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ORIGINAL ARTICLE

Insomnia and emotion regulation

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Abstract

OBJECTIVE: Insomnia and affective disorders are among the most common and disabling health problems of our society. Although there seems to be a clear link between poor sleep and problems in emotional regulation, it is still an area with many remaining questions. While the cognitive and behavioural consequences of poor sleep and insomnia have been studied in depth in recent decades, emotional experience empirical findings in this area still need to be replicated and confirmed.
METHOD: Review article included studies published from January 1990 to March 2020 accessed via PubMed database. The keywords "Insomnia, Emotional regulation, Nightmares, Mental disorders, Sleep quality, Nightmares treatment" were used in various combinations. The total of 145 articles was found, and after their complete review, 42 papers were selected. Secondary texts from reference lists of primarily selected articles were examined and added to the primary document list. Finally, a total of 159 articles were included in the review.
RESULTS: Sleep is involved in emotion regulation both in the general population and individuals with various mental disorders. Several studies found that pre-sleep emotional activation of negative and positive emotions disturbs sleep by enhancing emotional excitement. On the other hand, many studies showed that poor sleep quality and sleep deprivation adversely affects the emotional functioning in adults. The results of the studies summarized in this review show that emotional regulation can mediate the effect of insomnia on various psychiatric disorders. Insomnia can be a significant risk factor that should be targeted in various psychiatric disorders.
CONCLUSION: Targeted prevention of affective disorders in patients who have insomnia, as well as identification of transformation mechanisms, could be an advantageous approach to alleviating their burden. Complex treatment, including cognitive-behavioural therapy for insomnia, added to the primary treatment of these disorders, is recommended.

INTRODUCTION

Insomnia is one of the most common sleep disorders (AASM 2014, APA 2013), affecting approximately one-third of the adult population. Insomnia is defined as a persistent difficulty with sleep initiation, duration, consolidation, or quality that occurs despite adequate opportunity and circumstances for sleep, and results in some form of daytime impairment (AASM 2014). These difficulties are associated with negative daily consequences such as fatigue, mood swings, depression, decreased alertness, disturbed attention, concentration, memory, and performance (van Dongen *et al.* 2003, Scott *et al.* 2006, Aldao & Nolen-Hoeksema 2012). Patients with insomnia sleep 25 minutes less than healthy sleepers (Riemann *et al.* 2015) and chronic insomnia (i.e., symptoms of insomnia at least three times a week for at least three months) harm health (Sarsour *et al.* 2010, Riemann 2007) and quality of life (Kyle *et al.* 2010). Insomnia is also often associated with other psychiatric disorders (Staner 2010, Park *et al.* 2018, Nordahl *et al.* 2018, Miller *et al.* 2020, Sevilla-Cermeño *et al.* 2020), may be recognized as a risk factor for the development of depression (Baglioni *et al.* 2011, Li *et al.* 2016), bipolar disorders (Palagini *et al.* 2019, Morton & Murray 2020), and worsens mood instability in patients with borderline personality disorder (Grove *et al.* 2017, Provencher *et al.* 2020). For these reasons, DSM-5 (APA 2013) blurs the distinction between primary and secondary insomnia and identifies an "insomnia disorder" that may or may not be in comorbidity with other disorders. Insomnia is also an independent risk factor for incapacity for work and reduced work performance and is associated with high direct and indirect costs of the health care system and society (Léger & Bayon 2010, Kucharczyk *et al.* 2012, Léger *et al.* 2013).

Insomnia has also been associated with decreased emotional control (Baglioni *et al.* 2010). This could have important implications for the functioning of affected individuals, as insomnia can affect mental health both directly and by mediating emotional dysregulation. According to Gross (2015), the terms "emotional regulation" and "emotional dysregulation" refer to the processes by which individuals change or maintain the intensity or valency of the emotional experience in order to respond appropriately to the demands of the environment. Emotional regulation can be conscious/overt or unconscious/covert (Butler *et al.* 2007, Baglioni *et al.* 2011). Several authors have tried to identify different types of regulatory strategies that we use in our daily lives to adjust the size and/or type of emotional experience or emotional events (Aldao *et al.* 2010).

The ability to adaptively regulate emotions is essential for healthy functioning. Both negative and positive emotions can be regulated (Ball *et al.* 2013). Over the years, many authors have focused mainly on strategies used to influence and control negative emotions because these are related to psychopathology (Aldao *et al.* 2010, Aldao & Nolen-Hoeksema 2012). Moreover, different theoretical models have highlighted various specific strategies that are adaptive or maladaptive. Maladaptive strategies generally considered to be associated with a negative outcome are avoiding, ruminating, and suppressing (especially suppressing emotional expression or experience), while adaptive strategies include problem-solving, acceptance, and reframing (Aldao *et al.* 2010).

However, adaptiveness of the regulatory strategies depends on the context (Butler *et al.* 2007). A new theory of perspective (Bonanno & Burton (2013) stated that flexible adaptation of human behaviour in various stressful situations is equally important, if not more significant than the ability to use any (generally recognized) positive strategy. Most scientific literature has looked into the relationship between the maladaptive strategies, demonstrating that their use is associated with psychiatric disorders such as anxiety disorders (Ball *et al.* 2013, Reinecke *et al.* 2015), PTSD (Fonzo *et al.* 2017, Miller *et al.* 2020), depression (Ehring *et al.* 2010, Joormann & Gotlib 2010, Brockmeyer *et al.* 2012, Berking *et al.* 2014), obsessive compulsive disorder (Raines *et al.* 2015), eating disorders (Aldao *et al.* 2010, Clyne *et al.* 2010, Aldao & Nolen-Hoeksema 2012), or borderline personality disorder (Grove *et al.* 2017, Provencher *et al.* 2020). Besides, recent results suggest that emotional control problems may also be related to symptoms of cognitive impairment in other psychiatric disorders (Gul & Ahmad 2014).

