Nightmare Disorder in Women

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The aim of this study is to identify the short-term proximate triggers and effects of nightmares in adult women. In total, 85 females and 29 males participated in a 2-week intensive longitudinal assessment of mood, stress, social conflict, and sleep architecture measures. Sleep architecture was monitored with the DREEM–3 Headband device. Multilevel modeling analyses were conducted with lagged and cross-lagged effects estimates. Although women reported greater regular dream recall rates than men (9.76 women and 7.93 men), they reported the same number of nightmares as men (1.48 women and 1.48 men). Women displayed elevated percentage of light sleep in association with regular dreams, disturbing dreams, and nightmares and lesser amounts of percentage of deep sleep (N3%) for all three dream types. Z score conversions for N3% demonstrated a more dramatic reduction in N3% for females versus males on nights with disturbing dreams/nightmares. Female participants had significantly higher wake after sleep onset compared to males, with an estimated increase relative to men of 18.012 min ($SE = 6.313$, $p = .006$). An increase in stress 4 days prior to a nightmare significantly predicted that nightmare (estimate = 0.188, $p = .020$). Gender strongly mediated the effect of stress leading to a future nightmare. The interaction between gender and nightmares was positive and significant ($p = .0015$), with 23.9 more minutes awake after sleep onset than males 3 days after a nightmare occurrence. Women with nightmares may be disproportionately sleep deprived relative to male counterparts.

This article was published Online First April 24, 2025.
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This research was funded by the John F. Templeton Foundation and was performed by the National University under subcontract with the Shirley Ryan AbilityLab (Grant 62034). The authors have no conflicts of interest to declare. The data underlying this article will eventually be made available on the Open Science Framework site. Readers should forward inquiries to the corresponding author in the meantime.

Patrick McNamara served as lead for funding acquisition, project administration, resources, and supervision. John Balch contributed equally to methodology and visualization. Patrick McNamara and John Balch contributed equally to conceptualization. Patrick McNamara, John Balch, Rachel Raider, and Chanel Reed contributed equally to writing–original draft and writing–review and editing. John Balch, Rachel Raider, and Chanel Reed contributed equally to data curation. Patrick McNamara, John Balch, and Rachel Raider contributed equally to formal analysis. John Balch and Rachel Raider contributed equally to investigation. Rachel Raider and Chanel Reed contributed equally to project administration.

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AMERICAN PSYCHOLOGICAL ASSOCIATION
Dreaming

ISSN: 1053-0797
2025, Vol. 35, No. 3, 254–268
https://doi.org/10.1037/drm0000309

Stress and insomnia precede the nightmare and insomnia follows. Such sleep deprivation contributes to a cycle where nightmare-related sleep-avoidant behavior leads to insomnia and build-up over time of a significant sleep debt.

Keywords: nightmare disorder, sex differences, women, N3, insomnia

The *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (*Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition, *Text Revision*-[F51.5]) and *International Classification of Diseases*, Tenth Revision, *Clinical Modification* Diagnosis Code F51.5 manuals define nightmare disorder (ND) as a parasomnia involving repeated awakenings from extremely dysphoric dreams (World Health Organization, 2019). Upon awakening, the individual is oriented and alert and has a clear recall of the content of the dream, which in turn is associated with clinically significant distress and impairment in daytime functioning. Clinicians generally endorse the one nightmare per week for more than a year as a criterion for ND (Nadorff et al., 2015). Nightmares are 2–3 times more common in women than in men with most studies also reporting greater severity of nightmare distress among women (American Psychiatric Association, 2013; Cox et al., 2023; Sedano-Capdevila et al., 2021; Van Schagen et al., 2017). Epidemiological studies (Belicki, 1992; Bixler et al., 1979; Gieselmann et al., 2019; Haynes & Mooney, 1975; WHO, 2019) indicate that 2%–6% (about 6.4–15 million people) of the adult American population experience nightmares at least once a week.

