A Systematic Review of the Relationship Between Daily Stress and Sleep

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Abstract

Sleep problems and stress affect many people worldwide and are deemed to be deeply connected to each other. This systematic review explores the daily relationship between perceived stress and sleep to gain a clear overview and better understanding regarding this complex interaction. It looks at how daily perceived stress impacts sleep quality and duration and how poor sleep can increase stress levels the next day, creating a cycle that could have negative health consequences. Using the PRISMA guidelines for systematic reviews, 12 studies published between 1996 and 2023 have been identified from the database. These studies included both general and clinical populations and used different study designs to examine the stress sleep relationship on a daily scale. A part of the studies reported that higher daily perceived stress was linked to and predicted poorer sleep outcomes. Some studies also indicated that poorer sleep predicted elevated stress levels suggesting its bidirectional nature. However, differences across studies in design, operationalisations, measurements and study characteristics made it difficult to infer meaningful conclusions. Since a better understanding of this relationship is vital for increased health, future researchers should aim to explore this association further taking into account its bidirectional nature on a daily scale with more standardized studies.

A Systematic Review of the Relationship Between Daily Stress and Sleep

The relationship between sleep and stress has garnered significant attention in clinical practice, scientific research and popular media over the years. Sleep disturbances and stress affect a substantial portion of the global population, with around one in four people in Europe suffering from sleep disturbances (van de Straat & Bracke, 2015). Problems in these areas are deemed to have considerable impacts on well-being (Breier et al., 1987; Haack & Mullington, 2005) as well these variables are widely regarded to influence one another. Understanding the intricate relationship between stress and sleep is essential in clinical practice and psychological research and for development of science based interventions.

Understanding sleep

To understand the relationship between sleep and stress better, it is crucial to first comprehend sleep and stress individually. Sleep is a complex biological process that is vital for physical and mental functioning (Siegel, 2005). It plays a key role in processes such as memory consolidation, metabolic regulation, and in proper functioning of the immune system (Xie et al., 2013; Diekelmann, 2014; Inostroza and Born, 2013). Disruption in sleep is often associated with a wide range of negative effects in physical and mental functioning, including cognitive deficits and disruptions in circadian processes such as cortisol secretion (Grandner et al.2013; Gillin, 1998; Goel et al., 2009; Harrison & Horne, 2000; Omisade et al., 2010; Spiegel et al., 1999). Additionally, poor sleep is linked to impaired emotional functioning and regulation (Goldstein & Walker, 2014; Zohar et al., 2005; Baum et al., 2014; Mauss et al., 2013). Disruption in sleep is a transdiagnostic symptom in many mental disorders and an important therapeutic target since it is common in many mental disorders (Benca et al., 1992; Kalucy et al., 2013). It is frequently considered a risk factor of several mental disorders like depression and anxiety (Baglioni et al.,2011; Neckelmann et al., 2007; Breslau et al., 1996; Ford et al., 1989; Jansson-Frojmark M et al., 2008). Sleeping problems thus negatively affect well-being in several ways.

Insufficiency in sleep encompasses both a lack of sleep duration and sleep quality. Sleep quality is a multifaceted concept that contains a collection of sleep measures including total sleep time, sleep onset latency, sleep efficiency, sleep disturbances and more (Krystal & Edinger, 2008). Sleep duration is commonly defined as the total time in a sleeping state, and often used as just one of the indicators for sleep quality. Sleep duration and sleep quality are inextricably linked, people with short or long sleep durations are more likely to experience disturbances in sleep quality (Xiang et al., 2009; Park et al., 2010; Kripke et al., 2002) However, the other facets of sleep quality are often overlooked in favor of focusing solely on sleep duration, which is only one indicator of sleep quality. Both sleep quality as a whole and sleep duration are equally important in predicting future health (Yu Sun Bin, 2016). Studies have shown that the effects of sleep duration and quality are not simply additive (Rod et al., 2014; Chien et al., 2010).

In psychological research, (daily) sleep can be measured subjectively (dairies) and objectively (actigraphy). Studies have illustrated that subjective and objective measures in sleep duration and sleep efficiency are not always strongly correlated (Jackowska at al., 2011; Armitage et al., 1997). These discrepancies could be affected by several factors like mood at awakening, insomnia, negative bias, and impaired memory (Balliet et al.,2016; Dinapoli et al., 2017). In this review both subjective and objective sleep measures are included, to gain a more comprehensive understanding of sleep.

Understanding stress

Acute stress is often defined as the body's response to internal or external demanding stimuli in order to adapt to such situations (Beck et al., 2023). These stimuli are commonly referred to as stressors. Stressors can widely vary involving interpersonal stressors, negative live events, and work- or psychological stressors (Nicolai et al., 2013; Wheaton, 1999; Block et al., 2020; Monroe & Slavich, 2016). The term stress is often used to describe the body's and psychological reactions to adapt to these stressors. On a physiological level, this response is regulated through activation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS) (Beck et al., 2023; Chrousos and Gold, 1992; Chrousos, 2009). Similarly to sleep problems, stress is associated with a wide variety of negative consequences for physical and mental health. Higher stress is shown to be associated with weakening of the immune system and more chronic diseases (Liu et al., 2017). Previous studies have also linked perceived stress with loneliness (Campagne,2019; Crespo-Sanmiguel et al., 2021), increased depressive symptoms, particularly in older adults (Tsai et al., 2013; Tsai & Chang, 2016; Vallejo et al.,2018), and anxiety symptoms (Ibrahim et al., 2024). Stress can also impair cognitive functioning and disrupt functional emotional regulation (Tempesta et al., 2018; Durmer & Dinges, 2005). Furthermore, Alleyne et al. (2010) found that high levels of perceived stress were associated with low levels of life satisfaction and was even one of the major predictors of life satisfaction among students. In research, stress is often quantified either as subjective perceived stress or as an objective biomarker, for instance, cortisol. In this review the choice is made to focus solely on subjective or perceived stress.

