



Original Article

Daily stress, presleep arousal, and sleep in healthy young women: a daily life computerized sleep diary and actigraphy study



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ABSTRACT

Objective: Our study aimed to further elucidate the mediating role of presleep arousal in the relationship between daily stress and sleep by investigating subjective sleep quality and actigraphy-assessed sleep efficiency (SE) on both within- and between-participant levels in a sample of healthy young women.

Methods: Multilevel modeling was applied on electronically assessed data comprising 14 consecutive nights in 145 healthy young women to assess the relationship between daily stress, presleep (somatic and cognitive) arousal, and sleep on both levels between participants and within participants across days.

Results: Higher levels of daily stress were consistently and significantly associated with higher levels of somatic and cognitive arousal. Somatic arousal mediated the relationship between daily stress and worsened subjective sleep quality on the between-participant level, while cognitive arousal mediated the relationship between daily stress and worsened subjective sleep quality on the within-participants level. Unexpectedly, healthy young women showed higher SE following days with above-average stress with somatic arousal mediating this relationship.

Conclusions: Our data corroborate the role of presleep arousal mediating the relationship between daily stress and subjective sleep quality. Interestingly this effect was restricted to somatic arousal being relevant on interindividual levels and cognitive arousal on intraindividual levels. For young and healthy individuals who experience high stress and arousal, well-established cognitive-behavioral techniques could be useful to regulate arousal and prevent worse subjective sleep quality.

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1. Introduction

Sleep disturbances are widely prevalent and represent a momentous health problem in the general population. The point prevalence of primary insomnia is estimated to lie between 2% and 6%, though self-reported sleep disturbances in healthy populations range up to more than 40% [1–5]. The impact of insomnia and other sleep disturbances is known to be severe and includes reduced quality of life and well-being as well as impaired daytime-functioning and working ability, and thus is a potential risk factor for subsequent health problems [1,2,6]. Accordingly, insomnia and sleep difficulties are associated with increased work absenteeism and healthcare costs [2–4,7].

Various psychological factors, such as stress, daily hassles, rumination, and hyperarousal have been found to play an essential

role in the development of sleep disturbances [8–11], but the search for the specific roles and interplay among these factors is still ongoing. Our study aimed to further investigate the relationship between daily stress and hyperarousal and the influence of both factors on sleep and sleep disruptions.

Stress is one of the most common and well-known antecedents of insomnia and has been associated with impaired sleep in a variety of ways. Previous research shows that minor and major stressful events correlate with more sleep disturbances [12–15]. Major stressors usually are described as life events, such as severe illness or significant losses (e.g., death, divorce, work loss), and have been found to occur with greater incidence in the time preceding the onset of insomnia or to be associated with increased risk for the development of sleep problems [14–17]. Minor stressors usually appear with higher frequency and more likely on a daily basis (e.g., arguments, time pressure, work demands), and they have been associated with more disturbed sleep [12,13,18,19]. Additionally long-term stressors such as childhood adversities have been

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found to predict sleep problems several years later [20–24]. On a more acute daily basis, the experience of acute stress during the day was associated with impaired sleep the following night [25–30].

Well-established theories about hyperarousal and sleep postulate that physiological and cognitive arousal before bedtime is detrimental for sleep and contribute to the worsening of sleep problems [31,32]. Cognitive arousal consists of intrusive cognitions experienced as being uncontrollable, and physiological or somatic arousal is described as the perception of vegetative arousal (e.g., elevated heart rate, sweating [33]). In an integrative model, Morin [31] indicated that hyperarousal has a causal influence on sleep disturbances. In this model, the balance between sleep and wakefulness is regulated by the amount of arousal, and only low levels of arousal are compatible with sleep. Espie [32] further proposed that the inhibition of de-arousal processes in particular leads to the development of insomnia. Based on these theoretical frameworks, various studies tested the association between arousal and sleep and have confirmed that hyperarousal plays a major role in insomnia and sleep disturbances [10,11,34]. High arousal is more prevalent in poor than in good sleepers and can be measured on various physiological levels, such as sympathetic nervous system activation, hormone secretion, and high-frequency electroencephalogram activation [10,11,34]. In addition to the higher prevalence of arousal in insomniacs, there is evidence that high physiological and cognitive arousal also are prevalent in healthy populations and might constitute a preceding factor in the development of sleep disorders [35–37]. Even deliberately induced stress in the laboratory and the following increase in arousal at bedtime acutely worsen sleep in both poor and good sleepers [25,38,39].

