Computers in Human Behavior Reports 22 (2026) 101030

Contents lists available at ScienceDirect

Computers in Human Behavior Reports

journal homepage: www.sciencedirect.com/journal/computers-in-human-behavior-reports

The effect of a 14-day digital nudge-based sleep hygiene intervention on behavioural, cognitive, and emotional well-being in college students: An experimental approach

Tracy X. Chen [a,*], Chi-Ying Cheng [a], Michelle Koay [b], Chin Boon Soh [b], Andree Hartanto [a,**]

[a] School of Social Sciences, Singapore Management University SMU, Singapore
[b] Mrs Wong Kwok Leong Student Wellness Centre, SMU, Singapore

ARTICLE INFO

Keywords:
Sleep
Sleep hygiene
Bedtime procrastination
Nudge theory
Digital intervention
College
Well-being

ABSTRACT

Sleep is essential for one's cognitive, psychological, and physical health. Yet, college students often face sleep deprivation due to academic demands, social obligations, and extracurricular commitments. This study implemented a 14-day Digital Nudge-Based Sleep Hygiene Intervention, delivered via a digital platform, to encourage healthier sleep practices among college students. Grounded in nudge theory, the digital intervention used subtle behavioural prompts to improve participants' sleep hygiene without imposing restrictions, demonstrating high adherence and scalability. Participants were guided through daily tasks to enhance autonomy and motivation, such as creating calming bedtime routines. The digital intervention led to positive outcomes across four domains: sleep and physical outcomes e.g., lower bedtime procrastination ($|d| = 0.55$) and self-reported physical health ($|d| = 0.40$), behavioural outcomes e.g., higher productivity ($|d| = 0.35$), goal progress ($|d| = 0.40$), and self-control ($|d| = 0.38$), cognitive outcomes e.g., lower cognitive failures ($|d| = 0.28$) and higher mindful attention ($|d| = 0.30$), and emotional outcomes e.g., lower anxiety ($|d| = 0.35$) and higher life satisfaction ($|d| = 0.44$). These findings demonstrate the promise of digital, nudge-based interventions in promoting sleep hygiene and related functional outcomes among college students. However, further research is needed to assess long-term efficacy and generalisability across diverse populations.

1. Introduction

Sleep is a foundational pillar of overall well-being, significantly influencing one's cognitive, psychological, and physical health (Perry et al., 2013; Ramar et al., 2021; Vandekerckhove & Wang, 2017; Zhai et al., 2018). Adequate sleep plays a crucial role in emotional regulation, memory consolidation, and cognitive processes (Walker & van Der Helm, 2009). During sleep, the brain processes and stores information gathered throughout the day, which is vital for effective learning and decision-making (Diekelmann & Born, 2010). Sleep deprivation, conversely, is linked to impairments in attention, executive function, and emotional control, and is a risk factor for both physical and mental health disorders, including cardiometabolic disease, diabetes, obesity and mood dysregulation (Chattu et al., 2018; Goel et al., 2009; Killgore, 2010; Lim & Dinges, 2010; Spiegel et al., 2005; Tubbs et al., 2020). Emotional regulation, in particular, is affected through disrupted prefrontal-limbic connectivity, reducing one's ability to manage stress and increasing reactivity to negative stimuli (Chen et al., 2024; Goldstein & Walker, 2014; Tempesta et al., 2018). Insufficient sleep has also been found to be associated with poorer problem-solving abilities and day-to-day functioning (Lim & Dinges, 2010; Pilcher & Huffcutt, 1996). Thus, maintaining sufficient sleep duration and quality is essential for optimal functioning.

Despite this, college students frequently face challenges in obtaining enough quality sleep (Lund et al., 2010; Owens et al., 2017). College students are particularly vulnerable to sleep disturbances, as the transition to university life often brings a unique set of challenges that can disrupt sleep patterns, including heightened academic responsibilities and changing social dynamics like increased peer interaction and extracurricular participation (Clark, 2005; Hershner & Chervin, 2014; Lüdtke et al., 2011; Tan et al., 2023). Many students experience irregular sleep schedules due to fluctuating class times, social activities, and

* Corresponding author. Singapore Management University, School of Social Sciences, 10 Canning Rise, Level 4, 179873, Singapore.
** Corresponding author. Singapore Management University, School of Social Sciences, 10 Canning Rise, Level 4, 179873, Singapore.
E-mail addresses: Tracychen.2023@phdps.smu.edu.sg (T.X. Chen), andreeh@smu.edu.sg (A. Hartanto).

https://doi.org/10.1016/j.chbr.2026.101030
Received 25 June 2025; Received in revised form 25 February 2026; Accepted 20 March 2026
Available online 30 March 2026
2451-9588/© 2026 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

part-time work (Gomes et al., 2011; Lund et al., 2010). Additionally, the prevalence of technology use further exacerbates sleep disturbances by delaying sleep onset and reducing one's sleep quality (Lemola et al., 2015). This behaviour is often associated with bedtime procrastination, a "voluntary delay of going to bed without external reasons despite knowing it will lead to negative outcomes" (Kroese et al., 2014). Bedtime procrastination is increasingly recognised as a self-regulation failure prevalent among college students, frequently influenced by digital distractions, inconsistent routines, and low perceived urgency to sleep (Exelmans & Van den Bulck, 2016; Pu et al., 2025; Zhang & Wu, 2020). Studies indicate that around 60% of university students report inadequate sleep quality measured by the Pittsburgh Sleep Quality Index (PSQI) (Buboltz et al., 2001). Poor sleep hygiene, such as irregular sleep-wake patterns and late-night caffeine or alcohol use, is also highly prevalent in these populations (Brown et al., 2002; Taylor et al., 2011).

The consequences of such sleep disruption among college students are profound, extending across emotional, academic, and behavioural domains. Impaired sleep has been linked to increased stress, fatigue, and decreased emotional regulation (Benham, 2010; Galambos et al., 2009). Students with insomnia often report a range of psychological issues, including depression, anxiety, obsessive-compulsive tendencies and reduced overall quality of life (Gaultney, 2016; Hellberg et al., 2019). Sleep disturbances correlate with lower Grade Point Averages (GPA) and impaired cognitive functioning including decision-making and planning, which are crucial for academic success (Alapin et al., 2000; Buboltz et al., 2001; Curcio et al., 2006; Frau et al., 2019). Accordingly, inadequate sleep has been linked to greater likelihood of academic procrastination, reduced motivation, and a higher risk of burnout (Becker et al., 2018; Hershner & Chervin, 2014). Ruminating on stressful events like exams can worsen sleep problems, creating a vicious cycle of sleep-onset latency and repeated rumination (Guastella & Moulds, 2007; Li et al., 2019; Zoccola et al., 2009). Moreover, students with poor sleep quality have been found to engage in more risky behaviours such as substance abuse and aggression, which can compound the challenges they face (McKnight-Eily et al., 2011; Vail-Smith et al., 2009).

Given the widespread negative outcomes of poor sleep quality, there has been a growing focus on interventions aimed at improving sleep within this population. Cognitive-Behavioural Therapy for Insomnia (CBT-I) has emerged as an effective treatment for reducing symptoms of chronic sleep disturbances (Taylor et al., 2014; Tsai et al., 2022; Zimmerman, 2011). However, despite its efficacy, significant barriers to uptake and adherence persist due to its structured nature consisting of sleep restriction protocols and intensive cognitive restructuring which students find too time-consuming, demanding or complex (Dyrberg et al., 2021; Marques et al., 2019; Mellor et al., 2021). A systematic review by Koffel et al. (2018) further highlights barriers at the patient, provider, and system levels, including limited awareness and insufficient access to trained providers. Even self-help adaptations of CBT-I, though more accessible, experience notable attrition rates of around 35% (Ho et al., 2014), with brief telephone support only modestly improving engagement. Moreover, CBT-I primarily targets insomnia, whereas many students suffer from subclinical sleep difficulties related to lifestyle and self-regulation. Recent reviews emphasise that specialised sleep interventions for college students remain scarce and underdeveloped (Beattie et al., 2015; Hirshkowitz et al., 2015). Alternative interventions are needed to better address these broader behavioural sleep challenges in this demographic.

In response, a variety of educational and digital interventions have been tested. Educational approaches, including brief online interventions, led to improved sleep behaviours, sleep quality, and depression scores (Hershner & O'Brien, 2018; Quan et al., 2018). A single lecture on sleep hygiene resulted in increased sleep duration and decreased fatigue (Anderson et al., 2022). Web-based interventions focusing on sleep also enhanced sleep quality and reduced alcohol consumption (Fucito et al., 2017). A meta-analysis of psychological interventions for sleep improvement in college students found moderate to large effect sizes for overall sleep-related outcomes, global measures of sleep disturbances, and sleep-onset latency (Saruhanjan et al., 2021). Overall, these interventions have demonstrated efficacy in addressing sleep deprivation, poor sleep habits, and mood issues among college students, potentially offering an effective approach to improving sleep and academic performance (Hershner & O'Brien, 2018; Saruhanjan et al., 2021).

However, though the findings seem promising, these interventions face several important limitations. Educational interventions, such as brief lectures or online modules, often improve sleep knowledge but show limited success in driving sustained behavioural change (Anderson et al., 2022; Hershner & O'Brien, 2018; Quan et al., 2018). Web-based programs, although effective in enhancing sleep quality and reducing alcohol consumption (Fucito et al., 2017), commonly struggle with participant engagement and retention, where studies report dropout rates as high as 30–50% (Becker & Torous, 2019; Nam et al., 2023). This threatens the effectiveness and real-world applicability of such interventions. Moreover, meta-analyses highlight substantial variability in intervention designs and a reliance on self-reported outcomes without participant blinding, which increases bias and limits generalisability (Saruhanjan et al., 2021). Together, these gaps highlight the need for interventions that not only deliver information but also address motivational barriers and promote consistent behavioural engagement through accessible, technology-based strategies.

To address both behavioural and motivational aspects often overlooked in current studies, researchers have turned to behavioural science frameworks, particularly Nudge Theory, to design low-effort, motivationally supportive strategies for encouraging healthy behaviour without restricting autonomy (Thaler & Sunstein, 2009). Nudges subtly alter the choice environment to prompt better decisions in a non-coercive way, often by using reminders, defaults, or simplification to reduce friction and harness bounded rationality (De Paolis et al., 2025; Pena Madeira Gouveia DeCampos, 2021). They have shown promise in addressing problematic smartphone use, which can impact sleep quality (Kasturiratna et al., 2025; Olson et al., 2023). While research on sleep-specific nudges is limited, text message-based interventions have demonstrated positive effects on sleep duration (Gipson et al., 2019; Tavernier & Adam, 2017). A 6-week text message sleep hygiene intervention improved sleep knowledge, hygiene practices, and sleep quality in college students (Gipson et al., 2019). A pilot study on personalised sleep-coaching messages also found that adherence to wake-time recommendations was associated with improvements in overall sleep health, although individual sleep metrics did not show significant changes (Schneider et al., 2023). These findings suggest that digital nudge-based interventions may be a promising approach for promoting healthy sleep behaviours, and more research is needed to establish their effectiveness across different populations and contexts.

The present study thus leverages the potential of nudge-based interventions to address the challenges of ensuring college students adhere to healthy sleep habits amidst their busy schedules by implementing a 14-day Digital Nudge-Based Sleep Hygiene Intervention. The digital intervention, delivered via Telegram, was designed using principles from nudge theory to subtly encourage participants to adopt healthier sleep habits without overt coercion. It incorporated multiple nudge strategies including daily reminders, information about healthy sleep hygiene habits, simplification of the concept of sleep hygiene and social cues which included reactions from other participants. Participants were only briefly informed that the study aimed to investigate how students respond to the implementation of sleep challenges, thus preserving the single-blind nature of the study, reducing demand characteristics and enhancing the reliability of the results (McCambridge et al., 2012).

Participants would receive a list of tasks as part of the intervention, where the tasks served as behavioural nudges: subtle prompts intended to encourage participants to adopt better sleep habits. Examples of tasks included creating a calming bedtime routine, with reminders carefully phrased to motivate participants by making the desired behaviour more

salient and appealing (Thaler & Sunstein, 2009). Additionally, the tasks provided to participants were framed to emphasise positive behaviour change without imposing restrictions, aligning with the libertarian paternalism approach of nudge theory – encouraging participants to make healthier choices while preserving their autonomy (Thaler & Sunstein, 2009). To enhance engagement, the study employed a partial default nudge, as participants were encouraged to complete the challenges while still being free to opt out at any time. The overall digital intervention aimed to consistently guide participants towards adopting beneficial sleep behaviours through subtle prompts and cues over the period of intervention, in accordance with nudge theory's emphasis on choice architecture and behavioural design (Sunstein, 2014; Thaler & Sunstein, 2009). Further, by using a digital platform, the intervention enhances accessibility and aligns with the busy lifestyles of college students, who are also technology-savvy. This is supported by previous research on text-message-based sleep interventions (Filion et al., 2015; Gipson et al., 2019; Hirshkowitz et al., 2015; Jones et al., 2020; Tavernier & Adam, 2017).

