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Are vasomotor symptoms associated with sleep characteristics among symptomatic midlife women? Comparisons of self-report and objective measures

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Abstract

Objective—Many women report vasomotor symptoms (VMS) and sleep problems during the menopausal transition. Although reported VMS are consistently related to reported sleep disturbance, findings using physiologic measures of VMS or sleep have been more mixed. Our objective was to examine whether more VMS during sleep are associated with poorer sleep among midlife women with VMS using physiologic measures of both VMS and sleep.

Methods—A subcohort of participants (N = 52) with VMS, a uterus and both ovaries, and free of medications affecting VMS from the Pittsburgh site of the Study of Women's Health Across the Nation underwent four 24-hour periods of in-home ambulatory VMS and sleep measurement. Measures included sternal skin conductance for the measurement of VMS, actigraphy for assessing sleep, a VMS diary, and a sleep diary completed before bed and upon waking. Associations between VMS and sleep were evaluated using generalized estimating equations with covariates age, body mass index, medications affecting sleep, race, financial strain, and depressive symptoms.

Results—More VMS recalled upon waking were associated with significantly lower actigraphy-assessed sleep efficiency, significantly higher wakefulness after sleep onset, and somewhat longer sleep latency. Conversely, physiologically measured VMS and VMS reported during the night were largely unrelated to sleep characteristics.

Conclusions—Associations between VMS and sleep may depend more on the awareness of and recall of VMS rather than solely on their physiologic occurrence.

Keywords

Hot flashes; Night sweats; Vasomotor symptoms; Sleep; Actigraphy; Menopause

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Vasomotor symptoms (VMS), or hot flashes and night sweats, and sleep disturbance are common complaints among midlife women. Data from the Study of Women's Health Across the Nation (SWAN) indicate that approximately 70% of women report VMS at some point during the menopausal transition.[1] Approximately 30% to 40% of midlife women report sleep disturbance.[2] Women frequently cite VMS at night as the source of this sleep disturbance,[3] and epidemiologic investigations using questionnaire measures of VMS and sleep show VMS to be a consistent correlate of reported sleep disturbance. In fact, in SWAN, women reporting VMS at least 6 or more days in the past 2 weeks had a 2 to 3 times higher odds of reporting all three kinds of sleep disturbance assessed (trouble falling asleep, nighttime waking, and early morning wakening) relative to women without VMS.[2] Similarly, data from diary studies, in which women report VMS and sleep characteristics in diaries completed daily, show that the presence of reported VMS is a consistent predictor of sleep disturbance.[4,5]

Although most studies on VMS and sleep use self-report measures, these measures, particularly for phenomena occurring during sleep, have noted limitations, including memory and reporting biases.[6–8] However, VMS and sleep can both be assessed physiologically, and studies using physiologic measures of sleep and/or VMS have shown much more mixed findings. Our previous work with physiologic measures of hot flashes found that reported sleep hot flashes, but not physiologic hot flashes, were associated with reported sleep problems.[6] Studies using physiologic measures of both sleep and VMS have generally been small and produced mixed findings. Although an early study using polysomnography (PSG) found some evidence of a relation between VMS and wakening episodes,[9] subsequent work has found less consistent associations.[10–13] Therefore, much remains to be learned about the relation between VMS and sleep problems in midlife, particularly when both VMS and sleep are assessed physiologically.

In this investigation, we examine whether more VMS during sleep are associated with greater sleep disturbance among midlife women with VMS. We use both physiologic (sternal skin conductance for VMS, actigraphy for sleep) and diary measures of both VMS and sleep. We examine these relations in the context of a 4-day ambulatory monitoring protocol conducted as participants went about their daily activities.

METHODS

Study population

The study sample was a subcohort of participants (N = 52) of the Pittsburgh site of the SWAN. SWAN is a cohort study designed to characterize the menopausal transition and is conducted at seven sites across the United States. Details of SWAN procedures have been reported previously.[14] At enrollment (1996–1997), SWAN participants (N = 3,302) were aged 42 to 52 years, had an intact uterus and at least one ovary, were not pregnant or breast feeding, had menstruated within 3 months, and were not using oral contraceptives or hormone therapy.