Although there seems to be a clear link between insomnia or poor sleep and difficulty in regulating emotions, it is still a developing research area that needs replication studies to confirm or disprove consistent empirical evidence. One instance is experimental research performed by Kyle *et al.* (2014) that showed a decrease in perceived negative emotions in patients with chronic insomnia. This review is a selection of papers that studied the topic and highlighted gaps and suggestions for future research and treatment.

Insomnia and affective disorders are among the most common and disabling health problems of our society (Riemann 2011, Kucharczyk *et al.* 2012). Targeted prevention of affective disorders in vulnerable persons, as well as identification of transformation mechanisms from sole insomnia to fully expressed affective disorder such as major depressive episode, could be the most advantageous approach to alleviating their increasing global burden (Cuijpers *et al.* 2012).

As of today, new topics for research are emerging, and recent studies used in this review are shedding new light on many aspects in the field such as the role of circadian rhythms and links between insomnia and depressive disorders. For these reasons, we conducted a review exploring the relationship between poor sleep and emotional regulation with suggestions for further

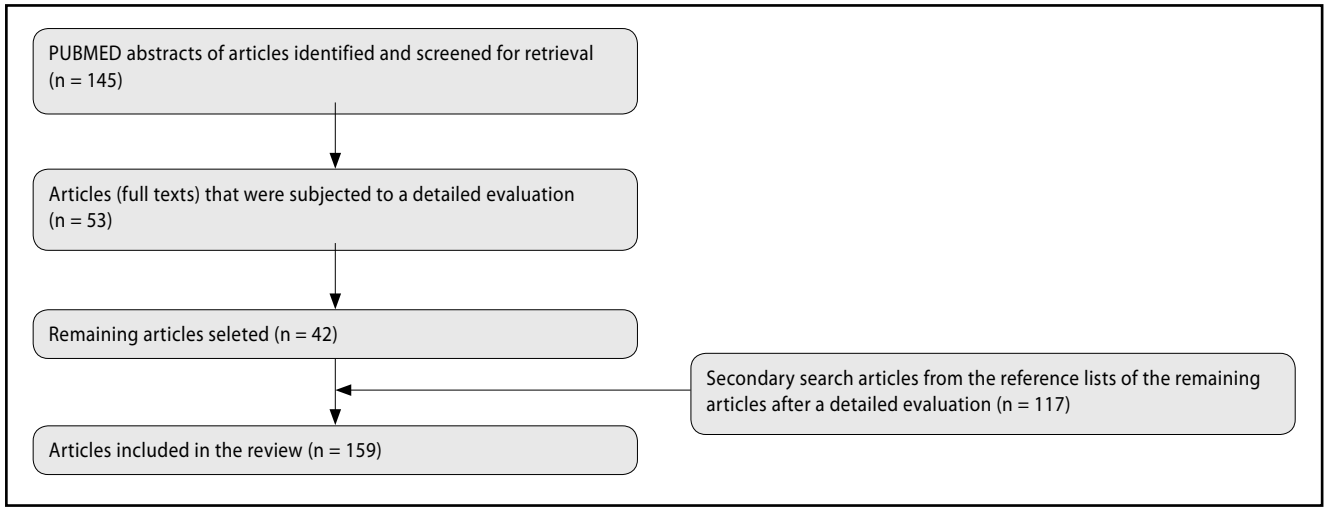

Fig. 1 . Summary of the selection process
Best matched for (Insomnia and emotional regulation) or (nightmares and emotional regulation) or (insomnia and mental disorders and emotional regulation) or (insomnia and emotional regulation and nightmares treatment) or (sleep quality and emotional regulation) or (sleep quality and mental disorders and emotional regulation) or sleep quality and emotional regulation and nightmares treatment)

research agenda. Following research questions were formulated:

(1) Do emotional experiences affect sleep?
(2) Does the quality of sleep affect emotional experiences?
(3) What is the impact of insomnia on emotional regulation?
(4) How do insomnia and emotional regulation look in affective, anxiety, obsessive compulsive, post-traumatic stress disorder and borderline personality disorders?

METHOD

Studies used in this narrative review were obtained through the PubMed database among texts published from January 1990 to March 2020. The search terms were: insomnia / emotional regulation / nightmares / mental disorders / sleep quality. Filters have been activated to narrow the search: Clinical Review, Review, People, Adults: 19+ years. Additional sources were obtained by reviewing the literature lists of primarily selected articles, including the book chapters listed in the articles. The texts were collected, systematized according to their evidence-based relevance. The selected articles had to meet the following inclusion criteria: (1) published in peer-reviewed journals; (2) human studies; or (3) reviews on a related topic; (4) book chapters in a related topic. The exclusion criteria were: (1) extracts from conferences; (2) comments. Primary keyword search yielded a total of 145 articles, of which only 53 articles met the inclusion criteria and were subjected to a detailed examination each by 2 researchers. After a complete review of the full texts, 42 papers were selected, 11 papers were excluded after the evaluation and discussion of the research team due to reservations to the methodology of the studies. Secondary contributions from reference lists of primarily selected articles were examined, evaluated for suitability, and added to the primary document list (n = 159). A total of 159 contributions (Figure 1) were included in the review process, following the PRISMA guidelines (Page & Moher 2017).

HOW DOES EMOTIONAL EXPERIENCE AFFECT SLEEP?

Empirical research generally supports the idea that negative emotions experienced at bedtime affect sleep quality. The influence of positive emotions on sleep is a subject of continuing discussion. According to the theory of Espie *et al.* (2006), pre-sleep emotional activation of negative and positive emotions disturbs sleep by enhancing emotional excitement. However, empirical evidence supporting this theory is still scarce, and sometimes the inverse relationship has also been noted. In a cross-sectional study, Steptoe *et al.* (2008) found that positive emotions predict better sleep quality. Wood *et al.* (2009) also found a connection between the emotions of gratitude that people experienced before bedtime and a better quality of sleep. In a two-week prospective study, Kalmbach *et al.* (2014) found that positive events during the day predicted a shorter latency of onset of sleep and longer overall sleep time at night.