Through the integration of digital nudge-based strategies to promote healthy sleep practices and improve one's sleep outcomes, this study aims to provide valuable insights into effective interventions tailored to the unique needs of university students. It is hypothesised that participants in the 14-Day Digital Sleep Hygiene Intervention will demonstrate significantly better outcomes than the control group across four main domains: sleep, behavioural, cognitive, and emotional outcomes. Specifically, it is hypothesised that the intervention group will report higher sleep quality, lower bedtime procrastination, and better self-reported physical health compared to the control group. In terms of behavioural outcomes, the intervention group is expected to exhibit higher self-control capacity, greater productivity, greater goal progress, and lower procrastination. For cognitive outcomes, the intervention group is anticipated to demonstrate greater effectiveness in implementation intention, fewer cognitive failures, and higher mindful attention awareness. Regarding emotional outcomes, the intervention group is hypothesised to report lower levels of anxiety, depression, and perceived stress, as well as higher levels of life satisfaction.

2. Method

2.1. Participants

To estimate the necessary sample size, a power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2009). Assuming a medium effect size ($d = 0.50$), with a power level of 0.80 and a two-tailed $\alpha = 0.05$, the analysis indicated that 128 participants (64 per group) would be sufficient for detecting statistically significant effects. To account for potential attrition and ensure higher statistical power, we recruited a larger sample than the minimum required. A total of 269 college students were enrolled in the current study (Mean age = 22.8, gender (% female) = 76.2). Thirty-six participants dropped out of the study as they failed to complete the questionnaire survey, resulting in a final sample of $N = 233$. Participants were recruited from a local university in Singapore in exchange for mall vouchers. To be eligible for the study, participants must be college students, aged 18 and above, and users of the Telegram application. All participants provided informed consent and data collection was approved by the local institutional review board [IRB-24-046-A034(324)].

2.2. Procedure

This study was not preregistered. The intervention was delivered in collaboration with the Student Wellness Centre in the university. Students who volunteered to participate in this study filled in a sign-up form on Qualtrics which included details about a 14-day sleep 'challenge' and other details of the study, including the need to fill in a questionnaire. After completing the form and giving their consent, participants were assigned to either the intervention or the control group using simple randomization via the random assignment function on Qualtrics. Participants assigned to the intervention group were informed that their sleep 'challenge' will begin on the 15th of March and told to look out for an Electronic mail (E-mail) which will be sent to them on the day, as well as a Telegram channel that they will be added into for daily reminders to do the sleep hygiene tasks. Participants assigned to the control group were instead informed that due to an influx of participants, their sleep 'challenge' will begin on the 29th of March, and similarly informed to look out for the E-mail and channel. Each participant received a 10-dollar CapitaLand voucher as compensation.

2.3. Intervention

While the researchers were aware of the true nature of the study, participants in both the experimental and control groups were only informed that the study aimed to investigate how students respond to the implementation of sleep challenges. This vague description was expected to help reduce demand characteristics in participants due to its partial single-blind nature. Participants in the intervention group received an Email on the 15th of March containing 14 sleep hygiene tasks. (Please refer to Table 1 for the list of sleep hygiene tasks and for the scientific evidence and rationale for including each task). These tasks contained a mixture of sleep hygiene tips and to-dos to improve one's sleep, such as listening to calming music or practicing stress-reducing techniques such as deep breathing before bed. In the meantime, the control group went about their usual daily activities as they were informed to wait for their 'challenge' to begin at the later date of 29th March.

Concurrently, as the email was sent out to the intervention group, the reminder for the first day of task was also sent in the Telegram channel where they were added in, together with an imagery and caption to encourage participants to fulfil the task. (Please refer to Fig. 1 for a picture of all the 14 reminders that were sent). All nudges were sent once daily at 12pm in the day to allow enough time for participants to be reminded of and to carry out the day's task, except for Day 1's which was sent at 10pm to allow for more study sign-ups. This midday timing was strategically chosen as prior research suggests that earlier nudges enhance follow-through on planning-related behaviours like bedtime routines by reducing present bias and closing the intention-action gap (Milkman et al., 2011). The decision to send nudges only once per day was also intentionally aligned with the principles of libertarian paternalism, which aim to guide behaviour without restricting individual freedom of choice (Thaler & Sunstein, 2003, 2009). By limiting reminders to a single prompt, participants retained full autonomy in deciding whether, when, and how to act on the suggestion. This approach avoids the potential intrusiveness or perceived coercion associated with repeated prompts, which may trigger psychological reactance or reduce intrinsic motivation (Balaskas et al., 2025; Lessard-Deschênes et al., 2025). At the end of the first 14 days, on the 29th of March, the link to the questionnaire survey was sent via Email and Telegram to both the experimental and the control group. At this point, the experimental group had completed the sleep intervention while the control group had yet to begin.

2.4. Measures

2.4.1. Sleep and physical outcomes

Sleep Quality. Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), a self-administered questionnaire (Mollayeva et al., 2016). The PSQI provides a composite score and consists of seven different component scores: (a) subjective sleep quality, (b) sleep latency, (c) sleep duration, (d) habitual sleep efficiency, (e) sleep disturbances, (f) use of sleep medication, and (g) daytime dysfunction. When scoring the PSQI, the seven component scores are calculated, with each score ranging from 0 (no difficulty) to 3 (severe

Table 1
List of sleep tasks and corresponding rationale for the 14-day sleep hygiene intervention.

Day	Sleep Hygiene Task	Supporting Evidence
1	Establish a consistent sleep schedule. Set a regular bedtime and wake-up time. Stick to this schedule for the entire 14 days.	Consistent sleep schedules have been found to be important for improving sleep quality, reducing stress, and enhancing performance in various contexts such as in workplaces (Barber et al., 2010; Finley & Cowley, 2005; Phillips et al., 2017; Takahashi, 2012).
2	Create a calming bedtime routine, incorporating activities such as reading, gentle stretching, or deep breathing.	Studies have shown that creating a calming bedtime routine, including activities such as deep breathing and stretching can also be beneficial for reducing sleep latency and improving other sleep and mood outcomes (Hershner & Chervin, 2014; Lund et al., 2010; Ong et al., 2014).
3	Optimise your sleep environment. Make your bedroom comfortable, dark, and quiet. Consider using blackout curtains or white noise machines.	It has been found that optimising one's sleep environment promotes one's sleep quality via improved sleep duration and decreased sleep disturbances (Muzet, 2007; Sexton-Radek & Hartley, 2013).
4	Limit screen time before bed. Avoid screens at least an hour before bedtime. Blue light emitted from devices can interfere with melatonin production.	Research has highlighted that limiting screen time is associated with increased sleep duration, earlier sleep onset, and better sleep quality (Carter et al., 2016; Demirci et al., 2015; Exelmans & Van den Bulck, 2016).
5	Practice mindful eating habits. Consume a well-balanced diet, limiting caffeine and heavy meals close to bedtime.	Practicing mindful eating indirectly has been found to help with improved sleep quality via the prevention of overeating and other poor eating habits (Binks et al., 2020; Chaput, 2014; St-Onge et al., 2016).
6	Engage in regular exercise. Incorporate regular physical activity into your day, aiming for at least 30 min. However, avoid intense workouts close to bedtime.	Research has shown that physical activity is particularly beneficial for improving insomnia symptoms, reducing daytime fatigue, and improving overall sleep quality (Chennaoui et al., 2015; Kredlow et al., 2015).
7	Practice stress-reducing techniques, such as meditation, deep breathing, or yoga.	Studies have highlighted how practicing stress-reducing techniques such as meditation, deep breathing and yoga reduces one's sleep disturbances and helps with one's sleep latency and quality (Busch et al., 2012; Rusch et al., 2019).
8	Limit afternoon naps. If you need to nap, keep it short (20-30 min) and avoid napping late in the day.	Naps of less than 30 min have been found to restore wakefulness and enhance performance and learning, while frequent or longer naps may contribute to sleep inertia and are linked to adverse health outcomes, particularly in older adults (Milner & Cote, 2009; Pilcher et al., 2001; Ye et al., 2015).
9	Monitor liquid intake before bedtime. Limit fluids close to bedtime to reduce the likelihood of waking up during the night to use the bathroom.	Studies highlight that pre-bedtime fluid intake, especially of caffeinated or sugary drinks, leads to increased insomnia symptoms (Drake et al., 2013; Hindmarch et al., 2000; C.-H. Tsai et al., 2019).
10	Spend time outdoors or in nature during the day to regulate your circadian rhythm.	It has been found that spending more time in daylight is strongly associated with enhanced sleep outcomes, including a more regulated circadian rhythm, fewer insomnia symptoms and an earlier chronotype (Melanson et al., 2018; Siraji et al., 2023; White et al., 2017).
11	Try relaxation techniques such as progressive muscle relaxation or guided imagery before bedtime.	Relaxation techniques, including progressive muscle relaxation and guided imagery, have been shown to help with reduced stress, fatigue and improved sleep quality in multiple populations including pregnant women (Dolbier & Rush, 2012; Hartanto, Kasturiratna, et al., 2023; Means et al., 2000).
12	Cultivate gratitude before sleep. Before bedtime, reflect on three things you are grateful for.	Research has highlighted the importance of cultivating gratitude especially before bedtime, as it boosts relaxation, fosters positive pre-sleep cognitions and reduces negative thoughts before bedtime, where grateful individuals experience better subjective sleep quality, increased sleep duration, and less sleep latency (Boggiss et al., 2020; Wood et al., 2009).
13	Enhance your sleep quality by listening to calming music before bedtime for a soothing and restful night's sleep.	Listening to calming music, including classical and other sedative music, before bed have been found to significantly shorten one's wake time after sleep onset and improve one's subjective sleep quality (Hu et al., 2023; Jespersen et al., 2019; Majeed et al., 2021).
14	Reflect on the positive changes made during the challenge and express gratitude for improved sleep.	Research has shown that improved sleep duration and quality is correlated with increased feelings of gratitude and flourishing, where greater appreciation gives rise to more positive affect and before-sleep thoughts (Emmons & McCullough, 2003; Hartanto, Kaur, et al., 2023; Sheldon & Lyubomirsky, 2006).

Note. Tasks such as limiting naps (Day 8) and increasing light exposure (Day 10) were intentionally brief to enhance compliance, but future designs may benefit from including time-of-day specificity, e.g. advising naps to end before 3 p.m. and morning light exposure to support circadian alignment. While Day 4's recommendation to reduce blue light exposure is consistent with traditional sleep hygiene guidance, recent evidence suggests melatonin suppression due to blue light may not always translate into poorer sleep outcomes, and that individual variability plays a significant role (Blume et al., 2022; Chellappa, 2021). Future interventions may benefit from more nuanced guidance aligned with emerging evidence.

difficulty). These component scores are then summed to generate a composite score, which ranges from 0 to 21. Higher scores reflect poorer sleep quality.

Bedtime Procrastination. Bedtime procrastination was measured using an adapted version of the existing Bedtime Procrastination Scale BPS (Kroese et al., 2014). The scale consists of 5 items which include the sample item “Thinking about a typical night in the past 2 weeks … I got distracted by things when I actually wanted to go to bed.” and is scored from 1 (Strongly disagree) to 5 (Strongly agree). Scores were averaged and higher scores indicate higher amounts of bedtime procrastination. For the current study, internal consistency for constituent items was also demonstrated (Cronbach's $\alpha = 0.74$).