The reasons for the greater preponderance of ND in women remain unknown and understudied (Van Schagen et al., 2017). In one of the original meta-analytic studies of gender differences in nightmare prevalence, Schredl and Reinhard (2011) reported that estimated effect sizes regarding the gender difference in nightmare frequency differed significantly from zero for adolescents and adults but not for elderly. The authors suggested that factors like dream recall frequency, depression, childhood trauma, and insomnia might help to explain this gender difference. In their recent narrative review of gender differences in common sleep disorders, Cappadona et al. (2021) suggested that the activity of either hypothalamic pituitary axis (HPA) or dysfunctional autonomic, specifically the sympathetic nervous system generates a negative loop involving sleep fragmentation and nightmares. One clue to this preponderance comes from the fact that insomnia is more common among women than men (Zhang & Wing, 2006) and in particular among women with ND (Delage et al., 2024). A higher proportion of women report concomitant insomnia and nightmares compared to men (Ohayon et al., 1997). Chronic insomnia of course is characterized by chronic sleep deprivation and the building up of slow wave sleep (SWS) deep sleep (N3) sleep debt. Interestingly, the build-up of sleep debt over time may be associated with nightmares. While nightmares are traditionally assumed to arise mainly from rapid eye movement (REM) sleep, Simor et al. (2012) showed that sleep architecture of nightmare sufferers is more pronounced in nonrapid eye movement sleep. They documented reduced overall sleep efficiency (SE), frequent awakenings from Stage 2 sleep, and significantly decreased SWS (N3). By contrast, however, Paul et al. (2015) found increased levels of SWS in frequent nightmare sufferers across three nights. Lin et al. (2020) documented increased sleep deprivation among adolescents with nightmares. It may be that nightmare occurrence and phenomenology depends, in part, on the interplay of dynamics between disrupted REM processes as well as sleep loss/avoidance/insomnia and then rebound or compensatory effects within SWS/N3. Based on this conjecture and these past studies, we predict that the key daily determinants of nightmare events (occurrence and distress level) in women would be changes in daily mood and distress levels, insomnia/sleep avoidance patterns, increased wake after sleep onset (WASO) levels, significant decrements in N3 as a percentage of total sleep, and resultant sleep rebound effects.

Participants and Method

We recruited volunteers from the community who answered adverts for a study on sleep, dreams, and nightmares. To be eligible, participants were required to: be at least 18 years old, reside in the United States, speak and read English, have reliable Wi-Fi, not have a current psychiatric or neurological diagnosis, and not have a current diagnosis of a sensitive skin condition (this final criteria was added during data collection after a few participants reported a negative, although nonsevere, skin irritation from wearing the Dreem 3 headband [DH]). Eligibility criteria regarding psychiatric and neurological diagnosis were self-reported by participants and were not screened using questionnaires at the time of invitation; however, those who scored beyond population norms according to the Depression, Anxiety, Stress Scale manual on any of the three categories of the Depression, Anxiety, Stress Scale in a baseline survey were not invited to participate in the full study. Volunteers ($N = 85$ females and 29 males[1]) were invited to participate in a 2-week study in the home. We aimed to have participants contribute a max of 14 days and a minimum of 10 days and nights of observations of daily stress, mood, social activities, sleep, and dream measures described below. Participants were sent a DH designed to derive sleep architecture measures. Participants were sent the DH along with Velcro extensions, an elastic sweatband, and a charger via United States Postal Service to their home, then met with a researcher over Zoom for a tutorial on how to properly wear it to achieve the best signal quality, including using the live signal check feature of the app. They were taught how to start the recording when they were ready to start falling asleep and how to stop the recording when they were ready to wake up in the morning as well as the procedure for charging and ensuring the data successfully transfers. After the training, they were instructed to wear the DH that night for habituation and to be sure they were wearing it in the best position for a quality recording. If the channel quality was extremely poor on multiple sensors, participants were asked to adjust the fit for another trial night. Those who continued to experience difficulties met with a researcher over zoom again to troubleshoot before continuing. Once an acceptable record quality was achieved, participants began the intensive longitudinal portion of the study, wearing the DH for 14 consecutive nights.

Institutional Review Board Coverage

The study was overseen by the Institutional Review Board, Study 2022-184-OTH, dated May 17, 2022. Informed consent was received from all participants.

[1] Two participants identified as trans males but were included due to being posttransition (Hyde et al., 2019).

Sample Characteristics

Participants reported an average of 1.48 ($SD = 1.71$) nightmares during the 2-week study, with 33 participants experiencing at least one nightmare per week during the study. The completion rate of daily/nightly assessments of mood, stress, social activities, and dreams and nightmares was 98.1% overall (98.2% morning surveys completed, 97.9% night surveys completed). Participants were on average 46 years old ($SD = 14.37$), predominantly female and White. Most participants had completed a bachelor's degree or higher and had a household income of over $50,000 a year.

