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ORIGINAL ARTICLE

Sleep and eating disorders among adults enrolled in a commercial weight loss program: associations with self-report and objective sleep measures

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Abstract

Purpose Some research suggests that eating disorders are related to poor sleep health. To increase knowledge on the relation between sleep and eating disorders, we used a multi-method approach to examine associations between sleep, chronotype, and eating disorder psychopathology.

Methods We investigated associations between ED psychopathology, both diagnostic categories (ascertained through self-report data) and dimensional measures, and self-report and ambulatory measures of sleep. Adults currently enrolled in a commercial weight loss program completed self-report measures as well as 1 week of ambulatory sleep monitoring and sleep diaries.

Results Participants with full- or sub-threshold bulimia nervosa and binge eating disorder reported significantly lower subjective sleep health and greater eveningness. Additionally, greater severity of eating disorder psychopathology was associated with lower subjective sleep health and greater eveningness. Eating disorder psychopathology was generally not related to objective sleep measures. Regarding diary measures, global eating disorder psychopathology was negatively correlated with subjective reports of feeling rested.

Conclusion Eating disorder psychopathology is associated with participants' subjective sense of sleep quality, but appears to have little relation to objective sleep characteristics.

Level of evidence Level V, descriptive study.

Keywords Eating disorders · Sleep · Ambulatory assessment · Sleep monitoring · Chronotype

Eating disorders are related to numerous mental and physical health complaints [1]. Specifically, research has shown associations between eating disorders and increased sleep problems [2]. Studies have shown that compared to their healthy counterparts, individuals with anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED) display disturbances in sleep [3–5]. In addition, studies have reported that poorer sleep is related to dimensional eating disorder measures including greater severity of overall eating disorder symptomatology and behaviors [6, 7]. Evidence suggests that eating disorder symptoms prospectively predict poorer sleep longitudinally [1, 8]. Understanding the association between sleep and eating disorders is important given that sleep may function to maintain or exacerbate eating disorder symptoms. For example, a recent study found that sleep reduced cognitive control (e.g., ability to inhibit response to stimuli) and heightened negative mood [9], which are two important risk factors for eating disorder symptoms [10, 11].

Recent studies examining the relation between sleep and eating disorders have primarily used self-report measures of sleep, which are limited by a number of inherent biases (e.g., retrospective recall biases). In addition, some other studies have examined sleep in individuals with eating disorders in

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the laboratory [12]. While laboratory studies have a number of strengths, they lack ecological validity, or generalizability to people's everyday lives and natural environment. Ambulatory assessment allows researchers to collect objective data in participant's natural environments, which limits retrospective recall bias while maximizing ecological validity. Ambulatory assessment involves participants wearing an ambulatory device that monitors individuals' sleep.

To increase knowledge on the relation between sleep and eating disorders, we used a multi-method approach to examine associations between sleep and eating disorder psychopathology. We investigated associations between eating disorder psychopathology, both diagnostic categories (i.e., BN vs. BED vs. no eating disorder) and a dimensional measure (i.e., global eating disorder symptoms), self-report and ambulatory measures of sleep, and chronotype. It was expected that eating disorder psychopathology would be related to poorer subjective sleep quality and an eveningness chronotype. Examination of associations between eating disorder psychopathology and objective sleep parameters was exploratory given the dearth of literature in this area.

Methods

Participants

The current study was a secondary analysis of a larger study focused on the association between sleep, health behaviors, and obesity risk among members of a commercial weight loss program available across the United States. The weight loss program involves nutrition, activity, and lifestyle coaching and planning as well as smart tracking technology. There were 1011 individuals who completed an online screener; 650 of these members were excluded, and 361 were eligible for participation. Over half (55.7%) were excluded because they already had a personal Fitbit account. To ensure participants were capable of normal sleep, individuals were excluded if they were currently receiving treatment for a sleep disorder (17.8%) or had an irregular sleep schedule (e.g., due to shift work; 22.2%). Participants who were physically unable to engage in daily physical activity were excluded as this variable was a central part of the parent study's primary objectives (10.3%). About 4.6% were excluded due to other criteria, including an age of fewer than 18 years, enrollment in the weight loss program for more than 4 weeks, or lack of a computer and/or internet access at home.

There were 314 invitations to begin the online survey that were sent out, and 212 chose to enroll in the study as participants. A small number of eligible individuals ($n = 18$) were randomly excluded from invitation due to a shortage of available study devices. Participants included new members of the weight loss program (85% female; 97% Caucasian), enrolled for no more than 4 weeks. All participants were at least 18 years old. The mean age of participants in the study was 44.28 years (SD = 12.54; Range = 18–78). The mean body mass index (BMI) of participants was 34.54 (SD = 7.50; Range = 22.32–61.81). BMI categories were as follows: 5.2% were normal weight (BMI > 18.5 and < 25), 28.6% were overweight (BMI > 25 and < 30), and 66.2% were obese (BMI > 30).