A subcohort of participants at the Pittsburgh SWAN site participated in SWAN FLASHES, an ancillary study using physiologic measures of hot flashes. SWAN FLASHES assessments occurred from 2008 to 2009, most closely corresponding to SWAN's 10th annual visit. By design,[14] the Pittsburgh site recruited only white and African American women. SWAN FLASHES inclusion criteria included reporting any hot flashes or night sweats in the past 2 weeks, having a uterus and both ovaries, not being pregnant, not using hormone therapy or selective serotonin reuptake inhibitors/serotonin norepinephrine uptake inhibitors for 3 months, and not currently undergoing chemotherapy for breast cancer. SWAN FLASHES

enrolled 52 women. One woman was excluded from this analysis because of missing sternal skin conductance data, for a final sample of 51 women (25 African American, 26 white women) included in primary models.

Design and procedures

During their SWAN FLASHES visit, height and weight were measured, questionnaires were administered, and participants were equipped with a VMS monitor, an electronic VMS diary, and a wrist actigraph. All women underwent monitoring as they went about their daily activities for 96 hours, consisting of two separate 48-hour sessions conducted within approximately 4 weeks of each other. Procedures were approved by the University of Pittsburgh institutional review board, and all participants provided written informed consent.

Vasomotor symptoms

Physiologic VMS—VMS monitoring was conducted using an ambulatory sternal skin conductance monitor and an electronic diary. Sternal skin conductance was recorded using the Biolog monitor (3991/2-SCL, UFI; Morro Bay, CA), a portable device worn in a pouch around the waist. The Biolog measures sternal skin conductance sampled at 1 Hz from the sternum via a 0.5-V constant voltage circuit passed between two silver/silver chloride electrodes (UFI) filled with 0.05 M KCl Velvachol/glycol paste.[15] Participants were instructed to avoid exercising and showering during monitoring.

Physiologic VMS events were classified via standard methods, wherein any skin conductance rise of 2 μmho in 30 seconds[16] was flagged automatically by UFI software (DPSv3.6) and edited for artifact.[17] Given that some women show submaximal events failing to reach the 2-μmho criterion,[18,19] all potential VMS events were visually inspected, and events showing the characteristic VMS pattern yet having less than 2 μmho per 30-second rise were coded as VMS. This coding has been shown to be reliable ($\kappa = 0.86$).[18,19] Moreover, when all analyses were repeated excluding submaximal events, the findings were comparable. A 20-minute lockout period was implemented after the start of each VMS event during which no further events were coded. To consider unequal monitoring durations, physiologically measured VMS were considered as a rate in which the number of VMS was divided by the duration of reported sleep time (participant-reported bedtime to the final wake time).

Self-reported VMS during sleep—To report VMS during sleep, participants were instructed to press the event mark buttons on the Biolog monitor and wrist actigraph when experiencing a hot flash/night sweat. These sleep-reported VMS were considered as a rate in which the number of VMS was divided by the duration of reported sleep time.

Morning diary-reported VMS—Upon waking, participants reported the number of hot flashes and night sweats they experienced overnight (0–5 or more for each) in a diary in which they also reported sleep characteristics (described below). They rated their hot flashes and night sweats with respect to severity and bother (each rated on 4-point scale ranging from “not at all” [0] to “a lot” [3]) in this diary. Because the terms *hot flashes* and *night sweats* were both clearly marked as referring to VMS occurring during sleep, they were combined into a diary-reported VMS variable for analysis.

Sleep

Actigraphic sleep—The participants wore a wrist actigraph and were instructed to complete a sleep diary each night before going to sleep and upon waking up the next morning during the monitoring period. Actigraphy data were collected using a Minimitter

Actiwatch-64 (Respironics Inc., Murrysville, PA) in 1-minute epochs and were analyzed using the Actiware Version 5.04 software program. Each awakening was defined as a total activity count greater than a sensitivity threshold of 40. Sleep diary data for bedtime and rise time were entered for calculation of sleep-wake variables. Actigraphy outcome variables included total sleep time (within the bedtime and rise time interval), sleep latency (bedtime to first sleep period), wakefulness after sleep onset (WASO; total minutes of wakefulness between sleep onset and final wake time) and sleep efficiency (100% × total sleep time/time in bed).

Diary-reported sleep—Upon waking on each monitoring day, the participants reported in their sleep diary how that night of sleep compared with a usual night for them (5-point scale ranging from "much worse" [0] to "much better" [4]) and how rested they felt (4-point scale ranging from "not at all" [0] to "a lot" [3]).

Questionnaire-reported sleep—In addition, at baseline, participants were asked via questionnaire to rate their sleep quality overall in the past month (4-point scale from "very bad" [0] to "very good" [3]).