Link between stress and sleep

Numerous cross-sectional studies link perceived stress to self-reported impaired sleep (Åkerstedt et al., 2002a,2002b; Doi et al., 2003; Hall et al., 2000). This connection is observed in various contexts, such as job-related stress, even when controlling for stressfulness at home (Bugard et al.,2009). Long term exposure to stress is even usually seen as the main cause of primary insomnia (AASM, 2005; Morin, 2003). Additionally, studies have shown that sleep disturbance can mediate the association between stress and incident of dementia and depression (Tan et al., 2023; Liu et al., 2017; Lui et al., 2021; Qin et al., 2023; Zhang et al., 2022)

The regulation of sleep involves various biological systems which are influenced by both internal and external factors, making it sensitive to other processes like stress. A biological mechanism involved in the relation between stress and sleep is the Hypothalamic-Pituitary-Adrenal (HPA) axis. Stress is associated with an increase in the hormones such as corticotropin releasing hormone (CRH) and cortisol and in the HPA system. Cortisol plays an important role in HPA axis regulation and reliably reflects the system's activity (Filaire et al., 2009a; Obayashi, 2013). The increase of these hormones lead to an increase in cognitive arousal which makes it incompatible with normal sleep (Steiger, 2002) . It is also likely that sleep impairment further increases activity in the HPA system promoting a vicious cycle between stress and sleep impairment (Akerstedt, 2006). Thus, the relationship works bidirectional as stress disrupts sleep and worse sleep also contributes to an increase in stress and stress reactivity. Since stress and sleep are both variables that occur and influence each other on a daily basis, this could possibly create a vicious cycle leading to negative physical and mental health consequences. Therefore examining the relationship between stress and sleep on the daily scale is necessary to understand the complexities and possible negative effects of the relationship.

Given the practical and ethical challenges, controlled experimental studies on the effects of stress on sleep in humans are limited. Consequently, most of the available data on the relationship between stress and sleep comes from studies conducted on laboratory rodents (Pawlyk et al. 2008). There have been experimental studies inducing psychological stress before

sleep where researchers reported a prolonged sleep onset latency (SOL) and a decrease in low-/high-frequency power in the electroencephalogram (EEG) during non-rapid eye movement (NREM) sleep, which is a measure of objective sleep quality (Wuyts et al. 2012a; Ackermann et al. 2019; Hall et al. 2007; Maes et al. 2014; Cordi et al. 2019; Hogan et al. 2020). However most studies on the relationship between stress and sleep are correlational and cross-sectional.
And while these studies are informative regarding the association, the cross sectional nature of studies lacks to give insight to the bidirectional predictive influences between the variables on a daily scale since the number of studies using Ecological momentary assessment (EMA) to study this phenomenon are still limited (Lee et al., 2023).

This review aims to give an overview and gain a better understanding of the connection between subjective stress and sleep in humans taking into account the importance of the bidirectional nature and daily scale of the relationship which most studies overlook. A better understanding of this relationship could give more insight into their complex nature and help develop interventions with regards to its bidirectional and daily nature. This review focuses specifically on subjective or perceived stress and not objective biomarkers. There is however consideration for both objective and subjective daily sleep measures and for both sleep duration and sleep quality measures.

Method

Protocol and Registration

The study was designed and written following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (Page et al., 2021). To ensure a transparent and reproducible research process, the review method, search strategy, screening procedure, and plans for data extraction were specified and documented in a protocol a priori, which is registered with OSF, accessible via (https://osf.io/24auc).

Search Strategy and Information Sources

The literature was conducted in Web of Science searching Core Collection and MEDLINE databases, and PsychINFO through EBSCOhost. Moreover, the process of searching for the included articles revolved around three main components. The first component represents the stress concept, the second component consists of the mental health outcome, and the third component consists of studies that include a daily measures design.

In order to search for these components, various query strings were used and combined using the “AND” prompt. For the stress concept, the strings included the following search terms: stress*, or “life event*”, or “negative event*”, or hassles, or trauma*, or abuse, or neglect, or "child* maltreatment", or "child* experiences", or violence, or disaster*. Meanwhile, for the mental health outcome, the following query strings were used: psychopathol*, or "mental disorder*", or anxiety*, or depress*, or "CIDI", or "DSM", or phobia*, or "ptsd", or "panic disorder*", or "GAD", or "MDD", or "MDE". Finally, for the daily measure design, the query strings that were used consisted of: diary, or daily, or "time series", or "time-series", or "experience sampling", or "ESM", or "ecological momentary assessment*", or "EMA", or "intensive longitudinal", or ambulatory, or "micro-longitudinal”. These strings were searched in the abstract or title. Validation procedures were not used to conduct this literature search.

Eligibility Criteria

This review considered only empirical studies. Dissertations, reviews, comments, opinion articles, books, book chapters, and others of similar nature were excluded. Protocols were included at the first stage to facilitate automatic prioritization in ASReview, but excluded during data extraction. ASReview is the program used to screen abstracts for eligibility. This program uses machine learning to prioritize the most relevant studies based on the abstract. Case studies (i.e. studies with a single participant) were also excluded. To be included in this review, articles had to use ambulatory measurements that were collected at least once a day for at least several consecutive days (i.e. $\geq$ 2 days in a row). These measures could include but were not limited to self-reported subjective measures, subjective measures reported by others, or objective measures (through a smartwatch or a similar device). If variables were measured daily but they only reflected a treatment that was administered daily (e.g. medication administration), or if the daily measurements came in the form of Intensive Care Diaries (ICD) taken by nurses on the general state of participants, the study was excluded. Finally, if daily measures were not measured in human participants but solely focused on global statistical reports (e.g. crime reports), the study was also excluded. This review only included human participants. During the full-text screening, articles were excluded if they were: not in English, if not empirical, if the full text was not available, or if the study had no daily measure.