Self-Reported Physical Health. Self-reported physical health was measured with a single item measure of “How would you rate your physical health these past 2 weeks?”. Responses were scored from 1 (Poor) to 5 (Excellent) and a higher score indicates better health. Such single-item self-reported health measures have been validated in numerous studies and are widely used due to their predictive validity and strong correlation with multi-item health scales. Research has found

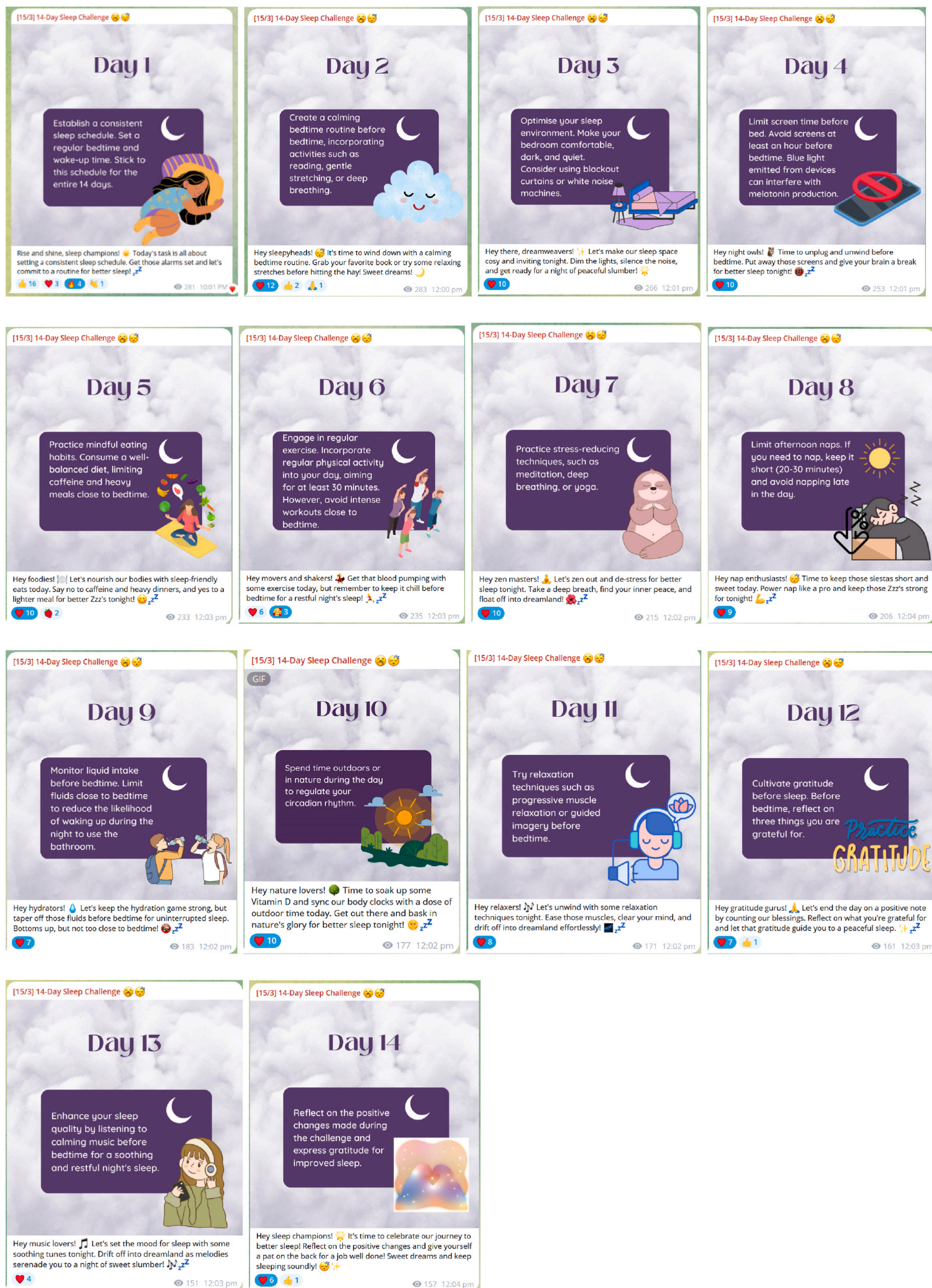

Fig. 1. Daily reminders sent to participants in the Telegram channel.

that such measures effectively predict mortality and other health outcomes, supporting their reliability in research (DeSalvo et al., 2006).

Compliance. Compliance was assessed by calculating the percentage of days each participant adhered to the prescribed sleep hygiene behaviours during the 14-day intervention period. Participants answered a checklist question indicating which of the days they completed the assigned behaviour accordingly. Compliance was computed as: (Number of days the participant adhered to the sleep task/14) $\times$ 100.

2.4.2. Behavioural outcomes

Productivity. Participants' perceived productivity was assessed using three study-specific items adapted from previous productivity measures (Binnewies et al., 2009; Sonnentag, 2003). The items of the scale include “These past 2 weeks, I was productive.”, “These past 2 weeks, I did a lot of things.” and “These past 2 weeks, I did nothing.” (reverse coded). Participants rated the extent to which they agreed with the statements, where items are given a score of 1 (Strongly disagree) to 5 (Strongly agree). The overall mean is then calculated, where higher scores indicate higher levels of productivity. (Cronbach's $\alpha = 0.83$).

Procrastination. Procrastination was measured using the 6-item procrastination scale adapted from the Irrational Procrastination Scale IPS (Steel, 2002). A sample item includes “These past 2 weeks, when I should be doing one thing, I did another.” Items are scored from 1 (Very seldom or not true of me) to 5 (Very often true, or true with me). Scores are averaged and higher scores indicate higher levels of procrastination. The IPS has been shown to have high reliability and validity across various clinical and non-clinical contexts (Rozental et al., 2014; Shaw & Zhang, 2021). In the current study, the Cronbach's alpha for the IPS was 0.89.

State Self-Control. State self-control was measured by an adapted version of the 5-item Brief State Self-Control Capacity Scale BSCS (Lindner et al., 2019). One sample item includes “I felt like my willpower was gone the past 2 weeks.” and items are scored from 1 (Not true) to 7 (Very true). The composite score is calculated by averaging the scores of all items and higher scores indicate higher levels of state self-control (Cronbach's $\alpha = 0.77$).

Goal Progress. Goal progress was measured using the single item “In the past 14 days, I have seen progress towards my goals for the month.” scored from 1 (Strongly disagree) to 5 (Strongly agree), where a higher score indicated higher goal progress.

2.4.3. Cognitive outcomes

Implementation Intention. Implementation intention was measured using the single item “In the past 14 days, I have taken steps to achieve my goals for the month.” scored from 1 (Strongly disagree) to 5 (Strongly agree), where a higher score indicated higher implementation intention.

Cognitive failures. Cognitive failures were measured using an adapted version of the 13-item Cognitive Failures in Everyday Life Scale developed and validated by Lange & Süß (Lange & Süß, 2014). The scale includes the sample item “Did you unintentionally say something twice, at any point of time these past 2 weeks? E.g. Greeting someone again” and is scored from 1 (Never) to 5 (All the time). Scores were averaged and higher scores indicate higher amounts of cognitive failures. The Cronbach's alpha for the current study was 0.93.

Mindful Attention Awareness. Mindful attention awareness was measured by an adapted version of Brown & Ryan's Mindful Attention Awareness Scale (MAAS) (Brown & Ryan, 2003). There are a total of 15 items and the composite score is calculated by averaging the scores of all items. One sample item includes “I break or spill things because of carelessness, not paying attention, or thinking of something else.” and items are scored from 1 (Almost always) to 6 (Almost never). Higher scores indicate higher levels of mindful attention awareness (Cronbach's $\alpha = 0.91$).

2.4.4. Emotional outcomes

Life Satisfaction. Life satisfaction was measured using an adapted version of Diener's Satisfaction With Life Scale (SWLS). The scale included 5 items which include the sample item “In most ways, these past 2 weeks have been close to ideal” and is scored from 1 (Strongly disagree) to 7 (Strongly agree) (Diener et al., 1985). Scores were summed and higher scores indicate higher life satisfaction (Cronbach's $\alpha = 0.89$).

Depression. Depression was measured using an adapted version of the 10-item Short Depression Scale Revised (CESD-10) (Andresen et al., 1994). The scale includes the sample item “I felt that everything I did was an effort.” and is scored from 1 (Rarely or none of the time) to 4 (All of the time). Scores were averaged and higher scores indicate higher risk of depression. The CESD-10 retains strong psychometric properties comparable to the full 20-item CES-D scale (Mohebbi et al., 2018); Cronbach's alpha for the CESD-10 was 0.84.

State Anxiety. State anxiety was measured by an adapted version of the short form of Marteau & Bekker's State-Trait Anxiety Inventory (STAI-6) (Marteau & Bekker, 1992). There are a total of 6 items and the composite score is calculated by averaging the scores of all items. One sample item includes “I was tense these past 2 weeks” and items are scored from 1 (Not at all) to 4 (Very much so). Higher scores indicate higher levels of state anxiety (Cronbach's $\alpha = 0.84$). The STAI-6 has also been shown to be a reliable and valid tool for measuring state anxiety, similar to the 20-item STAI, with high internal consistency and reliability (Tluczek et al., 2009; van der Bij et al., 2003).

Perceived Stress. Perceived stress was measured by an adapted version of the 4-item Perceived Stress Scale (PSS) developed by Cohen and colleagues (Cohen et al., 1983). One sample item includes “In the last 2 weeks, how often have you felt difficulties piling up so high that you could not overcome them?” and items are scored from 0 (Never) to 4 (Very often). The composite score is calculated by summing the scores of all items and higher scores indicate higher levels of perceived stress. The PSS-4 has also shown good psychometric properties in past studies, with adequate internal consistency and validity (Karam et al., 2012; Mitchell et al., 2008; Sanabria-Mazo et al., 2023). In the current study, the Cronbach's alpha for the PSS-4 scale was 0.70.

3. Results

Independent-samples t-tests were conducted to compare the experimental and control groups across four outcome domains: sleep, emotional, behavioural, and cognitive measures. The key findings of the study are summarised below (see Table 2). Effect sizes were interpreted using the benchmarks proposed by Funder and Ozer, 2019, which entails classification of standardised effect sizes of $r = 0.10$ as small, $r = 0.20$ as medium, and $r = 0.30$ or higher as large in psychological research. This is then respectively converted to Cohen's d, which translates to effect sizes of $d = 0.201$ as small, $d = 0.408$ as medium, and $d = 0.629$ as large. Overall compliance rate was 82.9% across the intervention group, with over 75% of participants completing at least 70% (10 out of 14) of the sleep hygiene tasks.

3.1. Key findings

3.1.1. Sleep and physical outcomes

Bedtime Procrastination. The experimental group showed a significantly lower bedtime procrastination score ($M = 3.05$, $SD = 0.80$) compared to the control group ($M = 3.49$, $SD = 0.80$), with a medium effect size t (231) = 4.27, 95% CI [0.24, 0.66], $p < 0.001$, $d = 0.55$.

Sleep Quality. There was a significant and medium difference in sleep quality between the experimental group ($M = 7.57$, $SD = 2.49$) and the control group ($M = 8.77$, $SD = 2.62$), t (230) = 3.55, 95% CI [0.53, 1.87], $p < 0.001$, $d = 0.48$, where the experimental group showed higher sleep quality.

Self-Reported Physical Health. The experimental group showed a significant albeit small difference in self-reported physical health ($M = 3.12$, $SD = 1.08$) compared to the control group ($M = 2.69$, $SD = 1.09$), t (231) = −3.06, 95% CI [−0.72, −0.16], $p = 0.002$, $d = -0.40$, where the experimental group participants reported higher physical health.

Compliance. The mean compliance rate across all participants in the intervention group was 82.9% (SD = 22.8%). A total of 75.2% of participants adhered to the intervention on at least 10 out of the 14 days, signalling at least a 70% compliance to the tasks.

Table 2
Summary of results.

Outcome	N	M (SD)	d	95% CI	t	df	p
Sleep Outcomes							
Sleep Quality			0.48	[0.53, 1.87]	3.55	230	<0.001***
Control	127	8.77 (2.62)					
Experimental	105	7.57 (2.49)					
Bedtime Procrastination			0.55	[0.24, 0.66]	4.27	231	<0.001***
Control	128	3.49 (0.80)					
Experimental	105	3.05 (0.80)					
Self-Reported Physical Health			−0.40	[-0.72, −0.16]	−3.06	231	0.002**
Control	128	2.69 (1.09)					
Experimental	105	3.12 (1.08)					
Behavioural Outcomes							
Productivity			−0.35	[-0.50, −0.08]	−2.70	231	0.007**
Control	128	3.73 (0.94)					
Experimental	105	4.02 (0.62)					
Procrastination			0.27	[0.01, 0.50]	2.04	231	0.043*
Control	128	3.07 (0.99)					
Experimental	105	2.82 (0.89)					
State Self-Control			−0.38	[-0.74, −0.14]	−2.90	231	0.004**
Control	128	3.69 (1.12)					
Experimental	105	4.13 (1.18)					
Goal Progress			−0.40	[-0.53, −0.11]	−3.04	231	0.003**
Control	128	3.52 (0.89)					
Experimental	105	3.84 (0.70)					
Cognitive Outcomes							
Mindful Attention Awareness			−0.30	[-0.52, −0.04]	−2.26	231	0.025*
Control	128	3.62 (0.98)					
Experimental	105	3.90 (0.87)					
Cognitive Failure			0.28	[0.02, 0.45]	2.16	231	0.032*
Control	128	2.71 (0.86)					
Experimental	105	2.47 (0.79)					
Implementation Intention			−0.39	[-0.48, −0.10]	−2.95	231	0.004**
Control	128	3.63 (0.82)					
Experimental	105	3.91 (0.64)					
Emotional Outcomes							
Depression			0.22	[-0.02, 0.28]	1.69	231	0.092
Control	128	2.26 (0.60)					
Experimental	105	2.13 (0.58)					
Anxiety			0.35	[0.06, 0.39]	2.67	231	0.008**
Control	128	2.66 (0.66)					
Experimental	105	2.43 (0.60)					
Stress			0.23	[-0.09, 1.33]	1.72	231	0.087
Control	128	7.87 (2.90)					
Experimental	105	7.25 (2.52)					
Life Satisfaction			−0.44	[-4.40, −1.13]	−3.34	231	<0.001***
Control	128	19.92 (6.69)					
Experimental	105	22.69 (5.77)					

Note. * Indicates statistical significance at $p < 0.05$, ** indicates $p < 0.01$, and *** indicates $p < 0.001$. Data for one participant was excluded from the Pittsburgh Sleep Quality Index PSQI (sleep quality) analysis due to an invalid response on the sleep duration item. CI refers to 95% CI of Mean Difference (Control – Experimental).

