Effectiveness of digitally delivered sleep interventions on sleep and mental health outcomes in postsecondary students: A systematic review

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Abstract

Introduction/Background: Students pursuing postsecondary education are a population at significant risk for both sleep problems and poor mental health outcomes such as depression and anxiety. Interventions such as sleep hygiene education and cognitive behavioural therapy (CBT) are commonly used treatments for sleep problems and have been effective in improving sleep and mental health in the university student population. Digitally-delivered CBT has also shown to be effective in improving sleep in youth, however it has not been evaluated in the postsecondary student population.

Objectives: The purpose of this systematic review was to critically appraise and synthesize the quantitative and qualitative evidence on the effectiveness and user experiences of digital sleep interventions to improve sleep and mental health outcomes in postsecondary students.

Method and analysis: We searched MEDLINE, CINAHL, Embase, and APA PsycInfo for studies published from 2000. We aimed to include randomized controlled trials (RCTs), cohort studies, case-control studies, qualitative studies, and mixed methods studies. We conducted paired screening of citations in two phases. We assessed risk of bias using established critical appraisal tools and extracted data pertaining to study characteristics, sleep and mental health outcomes, and methodological quality. We aimed to use a sequential approach at the review level to synthesize and integrate data across qualitative and quantitative research studies.

Results: We screened 5361 titles and abstracts in phase I and 58 full text articles were screened in phase II. Nine articles (representing 10 original studies) were found to be relevant and were critically appraised. Four studies investigated the effects of CBT (either combined or single techniques) and six assessed the effectiveness of digital sleep hygiene education. One study focused on the impact of relaxation music on sleep outcomes. Most studies (9/10) were found to have high risk of bias. Common sources of bias included unclear methods of randomization and allocation concealment, lack of similarity between groups at baseline, high attrition, and lack of valid and reliable methods of outcome assessment. Given the methodological limitations of the included studies, we are unable to conclude on the effectiveness of digital sleep interventions for postsecondary students compared to other interventions. We did not find any qualitative studies and therefore are unable to integrate findings on the experiences, views, expectations and beliefs of students and providers.

Conclusion: The COVID-19 pandemic continues to shape the delivery of mental health services to vulnerable populations including postsecondary students. It has become increasingly important to identify effective means of digitally delivering much needed services to those who need it most. While methodological limitations preclude firm conclusions, our review highlights the need for further investigation into effective digital alternatives for delivering sleep interventions to improve sleep and mental health outcomes in postsecondary students. Furthermore, qualitative studies exploring the views and preferences of students and providers are required to inform the development of novel interventions that are acceptable in this population.

OSF (Open Science Framework): https://osf.io/td3pc

Key words: systematic review, sleep, postsecondary student, interventions, mental health

Introduction

Healthy sleep is a critical component for overall health and wellbeing and has been deemed an important behaviour to improve public health[1]. Healthy sleep is comprised of many dimensions including sleep timing, adequate sleep duration and good sleep quality. Seven to nine hours of sleep per night is recommended for young adults[2], yet a considerably large proportion of the population does not meet these guidelines, sleeping either less than seven or more than nine hours per night[3]. Sleep problems, including disrupted sleep, are increasingly recognized as a risk factor for many mental health problems[4,5]. There is growing recognition and concern that students pursuing postsecondary education are a

population at significant risk for both sleep problems and poor mental health[6,7] including suicidal ideation, depression, and anxiety[8-13]. Many university students have poor sleep (i.e., insomnia symptoms of difficulty initiating or maintaining sleep, early morning awakening, or non-restorative sleep at any given time), and sleep disturbances[14] with about 60% who report suffering from poor sleep quality[15]. The unhealthy sleep reported in university students is associated with substantial distress and psychiatric morbidity[16,17]. Students reporting chronic insomnia, report significantly more fatigue, depression, anxiety, stress and stimulant use than students without insomnia[18]. Furthermore, those with poor sleep quality also reported delayed bed- and risetimes during the weekend, more anger, confusion, depression, fatigue and tension, more physical illness, daytime sleepiness, as well as more drug and alcohol consumption compared to good quality sleepers[15]. Furthermore, the dimension of circadian typology of circadian preference has also been associated with psychological symptoms such as depression and anxiety within the postsecondary population[19].