Data Collection Process

The pilot extraction phase consisted of 15 sources. Based on the pilot screening sheet, the information to be extracted was adjusted. A data extraction sheet was developed in Google Spreadsheets where the characteristics of the selected studies were extracted and recorded. In the primary data extraction phase, twelve extractors were involved. The extractors had a training phase, after which they worked independently. During the extraction phase, extractors had the opportunity to ask their project leader questions formed as comments in the datasheet or during the weekly meetings. The process of data extraction was supervised by the project leaders.

The following population characteristics from the included studies were extracted:

country, sample size, age (mean or range), population type, population subtype, physical health (problem/diagnosis), and mental health (diagnosis). Furthermore, the following ambulatory variables were extracted: sampling frequency/day, type of report (self-report, objective measures, or both), stress, affect/emotions, cognition, physiology, behavior, coping, mental health concept and its measurement, and other variables measured daily. The extracted variables measured cross-sectionally were the exact same as the ambulatory variables, except for sampling frequency.

Research question

This review employs the PEOC formatting to formulate the research question. It consists of the factors: Population, Exposure, Outcome and Context (Kolaski et al., 2023). Given the widespread link between stress and sleep is prevalent in various contexts, the population is kept broad for the scope of this review. Therefore the included studies contain samples of a clinical and general population with no restriction in age or other demographic indicators. Since this review focuses on the bidirectional relationship between stress and sleep on a daily basis, these variables are part of both the exposure and outcome component. Participants in the included studies were exposed to both sleep and daily stress on a daily basis which were also both measured as outcomes. The context with regards to this systematic review is to focus on studies that assess the relationship on a daily scale using EMA.

Selection from database

To identify relevant articles, specific filters were applied in the database. The first filter included studies with any form of daily perceived stress measure as indicated in the database. The second filter included studies with a daily sleep measure. Next, a brief screening of the abstracts was done to give an indication of the amount of studies that would likely be eligible for this review.

Before the full text screening, eligibility criteria were composed. These criteria were: a) subjective/perceived stress had to be measured daily; b) sleep duration or quality also had to be measured daily and could either be measured subjectively (e.g., sleep diary) or objectively (e.g., actigraphy); c) the relationship between perceived stress and sleep had to be analyzed (e.g., correlation). Based on the inclusion and exclusion criteria the full text screening was conducted. The articles after this screening were included in the review. A flow chart was made to highlight the selection process of the articles with regards to creating the entire database and for this specific research question.

Data items

The following data items were extracted from the included studies. Firstly, the study and population characteristics were included. These consisted of: Authors, year, country, sample size, female %, clinical or general sample type and sample subtype. For the daily stress measure, these items were included: what kind of daily stress was measured, how daily stress was measured, the scale the measurement used if applicable and the number of items/sources that measure daily stress. For the sleep measurement the following was extracted: what sleep variables were measured, how these were measured, what scale was used when applicable, how many items/sources measured sleep and of sleep was measured subjectively, objectively or both. For the relationship between the variables the next items were indicated: how/in what way the relationship was measured, what data analysis was used in the study, the type of estimate, the estimate and error measurement and the p value.

Data extraction

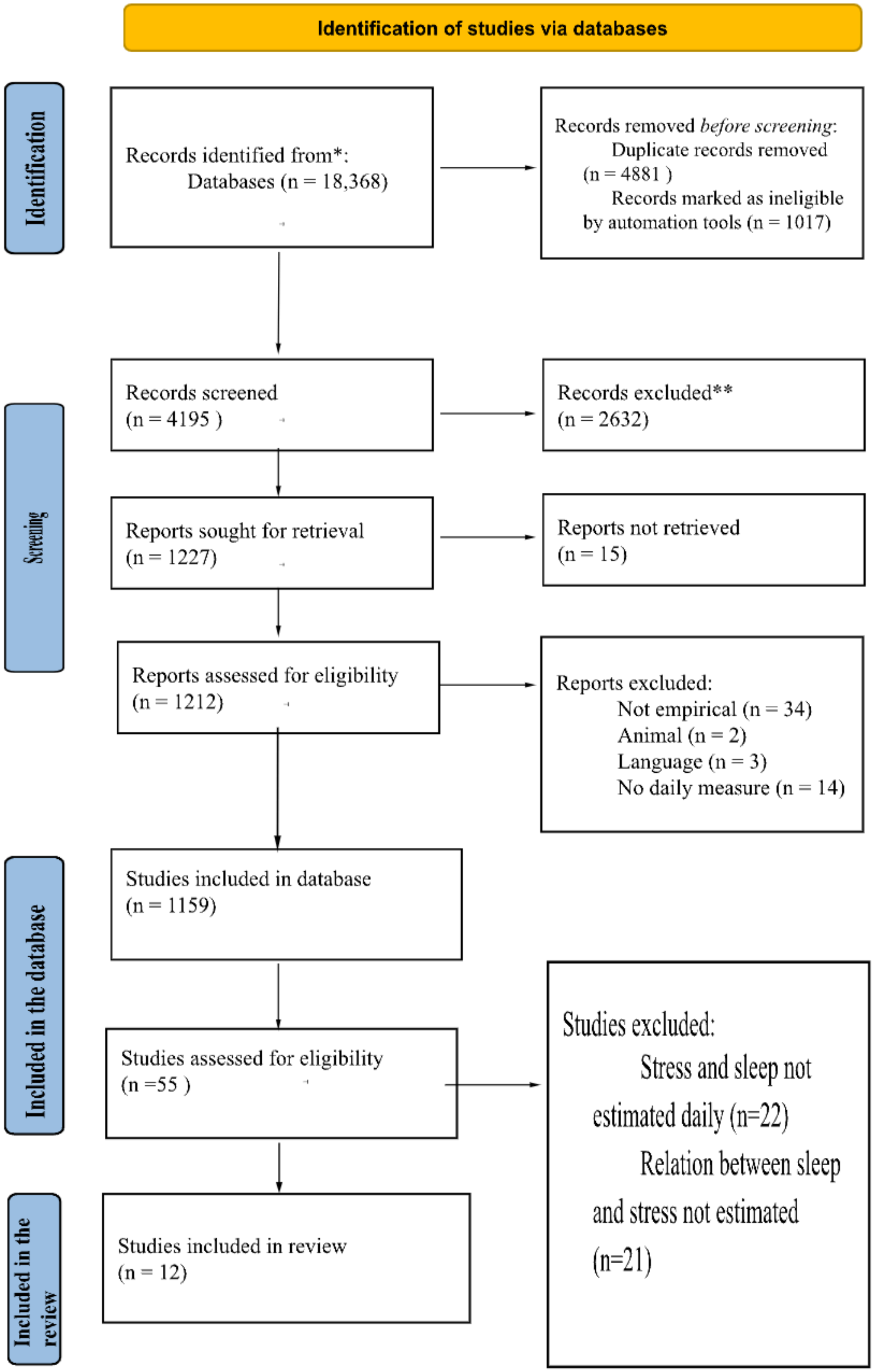
The data items were extracted from the included articles manually. A part of the relevant data was extracted as a group and incorporated into the spreadsheet, for instance study characteristics. Data items relevant specific to this research question were extracted solo and put into two tables to organize the data. The first table included all study characteristics and measurements of stress and sleep. The second table focused solely on the study outcomes concerning the relationship between daily stress and sleep. After synthesizing the data into the tables, the data was summarized in a narrative manner while keeping into account the methodological differences across the studies. P values and confidence intervals were considered in differentiating between significant and insignificant results, all the included studies utilized an alpha level of $p=0.05$ to determine statistical significance. Cohen (1988) his guidelines were used to differentiate between small (0.10 to 0.29 or -0.10 to -0.29), medium (0.30 to 0.49 or -0.30 to -0.49) and large (0.50 to 1.00 or -0.50 to -1.00) correlations.