Covariates

Demographics, medical history, medication use, and psychosocial factors were assessed by questionnaires during the SWAN FLASHES visit. Race/ethnicity was determined in response to the question "How would you describe your primary racial or ethnic group?" Menopause status was obtained from reported bleeding patterns and was categorized as perimenopausal (bleeding in previous 3 mo with decrease in cycle predictability in past year or between 3 and 12 mo of amenorrhea) or postmenopausal (12 mo or more of amenorrhea). Height and weight were measured at the SWAN FLASHES assessment via a fixed stadiometer (Seca, Hanover, MD) and calibrated balance beam scale (Healthometer, Alsip, IL), respectively, and these measures were used to calculate BMI (in kilograms per square meter). Self-rated general health was assessed on a 5-point Likert scale ("much worse" to "much better than a year ago"). Medication use was recorded at the time of the SWAN FLASHES baseline and in the sleep diaries. Medications affecting sleep were coded consistent with other SWAN protocols,[13] specifically opioids, antiepileptics, anxiolytics, hypnotics and sedatives, antidepressants (other than selective serotonin reuptake inhibitors/serotonin norepinephrine uptake inhibitors, an exclusion criterion), and antihistamines. Seven women were taking one of these medications, covaried in all models. The socioeconomic variables assessed were education, income, and financial strain ("How hard is it for you to pay for the very basics like food, housing, medical care and heating?" answered as "very hard," "somewhat hard," or "not hard at all"). The socioeconomic variable most strongly associated with sleep, financial strain (higher financial strain associated with poorer sleep), was included here, categorized as yes (very or somewhat hard to pay for basics) and no (not hard to pay for basics) because of small cell sizes. Alcohol and tobacco use were assessed in medical history forms (current number of drinks per day/week/month and cigarettes/day, respectively) administered at the SWAN FLASHES baseline and in evening sleep diaries (number of alcoholic drinks or number of cigarettes that day, respectively) administered daily during monitoring. Caffeine use (number of caffeinated drinks that day) was collected in evening daily sleep diaries. Physical activity was assessed via a modified Kaiser Permanente Health Plan Activity Survey[20] Depressive symptoms were assessed using the Center for Epidemiologic Studies Depression Survey.[21] Anxiety symptoms (Spielberger State-Trait Anxiety Scale)[22] and perceived stress (Cohen Perceived Stress Scale)[23] were also measured. However, given their high correlation with depressive symptoms ($r = 0.7$ and 0.8), only depressive symptoms were included as a covariate.

Statistical analysis

Variables were examined for distributions, outliers, and cell sizes. Physiologically monitored VMS, monitor-reported VMS, and sleep latency were natural log transformed, WASO was square-root transformed, and sleep efficiency was natural log transformed on (100 – efficiency) for analysis. Correlations between VMS measurement methods were examined via Spearman rank order and Pearson correlation coefficients. We also examined correlations between these methods in generalized estimating equation models, accounting for the clustering of nights within women; the findings were comparable, so we present the correlation coefficients here for ease of interpretation. Associations between VMS, covariates, and sleep characteristics were evaluated using generalized estimating equations, with an autoregressive correlation matrix and nights nested within women. Each VMS variable was considered in separate model. Variables known to be related to sleep (age, body mass index, use of medications that could affect sleep, race, financial strain, and depressive symptoms) were included as covariates in models to determine the independent associations between VMS and sleep characteristics. We additionally considered as covariates diary-measured caffeine, alcohol and tobacco use in models for sleep outcomes in which they showed a significant relation (more caffeine use was related to better sleep efficiency and lower WASO; more alcohol use was associated with feeling less rested; greater cigarette use was associated with rating that night's sleep as worse than usual). The use of these substances was not related to VMS, and associations between VMS and sleep were unchanged when covarying for them. Therefore, because of the lack of impact of these substances on models paired with the small sample size, these covariates were not included in final models. Menopause status was not included as a covariate because of the limited variability in this variable (there were only five women who were not postmenopausal) and its lack of association with sleep outcomes. Analyses were performed with SAS (v 9.2; SAS Institute, Cary, NC). Tests were two-sided, $\alpha = 0.05$.