Daily/Nightly Measures

Sleep Architecture

The DH (Paris, France) is wireless and worn during sleep to record, store, and automatically analyze physiological sleep data. It has been previously validated against polysomnography with an accuracy of 83.5 $\pm$ 6.4% compared with an average of 86.4 $\pm$ 8.0% for the five sleep experts scoring polysomnography (Arnal et al., 2020). The DH is made of foam and fabric with an elastic band with optional Velcro extensions to ensure a secure fit for different head sizes. The DH contains embedded sensors including electroencephalography (EEG) dry electrodes, frontal (F7, F8, and FpZ as the virtual ground) and occipital (O1 and O2) yielding seven derivations (FpZ-O1, FpZ-O2, FpZ-F7, F8-F7, F7-O1, F8-O2, FpZ-F8; 250 Hz with a 0.4–35 Hz bandpass filter), as well as a three-dimensional accelerometer that tracks movements, position, and respiration (based on movement of the head at a sampling frequency of 50 Hz). A bone conduction speaker delivers audio messages to the wearer when recordings are started and stopped, as well as a notification that a session is in progress if the button is pressed after the DH has successfully begun recording. The DH is used in conjunction with the "Alfin" application, freely available on Android and Apple iOS, which allows the transfer of stored data via Bluetooth. Participants were provided with app log-in details to ensure full data confidentiality and anonymity. Users can view metrics regarding their night's sleep on the app, and researchers can access participant recordings on servers to see data that the algorithm has automatically scored. These capacities, together with the price, ease of use, precision and reliability, and the collection of raw EEG and other relevant physiological data, make the DH an ideal candidate for high-quality large-scale longitudinal sleep studies in the home. Via Dreem, we measured several sleep architecture variables. These are computed for each night based on the 30-s resolution data provided by the DH: total sleep time (TST, min), SE (%, calculated as TST/total recording time), and sleep onset latency (min)—detected latency from lights-off to the beginning of the first 5 min of persistent sleep—calculated as the sum of epochs classified as wake before the first epoch classified as Sleep $\times$ Epoch Length (s)/60. WASO (min)—period of wakefulness occurring after sleep onset—calculated as the sum of epochs classified as wake after the first sleep Epoch $\times$ Epoch Length (s)/60. REM sleep (%)—percentage of REM sleep over TST—calculated as ("REM"/60)/TST $\times$ 100. N3 deep sleep (%)—percentage of deep sleep over TST—calculated as ("deep"/60)/TST $\times$ 100. Light sleep (N2%)–percentage of light sleep over TST–calculated as ("light"/60)/TST $\times$ 100.

Dream Collection

Each morning, participants were asked to report any dreams and then rate the content of their dreams in terms of mood and general themes. Dream content was assessed with free responses as well as the structured Dreamland Questionnaire (DL-Q; Dement, 1965). This questionnaire asks participants to rate dream content along a variety of adjectival scales, such as "strange versus familiar," ranging from −10 to +10, with scores in the negative indicating the "strange" end of the scale with lower scores being more extreme. They also rate the levels of various sensory contents in the dream ranging from −10 to +10 based on the presence or absence of sensation.

Mood

At morning and night, we asked participants to complete the Scale of Positive and Negative Emotions, a well-validated 12-item scale that measures different dimensions of positive and negative affect. To create an overall Scale of Positive and Negative Emotions score, a sum of the negative items is subtracted from a sum of the positive items.

Daily Social Events

Each night, the participants are asked to list three activities that they spent the most time doing that day along with a short description. They rate each activity on a scale for whether the activity made them feel positive/happy and stressed/upset, both ranging 1–7. They are also asked to list three social interactions with a short description. These interactions are then rated along a variety of dimensions, each ranging 1–7. For this study, we utilized the item which asked them to what extent each interaction included "arguing or having conflict." All items were averaged either across the three activities or the three social events.

Coding of Nightmares

Each morning, participants reported whether or not they recalled a dream and they gave a narrative summary of that dream if they could recall it. Participants were not explicitly asked whether they experienced a nightmare. Each dream report was read in its entirety by three judges—one researcher and two research assistants—to determine if the content was a nightmare based on the following criteria:

1. Although participants were not explicitly asked, if the dream was spontaneously described by the participant as a nightmare in their narrative, it was labeled as such by the judges.
2. The dream was labeled by coders as a nightmare if the narrative:
   i. Included fear words, such as "terrified" or "afraid."
   ii. Included a scenario that posed an immediate threat to the dreamer, such as being chased or trapped in a dangerous situation or if they reported pain.
3. When the narrative was lacking emotion descriptors or did not contain enough content, the adjective ratings from the DL-Q were used:

i. Reports with scores of −5 or lower on the scales for “scary/threatening versus relaxing/enjoyable” and/or “repulsing/aggressive versus caring/gentle” were usually considered a nightmare by the judges.
ii. For narratives that only included a small amount of nightmare content, were resolved before awakening, or did not include a fixation on the negative emotions or experiences, the scale ratings were used to decide between a nightmare or disturbing dream.