Results

Study selection

After applying two filters to the entire database, 55 studies were deemed eligible for this systematic review and proceeded to full-text screening. Among these, 22 studies were excluded because they did not measure stress, sleep, or both on a daily basis. Additionally, 21 studies were excluded because they did not measure the relationship between daily subjective stress and sleep. Consequently, the screening process resulted in a total of 12 articles being included. The entire screening process is illustrated in the PRISMA flow chart (Figure 1).

Figure 1



Identification of studies via databases
Identification
Screening
Included in the database
Included in the review
Records identified from*:
Databases (n = 18,368)
Records removed before screening:
Duplicate records removed
(n = 4881)
Records marked as ineligible
by automation tools (n = 1017)
Records screened
(n = 4195)
Records excluded**
(n = 2632)
Reports sought for retrieval
(n = 1227)
Reports not retrieved
(n = 15)
Reports assessed for eligibility
(n = 1212)
Reports excluded:
Not empirical (n = 34)
Animal (n = 2)
Language (n = 3)
No daily measure (n = 14)
Studies included in database
(n = 1159)
Studies assessed for eligibility
(n =55)
Studies excluded:
Stress and sleep not estimated daily (n=22)
Relation between sleep and stress not estimated (n=21)
Studies included in review
(n = 12)

Study characteristics

The studies in this review ranged from publication in 1996 to 2023. More than half of these studies were conducted in the USA (n=8). Other countries include Germany (N=2), Switzerland (N=1), Spain (N=1) and Canada (N=1). The sample size ranged from 19 being the lowest to 416 being the highest. All but one study reported a mean age with one study specifying an age range from 15 to 82 years. The lowest mean age was reported in two studies with the age of 18 and the highest was a study where the mean age of participants was 64 years. Five studies focused on a clinical sample and the other seven used samples from the general population. The majority of studies had more female participants with a total average of 63.32% compared to male participants. Measurement frequencies varied between one and six with most studies only measuring the variables once a day. The length of the EMA assessment ranged from 2 to 70 with the average being 23 days. See Table 1 for all study characteristics in detail.

Measurements of stress and sleep

Most studies measured general perceived daily stress, though some studies also focused on specific types of daily stress such as relationship stress (Haydon et al., 2023) or diabetes related stress (Jin et al., 2023). Different scales were used for instance likert scales or a scale from 0-100. The majority of studies directly included either a direct measure of sleep duration (Jin et al., 2023; Ben-Zeev et al., 2015) or sleep quality (Block et al., 2019; Lischetzke et al., 2021; Morin et al., 2003; Sorbi et al., 1996; Pulpopulos et al., 2020). Zawadzki et al. (2021) measured sleep duration and sleep quality both directly. Additionally, in the studies by Menghini et al. (2023), Haydon et al. (2023) and Sladek et al., 2020 wake after sleep onset (WASO) and total sleep time (TST) in minutes were used to measure sleep quality and duration respectively. Sladek et al. (2019) used sleep onset latency (SOL) as a measure of sleep quality. Five studies relied solely on self-reported sleep measures (Block et al., 2019; Lischetzke et al., 2021; Zawadzki et al., 2021; Morin et al., 2003; Sorbi et al., 1996), while another five used only objective methods to assess sleep (Ben-Zeev et al., 2015; Menghini et al., 2023; Haydon et al., 2023; Sladek et al., 2020; Sladek et al., 2019). Two studies incorporated both objective and subjective measures (Jin et al., 2023; Pulpopulos et al., 2020). Detailed information on the measurements of stress and sleep can be found in Table 1

Note. US = United States; CH = Switzerland; DE = Germany; ES = Spain; *CA = Canada*