Non-pharmacological interventions such as sleep hygiene education and cognitive behavioural therapy (CBT) are common first line treatment options for sleep problems[20,21]. CBT is effective and has been demonstrated to be superior to any single-component treatment such as stimulus control, relaxation training, and educational programs in the general population [20], the university student population[22], and in adults without sleep disorders[23]. CBT for insomnia (CBT-I) has been established as an effective treatment for primary insomnia in adults when delivered in person[24,25], over the telephone[26], as a self-help intervention mailed weekly to participants[27], or internet-delivered[28]. Furthermore, digitally-delivered CBT for insomnia has also been shown to be effective in improving sleep in youth[29]. However, this has not been adequately evaluated in the postsecondary population; although a feasibility study reports CBT delivered by e-mail to college students may improve sleep and reduce depressive symptoms[30]. Digital mental health interventions delivered to college students have demonstrated moderate effectiveness in improving depression, anxiety, and psychological well-being, and usability and acceptability outcomes were generally favorable[31]. Digital sleep intervention delivery, such as those delivered via mobile- and Web-based platforms, may be an attractive feature and a good fit with the culture of the postsecondary student population. Such interventions may widen the accessibility and circumvent many existing barriers to receiving traditional services.

Given the current global pandemic of COVID-19, postsecondary students may face additional challenges with their sleep and mental health[32,33]. As a result of the physical distancing measures put in place and closures of many industries leading to significant disruptions in their academic endeavours, pre-existing sleep problems are exacerbated, which in turn amplifies mental health outcomes such as anxiety and depressive symptomatology. Symptoms of anxiety, depression and stress have increased during this pandemic and are associated with sleep problems[34]. Furthermore, in-person mental health resources provided by postsecondary institutions to students have closed. In an effort to address this gap, some institutions have moved to providing care through a virtual platform, or tele-health services. However, the effectiveness of delivering sleep interventions in a digital format to the postsecondary population is unknown. Also, we lack understanding of the end user's (i.e., student, provider) experience, perspectives, attitudes and beliefs surrounding digital delivery of sleep interventions. Given this paucity of information – especially in a climate that may be forced to embrace virtual care options for service delivery in perpetuity as we slowly enter a 'new normal', we propose a systematic review of the literature to synthesize the best available evidence on the effectiveness of non-pharmacological sleep interventions delivered digitally. While we will examine interventions that target sleep specifically, we know that healthy sleep is critical for overall mental health and is also a symptom of many mental illnesses. Therefore, we will also report on mental health outcomes if reported.

Objectives

We aimed to systematically search, critically appraise and synthesize the quantitative and qualitative evidence on the effectiveness and user experiences of digitally delivered sleep interventions to improve sleep and mental health outcomes in postsecondary students. Our specific questions were:

1) What is the effectiveness of sleep interventions delivered digitally for improving sleep and mental health outcomes in postsecondary students?
2) What are the students' and/or providers' experiences, views, expectations and beliefs of sleep interventions delivered digitally?
3) What can be hypothesized from the integration of the quantitative and qualitative evidence about the effectiveness of sleep interventions delivered digitally to postsecondary students?

Knowledge gained from this study will inform university policy makers and mental health providers in delivering and planning interventions virtually.

Methods

We registered our systematic review with OSF (Open Science Framework; Registration available publicly at: https://osf.io/td3pc). We conducted and reported our systematic review according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[35].

Eligibility Criteria

Population

We targeted studies including postsecondary students of any age. We did not include age range limitations, as age of entry may vary between countries or programs. The term 'postsecondary' may refer to college, university, professional programs, technical schools (e.g., apprenticeship or trades certificate). All studies were included regardless of whether the study investigated students with healthy sleep, sleep disturbance or impaired or disordered sleep (with the exception of breathing-related sleep disorders).