3.1.2. Behavioural outcomes

Productivity. The experimental group showed small but significantly higher productivity scores ($M = 4.02$, $SD = 0.62$) compared to the control group ($M = 3.73$, $SD = 0.94$), t (231) = −2.70, 95% CI [−0.50, −0.08], $p = 0.007$, $d = -0.35$.

Procrastination. The procrastination scores of the experimental group were significantly lower ($M = 2.82$, $SD = 0.89$) compared to the control group ($M = 3.07$, $SD = 0.99$), with a small effect size t (231) = 2.04, 95% CI [0.01, 0.50], $p = 0.043$, $d = 0.27$.

State Self-Control. State self-control was significantly higher in the experimental group ($M = 4.13$, $SD = 1.18$) compared to the control group ($M = 3.69$, $SD = 1.12$), with a small effect size t (231) = −2.90, 95% CI [−0.74, −0.14], $p = 0.004$, $d = -0.38$.

Goal Progress. Goal progress was significantly higher in the experimental group ($M = 3.84$, $SD = 0.70$) compared to the control group ($M = 3.52$, $SD = 0.89$), with a small effect size t (231) = −3.04, 95% CI [−0.53, −0.11], $p = 0.003$, $d = -0.40$.

3.1.3. Cognitive outcomes

Implementation Intention. Implementation intention was significantly higher in the experimental group ($M = 3.91$, $SD = 0.64$) compared to the control group ($M = 3.63$, $SD = 0.82$), with a small effect size t (231) = −2.95, 95% CI [−0.48, −0.10], $p = 0.004$, $d = -0.39$.

Mindful Attention Awareness. The experimental group demonstrated significantly higher mindful attention awareness ($M = 3.90$, $SD = 0.87$) compared to the control group ($M = 3.62$, $SD = 0.98$), with a small effect size t (231) = −2.26, 95% CI [−0.52, −0.04], $p = 0.025$, $d = -0.30$.

Cognitive Failure. There was a significantly lower number of cognitive failures in the experimental group ($M = 2.47$, $SD = 0.79$) compared to the control group ($M = 2.71$, $SD = 0.86$), with a small effect size t (231) = 2.16, 95% CI [0.02, 0.45], $p = 0.032$, $d = 0.28$.

3.1.4. Emotional outcomes

Life Satisfaction. There was a significantly higher level of life satisfaction in the experimental group ($M = 22.69$, $SD = 5.77$) compared to the control group ($M = 19.92$, $SD = 6.69$), with a medium effect size t (231) = −3.34, 95% CI [−4.40, −1.13], $p < 0.001$, $d = -0.44$.

Depression. The level of depression in the experimental group ($M = 2.13$, $SD = 0.58$) was not significantly lower compared to the control

group ($M = 2.26$, $SD = 0.60$), $t\,(231) = 1.69$, 95% CI [−0.02, 0.28], $p = 0.092$, $d = 0.22$.

Anxiety. The experimental group showed significantly lower levels of anxiety ($M = 2.43$, $SD = 0.60$) compared to the control group ($M = 2.66$, $SD = 0.66$), with a small effect size $t\,(231) = 2.67$, 95% CI [0.06, 0.39], $p = 0.008$, $d = 0.35$.

Stress. There was no significant difference in stress levels in the experimental group ($M = 7.25$, $SD = 2.52$) compared to the control group ($M = 7.87$, $SD = 2.90$), $t\,(231) = 1.72$, 95% CI [−0.09, 1.33], $p = 0.087$, $d = 0.23$.

Overall, the 14-Day Sleep Hygiene Intervention demonstrated significant positive effects through a significantly higher level of one's sleep quality, lower bedtime procrastination, higher self-reported physical health, lower anxiety, higher life satisfaction, higher productivity, lower procrastination, higher state self-control, higher goal progress, higher mindful attention awareness, lower frequency of cognitive failures, and higher implementation intention of the experimental group as compared to the control group. The differences between the levels of depression and stress between the experimental and control group were not statistically significant.

4. Discussion

The findings from the 14-Day Digital Sleep Hygiene Intervention bring to light several important implications for the potential feasibility and benefits of such digital, nudge-based sleep interventions on college students' sleep, behavioural, cognitive and emotional well-being. Importantly, this study helps address key gaps in the existing sleep intervention literature, specifically the challenges of adherence, accessibility, and motivational engagement, by applying nudge-based strategies to support behavioural change (Stevens, 2015; Yoong et al., 2020). The high compliance rate observed of 82.9% across the intervention group, with over three quarters of participants completing at least 70% (10 out of 14) of the daily sleep hygiene tasks, suggests that such an approach may be well suited to the demands of student life. Delivered entirely online, the intervention capitalised on a digital platform and subtle reminders to embed sleep promoting actions into participants' daily routines in a minimally disruptive way (Farias, 2012; Gipson et al., 2019). The format used appears to align with students' lifestyle and technological habits and offers a potentially scalable and low-cost complement or alternative to more resource-intensive interventions.

This study also presents several strengths. First, it employs a brief and accessible format of digital intervention tailored to the unique lifestyles of college students. Unlike traditional Cognitive Behavioural Therapy for Insomnia (CBT-I), which often faces barriers to uptake and adherence, this intervention applies nudge-based behavioural principles to subtly influence sleep behaviours without requiring intensive engagement, thereby enhancing feasibility and adherence. Second, it incorporates multiple validated outcome measures across sleep, cognitive, behavioural, and emotional domains, allowing for a holistic assessment of participant outcomes. Third, the intervention leveraged a real-time digital platform (Telegram) to deliver reminders, which aligns with the digital fluency and behavioural patterns of modern student populations. Finally, the single-blind design and incorporation of libertarian paternalism principles (e.g., autonomy-preserving choice architecture) enhance internal validity and participant engagement, making this study a valuable contribution to digital health and behavioural science literature targeting youth populations.

In interpreting these findings, it is important to consider the specific mechanisms through which the nudge-based components of the intervention may have exerted their effects. Although mediators were not directly measured, several theoretically grounded pathways likely contributed to the observed improvements. First, the intervention relied on timely reminders, delivered earlier in the day, which function as behavioural cues that counteract present bias and limited attentional resources, and its effects are well-documented in choice architecture and implementation intention research (Milkman et al., 2011; Thaler & Sunstein, 2009). These mid-day prompts may have increased participants' likelihood of preparing for the sleep task in advance, thereby reducing bedtime procrastination. Second, each daily task was simplified and pre-specified, reducing cognitive load and eliminating the friction costs associated with planning, which is another potential way in which simplification and hassle-factor reduction support behavioural follow-through (Johnson et al., 2012). Third, participants' ability to see and respond to the reactions of others on the Telegram channel may have reinforced informal descriptive social norms, which have been shown to shift behaviour by signalling what others in a peer group are doing (Goldstein et al., 2008; Schultz et al., 2007). This sense of collective participation may have fostered social motivation and accountability. Fourth, students' own reactions in the channel may have provided opportunities for commitment formation and progress feedback, both of which are empirically supported mechanisms that enhance goal pursuit and adherence (Harkin et al., 2016; Locke & Latham, 2002; Rogers et al., 2015). Finally, the overall design of the programme aligns with libertarian paternalism, as participants retained full freedom to ignore or opt out of any task; this maintenance of autonomy while gently steering their choices is a core feature of nudge-based interventions and may enhance intrinsic motivation and engagement (Thaler & Sunstein, 2003, 2009). Together, these elements offer a theoretically informed account of how the intervention's nudge components may have facilitated behavioural change, despite the absence of direct mediator measurement.

Significant differences in sleep and physical outcomes were observed between the intervention and the control group. Specifically, participants in the intervention group reported lower bedtime procrastination ($M = 3.05$, $SD = 0.80$) than the control group ($M = 3.49$, $SD = 0.80$), $t\,(231) = 4.27$, $p < 0.001$, with a medium effect size, $d = 0.55$, and sleep quality was higher in the intervention group ($M = 7.57$, $SD = 2.49$) than in the control group ($M = 8.77$, $SD = 2.62$), $t(230) = 3.55$, $p < 0.001$, with a medium effect size, $d = 0.48$. These findings align with previous research suggesting that improvements in sleep hygiene can positively impact both sleep behaviours and sleep quality (Hall & Nethery, 2019; Mastin et al., 2006; Van Dongen et al., 2012). The lower bedtime procrastination levels in the intervention group suggest that the intervention potentially helped participants establish sleep routines that are more consistent, contributing to healthier sleep patterns. Additionally, the higher sleep quality scores observed in the intervention group also seems to have effects extended beyond an improved sleep metric, with participants reporting improved perceived physical health. This highlights the broader health benefits that come with adequate sleep (Haack & Mullington, 2005; Irwin et al., 2008). These results emphasise the effectiveness of the intervention in addressing common sleep challenges faced by college students, who are known for their high prevalence of sleep deprivation and inconsistent sleep habits due to academic demands and social commitments as aforementioned (Adams et al., 2017; Hershner & Chervin, 2014; Raley et al., 2016)

The intervention was also shown to translate to better behavioural outcomes in our college student participants. The intervention group ($M = 4.02$, $SD = 0.62$) demonstrated significantly higher levels of productivity relative to the control group ($M = 3.73$, $SD = 0.94$), $t(231) = -2.70$, $p = 0.007$, $d = -0.35$. Goal progress ($M = 3.84$ vs. 3.52), $t(231) = -3.04$, $p = 0.003$, $d = -0.40$, and state self-control ($M = 4.13$ vs. 3.69), $t(231) = -2.90$, $p = 0.004$, $d = -0.38$, were also significantly higher. Conversely, procrastination levels were significantly lower in the intervention group ($M = 2.82$, $SD = 0.89$) than in the control group ($M = 3.07$, $SD = 0.99$), $t(231) = 2.04$, $p = 0.043$, $d = 0.27$. These small to moderate effects suggest that simple and accessible digital, nudge-based behavioural interventions as such can translate into tangible changes in students' everyday productivity and goal-oriented behaviours. Differences in state self-control and procrastination between the intervention and control group indicate that sleep hygiene interventions can have

important positive impacts on behaviours critical for academic success (Becker et al., 2018). Indeed, previous research has demonstrated how improved sleep hygiene is associated with improved goal commitment and goal-directed behaviours (Cheng et al., 2020; Valshtein et al., 2020). This further highlights the importance of sleep which does not only extend to better health and well-being but can also foster optimal performance in day-to-day academic tasks.

With respect to cognitive outcomes, the intervention group showed higher levels of implementation intention ($M = 3.91$ vs. 3.63), $t(231) = -2.95$, $p = 0.004$, $d = -0.39$, and mindful attention awareness ($M = 3.90$ vs. 3.62), $t(231) = -2.26$, $p = 0.025$, $d = -0.30$. Participants also reported fewer cognitive failures ($M = 2.47$ vs. 2.71), $t(231) = 2.16$, $p = 0.032$, $d = 0.28$. The higher mindful attention awareness reported in the intervention group suggests that such interventions may contribute to students' attentional capacities, enabling them to remain focused and attentive throughout their day, aligning to current research (Friedrich & Schlarb, 2018; Mak et al., 2017). The lower reported frequency of cognitive failures in the intervention group also points to a potential mechanism through which sleep interventions can positively influence academic outcomes; by minimising one's cognitive errors and any lapses in cognitive functioning. Current research suggests that sleep deprivation predominantly impairs sustained attention and working memory, with smaller but significant effects on complex cognitive tasks, highlighting that even brief periods of sleep loss may meaningfully degrade cognitive functioning (Lim & Dinges, 2010). Studies also support the role of improved sleep hygiene in enhancing cognitive control and decision-making abilities (Blake et al., 2017; Hamilton et al., 2021), demonstrating the potential cognitive benefits of such targeted sleep interventions that improve one's sleep quality.

Finally, in terms of emotional outcomes, the intervention group showed significantly lower anxiety ($M = 2.43$, $SD = 0.60$) compared to the control group ($M = 2.66$, $SD = 0.66$), $t(231) = 2.67$, $p = 0.008$, $d = 0.35$, and higher life satisfaction ($M = 22.69$ vs. 19.92), $t(231) = -3.34$, $p < 0.001$, $d = -0.44$., while showing a non-significant difference in depression and stress levels. The significantly lower levels of anxiety and higher levels of life satisfaction suggest that targeted sleep interventions can have meaningful effects on one's emotional well-being. This aligns with the growing body of evidence that supports the bidirectional relationship between sleep quality and emotional health, where day-to-day variation in sleep quality was strongly associated with emotional states, including anxiety (Cai et al., 2023; Kalmbach et al., 2017; Simor et al., 2015). Sleep deprivation was also found to affect one's emotional regulation, while emotional distress in turn disrupts one's sleep patterns and contributes to lower life satisfaction (Hall & Nethery, 2019; Kahn et al., 2013; Willroth et al., 2022). However, the non-significant differences in depression and perceived stress between the intervention and control groups may reflect the relatively stable, trait-like components of these constructs. Depression typically requires longer intervention periods to observe meaningful changes, as it involves entrenched cognitive, emotional, and behavioural patterns (Cuijpers et al., 2014). Similarly, although the Perceived Stress Scale (PSS) captures stress experiences over the past 2 weeks in our study, it also reflects relatively stable tendencies in stress appraisal that may not shift substantially over short periods (Cohen, 1988). As such, a two-week intervention may have been insufficient to induce significant improvements in these outcomes.