Table 1

Study characteristics and measurements of stress and sleep

Author, year	Country	N	Mean age sample	Type sample	Female % in sample	Sampling frequency/day	Length of EMA in days	Stress measured as:	How is stress measured?	Scale stress measure	Number of items/ sources	sleep measured as:	How is sleep measured?	Scale sleep	number of items/sources	sleep measure objective, subjective or both
Block et al., (2019)	CH; DE	284	21	Clinical (MDD,SP disorder)	66.5	1	7	one item anticipatory stress	"I am expecting a stressful day tomorrow"	0-100	1	sleep quality,	"How do you rate your sleep quality?",	0-100, visual analogue scale	7	subjective
Jin et al., (2023)	US	166	41	Clinical (type 1 diabetes)	54.80	5-6	14	self reported general and diabetes related stress	"how stressed are you right now?", "how stressed do you feel about your diabetes or diabetes management right now?"	0-100	2	sleep duration	"What time did you go to bed?, "What time did you wake up?", actigraphy	N/A	3	subjective, objective
Lischetzke et al., (2021)	DE	313	15-82	general	74.10	1	21	daily stress	"How stressed did you feel today?"	0-100	1	sleep quality	How well did you sleep last night?", "How restlessly did you sleep last night?" , "How easily did you fall asleep yesterday evening?"	5 point likert scale	3	subjective
Ben-Zeev et al., (2015)	US	47	23	general	21	1	50	one item stress	"Right now, I am . . ."	(1 = Feeling great to 5 = Stressed out)	1	sleep duration	Smartphone use data , accelerometer inferences , sound features, and light levels.	linear combination of these four factors.	4	objective

Zawadzki et al., (2021)	US	165	20	general	80.60	2	14	feeling stressed	‘How stressed do you currently feel?’	0 (not at all) to 6 (extremely	1	sleep duration; sleep quality	how long participants slept in minutes and hours, ‘How well did you sleep?'		2	subjective
Menghini et al., (2023)	US	93	18	Clinical (Insomnia)	63.40	1	60	Stressfulness of day	“How stressful was your day?”	(1= Not at all stressful to 5= Extremely stressful)	1	Sleep quality; sleep duration	FC3 device	TST; WASO		objective
Pulpopulos et al., (2020)	ES	44	64	general	40%	1	2	perceived stress	how stressful past and following day; cortisol	1 (not at all) to 5 (too much); saliva samples	2	sleep duration; sleep quality	sleep duration; sleep quality; actiwatch 2	1 (very good) to 5 (very bad); N/A	3	subjective; objective
Morin et al., (2003)	CA	67	40	Clinical (Insomnia)	56.70%	1	21	stress sum; stress freq; stress intensity	stressfulness of each event experienced event in 24 hours	(1 = occurred but was not stressful, 7 = caused me to panic)	3 days event dependent	Sleep; sleep quality	Bed and wake up time, SOL, nocturnal awakenings,and sleep quality	(1 = very restless) and (5 = very sound).	9	subjective
Sorbi et al., (1996)	US	19	35	Clinical (Migraine)	100%	4	70	stressfulness of daily hassles	rating stressfullness of daily hassles	100-mm visual analog scale	1	sleep quality	rating of sleep quality	100-mm visual analog scale	1	subjective
Haydon et al., (2023)	US	416	29	general	N/A	1	12	relationship stress	how much stress they felt in their romantic relationship that day	1 (no stress) to 7 (extreme stress).	1	sleep quality	actigraph	WASO	1	objective
Sladek et al., (2019)	US	61	21	general	75%	4-5	8	one item stress	severity of most stressfull situation; cortisol	(0 = not at all stressful to 4 = very stressful); saliva sample	2	sleep quality; sleep duration	actigraph	SOL;TST	1	objective
Sladek et al., (2020)	US	209	18	general	64.40%	5	3	stress severity	how stressfull most stressfull event in last hour was; cortisol	(0 = no stress at all to 10 = extreme stress); saliva sample	2	Sleep duration	actigraphy	TST	1	objective

Study outcomes

The reviewed studies used various methods to explore the interaction between daily stress and sleep quality or duration. Four studies utilized correlation models to identify the strength of the association between these variables (Lischetzke et al., 2021; Morin et al., 2003; Sorbi et al., 1996; Sladek et al., 2020). Five other studies used regression models to examine the predictive nature of this relationship (Block et al., 2019; Jin et al., 2023; Ben-Zeev et al., 2015; Zawadzki et al., 2021; Pulpopulos et al., 2020). Additionally, three studies combined both correlation and regression analyses (Menghini et al., 2023; Sladek et al., 2019; Haydon et al., 2023). Among the regression studies, four exclusively used stress as the predictor variable (Zawadzki et al., 2021; Block et al., 2019; Sladek et al., 2019; Pulpopulos et al., 2020), two used sleep as the predictor (Jin et al., 2023; Ben-Zeev et al., 2015), and two studies considered both stress and sleep as predictor and outcome variables, providing a more comprehensive view of the bidirectional influences between stress and sleep (Menghini et al., 2023; Haydon et al., 2023). In terms of study designs, three studies utilized a within-subjects design to examine fluctuations in stress and sleep within individuals over time (Jin et al., 2023; Morin et al., 2003; Sorbi et al., 1996). Four studies employed a between-subjects design, comparing different participants (Block et al., 2019; Ben-Zeev et al., 2015; Pulpopulos et al., 2020; Sladek et al., 2020). Finally, five studies adapted both within- and between-subjects designs to capture both intra- and inter-individual variability (Lischetzke et al., 2021; Sladek et al., 2019; Haydon et al., 2023; Zawadzki et al., 2021; Menghini et al., 2023).