RESULTS

Participants were, on average, 58 years old, postmenopausal, and overweight (Table 1). Approximately half of the participant sample was African American, and the remaining women were white. On average, approximately three VMS per night per woman were detected by the monitor, two were reported during the night via button press, and three were reported in the diary upon waking (Table 2). Women reported sleeping an average of 7.5 (SD, 1.3) hours per night, yet per actigraphy, they slept an average of 6 hours per night and experienced an average of 55 minutes of WASO, broadly consistent with a larger sample of the SWAN cohort[13] and other normative data.[24,25] We examined the correlations between self-reported and physiologic measures of VMS (Table 3). Physiologically measured VMS were moderately and significantly associated with VMS reported on the monitor during sleep. However, physiologically measured VMS were not correlated with the number of VMS reported in the diary upon waking. Self-reported VMS, whether reported during sleep or in the morning upon waking, were moderately and significantly correlated with each other. Correlations between sleep measures are reported in Supplementary Table 1 (See Table, Supplemental Digital Content 1, http://links.lww.com/MENO/A17).

When relations between VMS and sleep in multivariable linear regression models are considered, reporting more VMS in the morning diary was associated with poorer actigraphic sleep efficiency and higher WASO (Table 4). In addition, reporting more VMS in the morning diary was associated with somewhat longer actigraphic sleep latency and rating the previous night's sleep as worse than normal. For example, women reporting no VMS in their diaries had approximately 41 minutes of wakening during the night, had 87% sleep efficiency, and took 6 minutes to fall asleep, compared with 77 minutes of wakening during the night, 80% efficiency, and 13 minutes to fall asleep among women with 10

reported VMS in their diaries. VMS reported throughout the sleep period were not related to sleep characteristics. Moreover, physiologically measured VMS were largely unrelated to sleep, except rating the previous night's sleep as worse than usual. Neither reported nor physiologic VMS were associated with questionnaire-rated sleep quality.

Several additional analyses were conducted. First, we examined whether any of the relations between VMS and sleep varied by race/ethnicity and found no significant interactions. Second, given that not all VMS are perceived as bothersome and the possibility that the more severe or bothersome VMS are associated with sleep, we examined ratings of VMS severity or bother provided in the morning diary in relation to sleep. Ratings of VMS severity and bother in the morning diary were strongly correlated with diary-reported VMS frequency ($r = 0.57–0.62$, $P < 0.0001$) and showed similar patterns in relation to actigraphic sleep as diary-reported VMS frequency (data not shown). However, VMS severity and bother had somewhat more pronounced relations with morning diary-rated sleep than VMS frequency. In multivariable models, more severe (b [SE] = −0.13 [0.03], $P < 0.0001$) and bothersome (b [SE] = −0.15 [0.05], $P = 0.001$) VMS were significantly associated with rating last night's sleep as worse than usual. More bothersome VMS (b [SE] = −0.10 [0.04], $P = 0.02$) were associated with feeling less rested in the morning.

DISCUSSION

In this investigation of women with VMS, reporting more VMS in a diary upon waking in the morning was associated with poorer sleep efficiency, more awakenings at night, and taking a longer time to fall asleep as assessed through actigraphy, controlling for relevant confounders. Conversely, physiologically assessed VMS measured during sleep were largely unrelated to sleep. Physiologically measured VMS were also not significantly correlated with morning diary estimates of VMS. Therefore, more VMS recalled upon waking, but not physiologically assessed VMS or VMS reported during sleep, were related to poorer actigraphic sleep.

Previous epidemiologic research using self-report measures of VMS and sleep has shown robust relations between self-reported VMS and sleep. However, research with physiologic measures of VMS and sleep has been more mixed. Several small studies using PSG sleep measures and skin conductance measures of VMS have largely shown null associations between VMS and sleep[11] or associations for half of the night.[13] Studies using actigraphy measures of sleep and reported VMS have produced mixed findings, with one study showing links between diary-reported VMS and actigraphic nighttime wakefulness[25] but with another study not showing these associations.[26] Our previous work underscored that links between VMS and sleep are probably for diary-reported VMS only[6] but was limited by its assessment of sleep. The present study is notable for being one of the few studies to use both physiologic and self-report measures of VMS and sleep in the home setting. We found that morning diary-reported VMS but not physiologic VMS or VMS reported during the night were related to poorer actigraphic sleep.

