The role of cognitive emotion regulation strategies in objectively measured sleep

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Tiivistelmä - Referat - Abstract

Aims. Human sleep is influenced by several biological and environmental factors. Furthermore, day-time experiences and emotion-related processes are likely to impact the subsequent sleep. However, it has been suggested that emotions may not have a direct impact on the quality or duration of sleep, but emotion regulation may have a noteworthy part in between. The aim of the present study is to investigate the effect of cognitive emotion regulation strategies on objectively measured sleep in adolescents. Ten distinct cognitive emotion regulation strategies and their association on sleep duration, sleep quality, regularity, and the timing of sleep phase was examined. The possible links between theoretically adaptive and maladaptive strategies and sleep were investigated as well.

Methods. Sleep and cognitive emotion regulation strategies of 329 adolescents (67.1% girls, age *M*=17.47) were measured in SleepHelsinki!, a University of Helsinki –based research project. Sleep was measured objectively with actigraphy. Regression analyses were performed between distinct emotion regulation strategies and sleep outcomes, and between two composite variables (*adaptive* and *maladaptive strategies*) and sleep outcomes.

Results and Conclusions. The average sleep duration of adolescents was 6.55 hours on weekdays and 7.41 hours on weekends, which is considerably less that the recommended 8-10 hours. A clear link between emotion regulation strategies and the timing of the sleep phase was found. The overall use of adaptive strategies as well as the use of distinct adaptive strategies was related to an earlier midpoint of the sleep phase on weekdays. Furthermore, the more rumination and catastrophizing were used, the later the sleep midpoint occurred. However, the link between emotion regulation strategies and duration, quality and regularity of sleep remains elusive. The results obtained in the present study suggest that the usage of various emotion regulation strategies is connected to the timing of nighttime sleep, particularly on weekdays. Sufficient emotion regulation is likely necessary for good nighttime sleep, but the adaptivity of the strategy may depend on complex person-, situation- or emotion-related matters.

Keywords

Sleep, adolescents, emotion regulation, cognitive emotion regulation strategies

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Tiivistelmä - Referat - Abstract

Tavoitteet. Ihmisen uneen vaikuttavat monet biologiset ja ympäristöön liittyvät tekijät. Myös päivän aikana koetut tunteet ja kokemukset voivat vaikuttaa seuraavan yön uneen. Tunteilla ei välttämättä ole kuitenkaan suoraa vaikutusta unen laatuun ja määrään, vaan yhteyteen saattaa vaikuttaa merkittävällä tavalla tunteiden säätely. Tämän tutkimuksen tarkoituksena on selvittää kognitiivisten tunteiden säätelyn strategioiden yhteyttä objektiivisesti mitattuun uneen. Tutkimuksessa tarkastellaan kymmenen erillisen strategian yhteyttä unen määrään, laatuun, ajankohtaan ja ajankohdan säännöllisyyteen. Lisäksi tarkastellaan teoreettisesti adaptiivisten ja epäadaptiivisten strategioiden mahdollista yhteyttä uneen.

Menetelmät. Kognitiivisia tunteiden säätelyn strategioita ja unta mitattiin yhteensä 329 nuorella (tyttöjä 67.1%, iän keskiarvo = 17.47) osana Helsingin yliopiston SleepHelsinki! -tutkimusprojektia. Unta mitattiin objektiivisesti aktigrafilla. Tunteiden säätelyn yhteyttä unimuuttujiin tutkittiin regressioanalyyseillä ensin erillisten strategioiden osalta sekä toiseksi adaptiivisten ja epäadaptiivisten tunteiden säätelyn strategioiden osalta.

Tulokset ja johtopäätökset. Nuorten kokonaisuniaika oli keskimäärin 6.55 tuntia arkisin ja viikonloppuisin 7.41 tuntia. Määrät ovat selvästi alle 8-10 tunnin suosituksen. Tutkimuksessa löytyi selkeä yhteys tunteiden säätelyn strategioiden ja unijakson ajoittumisen väliltä. Sekä useat yksittäiset adaptiiviset strategiat että adaptiivisten strategioiden käyttö ylipäätään oli yhteydessä aikaisempaan unijakson ajoittumiseen. Ruminointi ja katastrofointi taas olivat yhteydessä unen myöhäisempään ajoittumiseen. Yhteys tunteiden säätelyn strategioiden sekä unen kokonaismäärään, laadun tai säännöllisyyden välillä jäi tässä tutkimuksessa epäselväksi. Tulokset viittaavat siihen, että useilla tunteiden säätelyn strategioilla saattaa olla yhteys nuorten yöunen ajoittumiseen erityisesti arkisin. Riittävä tunteiden säätely lienee tarpeen laadukkaalle yöunelle, mutta tietyn strategian adaptiivisuus saattaa kuitenkin riippua monista, toisiinsa kietoutuneista, yksilöön, tilanteeseen ja tunteeseen liittyvistä tekijöistä.

Avainsanat – Nyckelord - Keywords

Uni, nuoret, tunteiden säätely, kognitiiviset tunteiden säätelyn strategiat

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Introduction

Our daily sleep and wakefulness are influenced by several factors. Biological, environmental and psychosocial determinants of sleep are cognate and overlap with each other. We have biological differences impacting when we feel tired or want to go to sleep. These tendencies are influenced for example by social relationships, academic pressure and amount of sunlight. An intensive movie or excitement of a next day's presentation may rob the night's sleep and strong emotions may lead to insomnia or make us extremely tired. All of these different components compose the variation of sleep and wake in our everyday life and affect the features of sleep.

Regulation of sleep

From the viewpoint of the biological component, sleep is regulated by two separate, but mutually interacting processes: a sleep-dependent homeostatic process S and a circadian, sleep-independent process C (Borbely, 1982; Borbely, Daan, Wirz-Justice & Deboert, 2016). In process S, the need for sleep slowly increases as a homeostatic response to the duration of wakefulness and decreases exponentially during sleep. When measured using EEG signals, this process is marked by slow wave activity in NREM sleep and theta activity during wakefulness (Borbely et al., 2016).

Process C supports sleep or wakefulness according to the time of the day. This manifests in continuous rhythmic variation in sleepiness, regardless of previous sleep or wakefulness. This variation follows an approximately 24-hour cycle and is governed by the suprachiasmatic nuclei (SCN) in the hypothalamus (Borbely, 1982; Borbely et al., 2016). REM sleep follows the circadian component of the sleep-wake cycle and is therefore relatively resistant to manipulations of previous sleep time (Borbery, 1982; Borbery et al., 2016; Lee, Swanson & de la Iglesia, 2009).

Sleep propensity depends on both processes: when Process S approaches the upper threshold of process C, it triggers sleep, and when process S approaches the lower threshold of process C, it triggers awakening (Borbely et al., 2016) (Figure 1). Together, they have a great impact on the specific sleep stages and the duration and timing of sleep (Borbely, 1982; Lee et al., 2009). Even though these processes are regulated separately, they interact and have reciprocal influences. Recent research indicates that process S may not only be dependent on the time spent awake, but also on the time of the day (Deboer, 2018). On the other hand, homeostatic sleep pressure may alter the influence of the circadian clock on physiology and behavior (Borbely et al., 2016). It appears that both processes use the information of the other and interact constantly in a complex manner (Borbely et al., 2016).

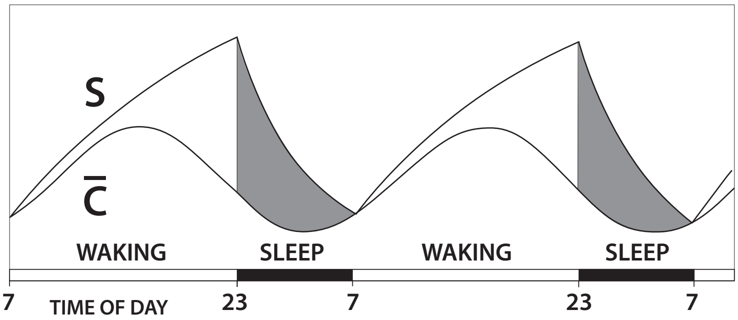

Figure 1. Borbély's model of sleep-wake regulation (Borbély et al., 2016). S represents homeostatic sleep pressure (process S). $\bar{C}$ represents negative function of the circadian sleep pressure, process C. When the distance between these processes is largest, sleep propensity will be largest.

Human sleep-wake cycle is strongly regulated by biological processes, which are influenced by a variety of inner and outer environmental factors. Light-orienting behavior, activity, time spent outdoor, caloric intake and metabolic processes are all connected to how and when we sleep (Aschoff, 1993; Green, Pollac & Smith, 1987 & Roenneberg & Merrow, 2007;). Moreover, day-time experiences and emotion-related processes are likely to impact the following sleep (Baglioni et al., 2010; Gruber, & Cassoff, 2014; Palmer & Alfano, 2016; Vandekerckhove & Wang, 2017). Indeed, in a study by Lund and colleagues, academic and emotional stress explained the most of poor quality sleep in adolescents, resulting in shorter sleep duration and later timing of the sleep phase (Lund, Reider, Whiting & Prichard, 2010). Moreover, pre-sleep negative emotions have been shown to have an impact on the subsequent sleep physiology, leading to longer sleep onset latency, shorter sleep duration, and poorer sleep efficiency (Vandekerckhove et al., 2011).

Sleep and adolescence

Variants in genotype produce individual differences in circadian properties. These include the length of the circadian period or the temporal relationship with naturally occurring cues, such as sun light, body temperature or melatonin release (Roenneberg & Merrow, 2007). Individual differences in the relation between the inner and outer clock are referred to as chronotypes. In other words, individuals may synchronize earlier or later to the same light-dark-cycle, depending on their biological clocks (Roenneberg & Merrow, 2007; Roenneberg, Pilz, Zerbini & Winnebeck, 2019). In addition to genetic influence, chronotype is also affected by age and sex (Roenneberg & Merrow, 2007).