Associations

Five studies found mostly or only significant negative associations between higher stress levels and poorer sleep outcomes (Block et al., 2019; Jin et al., 2023; Ben-Zeev et al., 2015;

Morin et al., 2003; Sorbi et al., 1996). These studies showed that higher daily stress is linked to reduced sleep quality and shorter sleep durations. Five studies reported mixed results regarding the significance of the association between stress and sleep (Zawadzki et al., 2021; Menghini et al., 2023; Lischetzke et al., 2021; Haydon et al., 2023; Sladek et al., 2019). The remaining two studies found mostly or only insignificant findings (Pulpopulos et al., 2020; Sladek et al., 2020). In the seven studies that conducted correlational analyses, correlations ranged from no correlations (0-0.10) (Lischetzke et al., 2021; Menghini et al., 2023; Haydon et al., 2023), small correlations (0.1-0.3) (Morin et al., 2003; Menghini et al., 2023; Sladek et al., 2020; Sladek et al., 2019; Haydon et al., 2023), to medium correlations (0.3-0.5) (Sorbi et al., 1996; Lischetzke et al., 2021).

Unidirectional and bidirectional Regression

Of the eight studies that utilized a regression model, three found that stress significantly predicted poorer sleep outcomes (Block et al., 2019; Zawadzki et al., 2021), while Sladek et al. (2019) only reported significant predictions on a between person level. Pulpopulos et al., 2020 only reported a significant effect of expected stress of the following day on objective sleep quality, all other outcomes of stress predicting sleep quality in this study were insignificant. Two studies showed that sleep predicted subsequent stress levels, with poor sleep increasing next-day stress (Jin et al., 2023; Ben-Zeev et al., 2015). However, sleep did not significantly predict diabetes related stress in the study from Jin et al. (2023). Moreover, two studies conducted a regression analysis that was bidirectional in its prediction of stress and sleep outcomes. Menghini et al. (2023) identified that prior day stress predicted worse sleep duration but not sleep quality, while sleep duration and quality predicted next-day stress. Haydon et al. (2023) reported that stress predicted worse sleep quality on the within person level but not at a between person level.

However sleep quality predicted next day stress only on the between person level and not on the within person level.

Between and within person model

Out of the nine studies analyzing the relationship at the between person level, four studies indicated negative associations between stress and sleep outcomes (Block et al., 2019; Ben-Zeev et al., 2015; Sladek et al., 2019; Lischetzke et al., 2021), three reported mixed results (Haydon et al., 2023; Zawadzki et al., 2021; Menghini et al., 2023), and two found mostly or entirely insignificant findings (Pulpopulos et al., 2020; Sladek et al., 2020). Among the eighth studies that conducted analyses on a within person level, four studies reported mostly or all significant associations between stress and sleep (Jin et al., 2023; Morin et al., 2003;Zawadzki et al., 2021; Sorbi et al., 1996), two reported mixed findings (Menghini et al., 2023; Haydon et al., 2023), and two showed mostly or entirely insignificant findings (Sladek et al., 2019; Lischetzke et al., 2021).

Sleep quality and sleep duration

Of the six studies that operationalized sleep outcomes as sleep duration, three studies reported significant associations between stress and sleep (Jin et al., 2023; Ben-Zeev et al., 2015; Menghini et al., 2023), another two studies found mixed results (Zawadzki et al., 2021; Sladek et al., 2019). Sladek et al. (2020) did not report an association between stress and sleep duration. Among the nine studies where sleep quality was used as sleep measurement, four identified mostly significant associations (Block et al., 2019; Zawadzki et al., 2021; Morin et al., 2003; Sorbi et al., 1996), and three studies reported mixed outcomes concerning this relation (Menghini et al., 2023; Haydon et al., 2023; Lischetzke et al., 2021) The final two studies found mostly or only insignificant results (Pulpopulos et al., 2020; Sladek et al., 2019).

Subjective and objective sleep measures

Four out of the seven studies that measured sleep subjectively found mostly significant results (Block et al., 2019; Morin et al., 2003; Sorbi et al., 1996; Jin et al., 2023). Two studies reported mixed results regarding the association between stress and subjective sleep (Lischetzke et al., 2021; Zawadzki et al., 2021), while Pulpopulos et al. (2020) found no significant results. Among the seven studies incorporating objective sleep measures, two found mostly or only significant results. (Ben-Zeev et al., 2015; Jin et al., 2023). Four reported mixed results (Menghini et al., 2023; Haydon et al., 2023; Sladek et al., 2019; Pulpopulos et al., 2020), and one did not identify any significant results (Sladek et al., 2020). Pulpopulos et al. (2020) also examined the effects of stress on the discrepancy between subjective and objective sleep, however none of these results were significant. All results are presented in table 2.

Table 2

Outcomes of the relation between stress and sleep

Author, year	how is relationship measured	type of data analysis	what kind of estimate	estimate(s)	p value
Block et al., (2019)	Effect of Anticipatory stress as predictor of sleep quality	Hierarchical regression model	Regression coefficient	b = −0.07	p = .001
Zawadzki et al., (2021)	Effect of appraised stress and T-1 stress on sleep duration and sleep quality	Between and within person regression model on day level and stress T-1 level	Regression coefficient	***Day level model*** **Between person effect** Sleep duration b= -10.17 SE= 9.57 Sleep quality b= -0.07 SE= 0.12 **Within person effect** Sleep duration b= -6.04 SE= 2.88 Sleep quality b= -0.07 SE= 0.03 ***Stress T-1 Lagged model*** **Between person effect** Sleep duration b= -10.39 SE= 9.73 Sleep quality b= -0.09 SE= 0.13 **Within person effect** Sleep duration b= -0.24 SE= 3.00 Sleep quality b= -0.05 SE= 0.03	***Day level model*** **Between person** Sleep duration p>0.05 Sleep quality P<.0.05 **Within person** Sleep duration p<0.05 Sleep quality **P<.0.05** ***Stress T-1 Lagged model*** **Between person** Sleep duration p>0.05 Sleep quality P>.0.05 **Within person** Sleep duration p>0.05 Sleep quality P<.0.05
Jin et al., (2023)	Effect of sleep duration on next day general and diabetes related stress	Within person regression model	Regression coefficient	**General stress** b= −1.50 95%CI= (−2.17, −0.83) **Diabetes related stress** b= −0.37 95%CI= (−0.95, 0.22)	**General stress** p <0.001 **Diabetes related stress** p= 0.22
Lischetzke et al., (2021)	Between and within person association between daily stress and sleep quality	Correlation model	Correlation coefficient	**Between person** r= -0.44 **Within person** r= -0.02	**Between person** p <0.001 **Within person** p>0.05
Ben-Zeev et al., (2015)	Effect of sleep duration on daily stress	Mixed effect linear model	Regression coefficient	b= -0.04 SE = 0.02	p = .0493