There were 125 participants who completed the study protocol. Participants withdrew from the study for the following reasons: study was too much work ($n = 13$), equipment and/or programs were difficult to use/malfunctioning ($n = 12$), health/family/work related issues ($n = 6$), Fitbit was not comfortable to wear ($n = 1$), and unspecified reason ($n = 55$). Attrition analyses indicated there were no significant differences in sociodemographic variables (age, BMI, education, annual income, gender, race, marital status) between individuals who completed the entire study and those who ended participation early.

Procedure

Within 3 weeks of enrolling in the weight loss program, a program staff member emailed new members a brief description of the study and invited interested individuals to follow an electronic link to be screened for eligibility. All online assessments including the screener were administered through PsychData, and this initial assessment included electronic informed consent, a brief screening questionnaire to evaluate inclusion/exclusion criteria, and a request for contact information. Qualified participants were emailed a link to a set of online questionnaires and an electronic informed consent. In addition to measuring sociodemographic and health-related information, the questionnaires included measures of eating disorder symptoms, chronotype, and sleep. To maximize study efficiency, participants had 48 h to complete the online assessment before their link expired and they were no longer eligible.

After completing the online survey on time and in full, participants were asked to monitor their sleep and physical activity for 1 week. They were mailed a package with a Fitbit Charge HR, the Fitbit charger and dongle, and detailed instructions on using and synching the Fitbit. The package also contained a paper copy of instructions for completing a daily sleep diary and the link to access the diary online. Participants were instructed to wear the Fitbit night and day for 1 week on their nondominant wrist, synching the device to a computer every night and charging every few days as needed. Participants were instructed to charge the Fitbit during the day when possible.

Concurrently, participants completed daily sleep diaries at bedtime and upon waking to monitor perceived sleep

quality and characteristics. Study staff monitored adherence to the daily diary assessments and Fitbit synching, and nonadherent participants were contacted by email to provide reminders or technical support. At the end of 1 week participants returned study materials in a prepaid mailing envelope and received $50 compensation.

Materials

Eating disorder symptoms

The Eating Disorder Diagnostic Scale (EDDS) is a 22-item self-report measure used to assess DSM-IV diagnostic criteria for AN, BN, and BED [13]. The EDDS also provides a composite score for eating disorder symptomology, with higher scores indicating greater symptomatology [14]. Sample items include: "Over the past 3 months, have you felt fat?" and "How many days per week on average over the past 6 months have you eaten an unusually large amount of food and experienced a loss of control?" Participants reported the frequency with which they experience cognitions and engaged in behaviors consistent with eating disorder pathology. This measure has shown adequate reliability and validity [13, 14].

Chronotype

The 13-item Composite Scale of Morningness (CSM) is measure used to assess chronotype [15]. The measure improves upon prior measures by combining 9 items from the Morningness-Eveningness Questionnaire and 4 items from the Diurnal Type Scale into one scale [16, 17]. Participants have 4 or 5 response options for every item of the CSM and they are instructed to choose the response that best corresponds to their sleep-wake timing preferences. Each response option is assigned a value from 1 to 4 or 1 to 5, with 1 representing extreme eveningness and 4 or 5 representing extreme morningness. Responses for all items are summed. Total scores range from 13 to 55; scores of 22 and less indicate evening type, scores of 23–43 indicate intermediate type, and scores of 44 and above indicate morning type. Good reliability and validity of the CSM have been demonstrated [15, 18, 19]. Cronbach's alpha in the present sample was 0.89.

Sleep

The SATED scale is a five-item self-report measure that may be used to assess five principal dimensions of sleep health: satisfaction with sleep, alertness during waking hours, timing of sleep, sleep efficiency, and sleep duration [20]. Individuals report the extent to which they experience or engage in each of the five sleep health domains on a scale from 0 (*rarely/never*) to 2 (*usually/always*). Items are summed to calculate a total sleep health score ranging from 0 to 10 with higher values indicating better sleep health. Cronbach's alpha for this measure was 0.62. Because Cronbach's alpha may be sensitive to the number of items in the measure, we used the Spearman–Brown Prophecy formula to calculate the projected alpha value if the number of items in the SATED were doubled [21]. The results of this test suggested that increasing the number of items in the scale to 10 would improve the reliability of the measure. The projected Cronbach's alpha was acceptable for the current study ($\alpha = 0.77$).