Schmindt *et al.* (2011) found that feelings of regret before falling asleep are associated with the severity of insomnia. Another controlled study by the same research group (Schmidt & van der Linden 2013) found that experimental induction of regret in healthy students increased the latency of sleep onset. In a controlled study using polysomnography, Vandekerckhove *et al.* (2011)

experimentally induced cognitive failure in healthy adults that led to reduced sleep efficiency, decreased total sleep time, decreased percentage of REM sleep, as well as increased sleep onset latency, increased wake-up after the onset of sleep and increase of the proportion of slow-wave sleep (SWS).

To summarize studies shows that negative emotional experience worsens the quality of sleep, whereas positive emotional experience is a subject of discussion. Some studies suggesting emotional excitement, both positive and negative have a negative effect on sleep, while other studies show that positive events and emotions lead to a better quality of sleep.

HOW DOES QUALITY OF SLEEP AFFECT EMOTIONAL EXPERIENCE?

Several correlation and experimental studies have shown that overnight deprivation or multiple night sleep restraint (chronic sleep restraint) adversely affects the emotional functioning of adults (Killgore *et al.* 2008, Franzen *et al.* 2009, Babson *et al.* 2010). Experimental induction of sleep deprivation increases the negative emotions and decreases the positive emotions (Franzen *et al.* 2009, Babson *et al.* 2010, Talbot *et al.* 2010). Tempest *et al.* (2010) investigated the effect of sleep deprivation on the emotional evaluation of standardized visual stimuli (pleasant, neutral, and unpleasant stimuli) selected from the International Affective Pictures Stimuli (IAPS) (Lang *et al.* 1999). Forty healthy participants divided into deprived and non-deprived group evaluated emotional valence and arousal induced by images. Daytime activity and time in bed were assessed by actigraphy. Both groups rated similarly pleasant and unpleasant images. There was no significant effect of sleep deprivation. However, the deprived group evaluated neutral stimuli as significantly more harmful compared to the non-deprived group. The authors explain this finding according to the adaptive principle of "better safe than sorry" (Gilbert 1998), suggesting that sleep deprivation may exacerbate this tendency. They also found that the deprived group showed higher negative mood scores than well-rested participants.

Another study looked at the effect of sleep deprivation on facial expression after emotional stimulation. Emotional facial expression plays an essential role in successful social interaction in everyday life. Minkel *et al.* (2011) found a reduction in facial emotional expressivity in people with sleep deprivation while watching emotional movie clips. Schwarz *et al.* (2013) studied the effect of shortened night sleep on facial responses to emotional stimuli using EMG and evaluated valency and arousal. The results showed a slower facial muscular response to all types of emotional stimuli after sleep reduction, but no difference in valency and arousal.

The study of Talbot *et al.* (2011) investigated the impact of sleep deprivation on the affective state in a sample of adolescents and adults. The probands measured their usual sleep through sleep diaries and actigraphy for five consecutive nights, and then performed two consecutive nights of sleep deprivation and then had a restful night. After each night, they evaluated the Affective Functioning Battery data, which included the Positive and Negative Affect Schedule and its version for children (PANAS and PANAS-C), the generation of fear, and the most threatening worries and catastrophic task. They found that individuals reported fewer positive effects during sleep deprivation than at rest.

The young adult population was studied by Haack & Mullington (2005). The authors examined the effect of sustained sleep reduction of 50% than normal sleep time for 12 days on emotional and physical well-being. They found a decrease in optimism/sociability (15 %) and increased physical discomfort (3%) with an increase in stomach pain, back pain and generalized body pain.

Overall, the results of the studies described above allow to conclude that poor sleep quality and sleep deprivation are associated with more negative emotional experiences, but few studies have investigated daily emotional experiences in insomnia patients. For example, a study by Buysse *et al.* (2007) using a tool to evaluate immediate surrounding of subjects showed that individuals with insomnia had a more negative and less positive attitude toward their surrounds compared to good sleepers. Another study (Smith *et al.* 2015) using the same design for two weeks revealed that different subjective sleep indexes (i.e., total sleep time, sleep efficiency, and wake time) in insomnia subjects were associated with assessments of daily functioning including mood compared to a good sleep group that showed no association.

As mentioned above, sleep and emotions can be mutually conditioned (Kahn *et al.* 2013). The two-way hypothesis assumes that daily emotions disturb sleep, and conversely, poor sleep may increase the emotional experience the next day. However, this two-way link has been only indirectly confirmed, and only a few studies have directly addressed it. To study the bidirectional sleep and emotion hypothesis, Simor *et al.* (2015) used a seven-day prospective design with its data on sleep and emotion (Positive and Negative Affect Schedule, PANAS). In the study, students were requested to fill in a sleep diary every afternoon and evaluate their emotional experience during the day. Individuals reporting poor sleep quality also described more negative and less positive emotions during the day compared to good sleepers. Similarly, participants who reported having more positive and less negative emotions also had better sleep quality. However, the results of the study did not support the two-way hypothesis: the sleep diary completed in the morning predicted the emotional experience reported in the afternoon. In contrast, daily emotional experiences did not predict the quality of sleep the following night. Other studies

utilizing PANAS (Norlander *et al.* 2005, Scott & Judge 2006, McCrae *et al.* 2008) supported the hypothesis that poor sleep quality increases negative emotions and decreases positive emotions.

Takan *et al.* (2014) suggest the presence of a self-sustaining vicious circle involving repetitive thoughts, mood, and impaired sleep quality. They used a weekly mobile phone experience (ESM) sampling to gather the content of participants' thoughts and mood eight times a day. Daytime activity and time in bed were assessed by actigraphy. The results showed that recurring thoughts are associated with longer sleep onset latency, decreased sleep efficiency, and decreased overall sleep time. They also found that impaired sleep efficiency was associated with a decrease in the positive effect of the following morning, and the decreased positive mood was associated with an increase in recurring thoughts throughout the day in a vicious circle.

To summarize, it is theorized that the relationship between quality of sleep and emotional experience is bidirectional. Several studies confirmed that sleep deprivation leads to a more negative evaluation of everyday stimuli with one study showing decrease even in facial muscle response. Insomnia patients are affected by this as well and accordingly perceive everyday neutral surroundings more negatively. There is a need for further confirmation a replication of the results as some works did not confirm bidirectionality, showing that quality of sleep predicted emotional experience, however emotional experience throughout the day did not predict the quality of sleep.