Beyond statistical significance, several of the observed effects represent changes that prior research suggests may be meaningful for everyday functioning. The reduction in bedtime procrastination aligns with evidence showing that even modest decreases in this behaviour are associated with better sleep quality, greater restorative sleep, and improved next-day functioning (Kroese et al., 2014; Kühnel et al., 2018). The 1.2-point difference in sleep quality exceeds the commonly referenced threshold for clinically relevant change on the Pittsburgh Sleep Quality Index, where a 1-point difference has been associated with meaningful improvements in sleep restoration and daytime alertness (Backhaus et al., 2002; Buysse et al., 1989). Small improvements in perceived physical health may also be consequential, given that improved self-report physical health has been found to predict degree completion and Grade Point Average (GPA) in student samples (Ruthig et al., 2011; Vaez & Laflamme, 2008). Similarly, the observed gains in productivity, goal progress, and self-control fall within effect size ranges linked to better academic outcomes and reduced stress (Sirois, 2014; P. Steel & Klingsieck, 2016). The difference in cognitive failures (≈ 0.24 points) may not be trivial, as changes of this magnitude are associated with fewer everyday attentional lapses and cognitive slips (Broadbent et al., 1982; Rast et al., 2009). Additionally, the medium-sized differences in anxiety and life satisfaction reflect changes that are meaningful at the subjective experience level; for instance, a 2–3-point increase on the Satisfaction With Life Scale is interpreted as a noticeable enhancement in perceived life quality (Pavot & Diener, 2008). Sleep-emotion research further shows that even small improvements in sleep quality can meaningfully reduce anxiety and emotional reactivity in daily life (Vandekerckhove & Wang, 2017). Together, these patterns suggest that even a brief, low-intensity digital intervention can yield improvements that matter for students' daily functioning, well-being, and academic performance.

Despite these positive findings, some limitations of the study should be taken note of. First, there was no follow-up conducted to see if such effects can be sustained over time. Future studies could be carried out over a longer period such as in a longitudinal study or with a follow-up a few months after intervention to see if its effects are long-lasting. Second, although validated self-reported instruments were used, all measured outcomes relied on participants' self-report, which may introduce biases such as recall inaccuracies and social desirability. Future studies could incorporate more objective measures, like actigraphy or wearable-based sleep and health tracking to provide a more comprehensive understanding of the effects of sleep interventions. Third, participants in the study were mostly made up of females (76.2%), which may limit the generalisability of findings across genders. Research shows that men and women differ in their sleep patterns and how they engage with sleep interventions. Women on average report poorer sleep quality, higher rates of insomnia and appear to be more prone to bedtime procrastination compared to men (Zeng et al., 2020; Zhou et al., 2022). Such disparities could influence how each gender responds to digital sleep nudges. Thus, designing gender-tailored approaches for future research may be beneficial (Mong & Cusmano, 2016; Zeng et al., 2020). Fourth, the intervention was framed as a "sleep challenge," which may have attracted individuals already motivated to improve their sleep or those with a competitive mindset, introducing potential self-selection or social desirability bias. Given this label, some of the improvements observed may reflect general motivation or social desirability effects rather than the efficacy of the specific intervention content. Future studies might consider examining how different framings such as "sleep program" affect enrolment, adherence, and outcomes. Further, while the adherence observed is promising, it is important to acknowledge that participants received a monetary incentive (10-dollar voucher) upon study completion, which may have contributed to the high compliance. Future studies should consider disentangling the influence of extrinsic motivators like financial incentives from intrinsic ones such as the simplicity of the task design and delivery format, to better isolate the mechanisms driving adherence. Next, while the intervention tasks were designed to be simple, accessible, and evidence-informed, it should be acknowledged that some recommendations (e.g., on blue light exposure or napping) may not fully reflect the most current sleep science. For instance, newer studies have questioned the magnitude of blue light's impact on melatonin suppression in real-world settings and have highlighted the importance of timing and intensity of light exposure (Blume et al., 2023; Höhn et al., 2024). Given the rapidly evolving sleep literature, future interventions should incorporate up-to-date empirical findings to optimise accuracy and effectiveness. Finally, because the intervention was tested only in Singapore, the findings may not generalize to other cultural or

geographical contexts. Large cross-national studies have demonstrated that cultural factors like values of individualism vs. collectivism or attitudes toward work account for significant variability in sleep patterns and quality (Park et al., 2023). Similarly, behavioural "nudge" strategies that prove effective in one cultural context may be less impactful in another, since social norms and values shape how such interventions are received (Nittas et al., 2024). For example, an online insomnia program reported that African American women had lower engagement and smaller benefits with the standard version of the program but showed significantly improved adherence and outcomes with a culturally tailored version (Zhou et al., 2022). Future research should replicate this intervention across different cultures and customize optimal digital sleep nudges suited to the target population's cultural context.

The implications of this study are extensive, particularly for college populations, where students often struggle with irregular sleep patterns, high levels of stress, and academic challenges (Beiter et al., 2015; Gomes et al., 2011; Hershner & Chervin, 2014; Lund et al., 2010). The current study demonstrated an effective and scalable digital intervention to enhance behavioural, cognitive and emotional well-being among college students. Significant differences in sleep quality, anxiety, productivity, and goal progress between the intervention and control group suggest that integrating such digital nudge-based sleep hygiene interventions into university wellness programs could be an effective and practical way to enhance students' overall well-being and academic success. The use of choice architecture and other nudge principles fostered higher adherence to and completion rates of sleep hygiene interventions potentially through promoting a sense of autonomy and enhancing one's motivation (Kadura et al., 2024; Schneider et al., 2023). Future studies can investigate and measure the mechanism through which such nudge-based interventions are effective, especially in academic settings such as universities. By targeting students' sleep, universities can help them build a foundation for better mental and physical health, holistically supporting their academic development and personal well-being.

CRediT authorship contribution statement

Tracy X. Chen: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Chi-Ying Cheng:** Writing – review & editing, Supervision. **Michelle Koay:** Writing – review & editing, Resources, Project administration. **Chin Boon Soh:** Writing – review & editing, Resources, Project administration. **Andree Hartanto:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Ethical statement

Informed consent was provided by all participants in the study and data collection was approved by the local university's Institutional Review Board [IRB-24-046-A034(324)].

Funding statement

This work was supported by funds provided by the Singapore Management University SMU Mrs Wong Kwok Leong Student Wellness Centre MWKLSWC.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank our research assistants, Ping Zhi Cheng and Lin Min, for assisting during the data collection and for the creation of Qualtrics questionnaires alongside the first author.

Data availability

Data will be made available on request.

References

Adams, S. K., Williford, D. N., Vaccaro, A., Kisler, T. S., Francis, A., & Newman, B. (2017). The young and the restless: Socializing trumps sleep, fear of missing out, and technological distractions in first-year college students. *International Journal of Adolescence and Youth, 22*(3), 337–348. https://doi.org/10.1080/02673843.2016.1181557

Alapin, I., Fichten, C. S., Libman, E., Creti, L., Bailes, S., & Wright, J. (2000). How is good and poor sleep in older adults and college students related to daytime sleepiness, fatigue, and ability to concentrate? *Journal of Psychosomatic Research, 49*(5), 381–390.

Anderson, N., Horton, A., Gibson, M., Mullins, K., & Reynolds, A. (2022). Sleep hygiene education intervention: Sleep factors and cognition in college students. *Sleep, 45*, A54–A55.

Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994). Screening for depression in well older adults: Evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *American Journal of Preventive Medicine, 10*(2), 77–84.

Backhaus, J., Junghanns, K., Broocks, A., Riemann, D., & Hohagen, F. (2002). Test–retest reliability and validity of the Pittsburgh sleep quality index in primary insomnia. *Journal of Psychosomatic Research, 53*(3), 737–740. https://doi.org/10.1016/S0022-3999(02)00330-6

Balaskas, S., Yfantidou, I., Nikolopoulos, T., & Komis, K. (2025). The psychology of EdTech nudging: Persuasion, cognitive load, and intrinsic motivation. *European Journal of Investigation in Health Psychology and Education, 15*(9), 179. https://doi.org/10.3390/ejihpe15090179

Barber, L. K., Munz, D. C., Bagsby, P. G., & Powell, E. D. (2010). Sleep consistency and sufficiency: Are both necessary for less psychological strain? *Stress and Health, 26*(3), 186–193. https://doi.org/10.1002/smi.1292

Beattie, L., Kyle, S. D., Espie, C. A., & Biello, S. M. (2015). Social interactions, emotion and sleep: A systematic review and research agenda. *Sleep Medicine Reviews, 24*, 83–100.

Becker, S. P., Jarrett, M. A., Luebbe, A. M., Garner, A. A., Burns, G. L., & Kofler, M. J. (2018). Sleep in a large, multi-university sample of college students: Sleep problem prevalence, sex differences, and mental health correlates. *Sleep Health, 4*(2), 174–181.

Becker, T. D., & Torous, J. B. (2019). Recent developments in digital mental health interventions for college and university students. *Current Treatment Options in Psychiatry, 6*, 210–220.

Beiter, R., Nash, R., McCrady, M., Rhoades, D., Linscomb, M., Clarahan, M., & Sammut, S. (2015). The prevalence and correlates of depression, anxiety, and stress in a sample of college students. *Journal of Affective Disorders, 173*, 90–96.

Benham, G. (2010). Sleep: An important factor in stress-health models. *Stress and Health, 26*(3), 204–214. https://doi.org/10.1002/smi.1304

Binks, H., Vincent, E., Gupta, C., Irwin, C., & Khalesi, S. (2020). Effects of diet on sleep: A narrative review. *Nutrients, 12*(4), 936.

Binnewies, C., Sonnentag, S., & Mojza, E. J. (2009). Daily performance at work: Feeling recovered in the morning as a predictor of day-level job performance. *Journal of Organizational Behavior, 30*(1), 67–93. https://doi.org/10.1002/job.541

Blake, M., Schwartz, O., Waloszek, J. M., Raniti, M., Simmons, J. G., Murray, G., Blake, L., Dahl, R. E., Bootzin, R., & McMakin, D. L. (2017). The SENSE study: Treatment mechanisms of a cognitive behavioral and mindfulness-based group sleep improvement intervention for at-risk adolescents. *Journal of Sleep and Sleep Disorders Research, 40*(6). zsx061.

Blume, C., Cajochen, C., Schöllhorn, I., Slawik, H. C., & Spitschan, M. (2023). Effects of calibrated blue–yellow changes in light on the human circadian clock. *Nature Human Behaviour, 8*(3), 590–605. https://doi.org/10.1038/s41562-023-01791-7

Blume, C., Niedernhuber, M., Spitschan, M., Slawik, H. C., Meyer, M. P., Bekinschtein, T. A., & Cajochen, C. (2022). Melatonin suppression does not automatically alter sleepiness, vigilance, sensory processing, or sleep. *Sleep, 45*(11). https://doi.org/10.1093/sleep/zsac199. zsac199.

Boggiss, A. L., Consedine, N. S., Brenton-Peters, J. M., Hofman, P. L., & Serlachius, A. S. (2020). A systematic review of gratitude interventions: Effects on physical health and health behaviors. *Journal of Psychosomatic Research, 135*, Article 110165.

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology, 21*(1), 1–16. https://doi.org/10.1111/j.2044-8260.1982.tb01421.x

Brown, F. C., Buboltz, W. C., & Soper, B. (2002). Relationship of sleep hygiene awareness, sleep hygiene practices, and sleep quality in university students. *Behavioral Medicine, 28*(1), 33–38. https://doi.org/10.1080/08964280209596396

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822–848.

Buboltz, W. C., Brown, F., & Soper, B. (2001). Sleep habits and patterns of college students: A preliminary study. *Journal of American College Health, 50*(3), 131–135. https://doi.org/10.1080/07448480109596017

Busch, V., Magerl, W., Kern, U., Haas, J., Hajak, G., & Eichhammer, P. (2012). The effect of deep and slow breathing on pain perception, autonomic activity, and mood processing—An experimental study. *Pain Medicine, 13*(2), 215–228.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28*(2), 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Cai, H., Guo, J., Zhou, J., & Lai, Y. (2023). Psychological resilience mediates the association between sleep quality and anxiety symptoms: A repeated measures study in college students. *PLoS One, 18*(10), Article e0292887.

Carter, B., Rees, P., Hale, L., Bhattacharjee, D., & Paradkar, M. S. (2016). Association between portable screen-based media device access or use and sleep outcomes: A systematic review and meta-analysis. *JAMA Pediatrics, 170*(12), 1202–1208.

Chaput, J.-P. (2014). Sleep patterns, diet quality and energy balance. *Physiology & Behavior, 134*, 86–91.