The Fitbit Charge HR (Fitbit Inc., San Francisco, CA) is a commercially available, wrist-worn accelerometer that was used to measure objective nocturnal sleep characteristics for 1 week. The Fitbit uses movement to infer sleep and activity states in 1-min epochs. It provides an objective measure of various sleep characteristics for each night of sleep, including total sleep time in minutes (TST), number of nighttime awakenings during the sleep interval, and sleep efficiency (the percentage of time an individual is asleep during the period they are attempting to be asleep). Scores for each sleep variable are averaged across days to provide a general estimate of sleep characteristics for each individual. Fitbit devices have been shown to correlate with actigraphy, as both Fitbits and actigraphy have high degrees of sensitivity for detecting sleep and arousal [22].

In addition, this study used a modified version of the Pittsburgh sleep diary to measure daily sleep and waking behaviors [23]. The present analyses specifically examined participants' responses to one question from the diary. Participants responded to "This morning I feel rested" by indicating "Yes" or "No". The Pittsburgh sleep diary has been shown to be psychometrically sound [24, 25]. Mean scores were created representing the proportion of time individuals felt rested in the diary recording period.

Statistical analyses

Analyses were conducted to examine associations between eating disorder psychopathology and both self-report sleep questionnaires and ambulatory and diary sleep measures using SPSS version 23.0. Analysis of covariance (ANCOVA) models were calculated to investigate relations between eating disorder diagnostic groups (i.e., no eating disorder, BED, BN) and sleep measures controlling for age and BMI. Post hoc Tukey tests were run for significant ANCOVAs. Bivariate correlations were used to investigate relations between global eating disorder psychopathology and sleep measures. Given the small amount of missing data, available case analysis was used. False discovery rate (FDR) significance was used to correct for multiple comparisons including omnibus ANCOVAs and bivariate correlations [26]. The FDR

significance level was set at 0.10, which has been recommended for exploratory research [27].

Results

Descriptive statistics

There were 212 participants that completed self-report surveys. A subset of participants had useable Fitbit objective sleep data ($n = 106$), and another subset had useable sleep diary data ($n = 153$). Assessed with the EDDS, 22 participants (10%) met criteria for full- or sub-threshold DSM-IV BN, and 30 participants (14%) met criteria for full- or sub-threshold DSM-IV BED.

An ANCOVA revealed significant differences in sleep health, assessed via SATED, by eating disorder diagnostic group controlling for age and BMI, $F(2, 212) = 5.43$, $p = .005$, partial $\eta^2 = 0.05$, FDR $p < 0.10$. Post hoc tests showed that BN ($M = 6.36$, SD = 2.30) and BED ($M = 6.88$, SD = 1.74) significantly differed from the no eating disorder group ($M = 7.69$, SD = 2.00; $ps < 0.05$). BN and BED did not differ from one another. Similarly, global eating disorder psychopathology was negatively correlated with sleep health ($r = -.26$, $p < 0.001$, FDR $p < 0.10$) such that greater global eating disorder psychopathology was related to worse sleep health after controlling for age and BMI.

In contrast, ANCOVAs controlling for age and BMI showed that eating disorder diagnostic groups were not associated with any ambulatory or diary sleep measures, FDR $ps > 0.10$. Global eating disorder psychopathology was unrelated to sleep duration, sleep efficiency, and sleep set latency, (FDR $ps > 0.10$). Global eating disorder psychopathology was negatively correlated with subjective reports of feeling rested ($r = -.18$, $p = 0.03$, FDR $p < 0.10$).

Finally, an ANCOVA revealed significant differences in chronotype by diagnostic group controlling for age and BMI, $F(2, 213) = 3.70$, $p = 0.03$, partial $\eta^2 = 0.03$, FDR $p < 0.10$. Post hoc tests showed that BN ($M = 39.18$, SD = 6.29), but not BED, significantly differed from the no ED group ($M = 41.82$, SD = 4.78; $p = 0.03$). BN and BED did not differ from one another. After controlling for age and BMI, global eating disorder psychopathology was positively associated with greater eveningness ($r = -.27$, $p < 0.001$, FDR $p < 0.10$).

Discussion

This study examined associations between eating disorder psychopathology, both diagnostic groups and a global symptom measure, chronotype, and self-report and objective sleep (i.e., total sleep time in minutes, number of nighttime awakenings during the sleep interval, and sleep efficiency). Individuals with BN and BED and those with greater global eating disorder psychopathology were more likely to self-report unhealthy sleep patterns including poor sleep health and an eveningness chronotype. Further, global eating disorder symptoms were positively related to less self-report of feeling rested after waking in diary sleep assessments. However, neither diagnostic nor dimensional measures of eating disorder psychopathology were related to objective measures of sleep via Fitbit. Thus, it appears that eating disorder psychopathology is negatively related to individuals' subjective self-reports of sleep, but unrelated to overall objective sleep parameters including total sleep time, nighttime awakenings, or sleep efficiency.