In adults, an evening chronotype (that is, a later timing of sleep and activity), is often related to more psychological disturbances, such as depressive symptoms and anxiety (Gobin, Banks, Fins & Tartar, 2015; Hidalgo, Caumo, Posser, Coccaro, Camozzato & Chaves, 2009; Van den Berg et al., 2018), and maladaptive emotion regulation strategies (Watts & Norbury, 2017). It has been linked to higher stress perception (Roeser, Meule, Schwerdtle, Kubler & Schlarb, 2012) and poorer overall sleep quality (Gobin et al., 2015). A morning chronotype on the other hand has been linked to a lesser amount of tension and confusion, less mood disturbances (Gobin et al., 2015), lower emotional intelligence (Stolarski, Jankowski, Matthews & Kawalerczyk, 2016) and generally better sleep quality (Sun et al., 2019).

A clear age-related change in chronotype is the development of evening chronotype in adolescence. Across different cultures, adolescents are staying up and waking up later compared to children and adults, which is associated to hormonal changes in pubertal development (Carscadon, 2011; Hummer & Lee, 2016; Kuula et al., 2019). The shift in chronotype, as well as shortening of the sleep duration, continues through adolescence and early adulthood and stabilizes at the age of 30 (Kuula et al., 2019). This delay of sleep phase has been explained by developmental changes in process S and process C (Carscadon, Acebo & Jenny, 2004). The strongest evidence supports a theory in which homeostatic accumulation of sleep pressure during waking hours declines and as a result, adolescents experience less need to sleep in the evening (Hummer & Lee, 2016; Jenni, Achermann, & Carskadon, 2005). A lengthening circadian period and an increasing sensitivity to light exposure have also been suggested to affect sleep pressure (Carscadon et al., 2004), but current research does not support these hypotheses (Hummer & Lee, 2016).

It is also clear that psychosocial and lifestyle factors have an impact on adolescents' sleep quality, duration, and timing. It has been suggested that changing demands in youth might contribute to the development of an evening chronotype (Hummer & Lee, 2016). Increased social and academic demands, extracurricular activities and access to technology may encourage adolescents to stay awake longer. The delayed sleep phase may also be a consequence of arousal and anxiety, caused by these psychosocial factors, which override the biological regulation of sleep (Hummer & Lee, 2016). This explanation alone is not adequate to explain the alteration of chronotype, but it may maintain and even strengthen the later sleep-wake patterns.

Despite the delay in the sleep-wake pattern, early school or work schedules still demand early awaking, resulting in insufficient duration of total sleep time. Furthermore, the discrepancy between socially desirable schedule on weekdays, and delayed chronotype that appear on weekends, is producing a clear fluctuation of the timing of the sleep phase. This phenomenon is called *social jetlag* (Roenneberg et al., 2019).

Consequences of poor sleep

Sufficient sleep has a prominent role in mental health, well-being, and optimal cognitive functioning. Disrupted sleep is strongly associated with a wide variety of psychiatric disorders (e.g. Goldstein & Walker, 2014). Sleep deprivation has a determinant effect on mood (Watling, Pawlik, Scott, Booth & Short, 2017) and a maladaptive effect on emotional reactivity, social functioning, and the ability to cope with stress (Vandekerckhove & Wang, 2017). Even slightly insufficient sleep (6 hours) as chronic state has a clear debilitating effect on mental well-being. In a study by Sullivan and colleagues the amount of sleep was strongly associated with mental health symptoms, and each additional hour of sleep was linked to decreased depression, hopelessness, nervousness, and restlessness in a large representative sample of adults (Sullivan, Kelly, Ordiah & Collins, 2018). In another recent study (Del Rio Joao et al., 2018), fewer hours of sleep were associated with increased psychological distress, and sleep problems were linked to a higher level of depression, anxiety and stress.

The U.S. National Sleep Foundation recommends 8 to 10 hours of sleep per night for 14- to 17-year-old adolescents (Hirshkowitz et al., 2015). It is often reported that adolescents worldwide do not follow this guideline (e.g. Gradisar, Gardner & Dohnt, 2011; Kuula et al., 2019; Ojio et al., 2016; Winsler et al., 2015). Inadequate sleep in adolescence has been associated with plenty of negative consequences. In the study by Winsler et al., (2015), high-school students reported sleeping 6.5 hours per night on average, while minority students and females reported even fewer hours. A mere 1 hour less of weekday sleep was associated with significantly greater odds of hopelessness, substance use, and serious considerations and attempts of suicide. In children and adolescents, sleep deprivation has been shown to be associated with increased depression, confusion, anger, frustration, and irritability (Vandekerckhove & Wang, 2017).

After one night of partial sleep deprivation (4 hours of sleep), adolescents reported diminished positive affect, higher anxiety and moderately increased reactivity to negative emotional images when compared to 9.5 hours sleep (Reddy, Palmer, Jackson, Farris & Alfano, 2017). In another experimental study, partial sleep restriction (4 hours of sleep) led to increased negative affect and negative affective behavior in a peer social context when compared to extended sleep (10 hours) (McMakin et al., 2016). In this study, self-reports also showed a decrease in positive affect after sleep restriction, while pupil measurements did not.

Poor sleep has also been associated with weaker emotional competence and empathy in adolescents (Brand et al., 2016). Adolescents who reported insomnia showed lower regulation and control of their emotions as well as poorer perception and understanding of their emotions, compared to those with no insomnia. In this study, empathy was measured using two different methods, leading to different results. The authors speculated that the differing results may reflect the cognitive and emotional components of empathy and concluded that it is possible sleep only has an effect on emotional, and not cognitive, empathy. Another study of empathy (Guadagni et al., 2018) focused on emotional empathy specifically. Subjective evaluations of sleep quality and earlier sleep phase both predicted the ability to empathetically respond to negative stimuli. Subjective sleep quality also predicted the arousal state in response to negative stimuli, which may be an indirect reflection of emotional empathy. Sleep duration predicted the general ability to share the emotions of others regardless of the emotion's valence.

Emotion regulation

Emotion regulation refers to the wide spectrum of internal and external processes that we use to monitor, evaluate, and modify our emotional reactions in order to reach our goals (Thompson, 1995). These processes happen consciously and unconsciously at the levels of biology, behavior, and cognition (Garnefski et al., 2001). In a widely used framework, emotion regulation is classified into problem-focused and emotion-focused regulation (Lazarus & Folkman, 1984). It can also be understood through the viewpoint of temporal locations. In the process model of emotion regulation, it is divided into five groups of processes that exist in different time points (Gross, 2014). We can choose the situations and environments we attend to and modify them to better meet our needs. We can selectively focus our attention on diverse features and stimuli and choose how to interpret them. Finally, we can also modulate our responses to these stimuli.

On the level of cognition, individuals use different strategies to cope with stress and to regulate negative emotions. It is well documented that poor sleep greatly influences the mood and cognitions the next day, but it is also possible that mood and emotions affect the following sleep (Vandekerckhove & Wang, 2016; Watling et al., 2017). Moreover, the sufficiency and adaptivity of the emotion regulation strategies used may play a significant role in this association.

It has been suggested that emotions may not have a direct impact on the quality or duration of subsequent sleep (Watling et al., 2017). In the study by Simor and colleagues (2015), day-time negative and positive affect were not associated with the quality of the following sleep. However, subjective sleep complaints preceded lower positive and higher negative emotions the next day. Watling and colleagues (2017) have proposed a model in which emotion regulation plays a key role between cumulating emotions and mood, which in turn leads to poor sleep or longer sleep latency. For example, if emotion regulation is sufficient, negative emotions and stress may not have consequences on mood and sleep. Repetitive negative thinking and the cognitive strategies used may strengthen or diminish the effect of emotions and stress on sleep.

Cognitive strategies of emotion regulation

Some cognitive strategies have argued to be more *adaptive*, downregulating negative feelings effectively, whereas others, *maladaptive* strategies, may prolong or increase the emotional stress related to a negative event. (Nolen-Hoeksema & Aldao, 2011; Aldao, Nolen-Hoeksema & Schweizer, 2010). Various maladaptive strategies, such as avoidance, suppression and rumination has been linked to psychological disturbances and maladaptive behavior. However, although adaptive strategies, such as reappraisal, problem solving and acceptance are thought to protect against psychopathology in research literature, the empirical evidence remains week (Nolen-Hoeksema & Aldao, 2011; Aldao, Nolen-Hoeksema & Schweizer, 2010).

Moreover, maladaptive strategies of emotion regulation may play a part in the delayed sleep phase that occurs in adolescence. In the study by Palmer et al. (2018), adolescents with sleep problems reported more use of maladaptive emotion regulating strategies, such as rumination, avoidance, and suppression, and less use of adaptive strategies, such as problem solving. In this study, the strategy of cognitive reappraisal was not associated with sleep problems. The authors suggested that the ability to use this strategy is relatively stable and not disrupted by sleep loss.

Cognitive emotion regulation can be represented through distinct dimensions of strategies: self-blame, blaming others, acceptance, refocusing on planning, positive refocusing, rumination, positive reappraisal, putting into perspective, catastrophizing and reflection (Garnefski et al., 2001; Trapnell & Cambell, 1999). *Self-blame* as a coping strategy has been linked to depression and other aspects of poor well-being (Anderson, Miller, Riger, Dill & Sedikides, 1994). *Blaming others* for one's misfortune has also been connected to lesser well-being (Tennen & Affleck, 1990). *Acceptance* of what one has experienced has been associated with self-esteem, optimism, and lower anxiety (Carver, Scheier & Weintraub, 1989). *Refocusing on planning* refers to the cognitive part of an action-focused coping strategy. Using this strategy means focusing attention on, and thinking of, what might be done in an emotionally arousing situation (Garnefski et al., 2001). *Positive refocusing* as a coping strategy refers to focusing on pleasant matters instead of the present event, and it may be adaptive in the short term but less so in the long term (Garnefski et al., 2001).

Rumination is a type of negative self-attentiveness, which is motivated by threats, losses, and injustices to oneself (Trapnell & Campbel, 1999). It is a form of negative repetitive thinking and a maladaptive emotion regulation strategy, in which one orients towards the past. As a coping strategy, rumination has been linked to depressive symptoms (Nolen-Hoeksema, Parker & Larson, 1994). In the study by Amaral and colleagues (2018), the effect of stress on sleep problems was moderated by rumination and negative affect in a large sample of students in higher education. Moreover, repetitive negative thinking and cognitive emotional strategies, such as rumination, self-blaming, catastrophizing, and acceptance, were directly associated with sleep problems (Amaral et al., 2018). In the sample of Vannikov-Lugassi et al., (2018), repetitive rumination predicted poor sleep quality. Those with maladaptive ruminative cognitive strategies at bedtime slept poorly, which in turn led to dissociation in young adults.