Chattu, V. K., Manzar, M. D., Kumary, S., Burman, D., Spence, D. W., & Pandi-Perumal, S. R. (2018). The global problem of insufficient sleep and its serious public health implications. *Healthcare, 7*(1), 1. https://www.mdpi.com/2227-9032/7/1/1.

Chellappa, S. L. (2021). Individual differences in light sensitivity affect sleep and circadian rhythms. *Sleep, 44*(2). https://doi.org/10.1093/sleep/zsaa214. zsaa214.

Chen, N. R., Majeed, N. M., Goh, A. Y., Koh, P. S., Chia, J. L., & Hartanto, A. (2024). Dispositional optimism, sleep, and trait affective mediators: A latent variable approach. *Personality and Individual Differences, 230*, Article 112801.

Cheng, S.-S., Zhang, C.-Q., & Wu, J.-Q. (2020). Mindfulness and smartphone addiction before going to sleep among college students: The mediating roles of self-control and rumination. *Clocks & Sleep, 2*(3), 354–363.

Chennaoui, M., Arnal, P. J., Sauvet, F., & Léger, D. (2015). Sleep and exercise: A reciprocal issue? *Sleep Medicine Reviews, 20*, 59–72.

Clark, M. R. (2005). Negotiating the freshman year: Challenges and strategies among first-year college students. *Journal of College Student Development, 46*(3), 296–316.

Cohen, S. (1988). *Perceived stress in a probability sample of the United States*.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*(4), 385–396.

Cuijpers, P., Karyotaki, E., Weitz, E., Andersson, G., Hollon, S. D., & Van Straten, A. (2014). The effects of psychotherapies for major depression in adults on remission, recovery and improvement: A meta-analysis. *Journal of Affective Disorders, 159*, 118–126.

Curcio, G., Ferrara, M., & De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews, 10*(5), 323–337.

De Paolis, G., Tiberio, L., & Caffaro, F. (2025). More sustainable choices in the workplace: A systematic review of nudge theory applications. *Frontiers in Psychology, 16*, Article 1556796. https://doi.org/10.3389/fpsyg.2025.1556796

Demirci, K., Akgönül, M., & Akpinar, A. (2015). Relationship of smartphone use severity with sleep quality, depression, and anxiety in university students. *Journal of Behavioral Addictions, 4*(2), 85–92.

DeSalvo, K. B., Bloser, N., Reynolds, K., He, J., & Muntner, P. (2006). Mortality prediction with a single general self-rated health question: A meta-analysis. *Journal of General Internal Medicine, 21*(3), 267–275. https://doi.org/10.1111/j.1525-1497.2005.00291.x

Diekelmann, S., & Born, J. (2010). The memory function of sleep. *Nature Reviews Neuroscience, 11*(2), 114–126.

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. *Journal of Personality Assessment, 49*(1), 71–75. https://doi.org/10.1207/s15327752jpa4901_13

Dolbier, C. L., & Rush, T. E. (2012). Efficacy of abbreviated progressive muscle relaxation in a high-stress college sample. *International Journal of Stress Management, 19*(1), 48.

Drake, C., Roehrs, T., Shambroom, J., & Roth, T. (2013). Caffeine effects on sleep taken 0, 3, or 6 hours before going to bed. *Journal of Clinical Sleep Medicine, 9*(11), 1195–1200. https://doi.org/10.5664/jcsm.3170

Dyrberg, H., Juel, A., & Kragh, M. (2021). Experience of treatment and adherence to cognitive behavioral therapy for insomnia for patients with depression: An interview study. *Behavioral Sleep Medicine, 19*(4), 481–491. https://doi.org/10.1080/15402002.2020.1788033

Emmons, R. A., & McCullough, M. E. (2003). Counting blessings versus burdens: An experimental investigation of gratitude and subjective well-being in daily life. *Journal of Personality and Social Psychology, 84*(2), 377.

Exelmans, L., & Van den Bulck, J. (2016). Bedtime mobile phone use and sleep in adults. *Social Science & Medicine, 148*, 93–101.

Farias, G. (2012). *The effects of an online sleep hygiene intervention on students' sleep quality* (Doctoral dissertation,Virginia Consortium for Professional Psychology, Old Dominion University). ProQuest Dissertations & Theses Global https://search.proquest.com/openview/3cfa7f29e2a397e85ffebeed258175e9/1?pq-origsite=gscholar&cbl=18750.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149

Filion, A. J., Darlington, G., Chaput, J.-P., Ybarra, M., & Haines, J. (2015). Examining the influence of a text message-based sleep and physical activity intervention among young adult smokers in the United States. *BMC Public Health, 15*(1), 671. https://doi.org/10.1186/s12889-015-2045-2

Finley, C. L., & Cowley, B. J. (2005). The effects of a consistent sleep schedule on time taken to achieve sleep. *Clinical Case Studies, 4*(3), 304–311. https://doi.org/10.1177/1534650103259743

Frau, R., Traccis, F., & Bortolato, M. (2019). Neurobehavioral complications of sleep deprivation: Shedding light on the emerging role of neuroactive steroids. *Journal of Neuroendocrinology, 32*(1), Article e12792.

Friedrich, A., & Schlarb, A. A. (2018). Let's talk about sleep: A systematic review of psychological interventions to improve sleep in college students. *Journal of Sleep Research, 27*(1), 4–22. https://doi.org/10.1111/jsr.12568

Fucito, L. M., DeMartini, K. S., Hanrahan, T. H., Yaggi, H. K., Heffern, C., & Redeker, N. S. (2017). Using sleep interventions to engage and treat heavy-drinking college students: A randomized pilot study. *Alcoholism: Clinical and Experimental Research, 41*(4), 798–809. https://doi.org/10.1111/acer.13342

Funder, D. C., & Ozer, D. J. (2019). Evaluating effect size in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science, 2*(2), 156–168. https://doi.org/10.1177/2515245919847202

Galambos, N. L., Dalton, A. L., & Maggs, J. L. (2009). Losing sleep over it: Daily variation in sleep quantity and quality in Canadian students' first semester of university. *Journal of Research on Adolescence, 19*(4), 741–761. https://doi.org/10.1111/j.1532-7795.2009.00618.x

Gaultney, J. F. (2016). Risk for sleep disorder measured during students' first college semester may predict institutional retention and grade point average over a 3-Year period, with indirect effects through self-efficacy. *Journal of College Student Retention: Research, Theory & Practice, 18*(3), 333–359. https://doi.org/10.1177/1521025115622784

Gipson, C. S., Chilton, J. M., Dickerson, S. S., Alfred, D., & Haas, B. K. (2019). Effects of a sleep hygiene text message intervention on sleep in college students. *Journal of American College Health, 67*(1), 32–41. https://doi.org/10.1080/07448481.2018.1462816

Goel, N., Rao, H., Durmer, J., & Dinges, D. (2009). Neurocognitive consequences of sleep deprivation. *Seminars in Neurology, 29*(4), 320–339. https://doi.org/10.1055/s-0029-1237117

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of Consumer Research, 35*(3), 472–482. https://doi.org/10.1086/586910

Goldstein, A. N., & Walker, M. P. (2014). The role of sleep in emotional brain function. *Annual Review of Clinical Psychology, 10*(1), 679–708. https://doi.org/10.1146/annurev-clinpsy-032813-153716

Gomes, A. A., Tavares, J., & De Azevedo, M. H. P. (2011). Sleep and academic performance in undergraduates: A multi-measure, multi-predictor approach. *Chronobiology International, 28*(9), 786–801. https://doi.org/10.3109/07420528.2011.606518

Guastella, A. J., & Moulds, M. L. (2007). The impact of rumination on sleep quality following a stressful life event. *Personality and Individual Differences, 42*(6), 1151–1162.

Haack, M., & Mullington, J. M. (2005). Sustained sleep restriction reduces emotional and physical well-being. *Pain, 119*(1–3), 56–64.

Hall, W. A., & Nethery, E. (2019). What does sleep hygiene have to offer children's sleep problems? *Paediatric Respiratory Reviews, 31*, 64–74.

Hamilton, K., Ng, H. T. H., Zhang, C.-Q., Phipps, D. J., & Zhang, R. (2021). Social psychological predictors of sleep hygiene behaviors in Australian and Hong Kong university students. *International Journal of Behavioral Medicine, 28*(2), 214–226. https://doi.org/10.1007/s12529-020-09859-8

Harkin, B., Webb, T. L., Chang, B. P. I., Prestwich, A., Conner, M., Kellar, I., Benn, Y., & Sheeran, P. (2016). Does monitoring goal progress promote goal attainment? A meta-analysis of the experimental evidence. *Psychological Bulletin, 142*(2), 198–229. https://doi.org/10.1037/bul0000025

Hartanto, A., Kasturiratna, K. T. A., Chua, Y. J., Ngo, J. A., Ong, J. S., Quek, F. Y., Soh, X. C., & Majeed, N. M. (2023). Does a 15-minute brief mindfulness breathing exercise temporarily enhance inhibitory control and cognitive flexibility? A within-subject experimental approach. *Collabra: Psychology, 9*(1). https://online.ucpress.edu/collabra/article/9/1/90219/197966.

Hartanto, A., Kaur, M., Kasturiratna, K. T. A. S., Quek, F. Y. X., & Majeed, N. M. (2023). A critical examination of the effectiveness of gratitude intervention on well-being outcomes: A within-person experimental daily diary approach. *The Journal of Positive Psychology, 18*(6), 942–957. https://doi.org/10.1080/17439760.2022.2154704

Hellberg, S. N., Buchholz, J. L., & Abramowitz, J. S. (2019). Insomnia and obsessive-compulsive symptom dimensions: The mediating role of anxiety and depression. *Journal of Obsessive-Compulsive and Related Disorders, 23*, Article 100482.

Hershner, S., & Chervin, R. (2014). Causes and consequences of sleepiness among college students. *Nature and Science of Sleep, 73*. https://doi.org/10.2147/NSS.S62907

Hershner, S., & O'Brien, L. M. (2018). Sleep education for college students. *Journal of Clinical Sleep Medicine, 14*(7), 1271–1272. https://doi.org/10.5664/jcsm.7248

Hindmarch, I., Rigney, U., Stanley, N., Quinlan, P., Rycroft, J., & Lane, J. (2000). A naturalistic investigation of the effects of day-long consumption of tea, coffee and water on alertness, sleep onset and sleep quality. *Psychopharmacology, 149*(3), 203–216. https://doi.org/10.1007/s002130000383

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Hillard, P. J. A., & Katz, E. S. (2015). National sleep Foundation's updated sleep duration recommendations. *Sleep Health, 1*(4), 233–243.

Ho, F. Y.-Y., Chung, K.-F., Yeung, W.-F., Ng, T. H.-Y., & Cheng, S. K.-W. (2014). Weekly brief phone support in self-help cognitive behavioral therapy for insomnia disorder: Relevance to adherence and efficacy. *Behaviour Research and Therapy, 63*, 147–156.

Höhn, C., Hahn, M. A., Gruber, G., Pletzer, B., Cajochen, C., & Hoedlmoser, K. (2024). Effects of evening smartphone use on sleep and declarative memory consolidation in Male adolescents and young adults. *Brain Communications, 6*(3). https://doi.org/10.1093/braincomms/fcae173. fcae173.

Hu, S.-P., Yang, Y.-M., Chen, W.-H., Lu, S.-S., Niu, T., Xia, Y.-Z., & Li, J.-Y. (2023). Effect of sleep ambient music on sleep quality and mental health in college students: A self-controlled study. *Frontiers in Psychology, 14*, Article 1171939.

Irwin, M. R., Olmstead, R., & Motivala, S. J. (2008). Improving sleep quality in older adults with moderate sleep complaints: A randomized controlled trial of Tai Chi Chih. *Sleep, 31*(7), 1001–1008.

Jespersen, K. V., Otto, M., Kringelbach, M., Van Someren, E., & Vuust, P. (2019). A randomized controlled trial of bedtime music for insomnia disorder. *Journal of Sleep Research, 28*(4), Article e12817. https://doi.org/10.1111/jsr.12817

Johnson, E. J., Shu, S. B., Dellaert, B. G. C., Fox, C., Goldstein, D. G., Häubl, G., Larrick, R. P., Payne, J. W., Peters, E., Schkade, D., Wansink, B., & Weber, E. U. (2012). Beyond nudges: Tools of a choice architecture. *Marketing Letters, 23*(2), 487–504. https://doi.org/10.1007/s11002-012-9186-1

Jones, K. E., Evans, R., Forbes, L., Schoenberger, Y.-M., Heaton, K., & Snyder, S. (2020). Research on freshman and sleeping habits: A text message-based sleep intervention. *Journal of American College Health, 68*(8), 864–871. https://doi.org/10.1080/07448481.2019.1626860

Kadura, S., Eisner, L., Lopa, S. H., Poulakis, A., Mesmer, H., Willnow, N., & Pigeon, W. R. (2024). Nudging towards sleep-friendly health care: A multifaceted approach on reducing unnecessary overnight interventions. *Applied Clinical Informatics, 15*(5), 1025–1039. https://doi.org/10.1055/a-2404-2344

Kahn, M., Sheppes, G., & Sadeh, A. (2013). Sleep and emotions: Bidirectional links and underlying mechanisms. *International Journal of Psychophysiology, 89*(2), 218–228.