Intervention

Our review included studies that investigated the effectiveness of non-pharmacological interventions aimed at improving sleep outcomes in the postsecondary student population including but not limited to: i) sleep education (e.g., sleep hygiene education or psychoeducation); ii) cognitive-behavioural therapy (CBT) or elements of CBT (e.g., stimulus control; sleep restriction); iii) relaxation and mindfulness (e.g., music therapy, progressive muscle relaxation); iv) multi-modal interventions (e.g., sleep education and relaxation techniques). To be included, sleep interventions had to be digitally delivered. Digitally delivered interventions are defined as those that use digital technology to support behaviour change. We included digital interventions that were delivered in a synchronous or asynchronous manner. Synchronous digital interventions involve a two-way flow of information and require real-time interaction between the patient and provider (e.g., videoconferencing, live chat, voice call)[36]. An asynchronous digital intervention involves a one-way flow of information and does not require real-time interaction between the patient and provider (e.g., email, mobile messaging, smart device applications, web-based platforms). Some behavioral interventions may have targeted multiple behaviours such as sleep, physical activity, and diet. In those instances, only the information relevant to a digitally delivered sleep intervention was included. The interventions were not restricted to a specific dose, frequency, intensity, duration or trainer qualification, but were recorded.

Comparison Groups

Studies comparing a sleep intervention to other non-pharmacological or pharmacological interventions, placebo or sham interventions, wait list, or no intervention were considered.

Outcomes

The quantitative component of this review includes studies that evaluated at least one sleep outcome (e.g., sleep knowledge, sleep habits, sleep hygiene, sleep duration, sleep onset latency, sleep quality, sleep efficiency). Sleep outcomes collected through self-report measures (e.g., Pittsburgh Sleep Quality Index, Insomnia Severity Index), or through objective measures (e.g., actigraphy) were included. Given that sleep and mental health are strongly associated, we also collected mental health outcomes if reported (e.g., depressive symptomatology, anxiety).

Study Design

For the quantitative component of this systematic review, we included randomized controlled studies (minimum 30 participants per arm at baseline), cohort studies and case-control studies (minimum 100 participants per exposed group). For the qualitative component, we aimed to include qualitative studies exploring user experiences of sleep interventions delivered virtually (e.g., phenomenology, grounded theory, ethnography, action research and descriptive qualitative studies). Mixed methods studies were only considered if data from the quantitative or qualitative components could be clearly extracted.

Exclusion Criteria

We excluded studies of participants with breathing-related sleep disorders (e.g., obstructive sleep apnea [OSA]) given that such disorders cannot be treated solely with non-pharmacological psychological interventions. Studies that did not investigate the effect of a specific intervention but focused on correlations or incidence/prevalence rates were also excluded. Study designs such as pilot studies assessing feasibility, protocol studies, cross-sectional studies, case reports, case series, systematic reviews and other review papers, clinical practice guidelines, cadaveric or animal studies and conceptual papers were excluded. Finally, publication types including letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, books and book chapters, conference proceedings, meeting abstracts, lectures and addresses, consensus development statements and guideline statements were also excluded.

Search Strategy

We developed the search strategy in collaboration with a health sciences librarian. A second librarian reviewed the search strategy using the Peer Review Electronic Search Strategy (PRESS) checklist[37,38]. We conducted an electronic search of the following databases from 2000 to present: MEDLINE (Ovid), Embase (Ovid), PsycINFO (Ovid), and CINAHL (Cumulative Index to Nursing and Allied Health Literature, EBSCO*host*). The searches included a combination of subject headings specific to each database (e.g., MeSH in MEDLINE) and free text words to capture interventions directed at sleep. We also searched the reference lists of all eligible articles for additional relevant studies. We did not limit studies by language.

Study Records

Data Management

Electronic search results were downloaded into Endnote X9 reference manager software (Clarivate Analytics, Philadelphia, Pennsylvania, USA). We removed duplicates and the remaining references were uploaded to the Evidence for Policy and Practice Information (EPPI) and Coordinating Centre Reviewer software for the screening, appraisal, and data extraction stages (EPPI-Reviewer V.4, UCL Institute of Education, University of London, UK). EPPI-Reviewer software store references, manages and monitors the data extraction process and provides an audit trail for the review.