Reflection is another way of focusing the attention to oneself (self-attentiveness), motivated by curiosity and epistemic interest. The use of reflection as a cognitive strategy has not been linked to psychological distress and has psychologically and statistically been classified a phenomenon distinct from rumination (Trapnell & Cambell, 1999).

Positive reappraisal refers to attaching positive thoughts and aspects of personal growth to an event experienced. This type of cognitive regulation has been linked to self-esteem, optimism, and low anxiety (Carver et al., 1989). In addition, *putting into perspective* means comparing the severity of the present event to other events (Garnefski et al., 2001). *Catastrophizing* refers to thinking processes that emphasise panic and horror (Garnefski et al., 2001). In a sample of adolescents with delayed sleep phase disorder, 87% reported catastrophized thinking before sleep (Hiller et al., 2014). More precisely, the themes that were most strongly associated with delayed sleep onset were concerns regarding the effect of poor sleep on academic performance and the ability to attend to school, and the social consequences thereof. This dysfunctional thinking was associated with a longer (subjective) sleep latency via anxiety. Similar results emerged in the study by Heath and colleagues (2018), which focused on the link between pre-sleep thinking and sleep onset in a sample of healthy adolescents. The study found that pre-sleep sleep-related cognitions were associated with subjective reports of sleep onset latency. Interestingly, when measured objectively using actigraphy, sleep onset latency was not related to pre-sleep cognitions. Considering that pre-sleep cognitions consisted of concerns related to falling asleep and the consequences of poor sleep, the authors speculated that these concerns may have led to overestimations of sleep onset latency.

In general, insufficient emotion regulation and coping may have a detrimental effect on sleep. For example, the ability to control anxiety has been linked to shorter sleep latency among both young and older adults, possibly via reduced anxiety and worry at bedtime (Gould et al., 2016). In a recent study by Hoag and colleagues (2016), emotion regulation was found to mediate the association between positive/negative affect and sleep quality among low-income women. In this study, emotion dysregulation was a more powerful contributor to poor sleep quality than either positive or negative affect. Positive affect was only related to sleep quality via emotion regulation, while negative affect influenced sleep quality both directly and via emotion dysregulation. Thus, negative affect appears to have a greater influence on sleep quality than positive affect and increases in positive affect do not necessarily translate into better sleep quality among those with high emotion dysregulation.

Previous research has found an association between cognitive emotion regulation strategies and sleep has been found, but a majority of the previous studies have relied on subjective measurement of sleep (Amaral et al., 2018; Heath et al., 2018; Hiller et al., 2014; Hoag et al., 2016; Palmer et al., 2018; Vannikov-Lugassi et al., 2018). Furthermore, the studies of emotion-related processes have often used inconsistent terminology: in particular, emotion and emotion regulation have been measured in an intermixed manner (Watling et al., 2017).

The present study focuses on how cognitive emotion regulation strategies affect objectively measured duration, quality, regularity, and timing of sleep in adolescents. Our aim is to determine whether the more adaptive cognitive strategies that have been linked to well-being, such as positive reappraisal, positive refocusing (Garnefski et al., 2001), acceptance and refocusing on planning (Carver et al., 1989), putting into perspective (Martin & Dahlen, 2005) and reflection (Trapnell & Cambell, 1999) are associated with more positive sleep outcomes. Correspondingly, we also aim to investigate whether the more maladaptive strategies, such as self-blame, blaming others, rumination, and catastrophizing, which have been linked to depressive and anxiety symptoms and lesser well-being (Garnefski et al., 2001, Tennen et al., 1990) are connected to poorer sleep quality and quantity as well as more variable circadian rhythms.

Research question and hypotheses

Research question: Are cognitive emotion regulation strategies related to sleep patterns?
H1: a) The use of adaptive cognitive strategies (positive reappraisal, positive refocusing, acceptance, refocusing on planning, putting into perspective and reflection) is associated with greater sleep quantity and better sleep quality. **b)** The use of more maladaptive strategies (self-blame, blaming others, rumination, and catastrophizing) is linked to lesser quantity and poorer quality of sleep.
H2: a) The use of adaptive cognitive strategies (positive reappraisal, positive refocusing, acceptance, refocusing on planning, and putting into perspective) is associated with regularity and earlier timing of sleep phase and **b)** the use of more maladaptive strategies (self-blame, blaming others, rumination, and catastrophizing) is linked to irregularity and later timing of sleep phase.

Methods

Procedure

Sleep Helsinki! is a University of Helsinki –based research project, which aims to produce new information regarding sleep and sleep disturbances in adolescence and to develop new evidence-based methods to alleviate and prevent sleep problems and difficulties maintaining a healthy sleep rhythm. Sleep Helsinki! is a population-based cohort study initiated in September 2016. The first phase consisted of an online survey in which information was gathered on adolescents' sleep, health, and behavior. In the second phase of the project, sleep was measured objectively using actigraphy. The data used in the present study comprises data from both the first and the second phase of the research project.

Participants

A total of 329 adolescents (67.1% girls) between the ages of 16 and 18 (*M*=17.47, *SD*=.68, range=15.90–18.91) completed both phases of the study. Initially, all Finnish-speaking adolescents aged 16 to 17 in Helsinki were invited to participate in the study, based on the information available from the Population Register Center in September 2016. Of all the adolescents living in Helsinki and born between 1999 and 2000 (*n*=10 476), there were 7 539 Finnish speakers. 3 789 of them were born in 1999 and 3 750 in 2000, 50 % of them female. A total of 1 411 adolescents participated in the online survey (phase 1), but a few had to be excluded due to technical difficulties related to the survey, leaving a total of 1 374 participants (18% of the invited 7 539). While most respondents were female (66 %), there was no significant difference between the mean age of the participants and that of the cohort (*p*=.34). After phase 1, a total of 552 participants were invited to the second phase of the study, in which actigraphy data was obtained from 329 of them.

Measures and questionnaires

Sleep

Sleep was objectively measured using actigraphy. Actigraphy is a validated method for estimating night-time sleep parameters across age groups (Martin & Hakim, 2011), specifically total sleep time and wakefulness after sleep onset (Marino et al., 2013). In the present study, actigraphy devices were worn on non-dominant wrists, and sleep parameters were estimated from movements recorded for 5.74 days on average during weekdays (*SD*=1.51, range=0-9) and 2.12 days on average during weekends (*SD*=0.70, range=0-4).

Sleep duration was measured using *total sleep time*, which refers to the amount of sleep after sleep onset, with any awakenings subtracted. Sleep quality was estimated by *sleep onset latency*, which refers to the time between going to bed and falling asleep, and by *wake after sleep onset* (WASO), which refers to the time of wakefulness after falling asleep. The timing of the sleep phase was assessed by calculating *the midpoint of the sleep* period, both on weekdays and weekends. The difference between these timepoints describes *social jetlag* i.e. irregularity of sleep phase and was calculated by subtracting the average midpoint during weekdays from the average midpoint during weekend. Positive values refer to later timing of the sleep phase during weekends, while negative values refer to later timing during weekdays. Values close to zero mean there is only a small difference between weekdays and weekends.

Emotion regulation

Cognitive emotion regulation strategies were measured with two questionnaires, assessing altogether ten distinct strategies. The Cognitive Emotion Regulation Questionnaire (CERQ) includes nine conceptually distinct subscales. Each of them consists of four items that focus on the respondent's characteristic style of thinking in threatening or stressful situations (Garnefski et al., 2001), and respondents are asked to assess each item using a 6-point scale from 0 (*never*) to 5 (*almost always*). The nine subscales measured by the CERQ were *self-blame, blaming others, acceptance, refocusing on planning, positive refocusing, rumination, positive reappraisal, putting into perspective,* and *catastrophizing*. The Cronbach's alpha reliability coefficients for these have been reported to vary from 0.68 to 0.83 (Garnefski et al., 2001).

The Rumination-Reflection Questionnaire (RRQ) measures dispositional self-consciousness, which consists of two distinct subscales: *rumination* and *reflection* (Trapnell & Campbell, 1999). The questionnaire consists of 28 statements, and the respondents' task is to evaluate their level of agreement with each statement by using a 5-point scale (1=*strongly disagree*, 5=*strongly agree*) (Trapnell & Campbell, 1999). The alpha reliability estimates of for the two subscales are .90 and .91, respectively (Trapnell & Campbell, 1999).

Statistical Analyses

Analyses were performed with IMB SPSS version 25. Separate linear regression analyses were performed, with each emotion regulation strategy as an independent variable and each sleep outcome as a dependent variable. Age (linear) and sex were adjusted for in all analyses.

In addition to the inspection of these ten distinct strategies, the theoretical categories of adaptive and maladaptive strategies were also examined. First, a confirmatory factor analysis was performed to evaluate whether the two-factor structure fit the data. Factors were allowed to correlate with each other. A model with oblimin rotation fitted the data well [$x^2(34)=122.59$, $p<.001$]. It explained 52.09% of the total variance. As expected, adaptive strategies loaded on one factor, named *adaptive emotion regulation*, while less adaptive strategies loaded on another, named *maladaptive emotion* *regulation*. Only *blaming others* did not load strongly on either factor (adaptive .21, maladaptive .17), and was left out from further analyses. The loadings for the two factors are shown in table 1.

Second, based on factor loadings, composite variables were created for *adaptive* and *maladaptive* strategies. Finally, the associations between these strategies and each sleep outcome were explored using linear regression analysis, with age and sex adjusted for.

Table 1 The loadings of the 11 emotion regulation strategies on two factors. Loadings above .3 are presented.