4. When Criteria a–c were not enough to determine if the report was a nightmare, awakening was taken into consideration: if the dream led to awakening, especially if it also resulted in difficulty falling back asleep, it was more likely to be labeled as a nightmare by judges.
5. If there was very little narrative recall, the report could still be considered a nightmare if the participant reported extreme DL-Q ratings and described waking mood effects. For example, “All I remember is that it was a pretty scary dream but I can’t remember details.” If they report feeling merely unpleasant, it was labeled by judges a “disturbing dream” but not a nightmare.

After applying all these exclusion and inclusion criteria individually, judges met as a group to discuss reports that did not have full blinded agreement until they reached a consensus among at least two-thirds of the raters. The interrater reliability coefficient between judges was .98 (scored using Krippendorff’s α). Of 1,568 morning surveys, there were 1,032 surveys that included recalled dream content. We found 169 surveys with at least one nightmare, 96 surveys with at least one disturbing dream, and 767 surveys with regular dreams (that might have been sad or unpleasant, but not to the extent of the disturbing dreams or nightmares).

Statistical Analyses

The intensive longitudinal design of the study allowed for the use of multilevel regression analyses (i.e., mixed-effects regression, random-coefficients modeling, and hierarchical linear modeling) to test the primary study hypotheses that daily stress/mood levels and N3 percentages would predict nightmare events. Multilevel regression techniques were developed to analyze nested, or hierarchical, data structures. The daily diary data, mood assessments, and sleep architecture assessments served as repeated measures that are nested within individuals. Sex difference constituted the group-level analyses. Strengths of the multilevel regression analytic procedures include: (a) capability of handling missing data and unbalanced designs (i.e., the number of assessment points and the timing of assessments can vary across participants); (b) addressing analytic issues that arises from aggregating over a large number of assessment occasions or not accounting for the nested structure of the data; (c) very efficient and powerful estimation procedures that utilize all data points available; and (d) modeling flexibility allowing for the inclusion of continuous or categorical, time invariant or time varying predictors and covariates. In our models, we included individual participant variability as a random effect, which adjusts the intercepts based on participant variability. Finally, lagged analyses was conducted iteratively to examine the temporal relationship between nightmare indices on day t and stress, mood and sleep measures in sliding windows from $t-1$ to $t-4$.

Results

Although women reported greater regular dream recall rates than men (9.5 per women vs. 7.76 per man), they reported the same number of nightmares as men (1.48 women and 1.48 men). However, women reported significantly greater numbers of disturbing dreams (77 or about 0.91 per woman vs. 0.66 per man). See Table 1 for all dream recall rates by gender.

We next looked at sleep architecture differences associated with each of the three dream types in men versus women across the 2-week study period. For this analysis, we had only 35 females and 20 males. But given the repeated measures design and the fact that we are comparing repeated measures (an average of about 11 nights of measures per subject) of N2%, N3%, and REM%, we have increased confidence that these analyses are reliable. Interestingly, there are no significant differences between men and women on percent time spent in REM sleep for any of the three dream types, though men displayed marginally greater REM% for disturbing dreams (28% vs. 23%). Women, however, displayed increased levels of N2% for all three dream types and substantially lesser amounts of N3% for all three dream types. See Table 2 for a full comparison of sleep stages by gender and dream type.

These sleep architectural differences between men versus women for the differing dream types become more explicit when we control for individual and sample means (see Figures 1 and 2). In particular, z score conversions for N3% demonstrate a more dramatic reduction in N3% for females versus males on nights with disturbing dreams and nightmares.

We next utilized mixed-effects models in order to control for interparticipant variability to assess WASO effects. The results (Table 3) indicated that female participants had significantly higher WASO compared to males, with an estimated increase of 18.012 min ($SE = 6.313$, $p = .006$). The intercept (which refers to male participants as the reference category) was 25.300 min ($SE = 5.018$, $p < .001$).

We then used lagged analysis (Table 4) to test whether or not gender was a significant factor in predicting nightmare occurrence as a response to daily stressors.