Selection Process

Pairs of trained, independent reviewers screened articles in two phases to determine eligibility. In phase I, paired reviewers screened titles and abstracts to determine possibly relevant and irrelevant citations based on the inclusion and exclusion criteria. In phase II, paired reviewers screened possibly relevant citations from phase I using the full-text article to determine eligibility. Any disagreements were resolved by discussion between the paired reviewers to reach consensus. If consensus could not be reached, a third reviewer independently appraised the article and discussed it with the other two reviewers to reach consensus. We conducted training exercises prior to initiating the screening process to ensure high inter-rater reliability. Prior to screening, three experienced reviewers piloted the screening criteria using a random selection of titles and abstracts. Once we reached an agreement of >90%, we moved ahead with phase I screening. Review members met often to discuss progress and any unanticipated problems.

Quality Assessment

Pairs of trained, independent reviewers critically appraised all relevant studies using the Scottish Intercollegiate Guidelines Network (SIGN) criteria for randomized controlled trials and cohort studies[39]. The SIGN criteria were used to determine the studies' internal validity (i.e., to evaluate the presence and impact of selection bias, information bias, and confounding on study results). If necessary, study authors were contacted for additional information needed to complete the critical appraisal. Reviewers reached consensus through discussion. An independent third reviewer was used to resolve disagreements if consensus could not be reached. Critical appraisal resulted in studies being deemed low risk of bias, 'some concerns', or high risk of bias. Risk of bias tables were constructed to summarize the methodological strengths and weaknesses of all relevant studies.

Data extraction and synthesis of results

One reviewer extracted data from all relevant studies into EPPI-Reviewer, which was used to build an evidence table. A second reviewer checked the data for accuracy. We aimed to extract data on the difference in mean change between groups and/or effect sizes for each comparison. Where these findings could not be extracted, individual group means and standard deviations were used to calculate difference in mean change with 95% confidence intervals. Due to heterogeneity of relevant studies with respect to study intervention type and outcome measures, a meta-analysis was not performed. We used the Synthesis without Meta-Analysis (SWiM) guidelines to report our findings. Our synthesis was stratified according to intervention type.

Results

We searched all electronic databases from 2000 to July 3, 2020 and screened 5361 records. Ten studies reported in nine publications[40-48] were critically appraised (Figure 1)[40,41,44]. Of the ten relevant studies, all assessed the effectiveness of digital sleep interventions on sleep and mental health outcomes in postsecondary students. We did not find any qualitative studies exploring the experiences, views, expectations or beliefs of students or providers regarding the digital delivery of sleep interventions.

Characteristics of included studies

The included studies used an RCT or cohort study design. Relevant studies were conducted in Australia (AUS)[44,48], the United Kingdom (UK)[40] and the United States (US)[41-43,45-47]. Four of the ten included studies recruited university students enrolled in general psychology courses[42,45,47]; the remaining studies recruited students from varied academic programs. Just one study included post-graduate students in their sample[40]. The mean age of participants ranged from 20 to 25[40-44,46,48]; three studies did not report the mean age of their sample[45,47]. The majority of study participants were female (range 56% to 89%).

Of the six studies reporting on ethnicity, five recruited samples that included mostly Caucasian students (range 57% to 86%). One study recruited a study sample that was 51% Asian[40-44,46]. Most studies recruited healthy students, with no specific mention of the presence or absence of sleep or mental health disorders[41-46]. Gipson et al. specifically excluded those with a medical diagnosis of a primary sleep disorder[43]. Oxtoby et al. recruited just one participant with a sleep disorder[48]; however 12% reported taking sleep medication. In the studies by Valshtein et al., 4.4% and 13.5% of participants were currently being treated for a sleep disorder or worked a night shift. Freeman et al. only recruited participants who screened positive for insomnia; 5% had received a previous diagnosis of a sleep disorder[44]. Furthermore, in this study, 33% of participants reported a psychiatric diagnosis.