Kalmbach, D. A., Arnedt, J. T., Swanson, L. M., Rapier, J. L., & Ciesla, J. A. (2017). Reciprocal dynamics between self-rated sleep and symptoms of depression and anxiety in young adult women: A 14-day diary study. *Sleep Medicine, 33*, 6–12.

Karam, F., Bérard, A., Sheehy, O., Huneau, M., Briggs, G., Chambers, C., Einarson, A., Johnson, D., Kao, K., Koren, G., Martin, B., Polifka, J. E., Riordan, S. H., Roth, M., Lavigne, S. V., Wolfe, L., & the OTIS Research Committee. (2012). Reliability and validity of the 4-item perceived stress scale among pregnant women: Results from the OTIS antidepressants study. *Research in Nursing & Health, 35*(4), 363–375. https://doi.org/10.1002/nur.21482

Kasturiratna, K. T. A. S., Chua, Y. J., & Hartanto, A. (2025). *A multifaceted nudge-based intervention to reduce smartphone use: Findings from a randomized cross-over trial*. Mobile Media & Communication. https://doi.org/10.1177/20501579251323246, 20501579251323246.

Killgore, W. D. (2010). Effects of sleep deprivation on cognition. *Progress in Brain Research, 185*, 105–129.

Koffel, E., Bramoweth, A. D., & Ulmer, C. S. (2018). Increasing access to and utilization of cognitive behavioral therapy for insomnia (CBT-I): A narrative review. *Journal of General Internal Medicine, 33*(6), 955–962. https://doi.org/10.1007/s11606-018-4390-1

Kredlow, M. A., Capozzoli, M. C., Hearon, B. A., Calkins, A. W., & Otto, M. W. (2015). The effects of physical activity on sleep: A meta-analytic review. *Journal of Behavioral Medicine, 38*(3), 427–449. https://doi.org/10.1007/s10865-015-9617-6

Kroese, F. M., De Ridder, D. T. D., Evers, C., & Adriaanse, M. A. (2014). Bedtime procrastination: Introducing a new area of procrastination. *Frontiers in Psychology, 5*. https://doi.org/10.3389/fpsyg.2014.00611

Kühnel, J., Syrek, C. J., & Dreher, A. (2018). Why don't you Go to bed on time? A daily diary study on the relationships between chronotype, self-control resources and the phenomenon of bedtime procrastination. *Frontiers in Psychology, 9*, 77. https://doi.org/10.3389/fpsyg.2018.00077

Lange, S., & Süß, H.-M. (2014). Measuring slips and lapses when they occur–ambulatory assessment in application to cognitive failures. *Consciousness and Cognition, 24*, 1–11.

Lemola, S., Perkinson-Gloor, N., Brand, S., Dewald-Kaufmann, J. F., & Grob, A. (2015). Adolescents' electronic media use at night, sleep disturbance, and depressive symptoms in the smartphone age. *Journal of Youth and Adolescence, 44*(2), 405–418. https://doi.org/10.1007/s10964-014-0176-x

Lessard-Deschênes, C., Pariseau-Legault, P., Billé, V., Sergerie-Richard, S., Hudson, E., Silva, B., Drouin, J.-S., Désilets, M., & Goulet, M.-H. (2025). Factors associated with perceived coercion in adults receiving psychiatric care: A scoping review. *Healthcare, 13*(15), 1868. https://doi.org/10.3390/healthcare13151868

Li, Y., Gu, S., Wang, Z., Li, H., Xu, X., Zhu, H., Deng, S., Ma, X., Feng, G., & Wang, F. (2019). Relationship between stressful life events and sleep quality: Rumination as a mediator and resilience as a moderator. *Frontiers in Psychiatry, 10*, 348.

Lim, J., & Dinges, D. F. (2010). A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin, 136*(3), 375.

Lindner, C., Lindne, M. A., & Retelsdorf, J. (2019). State self-control capacity Scale-5 items–german version. *Diagnostica*. Retrieved April 30, 2025, from https://psycnet.apa.org/doiLanding?doi=10.1037/t74180-000.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705–717. https://doi.org/10.1037/0003-066X.57.9.705

Lüdtke, O., Roberts, B. W., Trautwein, U., & Nagy, G. (2011). A random walk down university avenue: Life paths, life events, and personality trait change at the transition to university life. *Journal of Personality and Social Psychology, 101*(3), 620.

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*(2), 124–132.

Majeed, N. M., Lua, V. Y., Chong, J. S., Lew, Z., & Hartanto, A. (2021). Does bedtime music listening improve subjective sleep quality and next-morning well-being in young adults? A randomized cross-over trial. *Psychomusicology: Music, Mind, and Brain, 31*(3–4), 149.

Mak, W. W., Chio, F. H., Chan, A. T., Lui, W. W., & Wu, E. K. (2017). The efficacy of internet-based mindfulness training and cognitive-behavioral training with telephone support in the enhancement of mental health among college students and young working adults: Randomized controlled trial. *Journal of Medical Internet Research, 19*(3), Article e84.

Marques, D. R., Gomes, A. A., & Gellis, L. A. (2019). Insomnia in college students: Specificities regarding psychological treatment. *Sleep and Hypnosis (Online), 21*(3), 175–187.

Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the spielberger state—trait anxiety inventory (STAI). *British Journal of Clinical Psychology, 31*(3), 301–306. https://doi.org/10.1111/j.2044-8260.1992.tb00997.x

Mastin, D. F., Bryson, J., & Corwyn, R. (2006). Assessment of sleep hygiene using the sleep hygiene index. *Journal of Behavioral Medicine, 29*(3), 223–227. https://doi.org/10.1007/s10865-006-9047-6

McCambridge, J., De Bruin, M., & Witton, J. (2012). The effects of demand characteristics on research participant behaviours in non-laboratory settings: A systematic review. *PLoS One, 7*(6), Article e39116.

McKnight-Eily, L. R., Eaton, D. K., Lowry, R., Croft, J. B., Presley-Cantrell, L., & Perry, G. S. (2011). Relationships between hours of sleep and health-risk behaviors in US adolescent students. *Preventive Medicine, 53*(4–5), 271–273.

Means, M. K., Lichstein, K. L., Epperson, M. T., & Johnson, C. T. (2000). Relaxation therapy for insomnia: Nighttime and day time effects. *Behaviour Research and Therapy, 38*(7), 665–678.

Melanson, E. L., Ritchie, H. K., Dear, T. B., Catenacci, V., Shea, K., Connick, E., Moehlman, T. M., Stothard, E. R., Higgins, J., & McHill, A. W. (2018). Daytime bright light exposure, metabolism, and individual differences in wake and sleep energy expenditure during circadian entrainment and misalignment. *Neurobiology of Sleep and Circadian Rhythms, 4*, 49–56.

Mellor, A., Kavaliotis, E., & Drummond, S. (2021). P093 a systematic review of adherence to cognitive behavioural therapy for insomnia (CBT-I)-key findings. *Sleep Advances, 2*, Article A51.

Milkman, K. L., Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2011). Using implementation intentions prompts to enhance influenza vaccination rates. *Proceedings of the National Academy of Sciences, 108*(26), 10415–10420. https://doi.org/10.1073/pnas.1103170108

Milner, C. E., & Cote, K. A. (2009). Benefits of napping in healthy adults: Impact of nap length, time of day, age, and experience with napping. *Journal of Sleep Research, 18*(2), 272–281. https://doi.org/10.1111/j.1365-2869.2008.00718.x

Mitchell, A. M., Crane, P. A., & Kim, Y. (2008). Perceived stress in survivors of suicide: Psychometric properties of the perceived stress scale. *Research in Nursing & Health, 31*(6), 576–585. https://doi.org/10.1002/nur.20284

Mohebbi, M., Nguyen, V., McNeil, J. J., Woods, R. L., Nelson, M. R., Shah, R. C., Storey, E., Murray, A. M., Reid, C. M., & Kirpach, B. (2018). Psychometric properties of a short form of the center for epidemiologic studies depression (CES-D-10) scale for screening depressive symptoms in healthy community dwelling older adults. *General Hospital Psychiatry, 51*, 118–125.

Mollayeva, T., Thurairajah, P., Burton, K., Mollayeva, S., Shapiro, C. M., & Colantonio, A. (2016). The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep Medicine Reviews, 25*, 52–73.

Mong, J. A., & Cusmano, D. M. (2016). Sex differences in sleep: Impact of biological sex and sex steroids. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*(1688), Article 20150110. https://doi.org/10.1098/rstb.2015.0110

Muzet, A. (2007). Environmental noise, sleep and health. *Sleep Medicine Reviews, 11*(2), 135–142.

Nam, H., Chang, J., Trockel, M., Okajima, I., Yang, C.-M., Chan, N. Y., Li, S., & Suh, S. (2023). Predictors of dropout in university students participating in an 8-week e-mail-based cognitive-behavioral therapy for insomnia intervention. *Sleep and Breathing, 27*(1), 345–353.

Nittas, V., Daniore, P., Chavez, S. J., & Wray, T. B. (2024). Challenges in implementing cultural adaptations of digital health interventions. *Communication and Medicine, 4*(1), 7. https://doi.org/10.1038/s43856-023-00426-2

Olson, J. A., Sandra, D. A., Chmoulevitch, D., Raz, A., & Veissière, S. P. L. (2023). A nudge-based intervention to reduce problematic smartphone use: Randomised controlled trial. *International Journal of Mental Health and Addiction, 21*(6), 3842–3864. https://doi.org/10.1007/s11469-022-00826-w

Ong, J. C., Manber, R., Segal, Z., Xia, Y., Shapiro, S., & Wyatt, J. K. (2014). A randomized controlled trial of mindfulness meditation for chronic insomnia. *Sleep, 37*(9), 1553–1563.

Owens, H., Christian, B., & Polivka, B. (2017). Sleep behaviors in traditional-age college students: A state of the science review with implications for practice. *Journal of the American Association of Nurse Practitioners, 29*(11), 695–703.

Park, S., Zhunis, A., Constantinides, M., Aiello, L. M., Quercia, D., & Cha, M. (2023). Social dimensions impact individual sleep quantity and quality. *Scientific Reports, 13*(1), 9681. https://doi.org/10.1038/s41598-023-36762-5

Pavot, W., & Diener, E. (2008). The satisfaction with life scale and the emerging construct of life satisfaction. *The Journal of Positive Psychology, 3*(2), 137–152. https://doi.org/10.1080/17439760701756946

Pena Madeira Gouveia DeCampos, M. C. (2021). At the intersection of behavioural economics, nudging and regulation: Rethinking the process of nudge design for regulation. https://doi.org/10.48676/UNIBO/AMSDOTTORATO/9623.

Perry, G. S., Patil, S. P., & Presley-Cantrell, L. R. (2013). Raising awareness of sleep as a healthy behavior. *Preventing Chronic Disease, 10*, Article E133.

Phillips, A. J. K., Clerx, W. M., O'Brien, C. S., Sano, A., Barger, L. K., Picard, R. W., Lockley, S. W., Klerman, E. B., & Czeisler, C. A. (2017). Irregular sleep/wake patterns are associated with poorer academic performance and delayed circadian and sleep/wake timing. *Scientific Reports, 7*(1), 3216. https://doi.org/10.1038/s41598-017-03171-4

Pilcher, J. J., & Huffcutt, A. I. (1996). Effects of sleep deprivation on performance: A meta-analysis. *Sleep, 19*(4), 318–326.

Pilcher, J. J., Michalowski, K. R., & Carrigan, R. D. (2001). The prevalence of daytime napping and its relationship to nighttime sleep. *Behavioral Medicine, 27*(2), 71–76. https://doi.org/10.1080/08964280109595773

Pu, Z., Ng, A. S. C., Suh, S., Chee, M. W. L., & Massar, S. A. A. (2025). Failing to plan: Bedtime planning, bedtime procrastination, and objective sleep in university students. *Sleep Medicine, 132*, Article 106556. https://doi.org/10.1016/j.sleep.2025.106556

Quan, S. F., Ziporyn, P. S., & Czeisler, C. A. (2018). Sleep education for college students: The time is now. *Journal of Clinical Sleep Medicine, 14*(7). https://doi.org/10.5664/jcsm.7246, 1269–1269.

Raley, H., Naber, J., Cross, S., & Perlow, M. (2016). The impact of duration of sleep on academic performance in university students. *Madridge J Nurs, 1*(1), 11–18.