Subscale	Factor	
	1	2
Factor 1: adaptive emotion regulation		
Acceptance	.51	
Positive refocusing	.45	
Refocusing on planning	.74	
Positive reappraisal	.87	
Putting into perpective	.71	
Reflection (RRQ)	.36	
Factor 2: maladaptive emotion regulation		
Self-blame		.70
Rumination		.65
Catastrophizing (log)		.59
Blaming others (log)		
Rumination (RRQ)		.80

Results

Initial analyses

First, all emotion regulation and sleep variables were examined for missing values and for assumptions of multivariate analysis. 45 participants were found to have missing values, but their age and gender distribution did not differ from the distribution of those with non-missing values (respectively: p=.98 and p=.86). The percentage of missing values ranged from 1,5 % to 13.4 % depending on the variable. As these values were missing completely at random according to Little's MCAR test [$x^2(102)=118.35$, p=.13], the missing values were deleted pairwise. No participants were completely excluded from the analyses.

All variables were graphically examined and found to be normally distributed, with the exception of sleep latency, blaming others, and catastrophizing. To reduce extreme skewness, these three variables were logarithmically transformed. Finally, all distributions of pairwise residuals were examined and found to be homoscedastic.

Sample characteristics

The average sleep duration was 6.55 hours (*SD*=0.99) on weekdays and 7.41 hours (*SD*=1.21) on weekends (Table 2 & Figure 2). 94.9 % of adolescents slept less than eight hours and 26.0% slept less that 6 hours on weekdays. On weekends, 68.8 % slept less than eight hours and 11.6% less than six hours (Figure 2). The average sleep latency was 0.34 hours (*SD*=0.40) on weekdays and 0.29 hours (*SD*=0.37) on weekends. On average, the participants spent 0.91 hours (*SD*=0.35) awake after sleep onset on weekdays and 1.03 hours (*SD*=0.43) on weekends.

Table 2 Characteristics of the participants and sleep variables

	Mean (SD)	N (%)	min.	max.
Gender		329		
Female		230 (67.1)		
Male		99 (28.9)		
Age (in phase 1)	17.47 (0.68)	329	15.90	18.91
Sleep duration (decimal hours)				
Weekdays	6.55 (0.99)	312	2.69	10.16
Weekends	7.41 (1.21)	301	3.22	11.62
Wake after sleep onset				
Weekdays	0.91 (0.35)	312	0.18	2.27
Weekends	1.03 (0.43)	301	0.18	2.51
Sleep latency (decimal hours)				
Weekdays	0.34 (0.40)	312	0.01	4.79
Weekends	0.29 (0.37)	301	0.00	2.56
Sleep midpoint (hours:minutes)				
Weekdays	04:22 AM (1:17)	312	01:43	9:34 AM
Weekends	5:58 AM (1:34)	301	01:47	12:23 PM
Social jetlag (decimal hours)*	1.59 (1.23)	301	-2.24	5.97

* the discrepancy between a timing of the sleep phase on weekdays, and a timing of the sleep phase on weekends.

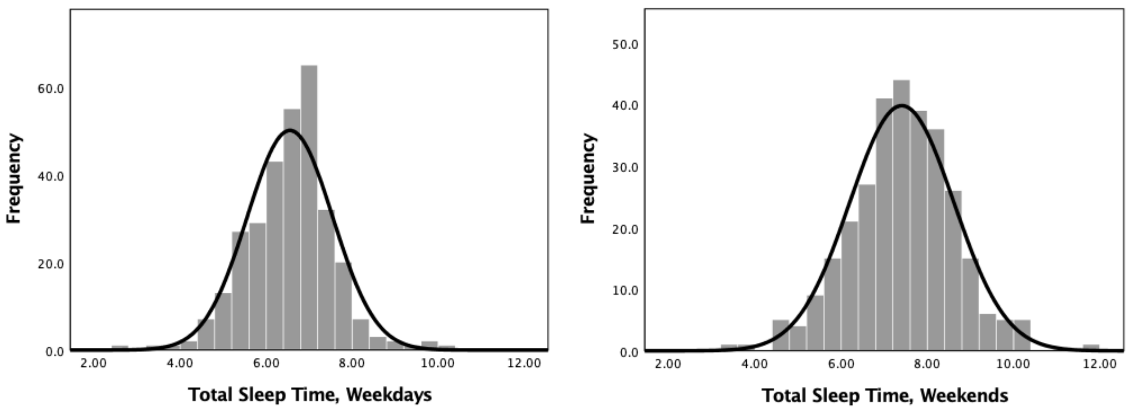

Figure 2. Total sleep time (hours) on weekdays and on weekends.

The midpoint of sleep varied substantially between individuals. On weekdays, the earliest midpoint was at 01:45 AM and the latest at 09:34 AM, with the average at 04:22 (*SD*=1:17) AM. On weekends, the earliest midpoint was at 01:47 AM and the latest at 12:23 PM (*M*=5:58, *SD*=1:34). The difference between the midpoint on weekdays and weekends (social jetlag) was on average 1.59 hours (*SD*=1.23). In other words, the average sleep midpoint occurred 1.59 hours later on weekends than on weekdays. For some individuals, the midpoint occurred later on weekdays than weekends, with the maximum difference at 2.24 hours. The correlations between sleep variables varied from -.01 (*p*=.88) (sleep latency on weekend and sleep duration on weekend) to .62 (p>.001) (irregularity of midpoint and midpoint on weekends) (Table 3a).

Table 3 a Correlations between sleep variables

	Sleep duration weekdays	Sleep duration weekends	Social jetlag	WASO, weekdays	WASO, weekends	Sleep latency, weekdays (log)	Sleep latency, weekends (log)	Midpoint, weekdays
Sleep duration weekends	.33**							
Social jetlag	-.25**	.12*						
WASO, weekdays	.17**	-.03	-.08					
WASO, weekends	-.09	-.21**	.01	.61**				
Sleep latency, weekdays(log)	-.06	.01	.08	.23**	.25**			
Sleep latency weekends (log)	-.02	-.01	.05	.22**	.22**	.52**		
Midpoint weekdays	-.05	-.11	-.21**	.10	.05	.18**	.11	
Midpoint, weekends	-.24**	.01	.62**	.02	.05	.18**	.12*	.64**

*** p < .001, ** p < .01, * p < .05, log=logarithmically transformed, WASO=Wake after sleep onset, Social jetlag=the discrepancy between a timing of the sleep phase on weekdays and weekends.

Description of the emotion regulation strategies

Regarding emotion regulation strategies, participants mostly reported using rumination (*M*=13.55, *SD*=3.42), acceptance (*M*=13.27, *SD*=3.27), reflection (*M*=13.03, *SD*=3.41), putting into perspective (*M*=12.59, *SD*=3.71), and positive reappraisal (*M*=12.21, *SD*=3.98). The least used strategies were blaming others (*M*=7.48, *SD*=2.65) and catastrophizing (*M*=7.72, *SD*=3.16). Means, standard deviations, and minimum and maximum values are presented in table 4.

Table 4 Descriptive statistics of the cognitive emotion regulation strategies

	Mean (SD)	N (%)	min.	max.
Self-Blame (CERQ)	11.31 (3.73)	337	4	20
Blaming others (CERQ)	7.48 (2.65)	337	4	20
Acceptance (CERQ)	13.27 (3.27)	337	5	20
Refocusing on planning (CERQ)	11.27 (3.24)	337	4	20
Positive refocusing (CERQ)	10.08 (3.68)	337	4	20
Rumination				
(CERQ)	11.34 (3.63)	337	4	20
(RRQ)	13.55 (3.42)	338	4	20
Positive reappraisal (CERQ)	12.21 (3.98)	337	4	20
Putting into perspective (CERQ)	12.59 (3.71)	337	4	20
Catastrophizing (CERQ)	7.72 (3.16)	337	4	18
Reflection (RRQ)	13.03 (3.41)	337	4.33	20

The correlations between emotion regulation strategies varied from .00 (p>.99, refocusing on planning and self-blame) to .64 (p >.01, refocusing on planning and positive reappraisal) (Table 3b). The correlations between the sleep variables and emotion regulation strategies varied from .00 to -.15 (Table 3c in appendix).

Relationship between emotion regulation strategies and sleep variables

Separate regression analyses were performed between each distinct emotion regulation strategy and each sleep variable, as well as between the two composite variables (adaptive and maladaptive strategies) and each sleep variable.

Regarding the distinct strategies, table 5 in appendix displays the standardized regression coefficients, t-values, R^2, R^2 change and F-values. With age and gender adjusted, rumination (CERQ) had a negative association with sleep latency on weekdays (β=-.13, t=-2.32, p=.02). Interestingly, rumination of RRQ had a significant negative connection to sleep latency on

Table 3b Correlations between emotion regulation strategies.

	Self blame (CERQ)	Blamig others (CERQ) (log)	Accep-tance (CERQ)	Refo-cusing on planning (CERQ)	Positive refocu-sing (CERQ)	Rumina-tion (CERQ)	Positive reapprai-sal (CERQ)	Putting into perspec-tive (CERQ)	Catastro phizing (CERQ) (log)	Rumina-tion (RRQ)
Blamig others (CERQ) (log)	.05									
Acceptance (CERQ)	.18**	.10								
Refocusing on planning (CERQ)	.00	.24**	.32**							
Positive refocusing (CERQ)	-.16**	.11	.11*	.43**						
Rumination (CERQ)	.45**	.17**	.33**	.27**	.01					
Positive reappraisal (CERQ)	-.11*	.15**	.43**	.64**	.37**	.22**				
Putting into perspective (CERQ)	.01	.13*	.41**	.50**	.35**	.18**	.63**			
Catastro-phizing (CERQ)(log)	.41**	.30*	.00	.01	-.09	.39**	-.13*	-.14**		
Rumination (RRQ)	.57**	.08	.03	-.22**	-.30**	.43**	-.29**	-.15**	.49**	
Reflection (RRQ)	.17**	.10	.24**	.21**	.03	.44**	.31**	.21**	.06	.15**

*** p < .001, ** p < .01, * p < .05, log=logarithmically transformed.

weekends, although the whole model remained insignificant (β=-0.13, *t*=-2.09, *p*=.04). Furthermore, wake after sleep onset on weekends was shorter for those using more rumination (RRQ) (β=-0.13, *t*=2.26, *p*=.03) and self-blame (β=-.15, *t*=-2.64, *p*=.01), even though, again, the whole model again remained insignificant.

