flashes were observed.

Significant associations were observed between self-reported sleep hot flashes and diary-rated acute arousals in this study, even after we controlled for the number of physiologic sleep hot flashes. Moreover, we observed suggestive relations between increased self-reported hot flashes and chronic sleep problems. Because we examined these relations in an exploratory fashion, they should be interpreted with caution. However, the results of this study do suggest that self-reported sleep hot flashes and objectively measured sleep hot flashes may diverge, with a tendency to observe relations between self-reported sleep problems and self-reported hot flashes. These findings may help shed light on the diverse findings cited previously, as the strongest evidence for an association between sleep, mood, and sleep hot flashes has generally derived from studies utilizing self-report instruments.

Mood symptoms during menopause commonly are attributed to sleep problems secondary to sleep hot flashes. The results of this study did show depression, anxiety, and to a lesser extent daily stress strongly related to sleep disturbance, consistent with other studies of midlife women (Owens & Matthews, 1998; Shaver, Johnston, Lentz, & Landis, 2002), although sleep hot flashes did not mediate this relation. Certain studies of self-reported symptoms have found women with negative mood more likely to report hot flashes (Bromberger et al., 2003, 2001; Collins & Landgren, 1994), although others have indicated no such relation (Avis et al., 2001; Hunter, 1990; Mitchell & Woods, 1996; Woods & Mitchell, 1997). Notably, evidence has suggested that psychosocial factors may play a larger role in midlife mood disturbance than aspects of menopause per se (Bromberger & Matthews, 1996; Kaufert, Gilbert, & Tate, 1992; J. B. McKinlay, McKinlay, & Brambilla, 1987; Woods & Mitchell, 1997).

Several study limitations deserve mention. First, in this study, we examined self-reported sleep. Subjective and objective sleep can differ, with menopausal women tending to appraise sleep more negatively without objective evidence of poor sleep (Polo-Kantola et al., 1999; Young et al., 2003). However, in this study, we did utilize a sleep measure with polysomnography-validated clinical cut points, which differs markedly from unvalidated or single-item measures of previous studies (Dennerstein et al., 1993; Kravitz et al., 2003; Owens & Matthews, 1998). Studies of self-reported sleep have generally overestimated associations between hot flashes, menopause, and sleep problems, and bias would be expected in the direction of falsely showing a relation where none existed. This study's results showed no such relation.

The women in this study showed lower sleep disturbance levels than other studies of reported sleep in midlife women (Dennerstein et al., 1993; Kravitz et al., 2003; Owens & Matthews, 1998). In this study, we used symptom frequency and severity criteria that were based on polysomnography and clinically diagnosed sleep disturbance (van Diest & Snel, 1990). Many previous studies have included a single-item measure of difficultly sleeping (Dennerstein et al., 1993; Kravitz et al., 2003) or measures not validated by polysomnography (Owens & Matthews, 1998). Importantly, some evidence indicates postmenopausal midlife women free of chronic disease or risk factors may not have impaired sleep relative to their younger premenopausal counterparts (Freedman & Roehrs, 2004). In this study, we did find marked elevations in comparison to the scale's validation sample (van Diest, 1990).

Several aspects of the study sample deserve mention. The sample of women in this study was relatively small. Power to evaluate relations between sleep and sleep hot flashes were limited, although it is notable that examination of parameter estimates revealed no suggestion of hypothesized relations. Moreover, the sample included women who varied with respect to menopausal stage, surgical status, ethnicity, and medication usage, including present antidepressant use and past HRT use. Although exploratory analyses indicated generally no significant differences in sleep, mood, or sleep hot flashes or their relations by most of these factors, power to detect subgroup differences was very limited. Moreover, information on certain of these factors, such as past HRT use, was limited. Given this potential diversity, the heterogeneity of the sample could operate to obscure findings. Hypotheses should be examined in larger samples and with greater ability to assess subgroup differences. One subgroup difference that was detected was antidepressant use, which was associated with fewer hot flashes, although the relatively little detail obtained about the use of these medications limited further understanding this association. However, women using antidepressants showed neither differential sleep, nor psychological characteristics, nor differential relations between sleep, mood, and sleep hot flashes from the rest of participants. Finally, this study included a volunteer sample of relatively high socioeconomic status with low levels of

psychological morbidity. A restriction of range may have limited the ability to detect relations between psychological factors and sleep hot flashes, and the sample may not be representative of the general population of menopausal women.

Study strengths include its physiologic hot flash measurement, allowing a more detailed assessment of sleep hot flashes. In this study, we also assessed self-reported hot flashes, allowing a comparison between these two measures. Moreover, we selected participants on the basis of experiencing at least one flash a day rather than severe and frequent hot flashes.