INSOMNIA AND EMOTION REGULATION

One of the most influential models of insomnia, the 3P model (Spielman *et al.* 1987), suggests the interaction of predisposing, precipitating, and persistent factors for its initiation and maintenance. Predisposing factors are present before the onset of insomnia and are believed to interact with underlying factors, increasing the risk of insomnia in vulnerable individuals. Stressful life events are a common predisposing factor of insomnia (Drake & Roth 2006). Individuals with insomnia exhibit increased cognitive and physiological stress-induced response to stressors (Bonnet & Arand 2010, Riemann *et al.* 2010). Physiological hyperarousal, which has been identified as a critical factor of insomnia, is present for 24 hours after a stressful event (Riemann *et al.* 2015) and can interact with cognitive and emotional responses to persistent insomnia (Harvey 2002, Morin & Espie 2003, Morin & Benca 2012, Palagini *et al.* 2017).

A typical characteristic of individuals with increased sleep reactivity to stress is hyperarousal, which is defined as the degree of sleep disturbance in response to stress events (Drake *et al.* 2004, Bonnet & Arand 2010). Sleep reactivity is also a predisposition to the development and maintenance of insomnia (Drake *et al.* 2004, Fernández-Mendoza *et al.* 2010, Drake *et al.* 2014, Jarrin *et al.* 2014).

Palagini *et al.* (2018) tried to determine the resistance in patients with insomnia and its association with factors contributing to the development and maintenance of insomnia. Fifty-eight patients with insomnia disorder and thirty-eight good sleepers entered the study. Resilience Scale for Adults (RSA), Ford Insomnia Response to Stress Test (FIRST), Pre-sleep Arousal Scale (PSAS), and Difficulties in Emotional Control (Difficulties) in Emotion Regulation Scale (DERS) were administered to detect psychiatric symptoms. Patients with insomnia had lower RSA scores and higher FIRST, DERS, and PSAS scores than good sleepers. After checking for anxiety/depression symptoms, low resistance correlated with high sleep reactivity to stress, cognitive hyperarousal, and emotional dysregulation before sleep. Emotional dysregulation mediated the relationship between low resistance and cognitive hyperarousal. The insomnia group showed low resistance, which was associated with high sleep reactivity to stress, emotional dysregulation, and hyperarousal. If resistance helps to minimize the extent of pathogenesis in the developmental process, early identification of vulnerable candidates should be useful to prevent the development and maintenance of insomnia.

In a pioneering study, Harvey (2001) compared individuals with insomnia and good sleepers by Thought Control Questionnaire for Insomnia (TCQ-I). The results showed that participants with insomnia used strategies of suppression, re-evaluation, and worry far more than good sleepers. Ree *et al.* (2005) developed a revised version of the Thought Control Questionnaire Insomnia (TCQI-R), which evaluates more cognitive-emotional control strategies. Participants living with insomnia were using all thought control strategies more often than controls, except for cognitive distraction, the only strategy associated with improved sleep quality. Suppressed aggression and worry are also associated with poorer sleep quality. Nota & Coles (2014) found that ruminations are connected with short duration of sleep. Nevertheless, very few studies have examined the relationship between the symptoms of insomnia and the ability to regulate emotions.

Racine and colleagues (2013) found that short and long sleep periods (less or more than average population sleep time, 6–8 hours) are associated with a reduced ability to regulate emotions in a population of 523 Afro-American women. Women, who slept 6–8 hours, had higher emotional regulation. The presence of insomnia symptoms can mediate the relationship between emotional regulation and sleep duration. A three-year study by Tavernier & Willoughby (2015) with 942 undergraduates showed a significant two-way link between sleep problems and emotional regulation. Students with more sleep problems reported less favourable social ties, and this, in turn, predicted more sleep problems. The authors also found that emotional control problems

mediated the relationship between sleep disorders and social ties. Mauss *et al.* (2013) found a positive relationship between poor sleep and impaired ability to regulate emotions. In particular, the authors examined the effect of retrospective measurements of sleep quality on an adaptive emotional control strategy: cognitive re-evaluation (CRA), considered to be the ability to cognitively turn a particular emotional adverse event to reduce its impact (Ochsner & Gross 2005). One hundred and fifty-six participants completed self-assessment questionnaires and laboratory tasks. In each lab session, they first measured subjective sleep quality over the past 24 hours and the whole week and cognitive re-evaluation (CRA) using movie clip tasks, following the procedures described by Troy and his colleagues (2010). The results showed a positive correlation between subjective assessment of sleep quality and cognitive re-evaluation of CRA. Last week's poor sleep quality was associated with reduced cognitive re-evaluation, while poor sleep over the past 24 hours was only marginally associated.

Consistent with the hypothesis that poor sleep is associated with the ability to regulate emotions, another study by Vanderlind *et al.* (2014) investigated how sleep problems and sleep stability relate to cognitive control that distracts attention from negative emotional stimuli. In particular, they examined the association of this relationship with depressive symptoms for three weeks. They found that poor sleep quality within three weeks was associated with increased depressive symptoms. Poor sleep quality also predicted greater difficulty in attention flexibility, subsequently leading to higher depressive symptoms. The experimental study by Vanderkerckhove *et al.* (2012) tested whether different emotional control strategies affect sleep physiology. Participants were instructed to use either a cognitive-analytical or experimental regulatory emotional strategy before polysomnographic evaluation. The results showed that the experiential approach was associated with an increase in overall sleep time and sleep efficiency index and a decrease in nocturnal awakening. However, there was an increase in sleep onset latency compared to the cognitive-analytical approach. A cross-sectional study by Sandra & Voinescu (2014) found that emotional control difficulties predicted poor sleep quality. The results show that emotional control problems were also associated with the presence of dysfunctional sleep convictions.