The midpoint of sleep on weekdays was earlier for those relying more on positive reappraisal (β=.19, *t*=-3.33, *p*<.01), positive refocusing (β=-.14, *t*=-2.40, *p*=.02) and refocus on planning (β=-.11, *t=-1.99*, *p*=.05) and less on rumination (RRQ) (β=.12, *t*=2.06, *p*=.04) and catastrophizing (β=.11, *t*=1.99, *p*=.05). Only positive reappraisal had a significant effect on sleep midpoint on weekends (β=-.15, *t*=-2.68, *p*=.01). All other associations remained non-significant.

The results of regression analyses between two composite variables, adaptive strategies and maladaptive strategies, and sleep are shown in table 6. After adjusting for age and gender, adaptive strategies were connected to earlier sleep midpoint on weekdays (β=0.13, *t*=-2.39, *p*=.02). Interestingly, maladaptive strategies were associated with shorter sleep latency on weekends

(β=-0.13, t=-2.17, p=.03) and shorter WASO on weekends (β=-0.16, t=-2.63, p=.01), albeit the models as a whole remained insignificant. All other associations remained non-significant.

Table 6. Linear regression analyses with adaptive or maladaptive emotion regulation as the independent variable and sleep variables as dependent variables. Age and sex have been adjusted for.

Variable	Sleep variable	β	t	R [1)]	R^2 [1)]	F [1)]
Adaptive emotion regulation						
	Sleep duration, weekdays	.01	.10	.14	.02	1.93
	Sleep duration, weekends	-.02	-.43	.24	.06	6.26***
	WASO, weekdays	.02	.30	.03	.00	0.08
	WASO, weekends	-.03	-.58	.06	.00	0.33
	Sleep latency, weekdays (log)	.01	.13	.11	.01	1.20
	Sleep latency, weekends (log)	.01	.09	.04	.00	0.12
	Midpoint, weekdays	**-.13**	**-2.39***	**.21**	**.04**	**4.65****
	Midpoint, weekends	-.11	-.15+	.21	.04	4.59**
	Social jetlag	-.01	-.09	.15	.02	2.15+
Maladaptive emotion regulation						
	Sleep duration, weekdays	-.04	-.66	.14	.02	2.07
	Sleep duration, weekends	-.10	-1.80+	.26	.07	7.34***
	WASO, weekdays	-.05	-0.88	.06	.00	0.31
	WASO, weekends	**-.16**	**-2.63****	**.16**	**.03**	**2.53+**
	Sleep latency, weekdays (log)	-.10	-1.75+	.15	.02	2.23+
	Sleep latency, weekends (log)	**-.13**	**-2.17***	**.13**	**.02**	**1.69**
	Midpoint, weekdays	.03	0.57	.16	.03	2.80*
	Midpoint, weekends	-.02	-.40	.18	.03	3.34**
	Social jetlag	-.09	-1.53	.17	.03	2.94*

1) The predictors in the model are age, sex, and positive/negative emotion regulation strategy. WASO=Wake after sleep onset
*** p < .001, ** p < .01, * p < .05, + p < .10

Discussion

The present study examined the associations between cognitive emotion regulation strategies and sleep in adolescence using objective measurement for sleep. Ten distinct cognitive emotion regulation strategies and their effect on sleep duration, sleep quality, regularity, and the timing of sleep phase were explored. Finally, a possible link between adaptive/maladaptive strategies and sleep was investigated.

The average sleep duration was considerably shorter than the recommendation of the U.S. National Sleep Foundation for adolescents (Hirshkowitz et al., 2015). Almost 95 % of adolescents in the present study slept less than the recommended eight to ten hours per night on weekdays, and almost

70 % slept less than that on weekends. These results are congruent with previous studies (Gradisar et al., 2011; Ojio et al., 2016; Winsler et al., 2015) The average sleep duration (6.55 h) was considerably shorter than a recently reported worldwide average in a large sample of 16-30-year-olds, 7.74 hours of sleep on weekdays (Kuula et al., 2019). The average on weekends in the present study (7.41 h) was in line with the worldwide average of sleep time on weekends: 7.82 h. It is clear that consistent with the worldwide trend, Finnish adolescents are seriously sleep deprived, especially during the school week.

In general, participants in the present study reported using adaptive strategies more than maladaptive strategies. However, the strategy used most often was rumination, followed by acceptance, reflection, putting into perspective, and positive reappraisal. The least used strategies were catastrophizing and blaming others. These results are consistent with previous studies (Garnefski et al., 2001; Trapnell & Cambell, 1999), with the exception of rumination. Regarding rumination, it is possible that the over-representation of girls in the present study had an effect on the results, as rumination as a strategy has been strongly linked to gender (Nolen-Hoeksema & Aldeo, 2011).

Emotion regulation and the duration and quality of sleep

Contrary to our first hypothesis, sleep duration was not influenced by any emotion regulation strategies. The overall use of adaptive or maladaptive strategies did not affect sleep duration either on weekdays or weekends. Sleep latency was partly influenced by rumination on both weekdays and weekends. The greater use of this strategy was linked to a shorter sleep latency on weekdays (when measured by CERQ) and weekends (when measured by RRQ), contrary to our first hypothesis. Surprisingly, maladaptive strategies, and in particular rumination and self-blame also led to a shorter time spent awake at night on weekends. However, all result regarding rumination were inconsistent: only one of two rumination scales produced significant results. Our first hypothesis did not receive support in this respect either. These partly inconsistent results are in contrary with previous studies, where the connection between emotion regulation strategies and subjectively measured sleep duration and quality has been found (Amaral et al., 2018; Heath et al., 2018; Hiller et al., 2014; Hoag et al., 2016; Palmer et al., 2018; Vannikov-Lugassi et al., 2018).

Unexpectedly, the use of maladaptive strategies predicted better sleep quality on weekends. Those who relied more on these strategies, and on rumination and self-blame in particular, fell asleep faster and remained faster asleep. One possibility is that those who rely more on maladaptive strategies also tend to have a later timing of sleep phase on weekdays, and as a consequence accumulate sleep debt during the week. Sleep debt caused by a late sleep midpoint becomes apparent in nonREM sleep deprivation, which is less resistant to manipulations of previous sleep time than REM-sleep (of the late part of the night) (Borbery, 1982; Borbery et al., 2016; Lee, Swanson & de la Iglesia, 2009). NonREM-sleep deprivation may lead to faster falling asleep on weekends and better maintenance of sleep during the night. It is also possible that those who tend to use more maladaptive strategies also use more alcohol, which in turn may be related to a short sleep latency. However, further research on this topic is needed.

Emotion regulation and the timing and regularity of sleep

More in line with previous research, the present study also found a link between emotion regulation strategies and the timing of the sleep phase. The midpoint of sleep on weekdays was influenced both by the overall use of adaptive strategies and by five distinct strategies: positive refocusing, refocusing on planning, positive reappraisal, rumination, and catastrophizing. The more adaptive strategies, particularly positive refocusing, refocusing on planning, and positive reappraisal, were used, the earlier the sleep midpoint occurred. Furthermore, the more rumination and catastrophizing were used, the later the sleep midpoint occurred. However, this result was also inconsistently observed, as the two scales measuring rumination produced differing results. On weekends, the sleep midpoint was only associated with positive reappraisal, but no link to either adaptive or maladaptive strategies was found. The irregularity of the sleep midpoint was not affected by the ten distinct or two overall strategies. In conclusion, our second hypothesis received only moderate support: the sleep midpoint on weekdays was affected by the adaptive (but not maladaptive) emotion regulation strategies, and by certain distinct adaptive and maladaptive strategies. On weekends, only one of the adaptive strategies was associated with it, and none of the maladaptive strategies. Regularity, however, was not associated with any of the strategies.

The association between cognitive emotion regulation strategies and the timing of sleep phase is in line with previous studies. A later timing of sleep phase (eveningness) has been linked to maladaptive emotion regulation strategies and an earlier timing of sleep (morningness) to adaptive strategies (Watts & Norbury, 2017). More precisely, cognitive reappraisal has been linked to a self-rated early chronotype. In the present study, the use of (overall and some distinct) adaptive strategies was associated with an earlier chronotype on schooldays, whereas maladaptive (distinct) strategies were linked to a later chronotype. However, this result was not observed on weekends. It is possible that on weekends adolescents who tend to use more adaptive strategies experience less pressure about school, and therefore stay awake for social reasons for as long as those using less adaptive strategies.

The content and quality of the emotion regulation measures

Regarding rumination, the two scales used yielded inconsistent results. These inconsistencies may have arisen from dissimilar emphases of the scales. While the items of CERQ focus on thoughts and inner feelings in a relatively neutral way (e.g. I want to understand why I feel the way I do about what I have experienced), the items of RRQ elaborate on the maladaptive and unwillingly repetitive ways of thinking about the past (e.g. I spend a great deal of time thinking back over my embarrassing or disappointing moments). Hence, neutral focusing on one's own thoughts (rumination/CERQ) did not predict a later sleep midpoint on weekdays, while repetitive focusing on past negative experiences (rumination/RRQ) did. Moreover, neutral focusing on one's thoughts/rumination (rumination/CERQ) predicted a shorter sleep latency on weekdays, but maladaptive focusing on the past (rumination/RRQ) did not. Unexpectedly, maladaptive and unwillingly repetitive rumination (Rumination/RRQ) predicted better sleep quality on weekends, which is difficult to explain.

In previous studies, catastrophizing has been linked to longer sleep latency (Hiller et al., 2014) and sleep onset difficulties (Heath et al., 2018). In the present study, such a connection was not found. However, there are some notable differences between these studies. Firstly, in the present study, the focus of catastrophizing was on overall negative experiences and life situations, e.g. "I keep thinking about how terrible it is what I have experienced", and therefore catastrophizing was not necessarily thematically or temporally connected to sleep. In the studies by Hiller et al. (2014) and Heath et al. (2018), the focus was on concerns regarding not being able to fall asleep. Secondly, the latency and sleep onset difficulties were based on sleep diaries, in other words, adolescents' subjective estimations of sleep latency. When observed objectively using actigraphy, the same result was no longer obtained (Heath et al., 2018). It is possible that those who catastrophize also tend to overestimate the sleep latency. In fact, sleep-related cognitions (e.g. worrying about the consequences of not being able to sleep) have been linked to overestimations of sleep latency (Heath et al., 2018). On the other hand, in actigraphy sleep is inferred from the lack of body movements, and as a result, total sleep time may be an overestimation (Martin & Hakim, 2011), particularly when studying those who have trouble falling asleep.