In conclusion, the results of this study indicate that sleep hot flash frequency was unrelated to reported sleep problems, mood, and daily stress. However, there was suggestive evidence that self-reported sleep hot flashes, which were not significantly related to physiologic sleep hot flashes, may be related to acute sleep problems. Sleep problems were related to negative mood and daily stress. Thus, this study suggests that midlife sleep disturbance may be more due to psychological functioning and life stressors than to physiologically assessed menopausal hot flashes.

References

Avis, N. E., Brambilla, D., McKinlay, S. M., & Vass, K. (1994). A longitudinal analysis of the association between menopause and depression. Results from the Massachusetts Women's Health Study. *Annals of Epidemiology, 4,* 214–220.

Avis, N. E., Stellato, R., Crawford, S., Bromberger, J., Ganz, P., Cain, V., et al. (2001). Is there a menopausal syndrome? Menopausal status and symptoms across racial/ethnic groups. *Social Science & Medicine, 52,* 345–356.

Barsky, A. J., Goodson, J. D., Lane, R. S., & Cleary, P. D. (1988). The amplification of somatic symptoms. *Psychosomatic Medicine, 50,* 510–519.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck Depression Inventory manual* (2nd ed.). Orlando, FL: Psychological Corporation.

Beck, A. T., Steer, R. A., & Garbin, M. G. (1988). Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review, 8,* 77–100.

Brantley, P., Waggoner, C., Jones, G., & Rappaport, N. (1987). A daily stress inventory: Development, reliability, and validity. *Journal of Behavioral Medicine, 10,* 61–74.

Bromberger, J. T., Assmann, S. F., Avis, N. E., Schocken, M., Kravitz, H. M., & Cordal, A. (2003). Persistent mood symptoms in a multiethnic community cohort of pre- and perimenopausal women. *American Journal of Epidemiology, 158,* 347–356.

Bromberger, J. T., & Matthews, K. A. (1996). A longitudinal study of the effects of pessimism, trait anxiety, and life stress on depressive symptoms in middle-aged women. *Psychology and Aging, 11,* 207–213.

Bromberger, J. T., Meyer, P. M., Kravitz, H. M., Sommer, B., Cordal, A., Powell, L., et al. (2001). Psychologic distress and natural menopause: a multiethnic community study. *American Journal of Public Health, 91,* 1435–1442.

Carpenter, J. S., Andrykowski, M. A., Freedman, R. R., & Munn, R. (1999). Feasibility and psychometrics of an ambulatory hot flash monitoring device. *Menopause, 6,* 209–215.

Carpenter, J. S., Gautam, S., Freedman, R. R., & Andrykowski, M. (2001). Circadian rhythm of objectively recorded hot flashes in postmenopausal breast cancer survivors. *Menopause, 8,* 181–188.

Collins, A., & Landgren, B. M. (1994). Reproductive health, use of estrogen and experience of symptoms in perimenopausal women: a population-based study. *Maturitas, 20,* 101–111.

Craig, K. D. (1994). Emotional Aspects of Pain. In P. D. Wall & R. Melzack (Eds.), *Textbook of pain* (pp. 261–274). New York: Edinburgh.

Dennerstein, L., Dudley, E. C., Hopper, J. L., Guthrie, J. R., & Burger, H. G. (2000). A prospective population-based study of menopausal symptoms. *Obstetrics and Gynecology, 96,* 351–358.

Dennerstein, L., Smith, A. M., Morse, C., Burger, H., Green, A., Hopper, J., et al. (1993). Menopausal symptoms in Australian women. *The Medical Journal of Australia, 159,* 232–236.

Erlik, Y., Tataryn, I. V., Meldrum, D. R., Lomax, P., Bajorek, J. G., & Judd, H. L. (1981). Association of waking episodes with menopausal hot flushes. *Journal of the American Medical Association, 245,* 1741–1744.

Freedman, R. R. (1989). Laboratory and ambulatory monitoring of menopausal hot flashes. *Psychophysiology, 26,* 573–579.

Freedman, R. R., & Roehrs, T. A. (2004). Lack of sleep disturbance from menopausal hot flashes. *Fertility and Sterility, 82,* 138–144.

Gath, D. (1998). The assessment of depression in peri-menopausal women. *Maturitas, 29,* 33–39.