Full descriptions of all interventions are provided in Table 1. Four studies investigated the effects of CBT (either combined or single techniques)[40,44,47] and six assessed the effectiveness of digital sleep hygiene education[41-43,45-47]. One study focused on the impact of relaxation music on sleep outcomes[48]. The digital method of delivery was asynchronous in all but one of the included studies; seven studies utilized a web-based method of delivery (e.g., interactive websites, online instructional sessions)[40-42,44,45,47], one study provided downloadable digital content via email[48] and one study utilized text messaging[43]. One study assessed the impact of synchronous online chats on the effectiveness of an online video about sleep hygiene[46].

All included studies assessed subjective and/or objective measures of sleep (e.g., questionnaires such as the Pittsburgh Sleep Quality index or the Insomnia Severity Index, sleep diaries, actigraphy). Three studies reported on mental health outcomes[40,41,48]. Follow-up duration was immediate[43,48] or short-term (less than 8 weeks)[41,42,44,47] in most studies. Two studies utilized a longer follow-up period; Freeman et al. followed participants for 22 weeks post-intervention and Quan et al. followed up with participants at the end of the semester.

Risk of bias

Full details of our risk of bias assessment for all relevant studies are outlined in Tables 2 and 3. All included studies had at least 'some concerns' with respect to risk of bias.

One RCT had a high drop-out in both study arms, leading to an overall risk of bias rating of 'some concerns'[41]. Eight RCTs were rated as high risk of bias due to the following limitations: 1) unclear randomization procedures[42,48]; 2) did not report on allocation concealment methods or did not appear to conceal allocation[42,44,46,47]; 3) blinding of participants and/or treatment providers was not possible[40,42,43,48] or the extent of blinding was unclear[47]; 4) did not report on similarity of groups at baseline[42,43,46-48]; 5) did not use valid and/or reliable methods of outcome assessment[46,47]; 6) did not report on proportions of those lost to follow-up within each group[42] or reported a high drop-out that was different between groups[40,44,46,48]; and 7) did not use an ITT analysis[43,46-48].

One cohort study had a high risk of bias due to the following[45]: 1) selection bias (lack of similarity between groups at baseline; 2) attrition bias (high drop out without a comparison between full participants and those lost to follow-up by exposure status); 3) detection bias (validity and reliability of outcome assessment); and 4) confounding factors (no consideration for confounding factors).

We contacted the authors of six RCTs[42-44,47,48] for additional information required to assess risk of bias. Three authors responded[43,44,47].

Synthesis of Evidence

We found a total of 10 studies (in 9 publications) that reported on the effectiveness of a digitally delivered sleep intervention for improvement in sleep and mental health outcomes (Table 1). We synthesized the results based on three groupings of sleep interventions: 1) digital CBT or elements of CBT[40,44,47]; 2) digital sleep education[41-43,45-47] and 3) music listening[48].

Digital Cognitive Behavioural Therapy (CBT)