Objective measurement of sleep

The inconsistencies with previous studies may also stem from differences in the measurement of sleep. Unlike the present study, the majority of previous research has relied on subjective self-reports of sleep. It has been suggested that objective and subjective estimations of sleep do not measure the same construct (Franzen, Siegle, & Buysse, 2008). In the study by Palmer and colleagues (2018), adolescents' sleep problems were related to lower usage of problem-solving and higher usage of suppression, rumination, and avoidance. Surprisingly, acceptance was also related to sleep problems, but reappraisal was not. However, sleep was assessed subjectively, using questions on difficulties initiating or maintaining sleep and early morning awakenings. In the present study, emotion regulation strategies (rumination, positive reappraisal, refocus on planning, catastrophizing, and positive refocusing) were associated with the objectively measured sleep midpoint, but not with any other sleep outcomes, while acceptance was not linked to sleep at all. Contrary to the study by Palmer et al., (2018), positive reappraisal was associated with sleep, more precisely with the sleep midpoint on weekdays. Furthermore, in the study by Reddy et al., (2017), reappraisal was resistant to partial sleep restriction in adolescents. In light of the present results, a tendency to use reappraisal may have a positive, or even protective, influence on the timing of the sleep phase.

In the study by Amaral et al. (2018), cognitive emotion regulation strategies, such as rumination, self-blaming, catastrophizing, and acceptance, were associated with self-reported sleep problems. These results received some support in the present study regarding the link between the sleep midpoint on weekends and rumination and catastrophizing. Furthermore, Vannikov-Lugassi et al. (2018) found a link between repetitive rumination and poor subjectively estimated sleep. Also, in a study where emotion regulation was found to mediate the association between positive/negative affect and sleep quality among low-income women, sleep was assessed with a self-rated questionnaire (Hoag et al., 2017).

Emotions, emotion regulation and sleep

It has previously been suggested that pre-sleep negative emotions are likely to affect subsequent sleep, causing longer sleep onset latency, shorter sleep duration, and poorer sleep efficiency (Vandekerckhove et al., 2011). Watling and colleagues (2017) proposed that emotion regulation plays a key role between accumulating emotions and mood, which in turn leads to poor sleep. As proposed in the model, sleep and mood are likely to have bidirectional association, called sleep-mood circle, whereby they are mutually reinforcing each other (Watling et al., 2017). Day-time emotions and stress affect the following sleep, and insufficient sleep at night alters the mood of the following day. Emotion regulation is proposed to act as a moderator between emotions and mood, either strengthening of weakening the influence on sleep. If adaptive and sufficient rather than maladaptive strategies are used, the following sleep is not disturbed and the mood of the next day is not affected. In the present study, the characteristic emotion regulation strategies did not, at least directly, affect subsequent sleep quality or quantity, but they did have an influence on the timing of the sleep phase. Two maladaptive strategies, rumination and catastrophizing, were directly linked to a later timing of sleep on weekdays when early waking is required. The overall use of positive strategies was similarly linked to an earlier midpoint of sleep on weekdays. In light of these results, emotion regulation strategies may be linked to sleep via the timing of the sleep phase.

However, the assumption regarding adaptive and maladaptive strategies may be premature. As Garnefski et al. (2001) have pointed out, different strategies may be useful in different situations and with different stressors. A strategy typically assumed adaptive may work best in some life situations, whereas in others it may be maladaptive. From this, it follows that it is not the use of the specific strategies, but the situation- and emotion-dependent sufficient regulation of emotion, that may lead to better quality or quantity of subsequent sleep.

Strengths and limitations of the current study

A major strength of the present study was that sleep was measured objectively by actigraphy. Furthermore, it was measured in the natural environment of adolescents, increasing the ecological validity of the results. However, the use of actigraphy devices was not supervised, and inappropriate use may have affected the reliability of the findings. Furthermore, the examination of cognitive emotion regulation strategies was based on self-reports, which may not always be a valid method for assessing the actual use of cognitive strategies (Todd, Tennen, Carney, Armeli & Affleck, 2004).

Due to the cross-sectional design, the present study cannot demonstrate true causality. Although emotion regulation strategies are considered relatively stable, more trait- than state-like properties, and emotion regulation could therefore be considered the cause and the sleep variables the outcome, the direction of causality requires further research. It is possible that the timing of sleep phase affects the strategies used, possibly via the effect sleep has on cognitive resources the following day. It is also possible that the strategies used are moderating (strengthening or diminishing) the effects of emotion on sleep.

Future research

Due to confounding terminology and confusion of constructs in previous research (Watling et al., 2017), it is necessary to investigate emotion regulation as separate from emotion. In addition to the present study, only few others have studied the role that emotion regulation plays in sleep, and instead of objective measures of sleep most of these studies have used self-evaluations. Future studies would benefit from designs that allow both constructs, emotion and emotion regulation, to be measured separately in relation to sleep. Also, when exploring the cognitive strategies of emotion regulation, it is essential to measure sleep objectively, keeping in mind that the differences in thinking tendencies also affect how accurately sleep can be evaluated. Future studies may also benefit from examining the possible confounding role of depression and other mental health problems, that have a connection to sleep as well as to emotion regulation strategies.

Conclusion

While the extant empirical evidence supports the close connection between sleep and emotions, the precise role of cognitive emotion regulation strategies remains elusive. Sufficient and adaptive emotion regulation is likely necessary for good nighttime sleep, however, the goodness of specific strategies may depend on complex person-, situation- or emotion-related matters. Categorizing specific strategies as adaptive or maladaptive may be a simplification and requires more research.

However, adolescents worldwide clearly tend to sleep too little. Furthermore, the results obtained in the present study suggest that the usage of various emotion regulation strategies is connected to the timing of nighttime sleep, particularly on weekdays. However, the link between emotion regulation strategies and duration, quality and regularity of sleep remains elusive. Both sleep deprivation and an extremely late chronotype may have a noteworthy part to play in the onset and maintenance of adolescents' well-being and (mental) health problems. Clinical applications designed to alleviate sleep problems may benefit from teaching sufficient and adaptive cognitive emotion regulation strategies to adolescents who suffer from sleep problems related to an extremely late chronotype.

References

Aldao, A., Nolen-Hoeksema, S. & Schweizer, S. (2010). Emotion-regulation strategies across psychopathology: A meta-analytic review. *Clinical Psychology Review* 30, 217–237.

Amaral, A.P., Soares, M.J., Pinto, A.M., Pereira, A.T., Madeira, N., Bos, S.C., Marques, M., Roque, C & Macedo, A. (2018). Sleep difficulties in college students: The role of stress, affect and cognitive processes. *Psychiatry Research*, 260, 331-337.

Anderson, C.A., Miller R.S., Riger, A.L., Dill, J.C. & Sedikides, C. (1994). Behavioral and Characterological Attributional Styles as Predictors of Depression and Loneliness: Review, Refinement, and Test. *Journal of Personality and Social Psychology*, 66, 3, 549-558.

Aschoff, J. (1993). On the Relationship between Motor Activity and the Sleep-Wake Cycle in Humans during Temporal Isolation. *Journal of Biological Rhythms*, 8, 1, 33-46.

Baglioni, C., Spiegelhalder, K., Lombardo, C. & Riemann, D. (2010) Sleep and emotions: A focus on insomnia. *Sleep Medicine Reviews,* 14, 227–238.

Borbely, A.A. (1982). A Two Process Model of Sleep Regulation. *Human Neurobiology*, 1, 195-204.

Borbely, A.A., Daan, S., Wirz-Justice, A. & Deboert, T. (2016). The two-process model of sleep regulation: a reappraisal. *Journal of Sleep Research*, 25, 131–143.

Brand, S., Kirov, R., Kalak, N., Gerber, M., Schmidt, N.B., Lemola, S., Correll, C.U. & Holsboer-Trachsler, E. (2016). Poor Sleep Is Related to Lower Emotional Competence Among Adolescents. *Behavioral Sleep Medicine*, 14(6), 602-614.

Carscadon, M.A. (2011). Sleep in Adolescents: The Perfect Storm. *Pediatric Clinics of North America*, 58(3), 637–647.

Carver, C.S., Scheier, M.F. & Weintraub, J.K. (1989). Assessing Coping strategies: a theoretically based approach. *Journal of Personality and Social Psychology*, 56, 267-283.

Carscadon, M.A., Acebo, C. & Jenny, O.G. (2004). Regulation of Adolescent Sleep – Implications for behaviour. *Annals of the New York Academy of Sciences*, 1021, 176-291.

Chaput, J-P., Gray, C.E., Poitras, V.J., Carson, V., Gruber, R., Olds, T., Weiss, S.K., Gorber, S.C., Kho M.E., Sampson M., Belanger K, Eryuzlu S, Callender L & Tremblay M.S. (2016). Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism*, 41, 266-82.

Deboer, T. (2018). Sleep homeostasis and the circadian clock: Do the circadian pacemaker and the sleep homeostat influence each other's functioning? *Neurobiology of Sleep and Circadian Rhythms,* 5, 68–77.

Del Rio Joao, K.A., de Jesus, S.N., Carmo, C. & Pinto, P. (2018). Sleep quality components and mental health: Study with a non-clinical population. *Psychiatry Research*, 269, 244-250.

Franzen, P. L., Siegle, G. J., & Buysse, D. J. (2008). Relationships between affect, vigilance, and sleepiness following sleep deprivation. *Journal of Sleep Research*, 17(1), 34–41.

Garnefski, N., Kraaij, V. & Spinhoven, P. (2001). Negative life events, cognitive emotion regulation and emotional problems. *Personality and individual Differences*, 30, 1311-1327.