Initially, we looked at gender on its own, revealing no significant effect on nightmare occurrence (estimate = −0.006, $p = .984$). First, we investigated the effect of stress on nightmare occurrence utilizing lagged variables for up to 5 days before the event. Since only the 4-day lag was significant, we removed the other lagged variables for the sake of a more parsimonious model. Stress during daily activities 4 days prior to a nightmare event had a positive and significant effect on nightmare occurrence (estimate = 0.188, $p = .020$). Assessing the relationship between stress and gender revealed a significant interaction, with being female and experiencing stress positively predicting nightmare occurrence (estimate = 1.067, $p = .001$), with the

Table 1
Dream Recall by Dream Types for Female and Male Participants

Number of completed surveys	Surveys	No recall	Dream	Disturbing	Nightmare
Female ($n = 85$), n (%)	1,167 total	360 (30.85)	604 (51.76)	77 (6.6)	126 (10.8)
Male ($n = 29$), n (%)	401 total	176 (43.89)	163 (40.65)	19 (4.74)	43 (10.72)

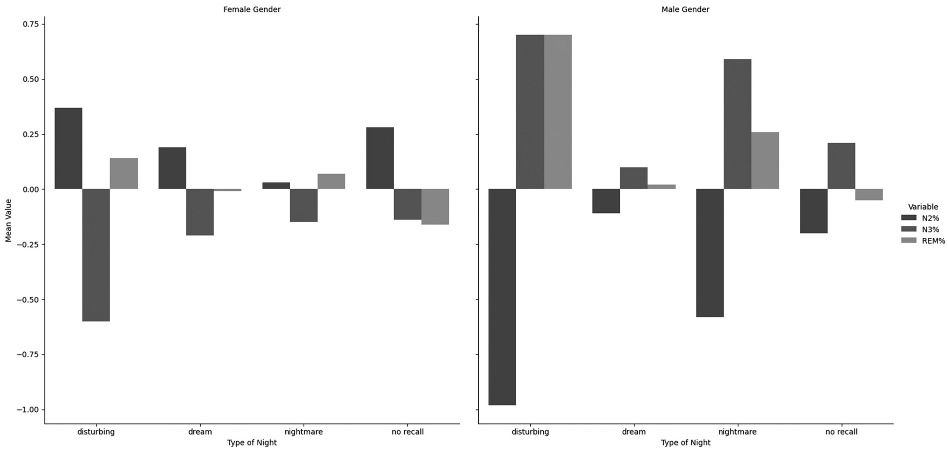
Table 2
Sleep Architecture by Dream Type

	No recall		Dream		Disturbing		Nightmare	
Sleep measure	Female ($n = 120$)	Male ($n = 94$)	Female ($n = 204$)	Male ($n = 118$)	Female ($n = 23$)	Male ($n = 11$)	Female ($n = 45$)	Male ($n = 25$)
N2%	53.93	48.66	52.92	49.61	54.93	40.12	51.20	44.53
N3%	18.49	22.07	17.68	21.02	13.64	27.26	18.37	26.12
REM%	21.1	21.94	22.82	22.50	23.42	27.68	22.82	24.3
TST	405.39 (87.49)	405.13 (86.48)	402.68 (90.1)	410.27 (91.5)	396.8 (91.43)	436.86 (94.36)	384.6 (102.63)	421.2 (88.24)
N2 duration	218.37 (60.08)	198.98 (64.81)	214.13 (68.17)	201.03 (56.67)	217.41 (59.54)	179.91 (67.9)	196.9 (71.32)	191.24 (71.3)
N3 duration	73.35 (36.62)	85.34 (35.59)	70.23 (37.88)	86.31 (32.87)	53.39 (34.94)	114.09 (23.9)	68.04 (42.06)	102.92 (32.73)
REM duration	87.85 (40.75)	90.55 (37.84)	89.65 (38.85)	95.01 (42.76)	94.04 (32.37)	118.5 (37.43)	90.3 (43.16)	105.24 (51.77)

Note. N2% = percentage of light sleep; N3% = percentage of deep sleep; REM% = percentage of rapid eye movement; TST = total sleep time: mean (standard deviation); Sleep stage durations are reported in minutes: mean (standard deviation); N2 = light sleep; N3 = deep sleep; REM = rapid eye movement.

Figure 1

Mean Values (Centered on Group Mean) of Sleep Type Percentages by Gender and Type of Night



Note. N2% = percentage of light sleep; N3% = percentage of deep sleep; REM% = percentage of rapid eye movement.

main effect for both being negatively and significantly associated with nightmare occurrence. This indicates that the effect of stress leading to a future nightmare is strongly mediated by gender effects.