Consistently, studies have found similar findings in relation to other mental health symptoms. For example, studies have shown associations between poor subjective sleep, but not objective sleep, and increased mood disturbance [28, 29]. Although studies are correlational, they suggest that psychiatric symptoms may negatively affect individuals' subjective experience of sleep, while having little effect on their actual sleep. For example, individuals experiencing eating disorder symptoms may wake up after a night of sleep with intrusive thoughts about food, dieting, and their weight and shape, which may leave them feeling less rested as it undermines the restorative function of sleep [30]. Further, eating disorder psychopathology is associated with less interoceptive awareness—i.e., perception of sensations from within the body—and deficits in interoceptive awareness are related to poor sleep quality in psychiatric samples [31]. Deficits in interoceptive awareness may impair ability to distinguish between internal sensations of feeling rested or not. Alternatively, poor sleep quality may further impair interoceptive awareness, which leads to increased eating disorder symptoms through failure to understand internal sensations such as emotions and physiological sensations [31]. Perceptions of poor sleep quality may also lead to increased psychosocial distress, particularly in women [32], which may, in turn, further exacerbate eating disorder symptoms [33]. Therefore, the assessment and management of subjective sleep disturbance in patients with eating disorders could improve treatment readiness and efficacy, even in the absence of objectively disturbed sleep.

Our study showed that an eveningness chronotype was related to increased eating disorder psychopathology. Prominent eating disorder behaviors (i.e., binge eating, purging) tend to occur at night [33], and thus, staying up later at night may allow more time for an episode to occur. Additionally, staying up late leaves more time for an individual to think about their weight or shape as well as stressful events that occurred during the day. This may increase vulnerability to binge eating and purging as these behaviors are often used to regulate negative emotional states [34].

The methodology used in this study may also explain the null findings regarding associations between objective sleep parameters and eating disorder symptoms. Both sleep and eating disorder symptoms may fluctuate day-to-day. However, in the current study, aggregated measures of objective sleep and eating disorder psychopathology were used. It may be the case that objective sleep parameters are associated with experiencing greater eating disorder symptoms only on days when individuals had poor sleep. For example, individuals may experience more eating disorder symptoms on a day where they slept only a few hours or had multiple awakenings during the previous night. Furthermore, on days when individuals had poor sleep the night before, they may wake up feeling more negative mood and have less ability to inhibit their response to stimuli [9], which could increase the chance of eating disorder symptoms occurring. Ecological momentary assessment studies that integrate ambulatory measures of objective sleep and self-report assessments of eating disorder psychopathology occurring throughout the day, both behaviors (e.g., binge eating) and cognitions (e.g., body dissatisfaction), are needed to further disentangle the association between sleep and eating disorder psychopathology.

The primary strength of the current study was the use of a multi-method approach to elucidate the association between eating disorder psychopathology and sleep that included both self-report measures of sleep as well as ambulatory measures collected in individuals' natural environments. However, one limitation of the study was that eating disorder psychopathology was only assessed via a self-report questionnaire, which is subject to retrospective recall biases and does not allow examination of within-day associations of sleep and eating disorder psychopathology. Other objective sleep measures may be more reliable in assessing objective sleep compared to Fitbit including actigraphy, polysomnography, and bed sensors [35]. In addition, participants were recruited from a commercial weight loss program, which was useful in obtaining variability in eating disorder psychopathology. However, results from this sample may not generalize to other samples of interest. Further, our sample was mostly Caucasian, which limits the generalizability of the sample to other groups. Finally, in this study, there were a large number of individuals who did not meet eligibility criteria for the study and a high attrition rate, which may have biased the study sample.

In conclusion, the current study showed that eating disorder psychopathology is related to individual differences in self-reported sleep and chronotype and unrelated to individual differences in objective sleep parameters (i.e., total sleep time, nighttime awakenings, and sleep efficiency). More research using multi-method approaches is needed to disentangle the association between eating disorder psychopathology and sleep. Ecological momentary assessment studies that capture daily and momentary variation in eating disorder psychopathology and sleep may be a fruitful avenue to pursue in future studies.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to report.

Ethical approval The Institutional Review Boards of Sanford Health and North Dakota State University approved this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Informed consent All eligible participants completed an electronic informed consent form prior to participation in the study.

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