Gobin, C.M., Banks, J.B., Fins, A.I. & Tartar, J.L. (2015). Poor sleep quality is associated with a negative cognitive bias and decreased sustained attention. *Journal of Sleep Research,* 24, 535–542.

Goldstain, A. & Walker, M.P. (2014). The Role of Sleep in Emotional Brain Function. *Annual Review of Clinical Psychology*, 10, 679–708.

Gould, C.E., Beaudreau, S.A., O'Hara, R., Edelstein, B.A. (2016). Perceived anxiety control is associated with sleep disturbance in young and older adults. *Aging & Mental Health*, 20(8), 856-860.

Guadagni, V., Burles, F., Valera, S., Hardwicke-Brown, E., Ferrara, M., Campbell, T & Iaria, G. (2017). The relationship between quality of sleep and emotional empathy. *Journal of Psychophysiology*, 31(4), 158-166.

Gradisar, M., Gardner, G. & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. *Sleep Medicine*, 12, 110–118.

Green, J., Pollac, C.P. & Smith, G.P. (1987). Meal Size and Intermeal Interval in Human Subjects in Time Isolation. *Psychology and Behavior*, 41, 141-147.

Gross, J.J. (2014). Emotion regulation: conceptual and empirical foundations. *Handbook of Emotion Regulation, 2nd Edition*. New York: Guilford; 2014.

Gruber, R. & Cassoff, J. (2014). The Interplay Between Sleep and Emotion Regulation: Conceptual Framework Empirical Evidence and Future Directions. *Current Psychiatry Reports*, 16, 500.

Hidalgo, M. P., Caumo, W., Posser, M., Coccaro, S. B., Camozzato, A. L. & Chaves, M. L. (2009). Relationship between depressive mood and chronotype in healthy subjects. *Psychiatry and Clinical Neurosciences*, 63, 283–290.

Hiller, R.M., Lovato, N., Gradisar, M., Oliver, M & Slater, A. (2014). Trying to fall asleep while catastrophising: what sleep-disordered adolescents think and feel. *Sleep Medicine,* 15, 96–103.

Hirshkowitz, M., Whiton, K., Albert, S.M., et al. (2015). National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health*, 1(1), 40-43.

Heath, M., Johnston, A., Dohnt, H., Short, M. & Gradisar, M. (2018). The role of pre-sleep cognitions in adolescent sleep-onset problems. *Sleep Medicine,* 46, 117-121.

Hoag, J.R., Tennen, H., Stevens, R.G., Coman, E. & Wu, H. (2016). Affect, emotion dysregulation and sleep quality among low-income women. *Sleep Health*, 2(4), 283-288.

Hummer, D.L. & Lee, T.M. (2016). Daily timing of the adolescent sleep phase: Insights from a cross-species comparison. *Neuroscience & Biobehavioral Reviews*, 70, 171-181.

Jenni, O.G., Achermann, P. & Carskadon, M.A. (2005). Homeostatic Sleep Regulation in Adolescents. *Sleep*, 28, 11.

Kuula, L., Gradisar, M., Martinmäki K., Richardson, C., Bonnar, D., Bartel, K., Lang, C., Leinonen, L & Pesonen, A.K. (2019). Using big data to explore worldwide trends in objective sleep in the transition to adulthood. *Sleep Medicine* 62, 69-76.

Lazarus, R.S. & Folkman S. (1984). Stress, Appraisal, And Coping. Springer.

Lee, M.L., Swanson, B.E. & de la Iglesia, H.O. (2009). Circadian Timing of REM Sleep Is Coupled to an Oscillator within the Dorsomedial Suprachiasmatic Nucleus. *Current Biology* 19, 848–852.

Lund, H.G., Reider, B.D.,Whiting, A.B. & Prichard, J.R. (2010). Sleep Patterns and Predictors of Disturbed Sleep in a Large Population of College Students. *Journal of Adolescent Health* 46, 124–132.

Marino, M., Li, Y., Rueschman, M.N., Winkelman, J.W., Ellenbogen, J.M., Solet, J.M., Dulin, H., Berkman, L.F. & Buxton, O.M. (2013). Measuring Sleep: Accuracy, Sensitivity, and Specificity of Wrist Actigraphy Compared to Polysomnography. *Sleep*, 36, 11.

Martin, J.F. & Hakim, A.D. (2011). Wrist Actigraphy. *Chest*, 39/6.

Martin, R.C & Dahlen, E.R. (2005). Cognitive emotion regulation in the prediction of depression, anxiety, stress, and anger. *Personality and Individual Differences,* 39, 1249–1260.

McMakin, D.L., Dahl, R.E., Buysse, D.J., Cousins, J.C., Forbes, E.E., Silk, J.S., Siegle, G.J., Franzen, P.L. (2016). The impact of experimental sleep restriction on affective functioning in social and nonsocial contexts among adolescents. *Journal of Child Psychology and Psychiatry*, 57(9), 1027-37.

Nolen-Hoeksema, S.& Aldao, A. (2011). Gender and age differences in emotion regulation strategies and their relationshipto depressive symptoms. *Personality and Individual Differences*, 51, 704–708.

Nolen-Hoeksema, S., Parker L.E. & Larson, J. (1994). Ruminative Coping with Depressed Mood following Loss. *Journal of Personality and Social Psychology*, 67, 1, 92-104.

Ojio, Y., Nishida, A., Shimodera, S., Togo, F. & Sasaki, T. (2016). Sleep duration associated with the lowest risk of depression/anxiety in adolescents. *Journal of Sleep and Sleep Disorders Research,* 39(8), 1555-1562.

Palmer C.A. & Alfano C.A. (2017). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews*, 31, 6-16.

Palmer C.A., Oosterhoff B., Bower J.L., Kaplow J.B. & Alfano C.A. (2018). Associations among adolescent sleep problems, emotion regulation, and affective disorders: Findings from a nationally representative sample. *Journal of Psychiatric Research*, 96, 1-8.

Reddy, R., Palmer, C.A., Jackson, C., Farris, S.G. & Alfano, C.A. (2017). Impact of sleep restriction versus idealized sleep on emotionalexperience, reactivity and regulation in healthy adolescents. *Journal of Sleep Research*, 26, 516–525.

Del Rio João, K.A., Saul Neves de Jesus, S.N., Carmo, C., & Pinto, P. (2018). Sleep quality components and mental health: Study with a non-clinical population. *Psychiatry Research*, 269, 244–250.

Roenneberg, T. & Merrow, M. (2007). Entrainment of the Human Circadian Clock. *Cold Spring Harbor Symposia on Quantitative Biology*, LXXII, 293-299.

Roenneberg, T., Pilz, L.K., Zerbini, G. & Winnebeck, E.C. (2019). Chronotype and Social Jetlag: A (Self-) Critical Review. *Biology*, 8, 54.

Roeser, K., Meule, A., Schwerdtle, B., Kubler, A. and Schlarb, A. A. (2012). Subjective sleep quality exclusively mediates the relationship between morningness–eveningness preference and self-perceived stress response. *Chronobiology International*, 29, 955–960.

Simor, P., Krietsch, K.N., Koteles, F. & McCrae, C.S. (215). Day-to-day variation of subjective sleep quality and emotional states among healthy university students-A 1-week prospective study. *International Journal of Behavioral Medicine*, 22(5), 625-634.

Stolarski, M., Jankowski, K.S., Matthews, G. & Kawalerczyk, J. (2016). Wise "birds" follow their clock: The role of emotional intelligence and morningness-eveningness in diurnal regulation of mood. *Chronobiology International*, 33(1), 51-63.

Sullivan, K. & Ordiah, C. (2018). Association of mildly insufficient sleep with symptoms of anxiety and depression. *Neurology, Psychiatry and Brain Research*, 30, 1-4.

Sun, J., Chen, M., Cai, W., Wang, Z., Wu, S., Sun, X. & Liu, H. (2019). Chronotype: Implications for sleep quality in medical students. *Chronobiology International*, 36(8), 1115-1123.

Tennen, H. & Affleck, G. (1990). Blaming others for threatening events. *Psychological Bulletin*, 108, 2, 209-232.

Thompson, R.A. (1995). Emotion Regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development*, 59, 2/3, The Development of Emotion Regulation. Biological and Behavioral Considerations, 25-52.

Todd, M., Tennen, H., Carney, M.A., Armeli, S. & Affleck, G. (2004). Do we know how we cope? Relating daily coping reports to global and time-limited retrospective assessments. *Journal of Personality and Social Psychology,* 86(2), 310–319.

Trapnell, P.D.& Campbell, J.D. (1999). Private Self-Consciousness and the Five-Factor Model of Personality: Distinguising Rumination From Reflection. *Journal of Personality and Social Psychology*, 76, 2, 284-304.

Van den Berg, J.F., Kivelä, L. & Antypa, N. (2018). Chronotype and depressive symptoms in students: An investigation of possible mechanisms. *Chronobiology International*, 35(9), 1248-1261.

Vandekerckhove, M., Weiss, R., Schotte, C., Exadaktylos, V., Haex, B., Verbraecken, J. & Cluydts, R. (2011). The role of presleep negative emotion in sleep physiology. *Psychophysiology* 48, 1738–1744.

Vandekerckhove, M. & Wang, Y. (2017). Emotion, Emotion Regulation and Sleep: An Intimate Relationship. *AIMS Neuroscience*, 5 (1), 1–22.

Vannikov-Lugassi, M. & Soffer-Dudek, N. (2018). Rumination and dissociation: The mediating role of poor sleep quality and presleep cognitions. *Psychology of Consciousness: Theory, Research, and Practice*, 5(2), 185-211.

Watts, A.L. & Norbury, R. (2017). Reduced Effective Emotion Regulation in Night Owls. *Journal of Biological Rhythms,* 32(4), 369-375.

Watling, J., Pawlik, B., Scott, K., Booth, S. & Short, M.A. (2017). Sleep Loss and Affective Functioning: More Than Just Mood. *Behavioral Sleep Medicine*, 15(5), 394-409.