Next, considering the higher levels of female insomnia in our data set and the hypothesized positive feedback between nightmares and insomnia, we also tested to see if gender and nightmare occurrences were predictive of future levels of insomnia (Table 5). Again, we tested the main effect for nightmares alone and then looked at the interaction with gender and looked at multiple time lags, settling on a 3-day lag.

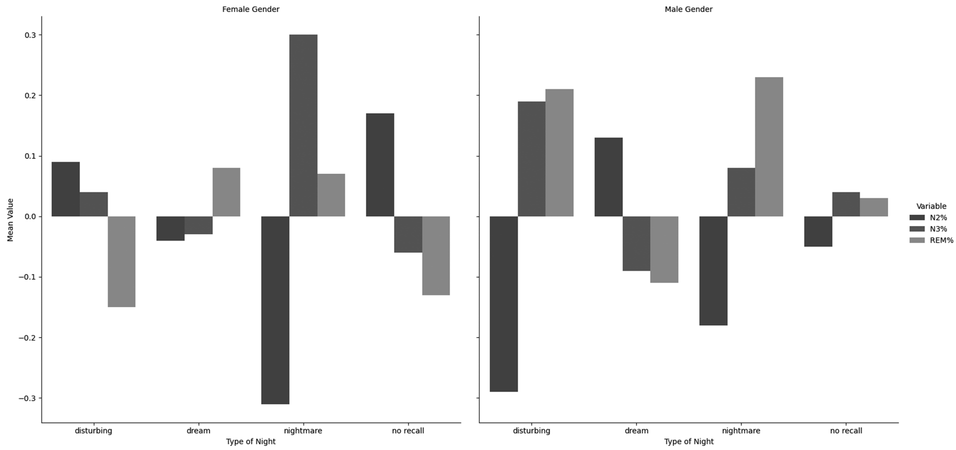
The main effect of gender was still significant ($p = .026$), with 15.229 more minutes awake after sleep onset. Nightmares no longer has a significant main effect, but the interaction between gender and nightmares was positive and significant ($p = .0015$), with 23.951 more minutes awake after sleep onset than males 3 days after a nightmare occurrence.

Discussion

To summarize our results, although women reported significantly greater overall dream recall rates than men, they reported the same number of nightmares during the study as men. Women displayed elevated N2% across all dream types (regular, disturbing, and nightmares) and overall lower levels of N3%. When controlling for individual differences, however, women showed elevated levels of N3% from their own baseline on the night of nightmare compared to men. Female participants had significantly higher WASO times compared to males, with an estimated increase relative to men of 18 min ($SE = 6.313$, $p = .006$). An increase in stress 4 days prior to a nightmare significantly predicted nightmare occurrence for women, with (estimate = 1.067, $p = .001$). The interaction effect between gender and stress was found to be quite strong, with both reference terms (female without stress and male with stress)

Figure 2

Mean Values (Centered on Participant Mean) of Sleep Type Percentages by Gender and Type of Night



Note. N2% = percentage of light sleep; N3% = percentage of deep sleep; REM% = percentage of rapid eye movement.

being significant with negative estimates. This indicates that the stress-lag effect causing nightmares is strongly mediated by gender. Nightmares and gender were also found to be significant predictors of increased levels of WASO with a 3-day lag, and the interaction between gender and nightmares was also positive and significant ($p = .0015$), with 23.9 more minutes awake after sleep onset than the reference level of males with no nightmares.

Our finding of an interaction effect between stress and gender is consistent with results reported by Garcia et al. (2021). These authors also used a daily diary design and multilevel analyses to study the associations of nightmares with daily stressors in nurses—over 90% of which were women. Multilevel models were used to examine bidirectional, within-person associations between daily stress and nightmares and cross-level moderation by baseline posttraumatic stress disorder symptoms. Nurses (47.2%) reported at least one nightmare across the 2 weeks. Days with greater stress were associated with higher odds of experiencing a nightmare ($OR = 1.22$, $p = .001$), as well as greater nightmare severity ($b = 0.09$, $p = .033$). Nightmare occurrence was associated with greater next-day stress severity ($b = 0.15$, $p < .001$). Our results, while largely consistent with Garcia et al., add the WASO and insomnia findings to the presumably bidirectional relationships between stress and nightmares.