There are several possible interpretations of these findings. One interpretation is that physiologic measures, particularly of VMS, are not accurately capturing the construct of interest. Correlations between physiologic and diary measures for both sleep and VMS tend to be small to moderate,[27–29] indicating that they are capturing different aspects of VMS or sleep. There are notable limitations in the physiologic measurement of VMS, such as in scoring algorithms that may have low sensitivity in some women,[18,19] and actigraphy, which is a measure of activity and thereby an indirect measure of sleep,[24] that should be kept in mind. These issues would be expected to increase error and reduce detection of relations. In the case of VMS here, correlations between physiologic and self-report measures taken

during sleep were significant and moderate. However, when VMS were reported in the morning, the correlation between physiologic and self-report VMS was weaker. Notably, the morning-reported VMS correlated best with actigraphic sleep. Morning estimates of VMS frequency experienced overnight may be influenced by a range of factors, including the severity of the VMS, which the monitors cannot quantify, as well as sleep quality the night before.[6] However, attempting to precisely recall events that occurred during the previous night while sleeping undoubtedly represents a reporting challenge even for the most adherent participant.

One of the factors affecting a woman's ratings of her VMS may be a poor night's sleep. A woman might be more likely to attribute a poor night of sleep to VMS or recall more VMS if awakened during the night for other reasons. We obtained two self-report measures of VMS: those reported during the sleep period via event mark and those reported retrospectively the next morning via diary. Only the VMS reported in the morning via diary were related to actigraphic sleep. This is particularly striking given that one would expect the relationship between VMS reported during sleep and sleep disturbance to be inflated because a woman had to be awake to report the VMS event during the night, which would presumably be reflected in measures of sleep continuity. These findings point to the potential importance of memory in relating VMS to sleep disturbance and further call into question the causal role of VMS in sleep disturbance. Finally, it is possible that a third variable, such as autonomic[30] or thermoregulatory dysfunction,[31] may lead to both VMS and sleep disturbance.

Several limitations of this investigation deserve mention. First, whereas actigraphy measures of sleep were obtained, measures that allow delineation of sleep staging, such as PSG, were not. Therefore, measuring the effects of various relationships between VMS and sleep by sleep stages (eg, non–rapid eye movement sleep) that could be relevant to these relations[13] was not possible here. Moreover, neither measures of sleep apnea nor periodic limb movements, which can be important determinants of sleep in this population,[12] were obtained. Furthermore, the women were monitored for 4 days, given the feasibility of physiologic VMS monitoring. This period is longer than most studies using physiologic measures of VMS, but it is shorter than some diary or actigraphy studies that follow participants for weeks or months.[4,5] Finally, this sample is relatively small and includes only women with VMS.

This study had several strengths. It is notable in its inclusion of a range of both self-report and physiologic measures of VMS and sleep, in contrast to much of the literature, which relies on self-report measures of VMS and/or sleep. These measures reduce memory and reporting biases inherent in questionnaire measures.[7,32] In addition, this study incorporated several improvements in the diary measurement of VMS during the previous work. Diary measures of VMS were obtained during the night as well as upon waking the next morning. This method stands in contrast to the common practice of obtaining reports of VMS and sleep recalled over the past 24 hours, a method that would be expected to inflate relationships between sleep and VMS and reduce precision in estimates of each. Our method allowed comparisons across VMS measures and reduced the memory errors known to occur with 24-hour diaries[8] because of delayed entry. Moreover, as opposed to only assessing the simple presence/absence of VMS, which is common in diary studies in this literature, the actual numbers of VMS were reported. Furthermore, women were measured for two nights twice and in the home setting, increasing the reliability of estimates and increasing external validity. Finally, this study was conducted in the context of a well-characterized sample of African American and white women who have been followed throughout the menopausal transition.

CONCLUSIONS

In summary, we have observed that diary-reported VMS upon waking, but not physiologically monitored or diary-reported VMS during the night, were related to poorer actigraphy-assessed sleep continuity and poorer subjective sleep ratings. These data build upon previous work, showing robust relations between subjectively reported VMS and sleep, and further call into question the issue of whether VMS disrupt subjective sleep quality by causing nighttime awakenings. These findings point to the importance of further considering symptom appraisal processes that occur with poor sleep. They also indicate the potential promise in considering a third process that may underlie both sleep disturbance and VMS during the menopausal transition, two troublesome and common experiences faced by many midlife women.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