Winsler, A., Deutsch, A., Vorona, R.D., Payne, P.A. & Szklo-Coxe, M. (2015). Sleepless in Fairfax: The difference one more hour of sleep can make for teen hopelessness, suicidal ideation, and substance use. *Journal of Youth and Adolescence*, 44(2), 362-378.

Appendix

Table 3 c

Table 3 c Correlations between sleep variables and emotion regulation strategies

	Duration weekdays	Duration weekends	Irregularity	WASO, weekdays	WASO, weekends	Latency, weekdays	Latency weekends	Midpoint weekdays	Midpoint, weekends
Self blame (CERQ)	-.03	-.03	-.07	-.09	**-.15****	**-.05**	**-.08**	-.05	-.08
Blamig others (CERQ)	-.07	**-.11**	-.08	-.07	-.06	.07	.02	.10	.01
Acceptance (CERQ)	-.02	-.01	.00	-.02	-.07	-.07	-.04	-.09	-.06
Refocusing on planning (CERQ)	.01	.05	.01	.03	.05	.05	.07	-.11	-.08
Positive refocusing (CERQ)	-.02	-.01	-.01	.04	.01	.04	.04	**-.14***	-.11
Rumination (CERQ)	.00	-.06	-.04	-.02	-.10	**-.15****	**-.11**	-.07	-.06
Positive reappraisal (CERQ)	.07	-.04	.00	.02	-.03	.00	-.01	**-.18****	**-.14***
Putting into perspective (CERQ)	-.05	-.02	.02	-.04	-.04	.03	-.04	-.10	-.08
Catastrophizing (CERQ)	.03	-.00	-.05	.04	-.08	.08	-.01	.10	.04
Rumination (RRQ)	.02	-.00	-.10	-.04	**-.13***	**-.10**	**-.12***	.07	-.00
Reflection (RRQ)	.05	-.04	-.02	.03	-.06	-.04	-.01	.03	.02

** $p < .01$, * $p < .05$, WASO=Wake after sleep onset

Table 5

Table 5. Linear regression analysis with cognitive emotion regulation strategies as the independent variable and sleep variables as dependent variables. Age and sex have been adjusted for.

Variable	β	t	R^2	R^2 change	F
Sleep duration, weekdays					
Step 1			.02		3.01
Gender	-0.14	-2.44			
Age	0.03	0.52			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	0.06	-0.99	.02	.00	2.33
Blaming others	-0.06	-1.01	.02	.00	2.35
Acceptance	-0.02	-0.37	.02	.00	2.05
Refocus on planning	0.01	0.20	.02	.00	2.01
Positive refocusing	0.03	-0.46	.02	.00	2.07
Rumination	-0.03	-0.45	.02	.00	2.07
Positive reappraisal	0.07	1.27	.02	.01	2.55
Putting into perspective	-0.06	-1.02	.02	.00	2.35
Catastrophizing	0.02	0.32	.02	.00	2.03
RRQ					
Rumination	-0.02	-0.25	.02	.00	1.95
Reflection	0.04	0.65	.02	.00	1.93

Sleep duration, weekends					
Step 1			.06		9.20***
Gender	-0.24	-4.29***			
Age	0.04	0.64			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.07	-1.26	.06	.01	6.67***
Blaming others	-0.09	-1.66	.07	.01	7.09***
Acceptance	-0.01	-0.14	.06	.00	6.12***
Refocus on planning	0.06	1.03	.06	.00	6.48***
Positive refocusing	-0.02	-0.31	.06	.00	6.14***
Rumination	-0.11	-1.90	.07	.01	7.39***
Positive reaapraisal	-0.03	-0.46	.06	.00	6.19***
Putting into perspective	-0.03	-0.55	.06	.00	6.22***
Catastrophizing	-0.03	-0.46	.06	.00	6.19***
RRQ			.06		
Rumination	-0.07	-1.15	.07	.01	6.66***
Reflection	-0.07	-1.17		.00	7.14***
Sleep latency, weekdays					
Step 1			.01		1.79
Gender	0.10	1.83			
Age	-0.04	-0.67			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.04	-0.65	.01	.00	1.33
Blaming others	0.06	1.03	.02	.00	1.55
Acceptance	-0.07	-1.24	.02	.01	1.71
Refocus on planning	0.04	0.77	.01	.00	1.39
Positive refocusing	0.04	0.78	.01	.00	1.39
Rumination	**-0.13**	**-2.32***	**.03**	**.02**	**3.00***
Positive reappraisal	-0.00	-0.05	.01	.00	1.56
Putting into perspective	0.03	0.56	.10	.00	1.30
Catastrophizing	0.09	1.62	.20	.01	2.07
RRQ					
Rumination	-0.08	-1.36	.02	.01	1.82
Reflection	-0.02	-0.42	.01	.00	1.43
Sleep latency, weekends					
Step 1			.00		0.16
Gender	0.02	0.36			
Age	0.02	0.40			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.08	-1.37	.01	.01	0.74
Blaming others	0.02	0.36	.00	.00	0.15
Acceptance	-0.04	-0.65	.00	.00	0.25
Refocus on planning	0.07	1.15	.01	.01	0.55
Positive refocusing	0.05	0.79	.00	.00	0.32
Rumination	-0.11	-1.88	.01	.01	1.29
Positive reappraisal	-0.01	-0.16	.00	.00	0.12
Putting into perspective	-0.04	-0.66	.00	.00	0.25
Catastrophizing	-0.00	-0.06	.00	.00	0.11
RRQ					
Rumination	**-0.13**	**-2.09***	**.02**	**.02**	**1.57**
Reflection	-0.01	-0.08	.00	.00	0.13
Wake after sleep onset, weekdays					
Step 1			.00		0.03
Gender	0.01	0.24			
Age	-0.00	-0.06			

Step 2					
CERQ					
Self blame	-0.09	-1.54	.01	.01	0.81
Blaming others	-0.07	-1.26	.01	.01	0.55
Acceptance	-0.02	-0.34	.00	.00	0.06
Refocus on planning	0.03	0.49	.00	.00	0.10
Positive refocusing	0.04	0.66	.00	.00	0.16
Rumination	-0.02	-0.28	.00	.00	0.05
Positive reappraisal	0.02	0.29	.00	.00	0.05
Putting into perspective	-0.04	-0.64	.00	.00	0.15
Catastrophizing	0.04	0.67	.00	.00	0.17
RRQ					
Rumination	-0.03	-0.58	.00	.00	0.17
Reflection	0.04	0.62	.00	.00	0.18
Wake after sleep onset, weekends					
Step 1			.00		0.28
Gender	0.02	0.40			
Age	0.03	0.57			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	**-0.15**	**-2.64****	**.03**	**.02**	**2.51**
Blaming others	-0.06	-1.09	.01	.00	0.58
Acceptance	-0.07	-1.26	.01	.01	0.71
Refocus on planning	0.05	0.83	.00	.00	0.41
Positive refocusing	0.01	0.24	.00	.00	0.20
Rumination	-0.10	-1.62	.01	.01	1.06
Positive reappraisal	-0.04	-0.60	.00	.00	0.30
Putting into perspective	-0.04	-0.69	.00	.00	0.34
Catastrophizing	-0.08	-1.28	.01	.01	0.73
RRQ					
Rumination	**-0.13**	**-2.26***	**.02**	**.02**	**1.92**
Reflection	-0.06	-1.00	.01	.00	0.55
Midpoint of sleep, weekdays					
Step 1			.02		3.36*
Gender	0.15	2.59*			
Age	-0.01	-0.08			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.03	-0.50	.02	.00	2.32
Blaming others	0.09	1.65	.03	.01	3.16*
Acceptance	-0.09	-1.55	.03	.01	3.05*
Refocus on planning	**0.02**	**-1.99***	**.03**	**.01**	**3.58***
Positive refocusing	**-0.14**	**-2.40***	**.04**	**.02**	**4.20****
Rumination	-0.04	-0.63	.02	.00	2.37
Positive reappraisal	**-0.19**	**-3.33****	**.06**	**.03**	**6.02****
Putting into perspective	-0.09	-1.60	.03	.01	3.10*
Catastrophizing	**0.11**	**1.99***	**.03**	**.01**	**3.59***
RRQ					
Rumination	**0.12**	**2.06***	**.04**	**.01**	**4.14****
Reflection	0.05	0.92	.03	.00	3.15*
Midpoint of sleep, weekends					
Step 1			.03		4.71*
Gender	0.13	2.27*			
Age	0.10	1.80			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.06	-0.99	.03	.00	3.47*
Blaming others	0.01	0.18	.03	.00	3.14*
Acceptance	-0.07	-1.14	.04	.00	3.58*
Refocus on planning	-0.09	-1.61	.04	.01	4.03**
Positive refocusing	-0.09	-1.65	.04	.01	4.07**

Rumination	-0.04	-0.64	.03	.00	3.27*
Positive reappraisal	**-0.15**	**-2.68****	**.05**	**.02**	**5.59****
Putting into perspective	-0.07	-1.25	.04	.01	3.67*
Catastrophizing	0.04	0.75	.03	.00	3.32*
RRQ					
Rumination	0.03	0.54	.03	.00	3.38*
Reflection	0.03	0.51	.03	.00	3.35*
<u>Irregularity in midpoint</u>					
Step 1			.02		3.34*
Gender	0.03	0.59			
Age	0.14	2.43*			
Step 2: Different emotion regulation strategies entered and removed					
CERQ					
Self blame	-0.06	-1.07	.03	.00	2.61
Blaming others	-0.08	-1.35	.03	.01	2.85*
Acceptance	-0.01	-0.12	.02	.00	2.23
Refocus on planning	-0.00	-0.01	.02	.00	2.22
Positive refocusing	0.01	0.13	.02	.00	2.23
Rumination	-0.04	-0.71	.02	.00	2.39
Positive reappraisal	-0.01	-0.14	.02	.00	2.23
Putting into perspective	0.02	0.34	.02	.00	2.26
Catastrophizing	-0.04	-0.73	.02	.00	2.40
RRQ					
Rumination	-0.10	-1.62	.03	.01	3.04*
Reflection	-0.02	-0.39	.02	.00	2.25

*** p < .001, ** p < .01, * p < .05