Freeman et al. assessed whether reducing insomnia (using CBT-I) would also improve mental health outcomes in UK college students[40]. Postsecondary students screening positive for insomnia (n=3755) were randomized to web-based CBT-I (combination of behavioural techniques, cognitive techniques and educational components) (n=1891, mean age 24.8, SD 7.7) or usual care (n=1864, mean age 24.6, SD 7.6). Compared to usual care, online CBT-I was associated with greater improvements in insomnia, paranoia, and hallucinations at 10 weeks (difference in mean change Sleep Condition Indictor [SCI-8]: -5.0 (95% CI -5.2; -4.6); Green et al. Paranoid Thoughts Scale [GPTS]: 3.4 (95% CI 2.9; 3.9); Specific Psychotic Experiences Questionnaire [SPEQ]: 1.8 (95% CI 1.5; 2.0)] and 22 weeks [difference in mean change SCI-8: -5.0 (95% CI -5.2; -4.7); GPTS: 3.7 (95% CI 3.2; 4.2); SPEQ: 1.8 (95% CI 1.6; 2.1)] post-randomization. Participants receiving online CBT-I also experienced significantly greater improvements in insomnia severity, nightmare severity, psychotic symptoms, depression, anxiety, function and psychological well-being at 10- and 22-weeks post-intervention (Table 3). At 10 and 22 weeks post-intervention, participants randomized to CBT-I were less likely to be categorized as being at ultra-high risk of psychosis [10 weeks: adjusted OR 0.26 (95% CI 0.15; 0.46); 22 weeks: adjusted OR 0.33 (95% CI 0.18; 0.59)] and satisfy cut-off scores for depressive disorder [10 weeks: adjusted OR 0.21 (95% CI 0.14; 0.32); 22 weeks: adjusted OR 0.32 (95% CI 0.21; 0.48)] and anxiety disorder [10 weeks: adjusted OR 0.32 (95% CI 0.21; 0.48); 22 weeks: adjusted OR 0.42 (95% CI 0.27; 0.64)]. Usual care was associated with greater improvements in symptoms of mania at 10 weeks [difference in mean change Altman Self-Rating Mania Scale (ASRM): -0.73 (95% CI -0.9; -0.6)] and 22 weeks [difference in mean change ASRM: -0.7 (95% CI -0.8; -0.5)] post-intervention. Participants receiving CBT-I were more likely to be categorized with a high probability of a manic or hypomanic condition at both follow-up points [10 weeks: adjusted OR 2.01 (95% CI 1.48; 2.73); 22 weeks: adjusted OR 1.89 (95% CI 1.34; 2.66)]. There was no significant difference between groups with respect to consulting mental health services, receiving a mental health diagnosis, taking psychiatric medication, or receiving psychological therapy. Due to the high attrition, particularly in the CBT-I group, study results may have been biased in favour of the CBT-Intervention. Furthermore, treatment uptake in the intervention group was very low (51% of participants did not receive a single session), which further brings into question the overall confidence in the study results.

Mairs and Mullen assessed the impact of an online implementation intentions exercise on sleep hygiene behaviours, sleep quality and insomnia symptoms in postsecondary students[44]. Implementation intentions is a behaviour change technique often provided as part of CBT in which individuals plan ahead for an action they will take to help them reach their goals. In this study, all students were encouraged to improve four areas of sleep hygiene: making the sleep environment restful, avoiding going to bed hungry or thirsty, avoiding stress and anxiety-provoking activities before bed, and avoiding caffeine within eight hours of bedtime. Participants were randomly assigned to receive: 1) online implementation intentions exercise; or 2) self-monitoring with a daily online sleep diary. Two weeks post-intervention, participants randomized to implementation intentions experienced slightly greater improvements in the number of days in the past two weeks they avoided going to bed hungry or thirsty [difference in mean change: -0.9 (95% CI -1.7; 0)] and in the number of days they avoided stress and anxiety-provoking activities before bed [difference in mean change: -1.5 (95% CI -2.3; -0.6)]. There were no significant differences between groups in other sleep behaviours (making the sleep environment restful, avoiding caffeine within eight hours of bedtime). The online implementation intentions exercise was also associated with significantly greater improvement in sleep quality [difference in mean change in Pittsburgh Sleep Quality Index (PSQI): 0.8 (95% CI 0.1; 1.2)] but not insomnia severity (Table 3). Although statistically significant, differences between groups were very small. This study also reported high attrition in the self-monitoring group which may have biased the study results in favour of the self-monitoring intervention as it is likely participants dropped out due to low acceptability of the intervention related to the daily commitment of keeping a diary. Therefore, our overall confidence in these findings is guarded due to a potential for bias.

Valshtein et al. performed two separate RCTs looking at the effectiveness of Mental Contrasting and Implementation Intentions (MCII)[47]. Mental contrasting is a self-regulation strategy that helps individuals identify goals and inner obstacles to achieving those goals. When paired together, MCII facilitates goal pursuit and goal implementation. In both studies, participants were encouraged to focus on the goal of getting to bed on time. In Study 1, postsecondary students (n=476) were randomized to one of two online interventions: 1) MCII (n=237); or 2) Positive Thinking (n=239). MCII was associated with a greater mean change in bedtime discrepancy (mean change in the difference between planned and actual bed time in minutes – MCII: 32.94; Positive Thinking: 14.10; p=0.001) three weeks following the intervention. In Study 2, postsecondary students from the same sample population were randomized (n=221) to one of two online interventions: 1) MCII (n=109); or 2) Online Sleep Hygiene Education (n=112). In the week following the intervention, participants randomized to MCII reported significantly lower daily subjective bedtime discrepancy scores (95% CI for difference between groups: -59.79; -15.92) and significantly greater commitment to reduce bedtime procrastination (95% CI for difference between groups 0.11; 0.72) than those randomized to online sleep hygiene education. Unclear methods of allocation concealment, lack of comparison between groups at baseline, and concerns regarding reliability and validity of selected outcome measures contributed to high risk of bias in these study findings. Furthermore, methods of reporting make it difficult to compare groups and interpret statistical and clinical importance.