Menghini et al., (2023)	Association between sleep and stress, regression of prior and next day stress on sleep	Correlation model, within person regression model	Correlation coefficient, Regression coefficient	***Correlations*** **Between person** Stress & TST r= -0.14 Stress & WASO r = 0.09 **Within person** Stress & TST r= -0.06 Stress & WASO r = -0.03 **Regression model** Prior day stress on TST b= -4.71 SE= 1.10 95%CI= (-6.87, -2.53) Prior day stress on WASO b= -0.53 SE= 0.35 95%CI= (-1.32, 0.06) Next day stress on TST b= -6.28 SE= 1.11 95%CI= (-8.45, -4.11) Next day stress on WASO b= -1.12 SE= 0.35 95%CI= (-1.81, -0.43)	Not specified
Pulpopulos et al., (2020)	Effect of perceived stress day before and expected stress coming day on subjective, objective sleep quality and the discrepancy between the two	Linear mixed regression model	Regression coefficient	**Subjective sleep quality** Perceived stress day before β= −0.191 95%CI= (−0.441, 0.059) Stress expected coming day β= 0.162 95%CI= (−0.093, 0.416) **Objective sleep quality** Perceived stress day before β= 0.153 95%CI= (−0.051, 0.356) Stress expected coming day β= −0.229 95%CI= (−0.426, −0.032) **Discrepancy in sleep quality** Perceived stress day before β= 0.027 95%CI= (-0.204,0.258) Stress expected coming day β= −0.028 95%CI= (-0.2630.207,)	**Subjective sleep quality** Perceived stress day before p = 0.132 Stress expected coming day p= 0.209 **Objective sleep quality** Perceived stress day before p= 0.139 Stress expected coming day p= 0.023 **Discrepancy in sleep quality** Perceived stress day before p= 0.814 Stress expected coming day p= 0.814
Morin et al., (2003)	Within person Association between stress on sleep efficiency and sleep quality averaged over participants	Correlation model	Correlation coefficient	Correlations ranged from: r= (-0.06, -0.10)	p< 0.05
Sorbi et al., (1996)	Within person association between stressfulness of hassles and sleep quality	Correlation model	Correlation coefficient	r = -0.41	N/A

Haydon et al., (2023)	Within and between person correlations and daily effects of stress and sleep quality and sleep quality on stress	Regression model	Regression coefficient	**Correlations** Between person r = 0.09 Within person r = 0.19 **Effect stress on WASO** Between person b= -4.00 SE= 2.20 95%CI= (−8.33, 0.33) Within person b= 1.10 SE= 0.39 95%CI= (0.34, 1.86) **Effect WASO on next day stress** Between person b= -0.002 SE= 0.001 95%CI= (−0.004, 0.000) Within person b= 0.001 SE= 0.001 95%CI= (−0.000, 0.002)	**Correlations** Between person p= 0.07 Within person p = 0.005 **Effect stress on WASO** Between person p > 0.05 Within person p < 0.05 **Effect WASO on next day stress** Between person p < 0.05 Within person p>0.05
Sladek et al., (2019)	Association between person stress, sleep duration and sleep quality; between and within person effect of stress on sleep duration	Correlation model; regression model	Correlation and regression coefficient	**Correlations** Stress and SOL r= -0.12 Stress and TST r= 0−.18 **Regression** Between Sleep duration b= -0.41 SE= 0.16 Sleep quality b= -0.33 SE= 0.20 Within Not significant	**Correlations** p> 0.05 **Regression** Between Sleep duration p< 0.05 Sleep quality 0.10>p>0.05 Within p>0.05
Sladek et al., (2020)	Association between average daily stress and sleep duration	Correlation model	Correlation coefficient	r = -0.10	p > 0.05

Discussion

This systematic review aimed to explore the relationship between daily stress and sleep. The research question was focused on the association and predictive effects of these variables on a daily basis by narratively analyzing twelve different studies. Some studies identified significant associations between higher levels of daily stress and poorer sleep outcomes, with most correlations showing small to medium effects. Additionally, studies reported that higher daily stress predicted poorer sleep quality and shorter sleep durations in the upcoming night, while others indicated that disrupted sleep increased stress the following day. The two studies that examined the relationship between stress and sleep bidirectionally found a mix of significant and insignificant results regarding the bidirectional predictions (Menghini et al., 2023; Haydon et al., 2023). Despite significant associations and influences between stress and sleep measures, inconsistencies and nuances were evident across the studies, with several reporting partly or entirely non-significant results.

Several factors could have contributed to these discrepancies. Firstly, different methodological approaches, for instance the differences in between and within subject designs. Some studies that utilized both designs reported only significant results at the between person level (Sladek et al., 2019; Lischetzke et al., 2021), suggesting the possibility that individual differences might play a crucial role. Studies by various researchers also illustrate this, both a reactivity to stress and sleep seem to differ across individuals in a trait-like pattern (Drake et al., 2004; Petersen et al., 2013; Sin et al., 2020; Yoo et al., 2023). However, studies which did find significant associations using within subjects designs also highlight variations over time, emphasizing the complexity of the stress-sleep relationship.