Empirical studies on the relationship between stress and sleep on a day-to-day basis using within-participant data measured over time are still scarce. Garde et al. [40] found evidence for a bidirectional association between stress and sleep, indicating a self-reinforcing vicious circle. In a representative sample of the Danish population, higher ratings of stress at bedtime were associated with ratings of poor sleep the following night. In addition, higher ratings of poor sleep in the morning were associated with higher ratings of stress during the subsequent day [40]. In a study by Hanson and Chen [41], the daily number of stressors reported by healthy young adults was associated with subsequent sleep time when moderated by family risk. On days with elevated levels of stress, sleep time was significantly reduced the following night. Akerstedt et al. [30] studied the relationship between stress and sleep over a period of 6 weeks in 50 healthy adults. They found bedtime stress and worries to be the two main predictors of subjective sleep quality. Still the potentially mediating effect of arousal between stress and sleep was not tested in those studies.

Morin et al. [8] tested the relationship between all three variables and found a significant relationship between daytime stress and nighttime sleep, with presleep arousal playing a mediating role. The authors collected prospective daily paper and pencil measures for 21 consecutive days in men and women aged 19–60 years with insomnia in addition to good sleepers. Data showed that subjective stress during the day was a significant predictor of self-reported subjective sleep quality the following night for both groups and higher levels of presleep arousal mediated this relationship. Objective sleep measures were not used in this study [8].

Our study aimed to extend these findings on the relationship between stress, presleep arousal, and sleep considering various important aspects at the same time in a large healthy sample. Therefore, both subjective and actigraphic sleep measures were assessed and computerized diaries were used to enhance compliance and reliability compared to paper and pencil data [42]. Furthermore, multilevel modeling was used to evaluate the relationship

on both levels (between participants and within participants across days). More specifically, it was hypothesized that participants reporting a higher level of stress compared to others also would experience a higher level of presleep arousal and comparably worse sleep (between-participant level). On the within-participant level, we expected that participants reporting a higher level of stress on a specific day compared to their own mean would experience higher presleep arousal and worse sleep the following night compared to days with a lower level of stress. It was further expected that presleep arousal would mediate the relationship between daily stress and sleep.

2. Methods

2.1. Participants

Data were collected in the context of a larger ongoing study about acute stress, emotion regulation, and sleep in young adults. Data for our analysis included a 2-week ambulatory assessment of sleep with actigraphic sleep measures and sleep diaries. The sample included young and healthy women (mean age, 21.7 ± 1.6 [standard deviation {SD} years]) who were recruited using flyers posted at two schools for healthcare professionals in Basel, Switzerland, or by e-mails within the schools. Potential study participants contacted the study office by e-mail or phone. They were first sent a screening questionnaire with the following inclusion criteria: female sex, age range between 18 and 25 years, German speaking, and good health.

Exclusion criteria for all participants included physical or psychiatric illness, pregnancy, regular and heavy tobacco use (>5 cigarettes a day), use of illegal drugs, use of any medication interfering with sleep, and night shift work. In a first office appointment, participants were further screened on inclusion and exclusion criteria and provided written informed consent. All remaining study participants were of either Swiss or German (86.9%) or other European nationality (13.1%), who received monetary compensation for their participation. The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee.

Out of 246 individuals who responded to the advertisements, 38 (15.4%) were excluded because they did not meet the inclusion requirements (men [$n = 5$]; not meeting age criterion [$n = 4$]; physical illness [$n = 6$]; psychiatric illness [$n = 3$]; medication [$n = 7$]; no regular sleep-wake cycle [$n = 7$]; heavy tobacco use [$n = 5$]; and not German speaking [$n = 1$]). Further 24 (9.8%) did not return the screening questionnaire. Of the 184 participants who were invited for the first appointment, 23 (12.5%) dropped out due to time restrictions or personal reasons and 12 (6.5%) did not respond to repeated invitations. Out of the 149 individuals who came to the first appointment, another three had to be excluded due to physical illness ($n = 1$), psychiatric illness ($n = 1$), and dropout ($n = 1$). The remaining 146 participants were finally eligible for the study and started the 2 weeks of assessment.

All of the 146 participants completed the study and returned their material after 2 weeks, which corresponds to a total of 2044 actigraphy-recorded nights. The data set of one individual could not be used due to incomplete information about sleep and wake times (sleep parameters could not be reliably calculated). Three participants had two nights each for which sleep parameters could not be reliably calculated, in which case the data of those two nights were excluded. Nine participants reported illness during the 2-week assessment. Therefore, all nights affected by illness including one night of convalescence were excluded from analysis (a total of 49 nights). This response left data of 145 participants with 1976 nights (96.7%).

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