Findings of neuroimaging studies support the existence of a relationship between sleep quality and emotional regulation. The main brain area involved in emotional regulation seems to be prefrontal cortex (PFC), which also plays an important role in cognitive control of emotions (Ochsner *et al.* 2004). Several studies suggest that cognitive control of emotions may be impaired by low-quality of sleep (Goel *et al.* 2009, Tucker *et al.* 2010). PFC is susceptible to sleep loss. Besides, the experimental study by Yoo *et al.* (2007) shows, how participants with sleep deprivation have reduced functional connectivity between cognitive control areas (middle prefrontal areas) and emotional responses (amygdala), compared to the control group when viewing negative emotional images. These findings are consistent with the results of studies using chronic deprivation (Baglioni *et al.* 2014) and partial acute deprivation (Motomura *et al.* 2013), which support the association of the two major domains and the role of emotional-regulatory control by prefrontal brain regions (Ochsner *et al.* 2004).

Although sleep contributes to a more robust consolidation of emotional memories in relation to neutral memories (Sterpenich *et al.* 2007, Wagner *et al.* 2007, Wassing *et al.* 2016), their later recollection may not be associated with similarly intense subjective emotional anxiety, autonomous arousal and activation of the amygdala (Yoo *et al.* 2007, van der Helm *et al.* 2011, Pace-Schott *et al.* 2011). REM sleep plays an essential role in this process (Gujar *et al.* 2011, van der Helm *et al.* 2011, Rosales-Lagarde *et al.* 2012, Spoormaker *et al.* 2012), although the role of non-REM sleep cannot be excluded (Talamini *et al.* 2013). It has been shown that a nap containing REM sleep influences emotional reactivity, while a nap without REM sleep does not (Gujar *et al.* 2011). Also, high-frequency electroencephalographic activity during REM sleep and fragmented REM sleep index prevent a decrease in perceived emotional distress (van der Helm *et al.* 2011).

These findings are particularly interesting because meta-analyses suggest that interruption of sleep continuity is among the most robust polysomnographic signatures of insomnia (Baglioni *et al.* 2014). Two studies show that this fragmentation is the most pronounced in REM sleep and may contribute to the development of sleep patterns of major depressive disorder, such as increased eye movement density (Feige *et al.* 2008, Riemann *et al.* 2012). Here, the term "restless REM sleep" refers to REM sleep with many phase events, including excitement and eye movement. These phase events commonly occur not only in insomnia (Riemann *et al.* 2012) but also in depression (Duncan *et al.* 1979) and posttraumatic stress disorder (PTSD) (Mellman *et al.* 2002, Germain 2013). If restless REM sleep disrupts the night-time processing of emotional distress, it could contribute to its build-up, which is manifested chronically by the state of arousal. It is noteworthy that hyperarousal is not only present in waking and sleeping in people suffering from major depressive disorder (Nofzinger *et al.* 2005), but is also of crucial importance in the pathophysiology of primary insomnia (Nofzinger *et al.* 2004, Riemann *et al.* 2010, Edinger *et al.* 2013) and is a premorbid characteristic of people vulnerable to insomnia (Riemann *et al.* 2012, Fernández-Mendoza *et al.* 2010).

Wassing *et al.* (2016) focused on the role of restless sleep with rapid eye movement (REM) (Riemann *et al.* 2012) and chronic physiological arousal (Bonnet & Arand 2010), which are characteristic of insomnia and major depressive disorders. Until now, studies of the

role of REM sleep in regulating emotions have focused on basic emotions such as fear, anger, and happiness. In psychological and psychiatric practice, however, clinically relevant emotions are conscious, including pride, guilt, embarrassment, humiliation, and shame. The Wassing *et al.* (2016) study focused on shame as it may interfere most with healthy psychological functioning (Schalkwijk 2010) and is predictive of depression development (Stuewig & McCloskey 2005), and PTSD symptoms, including hyperarousal (Feiring & Taska 2005). By hindering effective coping mechanisms, shame often hinders therapeutic progress to the extent that it can even lead to a negative therapeutic outcome (van Es *et al.* 2002).

Mechanisms underlying hyperarousal, a key symptom of insomnia, remain misunderstood and prevent cause-oriented treatment. Recently, sleeplessness with rapid eye movement (REM) has been found to have a significant effect on insomnia. Given the role of REM sleep in regulating emotions, Wassing *et al.* (2016) assumed that restless REM sleep could interfere with the nocturnal resolution of emotional distress, thereby contributing to the accumulation of excitement. Participants (n = 1,199) filled out questionnaires assessing the severity of insomnia, hyperarousal, awareness of emotional anxiety, and thought nightmares, which were found to be specific for restless REM sleep in 32 polysomnographically assessed participants. The experience of overnight distress increased with the severity of insomnia, while short-term awakening did not. The severity of insomnia was associated with hyperarousal and night-time thoughts that were directly related to restless REM sleep. Modelling the structural equation showed that 62.4% of the association between these key insomnia characteristics was explicitly mediated by reducing emotional distress overnight. Restless REM sleep reflects a process that interferes with the night-time resolution of distress. Its accumulation may support the development of chronic hyperarousal, which gives clinical importance to the role of REM sleep in regulating emotions in insomnia, depression, and posttraumatic stress disorder.

The mechanisms underlying hyperarousal anxiety in people with insomnia remain unclear. Wassing *et al.* (2019) investigated whether insomnia prevented nocturnal adaptation to emotional distress. The authors evoked a stressful self-awareness of the feeling of shame four times over three consecutive days by exposing 64 participants to their embarrassing out-of-tune singing that had been recorded previously during a karaoke session. Perceived physical, emotional and social anxiety was evaluated using the Experiential Shame Scale. Exposures with subsequent sleep resulted in relief from the body component of shame overnight in normal sleepers, but there was a marked opposite in those with insomnia. These findings experimentally show that people with insomnia experience a maladaptive type of sleep that worsens physically perceived distress. Maladaptive sleep could shed new light on posttraumatic stress disorder (PTSD) and mood swings at night, and on the contra intuitive effects of sleep deprivation in depression.