Given the methodological limitations of the included studies, we are unable to conclude on the effectiveness of CBT compared to other interventions. Although findings suggest that CBT is associated with statistically significant improvements in sleep and mental health outcomes in postsecondary students, it is likely that these findings contain bias and are therefore misleading. The high attrition rates bring into question the acceptability of the intervention within this specific population.

Digital Sleep Education

Hershner and O'Brien assessed the effect of a sleep education website on sleep knowledge and behaviours of US postsecondary students to a no intervention control group[41]. The online sleep education module was delivered in a single 20-minute session using a combination of videos and written content. Content was individualized based on the participants' sleep personality profile. At 8 weeks post-intervention, students randomized to online sleep education experienced greater improvements in sleep quality [difference in mean change in Pittsburgh Sleep Quality Index (PSQI): -1.09 (95% CI -1.65; -0.51)], sleep knowledge [difference in mean change: 0.88 (95% CI 0.31; 1.55)], sleep hygiene behaviours [difference in mean change on Sleep Hygiene Index (SHI): -2.10 (95% CI -3.34; -1.00)], and depression [difference in mean change on Patient Health Questionnaire (PHQ-9): -1.6 (95% CI -2.67; -0.29)]. There were no statistically significant differences between groups for mean change in sleepiness or general health (Table 3). At 8 weeks, students in the online education group were more likely than the control group to self-report earlier wake times [adjusted OR 2.40 (95% CI 1.30; 4.40] and less napping [adjusted OR 2.10 (9%% CI 1.10; 4.10)]; however, there were no differences in other self-reported sleep behaviours. Attrition was very high in both the intervention and control group, which again diminishes our overall confidence in these findings due to risk of bias.

Barber and Cucalon explored the effectiveness of a sleep education program specifically addressing technology use around bedtime on objective and subjective sleep outcomes[42]. Postsecondary students were randomized to receive either a 22-minute automated slide presentation on sleep hygiene behaviours with specific tips on avoiding sleep-disruptive technology use (STEPS-TECH) (n=43) or no intervention (n=35). Compared to no intervention, students randomized to STEPS-TECH had more total hours of sleep (Cohen's d = 0.50), fewer awakenings (Cohen's d = 0.45), and reported less technology use during sleep (Cohen's d = 0.47) one-week post-intervention. There were no statistically significant differences in sleep efficiency, subjective sleep quantity and quality, sleep hygiene behaviours, or

technology use before sleep (Table 3). Unclear methods of allocation concealment and inability to compare groups at baseline contribute to a high risk of bias in these findings.

Quan et al. compared two cohorts of US psychology students to assess the effectiveness of two sleep websites on sleep knowledge and behaviours[45]. Both groups received standard instruction on sleep as a part of usual course content and were given the opportunity to participate in a sleep module for extra credit. The first cohort was provided access to a Supplemental Sleep Website; which provided structured and interactive content related to sleep hygiene. The second group was provided with a link to a general sleep information website. Immediately following access to the websites, the group who accessed the Supplemental Sleep Website demonstrated greater sleep knowledge improvements [difference in mean change in sleep test score: -6.2 (95% CI -6.5; -5.8)] than the group who had access to the general sleep information website. This difference was maintained after completing practice sleep quizzes and a sleep test for extra credit [difference in mean change in sleep test score: -5.0 (95% CI -5.0; -4.4)] and at the end of the semester [difference in mean change in sleep test score: -1.1 (95% CI -1.4; -0.8)]. At the end of the semester, the group who had access to the Supplemental Sleep Website was also more likely to report changes in sleep habits [RR 1.4 (95% CI 1.2; 1.5)], a more consistent wake time [RR 1.7 (95% CI 1.2; 2.2)] and trying to get more or better sleep [RR 1.9 (95% CI 1.3; 2.9)] than those who had access to a general sleep website. High attrition, potential differences in source populations, reliability and validity of outcome assessment and confounding contributed to a high risk of bias, decreasing our overall confidence in these findings.