Sample characteristics

N	51
Age, mean (SD), y	58.30 (2.3)
Race, n (%)	
White	26 (51)
Black	25 (49)
Menopause status, n (%)	
Perimenopausal	5 (9.8)
Postmenopausal	46 (90.2)
BMI, mean (SD), kg/m^2	29.98 (5.0)
BMI category, n (%)	
<25 kg/m^2	9 (18)
25–30 kg/m^2	18 (35)
≥30 kg/m^2	24 (47)
Self-rated health relative to last year, n (%)	
Better/much better	9 (17.6)
Same	35 (68.6)
Worse/much worse	7 (13.7)
How hard it is to pay for basics, n (%)	
Very or somewhat hard	17 (33.3)
Not hard	34 (66.7)
Educational attainment, n (%)	
High school graduated	10 (19.6)
Some college/vocational training	26 (51.0)
College or above	15 (29.4)
Smoking status, n (%)	
Current regular smoker	6 (11.8)
Nonsmoker	45 (88.2)
Alcohol use, n (%)	
≥1 drink/wk	14 (27.5)
<1 drink/wk	37 (72.5)
Diary-reported alcohol use, median (IQR), drinks/day	0 (0.3)
Diary-reported caffeine use, median (IQR), servings/day	1.5 (2.1)
Diary-reported cigarette use, median (IQR), cigarettes/day	0 (0)
Depressive symptoms, mean (SD)	7.55 (6.5)
Trait anxiety, mean (SD)	33.80 (8.9)
Perceived stress scores, mean (SD)	11.73 (6.1)
Physical activity scores, mean (SD)	7.68 (1.5)
Use of medications impacting sleep, n (%)[a]	
Yes	7 (13.7)
No	44 (86.3)

IQR, interquartile range; BMI, body mass index.

[a]Opioids, antiepileptics, anxiolytics, hypnotics/sedatives, antidepressants, or antihistamines.

TABLE 2

VMS and sleep characteristics

Monitor VMS, average number per night, mean (SD)	
Physiologically monitored VMS	3.16 (2.1)
Monitor-reported VMS (reported throughout night)	1.65 (1.2)
Morning diary-reported VMS, average number per night, mean (SD)	3.09 (2.2)
Actigraphy-assessed sleep, average per night, mean (SD)	
Sleep time, min	360.38 (62.8)
Latency, min	19.61 (19.7)
Efficiency, %	80.71 (7.7)
Wakefulness after sleep onset, min	54.56 (22.7)
Morning diary-reported sleep	
Feeling rested, mean (SD)[a]	1.83 (0.7)
How this night compared with average night, mean (SD)[b]	2.00 (0.4)
Questionnaire-assessed sleep quality	
Very good or fairly good	34 (66.7)
Very bad or fairly bad	17 (33.3)

VMS, vasomotor symptoms.

[a]Range: 0 (not at all) to 3 (a lot).

[b]Range: 0 (much worse) to 4 (much better).

TABLE 3

Correlation between VMS measurements

	Physiologically measured VMS	Monitor-reported VMS[a]	Diary-reported VMS[b]
Physiologically measured VMS	—	0.52[c]	0.23
Monitor-reported VMS[a]		—	0.61[c]

VMS, vasomotor symptoms.

[a] Reported via event mark throughout night.

[b] Completed upon waking in the morning.

[c] $P < 0.0001$.

TABLE 4

Relationships between VMS and sleep characteristics

	Sleep time, regression coefficient (SE)	Efficiency, regression coefficient (SE)[a]	Latency, regression coefficient (SE)[b]	WASO, regression coefficient (SE)[c]	Feeling rested (diary), regression coefficient (SE)	How it compared with a usual night (diary), regression coefficient (SE)
Physiologically measured VMS[b]	−12.93 (22.7)	−0.24 (0.1)[d]	−0.57 (0.5)	−0.76 (0.7)	−0.44 (0.3)	−0.58 (0.3)[e]
Monitor-reported VMS[b]	−7.85 (24.0)	0.21 (0.2)	0.44 (0.5)	0.84 (0.8)	−0.15 (0.4)	−0.47 (0.3)
Diary-reported VMS	3.25 (2.3)	0.04 (0.01)[f]	0.07 (0.4)[d]	0.23 (0.06)[f]	−0.02 (0.02)	−0.06 (0.03)[e]

Adjusted for age, race, body mass index, difficulty in paying for basics, self-rated health, medication use, and depressive symptoms. Each VMS or sleep variable was considered separately.

WASO, wakefulness after sleep onset; VMS, vasomotor symptoms.

[a] Natural log transformed on (100 – efficiency), higher numbers indicate lower efficiency.

[b] Natural log transformed.

[c] Square root transformed.

[d] $P < 0.10$.

[e] $P < 0.05$.

[f] $P < 0.01$.