Gold, E. B., Sternfeld, B., Kelsey, J. L., Brown, C., Mouton, C., Reame, N., et al. (2000). Relation of demographic and lifestyle factors to symptoms in a multi-racial/ethnic population of women 40–55 years of age. *American Journal of Epidemiology, 152,* 463–473.

Hollander, L. E., Freeman, E. W., Sammel, M. D., Berlin, J. A., Grisso, J. A., & Battistini, M. (2001). Sleep quality, estradiol levels, and behavioral factors in late reproductive age women. *Obstetrics and Gynecology, 98,* 391–397.

Hunter, M. S. (1990). Psychological and somatic experience of the menopause: A prospective study [corrected]. *Psychosomatic Medicine, 52,* 357–367.

Kaufert, P. A., Gilbert, P., & Tate, R. (1992). The Manitoba Project: A re-examination of the link between menopause and depression. *Maturitas, 14,* 143–155.

Kravitz, H. M., Ganz, P. A., Bromberger, J., Powell, L. H., Sutton-Tyrrell, K., & Meyer, P. M. (2003). Sleep difficulty in women at midlife: a community survey of sleep and the menopausal transition. *Menopause, 10,* 19–28.

Kronenberg, F. (1990). Hot flashes: Epidemiology and physiology. *Annals of the New York Academy of Sciences, 592,* 52–86, 123–133.

Kuh, D. L., Wadsworth, M., & Hardy, R. (1997). Women's health in midlife: The influence of the menopause, social factors and health in earlier life. *British Journal of Obstetrics and Gynaecology, 104,* 923–933.

Ledesert, B., Ringa, V., & Breart, G. (1994). Menopause and perceived health status among the women of the French GAZEL cohort. *Maturitas, 20,* 113–120.

McKinlay, J. B., McKinlay, S. M., & Brambilla, D. (1987). The relative contributions of endocrine changes and social circumstances to depression in mid-aged women. *Journal of Health and Social Behavior, 28,* 345–363.

McKinlay, S. M., Brambilla, D. J., & Posner, J. G. (1992). The normal menopause transition. *Maturitas, 14,* 103–115.

Mitchell, E. S., & Woods, N. F. (1996). Symptom experiences of midlife women: Observations from the Seattle Midlife Women's Health Study. *Maturitas, 25,* 1–10.

Moe, K. E. (1999). Reproductive hormones, aging, and sleep. *Seminars in Reproductive Endocrinology, 17,* 339–348.

Neugarten, B. L., & Kraines, R. J. (1965). "Menopausal Symptoms" in Women of Various Ages. *Psychosomatic Medicine, 27,* 266–273.

Owens, J. F., & Matthews, K. A. (1998). Sleep disturbance in healthy middle-aged women. *Maturitas, 30,* 41–50.

Polo-Kantola, P., Erkkola, R., Irjala, K., Helenius, H., Pullinen, S., & Polo, O. (1999). Climacteric symptoms and sleep quality. *Obstetrics and Gynecology, 94,* 219–224.

Shaver, J. L., Johnston, S. K., Lentz, M. J., & Landis, C. A. (2002). Stress exposure, psychological distress, and physiological stress activation in midlife women with insomnia. *Psychosomatic Medicine, 64,* 793–802.

Spielberger, C. D. (1983). *Manual for the State–Trait Anxiety Inventory.* Palo Alto, CA: Consulting Psychologists Press.

Thurston, R. C., Blumenthal, J. A., Babyak, M. A., & Sherwood, A. (2005). Emotional antecedents of hot flashes during daily life. *Psychosomatic Medicine, 67,* 137–146.

van Diest, R. (1990). Subjective sleep characteristics as coronary risk factors, their association with Type A behaviour and vital exhaustion. *Journal of Psychosomatic Research, 34,* 415–426.

van Diest, R., & Snel, J. (1990). *The Sleep Wake Experience List.* In J. A. Home (Ed.), *Sleep '90: Proceedings of the 10th European Congress on Sleep Research, Strasbourg (France), May 20–25.* Bochum, Germany: Pontenagel Press.

Woods, N. F., & Mitchell, E. S. (1997). Pathways to depressed mood for midlife women: Observations from the Seattle Midlife Women's Health Study. *Research in Nursing & Health, 20,* 119–129.

Woodward, S., & Freedman, R. R. (1994). The thermoregulatory effects of menopausal hot flashes on sleep. *Sleep, 17,* 497–501.

Young, T., Rabago, D., Zgierska, A., Austin, D., & Laurel, F. (2003). Objective and subjective sleep quality in premenopausal, perimenopausal, and postmenopausal women in the Wisconsin Sleep Cohort Study. *Sleep, 26,* 667–672.