Ramar, K., Malhotra, R. K., Carden, K. A., Martin, J. L., Abbasi-Feinberg, F., Aurora, R. N., Kapur, V. K., Olson, E. J., Rosen, C. L., Rowley, J. A., Shelgikar, A. V., & Trotti, L. M. (2021). Sleep is essential to health: An American academy of sleep medicine position statement. *Journal of Clinical Sleep Medicine, 17*(10), 2115–2119. https://doi.org/10.5664/jcsm.9476

Rast, P., Zimprich, D., Van Boxtel, M., & Jolles, J. (2009). Factor structure and measurement invariance of the cognitive failures questionnaire across the adult life span. *Assessment, 16*(2), 145–158. https://doi.org/10.1177/1073191108324440

Rogers, T., Milkman, K. L., John, L. K., & Norton, M. I. (2015). Beyond good intentions: Prompting people to make plans improves follow-through on important tasks. *Behavioral Science & Policy, 1*(2), 33–41. https://doi.org/10.1177/237946151500100205

Rozental, A., Forsell, E., Svensson, A., Forsström, D., Andersson, G., & Carlbring, P. (2014). Psychometric evaluation of the Swedish version of the pure procrastination scale, the irrational procrastination scale, and the susceptibility to temptation scale in a clinical population. *BMC Psychology, 2*(1), 54. https://doi.org/10.1186/s40359-014-0054-z

Rusch, H. L., Rosario, M., Levison, L. M., Olivera, A., Livingston, W. S., Wu, T., & Gill, J. M. (2019). The effect of mindfulness meditation on sleep quality: A systematic review and meta-analysis of randomized controlled trials. *Annals of the New York Academy of Sciences, 1445*(1), 5–16. https://doi.org/10.1111/nyas.13996

Ruthig, J. C., Marrone, S., Hladkyj, S., & Robinson-Epp, N. (2011). Changes in college student health: Implications for academic performance. *Journal of College Student Development, 52*(3), 307–320. https://doi.org/10.1353/csd.2011.0038

Sanabria-Mazo, J. P., Gómez-Acosta, A., Annicchiarico-Lobo, J., Luciano, J. V., & Sanz, A. (2023). Psychometric properties of the perceived stress Scale-4 (PSS-4) in Colombians with university education. *medRxiv, 2023–09*.

Saruhanjan, K., Zarski, A., Bauer, T., Baumeister, H., Cuijpers, P., Spiegelhalder, K., Auerbach, R. P., Kessler, R. C., Bruffaerts, R., Karyotaki, E., Berking, M., & Ebert, D. D. (2021). Psychological interventions to improve sleep in college students: A meta-analysis of randomized controlled trials. *Journal of Sleep Research, 30*(1), Article e13097. https://doi.org/10.1111/jsr.13097

Schneider, L. D., Barakat, A., Ali, Z., Concepcion, C., Taylor, J. A., & Jiang, A. (2023). Pilot study of personalized sleep-coaching messages to promote healthy sleeping behaviors. *Frontiers in Sleep, 1*, Article 1071822.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science, 18*(5), 429–434. https://doi.org/10.1111/j.1467-9280.2007.01917.x

Sexton-Radek, K., & Hartley, A. (2013). College residential sleep environment. *Psychological Reports, 113*(3), 903–907. https://doi.org/10.2466/06.10.PR0.113x27z2

Shaw, A., & Zhang, J. J. (2021). A rasch analysis of the irrational procrastination scale (IPS). *Frontiers in Psychology, 11*, Article 615341.

Sheldon, K. M., & Lyubomirsky, S. (2006). How to increase and sustain positive emotion: The effects of expressing gratitude and visualizing best possible selves. *The Journal of Positive Psychology, 1*(2), 73–82. https://doi.org/10.1080/17439760500510676

Simor, P., Krietsch, K. N., Köteles, F., & McCrae, C. S. (2015). 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. https://doi.org/10.1007/s12529-015-9464-4

Siraji, M. A., Spitschan, M., Kalavally, V., & Haque, S. (2023). Light exposure behaviors predict mood, memory and sleep quality. *Scientific Reports, 13*(1), Article 12425.

Sirois, F. M. (2014). Procrastination and stress: Exploring the role of self-compassion. *Self and Identity, 13*(2), 128–145. https://doi.org/10.1080/15298868.2013.763404

Sonnentag, S. (2003). Recovery, work engagement, and proactive behavior: A new look at the interface between nonwork and work. *Journal of Applied Psychology, 88*(3), 518.

Spiegel, K., Knutson, K., Leproult, R., Tasali, E., & Cauter, E. V. (2005). Sleep loss: A novel risk factor for insulin resistance and type 2 diabetes. *Journal of Applied Physiology, 99*(5), 2008–2019. https://doi.org/10.1152/japplphysiol.00660.2005

St-Onge, M.-P., Mikic, A., & Pietrolungo, C. E. (2016). Effects of diet on sleep quality. *Advances in Nutrition, 7*(5), 938–949.

Steel, P. D. G. (2002). *The measurement and nature of procrastination*. University of Minnesota. https://search.proquest.com/openview/9efd03d37a2b3849bf9e5d6726c56fa4/1?pq-origsite=gscholar&cbl=18750&diss=y.

Steel, P., & Klingsieck, K. B. (2016). Academic procrastination: Psychological antecedents revisited. *Australian Psychologist, 51*(1), 36–46. https://doi.org/10.1111/ap.12173

Stevens, J. (2015). Behavioral economics strategies for promoting adherence to sleep interventions. *Sleep Medicine Reviews, 23*, 20–27.

Sunstein, C. R. (2014). *Why nudge?: The politics of libertarian paternalism*. Yale University Press. https://books.google.com/books?hl=en&lr=&id=89BpAwAAQBAJ&oi=fnd&pg=PA1&dq=Sunstein,+C.+R.+(2014).+Why+Nudge%3F:+The+Politics+of+Libertarian+Paternalism+(1st+ed.).+Yale+University+Press.&ots=By8zEjfFvY&sig=6RSXxs-xvifqfNZCqOxLjNhYQjs.

Takahashi, M. (2012). Prioritizing sleep for healthy work schedules. *Journal of Physiological Anthropology, 31*(1), 6. https://doi.org/10.1186/1880-6805-31-6

Tan, G. X., Soh, X. C., Hartanto, A., Goh, A. Y., & Majeed, N. M. (2023). Prevalence of anxiety in college and university students: An umbrella review. *Journal of Affective Disorders Reports, 14*, Article 100658.

Tavernier, R., & Adam, E. K. (2017). Text message intervention improves objective sleep hours among adolescents: The moderating role of race-ethnicity. *Sleep Health, 3*(1), 62–67.

Taylor, D. J., Clay, K. C., Bramoweth, A. D., Sethi, K., & Roane, B. M. (2011). Circadian phase preference in college students: Relationships with psychological functioning and academics. *Chronobiology International, 28*(6), 541–547. https://doi.org/10.3109/07420528.2011.580870

Taylor, D. J., Zimmerman, M. R., Gardner, C. E., Williams, J. M., Grieser, E. A., Tatum, J. I., Bramoweth, A. D., Francetich, J. M., & Ruggero, C. (2014). A pilot randomized controlled trial of the effects of cognitive-behavioral therapy for insomnia on sleep and daytime functioning in college students. *Behavior Therapy, 45*(3), 376–389.

Tempesta, D., Socci, V., De Gennaro, L., & Ferrara, M. (2018). Sleep and emotional processing. *Sleep Medicine Reviews, 40*, 183–195.

Thaler, R. H., & Sunstein, C. R. (2003). Libertarian paternalism. *The American Economic Review, 93*(2), 175–179. https://doi.org/10.1257/000282803321947001

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. Penguin.

Tluczek, A., Henriques, J. B., & Brown, R. L. (2009). Support for the reliability and validity of a six-item state anxiety scale derived from the state-trait anxiety inventory. *Journal of Nursing Measurement, 17*(1), 19.

Tsai, C.-H., Weng, S.-J., Liu, S.-C., Gotcher, D. F., Wu, H.-H., Chou, C.-A., & Kim, S.-H. (2019). A preliminary study of fluid intake before bedtime and insomnia symptoms. *Sleep and Biological Rhythms, 17*(2), 251–258. https://doi.org/10.1007/s41105-019-00206-3

Tsai, H.-J., Yang, A. C., Zhu, J.-D., Hsu, Y.-Y., Hsu, T.-F., & Tsai, S.-J. (2022). Effectiveness of digital cognitive behavioral therapy for insomnia in young people: Preliminary findings from systematic review and meta-analysis. *Journal of Personalized Medicine, 12*(3), 481.

Tubbs, A. S., Khader, W., Fernandez, F., & Grandner, M. A. (2020). The common denominators of sleep, obesity, and psychopathology. *Current Opinion in Psychology, 34*, 84–88.

Vaez, M., & Laflamme, L. (2008). Experienced stress, psychological symptoms, self-rated health and academic achievement: A longitudinal study of Swedish university students. *Social Behavior and Personality: An International Journal, 36*(2), 183–196. https://doi.org/10.2224/sbp.2008.36.2.183

Vail-Smith, K., Felts, W. M., & Becker, C. (2009). Relationship between sleep quality and health risk behaviors in undergraduate college students. *College Student Journal, 43*(3), 924–931.

Valshtein, T. J., Oettingen, G., & Gollwitzer, P. M. (2020). Using mental contrasting with implementation intentions to reduce bedtime procrastination: Two randomised trials. *Psychology and Health, 35*(3), 275–301. https://doi.org/10.1080/08870446.2019.1652753

van der Bij, A. K., de Weerd, S., Cikot, R. J., Steegers, E. A., & Braspenning, J. C. (2003). Validation of the Dutch short form of the state scale of the spielberger state-trait anxiety inventory: Considerations for usage in screening outcomes. *Community Genetics, 6*(2), 84–87.

Van Dongen, H. P., Bender, A. M., & Dinges, D. F. (2012). Systematic individual differences in sleep homeostatic and circadian rhythm contributions to neurobehavioral impairment during sleep deprivation. *Accident Analysis & Prevention, 45*, 11–16.

Vandekerckhove, M., & Wang, Y. (2017). Emotion, emotion regulation and sleep: An intimate relationship. *AIMS Neuroscience, 5*(1), 1.

Walker, M. P., & van Der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. *Psychological Bulletin, 135*(5), 731.

White, M. P., Pahl, S., Wheeler, B. W., Depledge, M. H., & Fleming, L. E. (2017). Natural environments and subjective wellbeing: Different types of exposure are associated with different aspects of wellbeing. *Health & Place, 45*, 77–84.

Willroth, E. C., Gatchpazian, A., Thai, S., Lassetter, B., Feinberg, M., & Ford, B. Q. (2022). The insulating function of sleep for well-being: Daily sleep quality attenuates the link between current affect and global life satisfaction. *Affective Science, 3*(2), 318–329. https://doi.org/10.1007/s42761-021-00092-4

Wood, A. M., Joseph, S., Lloyd, J., & Atkins, S. (2009). Gratitude influences sleep through the mechanism of pre-sleep cognitions. *Journal of Psychosomatic Research, 66*(1), 43–48.

Ye, L., Hutton Johnson, S., Keane, K., Manasia, M., & Gregas, M. (2015). Napping in college students and its relationship with nighttime sleep. *Journal of American College Health, 63*(2), 88–97. https://doi.org/10.1080/07448481.2014.983926

Yoong, S. L., Hall, A., Stacey, F., Grady, A., Sutherland, R., Wyse, R., Anderson, A., Nathan, N., & Wolfenden, L. (2020). Nudge strategies to improve healthcare providers' implementation of evidence-based guidelines, policies and practices: A systematic review of trials included within cochrane systematic reviews. *Implementation Science, 15*(1), 50. https://doi.org/10.1186/s13012-020-01011-0

Zeng, L.-N., Zong, Q.-Q., Yang, Y., Zhang, L., Xiang, Y.-F., Ng, C. H., Chen, L.-G., & Xiang, Y.-T. (2020). Gender difference in the prevalence of insomnia: A meta-analysis of observational studies. *Frontiers in Psychiatry, 11*, Article 577429. https://doi.org/10.3389/fpsyt.2020.577429

Zhai, K., Gao, X., & Wang, G. (2018). The role of sleep quality in the psychological well-being of final year undergraduate students in China. *International Journal of Environmental Research and Public Health, 15*(12), 2881.

Zhang, M. X., & Wu, A. M. S. (2020). Effects of smartphone addiction on sleep quality among Chinese university students: The mediating role of self-regulation and bedtime procrastination. *Addictive Behaviors, 111*, Article 106552. https://doi.org/10.1016/j.addbeh.2020.106552

Zhou, E. S., Ritterband, L. M., Bethea, T. N., Robles, Y. P., Heeren, T. C., & Rosenberg, L. (2022). Effect of culturally tailored, internet-delivered cognitive behavioral therapy for insomnia in black women: A randomized clinical trial. *JAMA Psychiatry, 79*(6), 538. https://doi.org/10.1001/jamapsychiatry.2022.0653

Zimmerman, M. R. (2011). *A randomized clinical trial of cognitive-behavioral therapy for insomnia in a college student population*. University of North Texas. https://search.proquest.com/openview/f2bb520ea9cb2afd061cfd9527a1629d/1?pq-origsite=gscholar&cbl=18750.

Zoccola, P. M., Dickerson, S. S., & Lam, S. (2009). Rumination predicts longer sleep onset latency after an acute psychosocial stressor. *Biopsychosocial Science and Medicine, 71*(7), 771–775.