To summarize sleep reactivity and overall arousal of the patient plays an important role in emotional regulation. Several studies showed that patients with insomnia are using less adaptive coping strategies during the day and have difficulty with emotional regulation. Also, here bidirectionality plays a role as some studies show that difficult control and regulation of emotions predicted poor sleep quality. These findings are further supported by neuroimaging and EEG studies showing less connectivity between cognitive and emotional regulation structures in the brain. EEG studies ale shows links between polysomnographic readings of insomnia, depressive and PTSD patients with hyperarousal to stress stimuli being suggested as a link between the psychopathology.

CIRCADIAN RHYTHMS AND EMOTION REGULATION

There is growing evidence of an existing association between emotion regulation and chronotypes (Baudoco *et al.* 2020). The majority of authors recognize chronotypes as a preference for morning/evening activities more than just sleep behaviour. Despite the critical role of habits, education and employment, numerous genetic factors associated with different chronotypes have been found (Ashbrook *et al.* 2020). Chronotypes frequently clearly set in childhood and adverse effects (namely especially ADHD, insomnia) of evening chronotype have been observed by some authors (Jafar *et al.* 2017, Miller *et al.* 2015).

Eveningness is considered to be bound with improper sleep habits and insomnia (Makarem *et al.* 2020). Numerous studies found a link between eveningness ("owl chronotype") and unipolar depression (Muller *et al.* 2018). Similarly, in bipolar affective disorder is an evening chronotype risk factor for poor prognosis. These subjects tend to have more depressive episodes (Melo *et al.* 2020). The possible role of common genetic predispositions (polygenic) for eveningness and depression or bipolar affective disorders may be an explanation of this interplay, according to genome-wide studies (McCarthy 2019).

Another link might be in melatonin secretion and its activity – the study of Zaki *et al.* (2020) studied 45 female subjects before having breast cancer surgery. The study showed a higher level of melatonin in morning chronotype patients ("larks"). There was an inverse link between melatonin level and depresivity. Similarly, Peacock *et al.* (2017) in his retrospective analysis of data gathered from 1399 patients with depression and control group of 2395 subjects found significantly lower melatonin level in patients with depression. Moreover, cortisol level in depressed patients was significantly higher. Castaño *et al.* (2019) found that

melatonin supplementation improved mood, anxiety levels, and quality of life and decreasing cortisol levels in patients with fibromyalgia. Another clinical implication resulting from circadian rhythms impact on the mood is bright light therapy (BLT). Rutten *et al.* 2019 studied BLT effect in Parkinson disease patients – he found both depresivity and cortisol level to be decreased in patients after completing the BLT course.

Prasko *et al.* (2010) evaluated the efficacy of a 6-week combined treatment with the bright light therapy as an add-on to SSRIs in 13 female drug-resistant depressed patients with comorbid borderline personality disorder who did not respond to prior 6-week administration of SSRIs. The application of bright white light led to a significant improvement in depression, anxiety, sleep and also self-injuring.

Alteration of circadian rhythms has also been proven to predispose to many different morbidities – cardiac diseases, addictive diseases, diabetes, obesity, malignancies and others (Kelleher *et al.* 2014). Makarem *et al.* (2020) studied 506 female subjects and found eveningness as a possible risk factor of cardiovascular diseases. The author concludes that those patients also had overall shorter sleep which might be the most critical link of eveningness and coexistence of health issues. Interestingly, evening chronotype was identified as an essential risk factor for various somatic diseases, and psychiatric comorbidities – e.g. in a cross-sectional study of 773 subjects with bipolar disorder and 146 controls the evening chronotype subgroup of bipolar disorder was associated with bronchial asthma, sleep apnoea, migraine and arterial hypertension (Romo-Nava *et al.* 2020).

To summarize, recent studies propose that circadian rhythms play essential roles in emotional regulation with some chronotypes being more susceptible to maladaptive emotional regulation. The proposed link between circadian rhythms and emotional regulation is melatonin in several works. However, these results need to be replicated and confirmed.

INSOMNIA AND EMOTIONAL REGULATION IN SELECTED PSYCHIATRIC DISORDERS

Depressive disorder

Insomnia can be a significant risk factor that can be targeted to prevent emerging or recurrent affective disorders (Manber *et al.* 2008, Baglioni *et al.* 2011). About 13% of people with insomnia develop a major depressive disorder during the year (Baglioni *et al.* 2011). Besides, remission rates after cognitive behavioural therapy are 21% lower in depressed patients with abnormal sleep compared to patients with relatively intact sleep (Thase *et al.* 1997). Therefore, it seems to be very important to understand the mechanisms involved in the role of insomnia in the regulation of disturbing emotions (Baglioni *et al.* 2011).

Many observational studies have focused on whether insomnia affects the risk of depression (Ford & Kamerow 1989, Chang *et al.* 1997, Roberts *et al.* 2000, Buysse *et al.* 2008, Cho *et al.* 2008, Roane & Taylor 2008, Kim *et al.* 2009, Szklo-Coxe *et al.* 2010). Baglioni *et al.* (2011) conducted a meta-analysis to investigate the relationship between insomnia and the risk of depression and the results showed that the overall odds ratio for insomnia predicting depression is 2.60 (95% confidence interval: 1.98–3.42). A meta-analysis of Li *et al.* (2016) also suggests that insomnia is significantly associated with the increased risk of depression, which has implications for preventing depression in individuals with symptoms of insomnia. Identifying modifiable risk factors for depression has a significant impact on primary prevention.

Theoretically, it has been suggested that a change in sleep physiology may contribute to the development of biased emotional processing in depression (Lau *et al.* 2020). A recent study by Lau *et al.* (2020) investigated the role of sleep, and especially the REM phase, in modulating the perception of emotional faces in depressed and non-depressed individuals by the nap paradigm. The authors provided the first evidence of the association of daily sleep, especially REM sleep, with a more negative perception of angry faces entirely in individuals with depression. The differentiated impact of sleep can contribute to the development of altered emotional processing in depression.