Another possible influencing factor could be the differences in operationalization of sleep outcomes, such as the discrepancy between sleep duration and quality. Despite that these operationalizations are inextricably linked (Xiang et al., 2009; Park et al., 2010; Kripke et al., 2002), there is still a degree of discrepancy since studies reported they are not simply additive (Rod et al., 2014; Chien et al., 2010). Both sleep duration and quality yielded mostly significant or mixed results with regards to associative or predictive outcomes. There did not seem to be a clear difference in findings when compared between the two, making it difficult to draw definitive conclusions about the stress-sleep relationship based on this discrepancy alone.

Thirdly, the differences in measurement tools used to estimate the variables could have impacted the findings. Namely, the difference in utilizing subjective and objective tools to measure sleep outcomes. These ways of estimating sleep are not always strongly correlated and can be influenced by various factors (Jackowska at al., 2011; Armitage et al., 1997; Balliet et al.,2016; Dinapoli et al., 2017). There were more significant associations found between subjective sleep and stress compared to objective sleep and stress. However taking into account all studies in this review, the results were too varied to make conclusions based on this distinction. Additionally, Pulpopulos et al., 2020 found no significant effect of stress on the discrepancy between objective and subjective sleep quality, suggesting that the method of sleep measurement may not significantly impact the observed relationship.

Variations in how perceived stress was measured across studies could also have contributed to the discrepancies. Studies varied in how stress was operationalized (e.g. anticipatory stress, stressfulness of event), in how the question was worded and in scales used to estimate stress level. This could have led to variability between stress measures. Additional factors that could have been of influence include differences of measurement frequencies across studies, differences in study lengths and study populations (e.g., clinical vs. general population).

Strengths and limitations

The strengths of this review lie in its thorough examination of the variables and their relationship by incorporating both subjective and objective sleep measures, considering both sleep duration and quality and various study designs. The review also included studies with different populations, exploring the relationship between stress and sleep in a broader context and it focused on the possible bidirectional predictive effects on a daily scale, which are often overlooked. Studies using EMA are still limited regarding this relationship (Lee et al., 2023). The focus on EMA assessment also resulted in the included studies being more ecological valid, stress and sleep were both measured directly in people's daily life. Furthermore, many of the studies included in this review were recent, with nine out of the twelve studies being published in the last five years. This lowers the chance of decreased validity due to outdated research.

However, several limitations of this review must also be acknowledged. The variability in measurements and designs across the studies also led to the results being difficult to interpret and compare, thus not being able to make clear inferences. Besides this, the review included correlational studies. Results of these studies can not be used to inference anything about the predictive bidirectional nature of the relationship. Of the regression studies only two actually looked at the relationship between stress and sleep outcomes bidirectionally, and found mixed results (Menghini et al., 2023; Haydon et al., 2023). Despite there being some results in other studies that are in line with bidirectional prediction on a daily scale. There simply is not enough evidence to make conclusions about the relationship at a bidirectional daily level. On top of that, only one regression model did indicate effect sizes, the others reported only unstandardized coefficients which also made them harder to compare.

Furthermore, this review focused solely on perceived stress and not objective stress biomarkers like cortisol. Studies linking subjective stress measures and objective stress show mixed results in how much they are related (O'brien et al 2013; Mendes, 2002). Including both types of stress operationalization could have provided an even more comprehensive understanding of the stress-sleep relationship. However, including this would have given even more variability in the ways of estimating this relationship. Because this review only focussed on subjective stress, reliance on self-reported data for stress but also for a portion of the sleep measurements, may have contributed to bias and influenced the overall accuracy.

Lastly, twelve different individuals coded the studies in the database, and despite most of the relevant outcome variables being coded by the person who conducted this review, this still could have led to less uniformity among interpretations of the variables and study characteristics.

Implications

Understanding the relationship better on a bidirectional daily level can have important clinical and public health implications. Interventions aimed at mitigating the impact of stress on sleep should consider factors such as the bidirectional nature on a daily scale since it encapsulates the intricacies of the relationship. Cognitive-behavioral therapy for insomnia (CBT-I) has been shown to be effective in improving sleep quality and duration by addressing maladaptive thoughts and behaviors related to sleep and in such manner could be effective in breaking the cycle of stress and sleep disturbances (Morin et al., 2003). Stress management techniques, such as mindfulness-based stress reduction (MBSR) can also help reduce stress levels and improve sleep (Gross et al., 2011). Moreover, public health initiatives should promote healthy sleep practices and stress management strategies to improve population health outcomes. For instance, educational programs emphasizing the importance of sleep hygiene and stress reduction techniques could be beneficial.

Future directions

To gain a better understanding of the relationship, future researchers should aim to address the limitations by conducting more intensive longitudinal studies that explore the predictive relationship between daily stress and sleep bidirectionally while carefully integrating both subjective and objective measures of stress and sleep. When conducting research on this relationship, is it important to keep in mind the several discrepancies that could limit the conclusions like the differences in study designs, operationalizations and measures. More standardization across research on the daily bidirectional relationship between stress and sleep would facilitate more meaningful conclusions. Other key areas future research could focus on are the negative effects of the potential vicious cycle between stress and sleep disruptions and further investigating possible mechanisms underlying the relationship and the mitigating factors. In addition, studying the effectiveness of specific interventions targeting both stress and sleep simultaneously, such as integrated stress and sleep management programs, would also be valuable.

In conclusion, this systematic review examined the relationship between daily stress and sleep on a daily scale. Just like in existing literature, this review does indicate there being an association between these two variables. However, based on the results and limitations of this review, it is difficult to make inferences about the bidirectional nature of the relationship on a daily scale. Future research should aim to explore this bidirectional relationship more on a daily scale with standardized research designs and measurements, since understanding this relationship better is necessary for improving both mental and physical health. Through conducting more targeted research, implementing effective and optimizing existing interventions and by promoting public health strategies that target both stress and sleep, overall well-being can be improved and both the prevalence and impact of stress and sleep related disturbances can be reduced.

*Note. studies indicated with * were included in this systematic review*

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