Table 3

Wake After Sleep Onset by Gender

Predictor	Estimate	2.5_ci	97.5_ci	*SE*	*df*	*t* statistics	*p*	Significance
(Intercept)	25.3	15.464	35.135	5.018	50.758	5.041	0	***
Female	18.012	5.64	30.385	6.313	51.443	2.853	.006	**

Note. ci = confidence interval; WASO = wake after sleep onset.
** $p < .001$. *** $p < .0001$.

Table 4
Mixed-Effects Logistic Models for Gender and Lagged Stress on Nightmares

Predictor	Estimate	2.5_ci	97.5_ci	*SE*	*Z* statistics	*p*	Significance
Gender							
(Intercept)	−2.485	−3.013	−1.956	0.27	−9.218	0	***
Female	−0.006	−0.594	0.582	0.3	−0.02	.984	
Lagged stress							
(Intercept)	−2.982	−3.511	−2.452	0.27	−11.04	0	***
Activity stress (T−4)	0.188	0.03	0.346	0.081	2.329	.02	*
Interaction model							
(Intercept)	−0.991	−2.184	0.202	0.609	−1.628	.104	
Female	−2.279	−3.577	−0.981	0.662	−3.441	.001	***
Activity stress (T−4)	−0.762	−1.384	−0.141	0.317	−2.403	.016	*
Female × Activity Stress (T−4)	1.067	0.424	1.711	0.328	3.25	.001	**

Note. ci = confidence interval; T = time/days.
* $p < .01$. ** $p < .001$. *** $p < .0001$.

We interpret our results as strongly suggesting that women are disproportionately affected by insomnia leading up to a nightmare (thus building up a sleep debt) and then for days after the nightmare. Their WASO percentages across each night are persistently higher relative to the men, particularly after disturbing dreams and nightmares. In addition, it appears that women with ND (like the men in our sample) attempt to repay the sleep debt on the night of the nightmare but are for some reason unable to satisfactorily do so. Women instead display a significantly reduced N3% relative to men on the night of the nightmare. They therefore undergo further insomnia in the days immediately following the nightmare event, thus setting up a vicious cycle of insomnia contributing to stress which then triggers disturbing dreams and finally nightmares which then leads to further WASOs and insomnia and so on. This admittedly speculative set of suggestions is supported in our view by the recent results reported by Pachi et al. (2023). These authors used online survey methods in 355 female and 78 male nurses to study the associations between nightmares, stress, and insomnia. Their findings revealed that female nurses had higher insomnia and nightmare distress scores but lower resiliency scores compared to males. Nightmare distress accounted for 24% of the insomnia variance, but resiliency acted as a mediator, attenuating the impact of nightmares on insomnia, with gender moderating this relationship.

As reviewed in the introductory part, previous research has shown that insomnia is more common among women than men, and in particular among women with ND. A higher proportion of women report concomitant insomnia and nightmares

Table 5
Wake After Sleep Onset After Nightmare Event

Predictor	Estimate	2.5_ci	97.5_ci	*SE*	*df*	*t* statistics	*p*	Significance
(Intercept)	36.125	29.357	42.893	3.453	56.363	10.462	0	***
Nightmare (T−3)	9.649	0.77	18.528	4.53	476.893	2.13	.034	*
(Intercept)	26.436	16.112	36.759	5.267	52.338	5.019	0	***
Female	15.229	2.196	28.261	6.649	53.708	2.29	.026	*
Nightmare (T−3)	−7.158	−23.093	8.777	8.13	482.116	−0.88	.379	
Female × Nightmare (T−3)	23.951	4.81	43.092	9.766	480.516	2.452	.015	*

Note. ci = confidence interval; T = time/days.
* $p < .01$. *** $p < .0001$.

compared to men. Our results provide some insight into potential causal mechanisms of these previously reported associations of insomnia and nightmares in women. The intensive longitudinal design allowed us to compute lagged analyses of events leading up to a nightmare event. Our data showed that a change in stress levels, an increase in WASO levels, and a reduction in N3% 4 days prior to the nightmare significantly predicted the nightmare event. Then when participants finally succumbed to sleep on the night of the nightmare, there was an N3 surge for men but less so for the women. Then WASO levels remained high for days after the nightmare event for women only. In short, women with ND appear to be chronically sleep deprived due possibly to an inability to efficiently repay cumulative sleep debt. However, our suggestion that women might accumulate sleep debt more than men is not directly tested in this study as no direct measure of sleep debt (e.g., multiple nights of cumulative SWS loss) was used. Our suggestions must therefore remain speculative.