In a study performed on nursing students, perceived stress mediated the association between sleep quality and anxiety symptoms in 85.3% of the cases, and mediated the relationship between sleep quality and depression symptoms in 60.0% of the cases (Zhang *et al.* 2018). This study suggested that in addition to promoting sleep, effective interventions to enhance mental health and well-being to identify unique stressors in nursing students are needed. These could be implemented by the identification of unique stressors and facilitation of the development of appropriate coping strategies.

Sleep deeply regulates the emotional and motivational state of mind (Perogamvros & Schwartz 2012). Mu & Huang (2019) focused on the brain cholinergic system, including cholinergic neurons in the basal forebrain, ventral striatum, habenula, and brainstem. Specifically, the authors presented an anatomical framework that emphasizes cholinergic signalling in an integrated reward and activation/sleep system and identifies gaps in knowledge about the potential roles of the cholinergic system in regulating emotions and sleep-mediated motivation. Sleep affects all aspects of brain function (Zhu *et al.* 2020). It restores not only cognitive control but also reassesses emotional and motivational regulation (Perogamvros & Schwartz 2015, Zhu *et al.* 2020). Although it is well known that sleep significantly affects emotional and motivational regulation, the underlying neural mechanisms remain elusive. The brain's cholinergic system is essential for a variety of functions,

including cognitive functions, learning and memory, sensory and motor processing, sleep and arousal, reward processing, and emotional regulation (Riemann *et al.* 2020, Yang *et al.* 2020). Although cholinergic functions in cognition, learning and memory, motor and sleep control, and excitement were well recognized, its interaction with sleep in regulating emotions and motivation has not been sufficiently studied.

Bipolar disorder

Sleep and circadian rhythms are involved in the development, course, and treatment of the bipolar disorder (Morton & Murray 2020). Current research in this population has provided further clarification on the occurrence of sleep problems and their relationship to affective symptoms and other clinical manifestations and their evaluation and treatment (Takaesu 2018). Symptoms of insomnia are prevalent in bipolar disorder (Bellivier *et al.* 2015). Palagini *et al.* (2019) studied 77 patients with type II bipolar disorder, a current episode depressive with mixed features. Patients were evaluated with SCID-DSM-5, Insomnia Severity Index (ISI), Difficulties in Emotion Regulation Scale (DERS), Scale for Suicide Ideation (SSI), and were evaluated for manic and depressive symptoms. Patients with symptoms of insomnia, compared to those without them, had higher scores on the DERS scale, including impulsivity, and on the SSI scale. Insomnia symptoms significantly predicted the severity of depressive symptoms, emotional dysregulation, and suicidality in patients with bipolar disorder. Emotional dysregulation significantly mediated the association between insomnia and depressive symptoms. Emotional impulsiveness further mediated the association between symptoms of insomnia and suicidality.

Posttraumatic stress disorder (PTSD)

Sleep disturbances are observed in a high degree in traumatized groups of patients and contribute to the development and maintenance of PTSD (Miller *et al.* 2020). The high incidence of sleep disorders associated with trauma exposure and PTSD indicates the need for effective sleep interventions in trauma survivors. Findings indicate that targeted sleep interventions can alleviate sleep and daily PTSD symptoms (Germain 2013). Attention has recently turned to the role of multidisciplinary and integration approaches, a comprehensive treatment of sleep disorders in PTSD is likely to require innovative assessment methods and multiple interventions (Fonzo *et al.* 2017). The method of compressing these components into a treatment plan acceptable to most patients with PTSD diagnosed remains in development (Miller *et al.* 2020).

Cognitive-behavioural therapy for insomnia (CBT-I) is the recommended treatment approach for insomnia in PTSD (Ong *et al.* 2009). Mixed ratings appear in a review of best practice in treating trauma-related nightmares (Winbush *et al.* 2007).

Borderline personality disorder

Sleep disorder is common in borderline personality disorder (BPD), but the reasons for this link are unclear. There is increasing evidence that emotional dysregulation is involved in a mutually aggravating relationship between the manifestations of BPD and insomnia (Grove *et al.* 2017, Provencher *et al.* 2020). While BPD features are often associated with suicidal thoughts and attempts, these behaviours are further intensified in individuals with sleep disorders (Provencher *et al.* 2020). Because BPD is often accompanied by using drugs or other substances, it is also important to examine the link between substance use disorders (SUDs) and insomnia. A SUD can disrupt sleep and promote insomnia, which in turn may increase motivation to use substances (Winbush *et al.* 2007). It has also been shown that insomnia precedes (i.e. predicts) SUDs and may be present during their withdrawal (Provencher *et al.* 2020).

Grove *et al.* (2017) tested emotional dysregulation as a mechanism underlying this interconnection. Two samples of college students (sample 1: N = 293; sample 2: N = 188) were asked to measure sleep quality, emotional dysregulation, and borderline features. Emotional dysregulation in BPD features correlated most strongly with worse global sleep quality across both samples. Furthermore, bootstrapping techniques revealed indirect associations based on the overall Difficulties in Emotion Regulation Scale (DERS) difficulty score as well as its several aspects (lack of strategies, lack of emotional clarity, lack of presence).

Obsessive-compulsive disorder

Current research into the relationship between obsessive-compulsive disorder (OCD) and insomnia is rare (Raines *et al.* 2015, Mondal *et al.* 2018, Nordahl *et al.* 2018, Sevilla-Cermeño *et al.* 2020). Individuals with OCD have a nearly seven-fold higher chance of receiving a diagnosis of insomnia or being given a drug with a specific indication for insomnia, compared to the general population (Sevilla-Cermeño *et al.* 2020). A study by Raines *et al.* (2015) investigated the relationship between OCD symptoms and insomnia and the potential mediating role of cognitive anxiety sensitivity problems. The sample consisted of 526 people recruited through Amazon's Mechanical Turk (Mturk), an online crowdsourcing market. The results revealed clear links between the unacceptable content of OCD thoughts and the symptoms of insomnia.

TREATMENT IMPLICATIONS AND POSSIBILITIES

While the cognitive and behavioural consequences of poor sleep and insomnia have been studied in depth in recent decades, emotional experience has been widely ignored, and empirical findings in this area still need to be replicated and confirmed. As a result,

cognitive behavioural therapy for insomnia (CBT-I), the primary non-pharmacological treatment for insomnia, is mostly based on behavioural and cognitive techniques.

However, the results summarized above suggest that cognitive behavioural therapy for insomnia programs could benefit from the inclusion of specific emotional management techniques and skills. Several studies have already been carried out to assess the effectiveness of programs that specifically address insomnia emotions. Ong with colleagues has published several studies that demonstrate that mindfulness protocols (Ong & Sholtes 2010) or their combination with the standard CBT-I program (Ong *et al.* 2008, Ong *et al.* 2009) are effective in reducing symptoms of insomnia. The protocol taught participants to respond to disturbed sleep with mindfulness rather than responding automatically by increasing their rest efforts. A systematic review published by Winbush and his colleagues (2007) identified seven studies evaluating mindfulness before 2007 and the same research group also published a document in 2011 (Gross *et al.* 2011) confirming the effectiveness of this approach.

In recent years, several authors have proposed brief psychoeducation interventions explicitly aimed at improving emotional recognition and regulation. These programs have been applied to patients with binge eating disorder (BED) who, as well as in insomnia, have been found to have a relationship between the severity of symptoms and negative influence or dysregulation of emotions. The effectiveness of these programs in reducing BED episodes has been demonstrated (Clyne *et al.* 2010, Svaldi *et al.* 2014). Although these findings appear promising, no studies have yet applied these protocols to insomnia.

DISCUSSION

The results of the studies summarized in this review show that emotional regulation can mediate the effect of insomnia on various psychiatric disorders. It appears that sleep disturbance or loss (acute or chronic) may impair the ability to use functional or flexible emotional control strategies, thereby increasing the negative mood, which in turn may change sleep in a vicious circle that produces adverse health outcomes over the long term. As far as we know, this complicated relationship does not yet support any direct evidence, except for the Tavernier & Willoughby (2015) study. Although the distinction between day and night processes seems to be enforced, most of the above studies support bilateral relationships within this complex view, namely that: negative emotions disturb sleep; sleep deprivation increases negative emotions and decreases positive emotions; deprivation of sleep worsens the use of adaptive emotional control strategies, and impaired emotional control capabilities are associated with poor sleep; if people are trained to use adaptive emotional control strategies (such as mindfulness acceptance), symptoms of insomnia can be reduced.

With regards to neurophysiological mechanisms that combine bidirectional insomnia and emotional regulation, sleep instability seems to be the right candidate of interest. Recent research suggests increased instability of NREM (Parrino *et al.* 2012) and REM Sleep (Riemann *et al.* 2012) as crucial neurophysiological mechanisms of insomnia. According to the REM hypothesis, instability requires this state of the brain a delicate balance between awakening and de-awakening brain mechanisms.

For this reason, it can often be interrupted by cognitive activity associated with waking before sleep. Chronic fragmentation of REM sleep can lead to emotional neural network dysfunctions, including limbic and paralimbic areas, which are specifically activated during REM sleep. This hypothesis would also partly explain the problems of regulating emotions in insomnia. As Gujar *et al.* (2011) proved, REM sleep plays an essential role in maintaining effective emotional categorization processes throughout the day. More specifically, through the facial recognition task, the authors found that loss of sleep increased the reactivity to negative emotions, while a daily nap reversed this effect and increased the impact of positive stimuli. Based on these outcomes, the authors conclude that REM sleep may be necessary for optimal homeostasis of emotional brain regulation.

Circadian rhythms and their dysregulation play an essential role in both insomnia and affective disorders. As proven by Castaño *et al.* (2019), melatonin supplementation might have a positive effect on depressive patients – decreases depresivity. Similarly, bright light therapy, as proven by Rutten *et al.* (2019) decreases depresivity. In both cases, the therapy reduced cortisol levels, indicating a role of cortisol for depression.

It should be emphasized that most of the literature reviewed in this work shows the effects of sleep deprivation on the emotional experience. Sleep deprivation, however, is not an "experimental model" of insomnia, since chronic sleep deprivation, which characterizes an insomnia disorder, may be associated with adaptation processes that do not occur during acute sleep manipulation. Few studies have assessed the association between usual bad sleep or usual good sleep and emotional experience or emotional regulation, suggesting that bad sleep is associated with an increase in negative or decreased positive emotions. Bad sleep is not the same as insomnia. Finally, emotional control training designed for BED has never been used for insomnia.

Future research agenda

For possible future research agenda, we propose a further investigation into bidirectionality of sleep and emotional experience and regulation. Additionally, the role of positive emotion on quality of sleep should be

explored to address the inconsistency in the findings. There is also a lack of systematic studies neurobiological links between circadian rhythms and emotional regulation and further affective disorders, melatonin being suggested first probable link. Adaptation process in patients with chronic insomnia should also be assessed in research and considered when comparing intervention in randomized control trials. Regarding psychiatric disorders studies showing the implication of early insomnia intervention on later development on affective a neurotic spectrum disorders should be considered with clear implication for day-to-day praxis.

CONCLUSION

Sleep is involved in regulating emotional regulation both in the general population and individuals with various mental disorders. Findings, as mentioned above, show that sleep is involved in regulating emotional evaluation. Several studies found that pre-sleep emotional activation of negative and positive emotions disturbs sleep by enhancing emotional excitement. In the opposite direction, many studies showed that poor sleep quality and sleep deprivation adversely affects the emotional functioning in adults. The results of the studies summarized in this review show that emotional regulation can mediate the effect of insomnia on various psychiatric disorders. These findings suggest daily dynamic links between sleep quality and next day's emotional state. Reduced facial responding to emotional stimuli can also disturb social contact after sleep deprivation. Lack of REM sleep in individuals with insomnia is related to increased emotional reactivity, at emotional, behavioural, and neural levels. Furthermore, there is a clear relation between circadian rhythm dysregulation, insomnia and emotion regulation with critical clinical consequences and implications for the therapy. Targeted prevention of affective disorders in vulnerable persons, as well as identification of transformation mechanisms, could be the most advantageous approach to alleviating their increasing global burden.

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