Why might women, or at least women with ND, be less efficient at achieving deep SWS or repaying sleep debt than men? Sleep debt is basically a measure of homeostatic need for sleep (Borbély, 1982; Daan et al., 1984). Borbély (1982) first formalized the insight that mammalian sleep involved a balance between sleep amount and sleep intensity and that sleep was therefore under homeostatic control. In his “two-process” model of sleep regulation, a sleep need factor called Process S (presumably associated with something like adenosine levels) increases during waking (or sleep deprivation) and decreases during sleep. Process S is proposed to interact with input from the light-regulated circadian system (Process C) that is independent of sleep and wakefulness rhythms. Process C slowly rises (mediated by circadian cortisol rhythms) helping to arouse the individual into wakefulness.

Sex hormone activity is known to significantly modulate components of both Process S (e.g., slow wave activity) and Process C (the morning rise in circadian cortisol activity). Indeed, sex hormones have been shown to affect circadian and dynamic changes in the HPA axis (Handa et al., 1994). The morning rise in circadian cortisol activity, for example, appears to be more prominent in women than men (Wüst et al., 2000).

But there may be additional factors contributing to the disproportionate amounts of nightmares and insomnia related to ND in women in this study. Factors we were not able to examine included preexisting insomnia, work, and/or family schedules involving late night or early morning obligations and other daily stressors. In addition, many women, for example, regularly take (or took for many years) oral contraceptives. The synthetic estrogens and progestins in these contraceptives significantly suppress the gonadal hormone axis and could therefore blunt the HPA axis reactivity and reduce the magnitude of the morning rise in cortisol rhythmic activity (Hertel et al., 2017). Lower morning cortisol activity levels have been detected in women taking contraceptives compared to naturally cycling women (Høgsted et al., 2021). The use of contraceptives has indeed been associated with less deep sleep as revealed with EEG measurements and a longer time to fall asleep (Burdick et al., 2002). In support of this proposed link between sex hormonal changes and the disruption in homeostatic sleep processes is the fact that complaints of insomnia increase from the time of the first menarche in girls (Johnson et al., 2006) and during pregnancy and perimenopause (Ciano et al., 2017; Hashmi et al., 2016).

In summary, our results are consistent with the claim that nightmare phenomenology differs for women versus men in that nightmares are more often associated with insomnia in women than in men. Stress, WASO, and a reduction in N3% precede and predict a nightmare event in women. On the night of the nightmare, there is only a blunted N3 surge suggesting an inability to repay sleep debt incurred in associated with the WASOs occurring in the lead up to the nightmare. After the nightmare, women remain sleep deprived relative to men. Given that sex hormones interact significantly with sleep neurobiology, it is possible that use of oral contraceptives that blunt circadian rhythmicity also blunt homeostatic sleep mechanisms, in particular preventing sufficiently intensity of SWA to repay the sleep debt.

Limitations of the Study

There are several limitations of this study. First, our method of scoring and classifying nightmares requires recalled dream narratives with enough content to be rated. Consequently, our findings surrounding nightmares only apply to recalled nightmare events, and caution should be exercised extending these findings to nights with no recall or fragmented nightmare events. Second, our sample showed an unusually high level of nightmare frequency compared to the overall population. This is likely due to our recruiting materials, some of which specifically targeted individuals with frequent nightmares but may have led to a self-selection bias. This self-selection bias in our sample may also partially be responsible for the fact that across the 2-week long study men and women reported about the same number of nightmares, which is contrary to what most studies have reported (women report more nightmares typically). The men in our sample were recruited into the study precisely because of their experience with nightmares. In addition, we note that the women in our study did indeed report significantly greater numbers of disturbing dreams. In addition, we had more women in this study than men. Therefore, a sample ratio of 3:1 introduces statistical power issues when comparing gender differences. Medication information was not incorporated into the analysis. Future research should include medication information. The DH automatic sleep scoring algorithm only reaches about 55% accuracy when detecting N1, which could affect accuracy of the sleep stage classifications and distributions (Arnal et al., 2020). Since participants were responsible for the placement of the headband, the signal quality varied throughout their 2-week participation in the study. Participants were instructed to start the recording when they were ready to start trying to fall asleep and end the recording when they woke up, but it is possible that some did not follow this instruction exactly, resulting in extra wake time being recorded, which would affect related metrics. It should also be noted that since the headband requires a smartphone or tablet along with strong, reliable Wi-Fi, those without full access to these resources were not able to participate, potentially biasing the sample.

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