In Valshtein et al.'s second study, the effectiveness of online sleep hygiene education with CBT for improvements in bedtime procrastination was completed in a RCT[47]. Postsecondary students were randomized to one of two online interventions: 1) MCII (see description above); or 2) online sleep hygiene education (12 tips to achieve better sleep). One week following the intervention, participants randomized to MCII reported significantly lower subjective bedtime discrepancy scores (95% CI for difference between groups: -59.79; -15.92) and significantly greater commitment to reduce bedtime procrastination (95% CI for difference between groups 0.11; 0.72) than those randomized to online sleep hygiene education. Unclear methods of allocation concealment, lack of comparison between groups at baseline, and concerns regarding reliability and validity of selected outcome measures diminish our overall confidence in the reported findings due to a high risk of bias. Furthermore, methods of reporting make it difficult to interpret findings.

An RCT by Gipson et al. (2019) looked at the effectiveness of sleep hygiene education delivered via text message on sleep behaviours and self-efficacy[43]. Postsecondary students without a medical diagnosis of a primary sleep disorder were randomized to receive either bi-weekly sleep hygiene text messages or bi-weekly healthy habits text messages for 6 weeks. Immediately following the text messaging intervention, students randomized to receive healthy habits text messages experienced greater improvement in sleep hygiene behaviours [difference in mean change in SHI: -2.7 (95% CI -4.1; -1.2)] than those randomized to the sleep hygiene text group. There were no other statistically significant differences between groups in sleep knowledge or self-efficacy for sleep hygiene post-intervention (Table 3). Lack of comparison between groups at baseline, high attrition and lack of intention-to-treat analysis all contribute to a high risk of bias in these findings.

Robbins and Niederdeppe (2017) assessed the effects of online chats on postsecondary students' intentions to adopt healthy sleep behaviours and on the perceived effectiveness of an online educational video about sleep hygiene[46]. Research assistants posed as peers and manipulated the tone of online chats to either positive or negative. Participants were randomized to one of four chat conditions: 1) positive chat (assistants spoke positively about sleep, the video and self-efficacy to achieve healthy amounts of sleep); 2) negative chat (assistants spoke negatively about sleep, the video, and their self-efficacy); 3) natural chat (no attempt to manipulate conversation); or 4) no chat. Immediately following the online chat, participants that were randomized to the positive chat condition responded with higher intention to adopt healthy sleep behavior (sleeping 7-8 hours most nights) compared to those in the negative chat

condition (mean: 1.4 vs. 0.9; p<0.001), but not for the natural chat (mean: 1.4 vs. 1.3; p=0.805) or no chat control conditions (mean: 1.4 vs. 1.0; p=0.190). There were no other statistically significant differences between groups with respect to behavioural intentions (Table 3). Participants randomized to the negative chat condition perceived the video to be less effective than those in the positive (p<0.001) or natural chat (p<0.001) conditions. These findings may be significantly biased due to inadequately described methods of allocation concealment, lack of comparison between groups at baseline, high attrition, and a lack of valid and reliable outcome measures. Furthermore, methods of reporting make it difficult to interpret findings.

The body of evidence for digital sleep education does not support any conclusions regarding effectiveness due to high risk of bias. Furthermore, effects of the interventions appear to be small and, in some cases, not clinically meaningful.

Music Listening

One study assessed the impact of listening to relaxing music on sleep and mental health outcomes. Oxtoby et al. (2013) randomized postsecondary students to either instrumental music or no music[46]. Music was downloaded by participants via an emailed link and participants were instructed to listen nightly for a period of two weeks. Immediately following the intervention, participants randomized to instrumental music experienced statistically significant within group changes in negatively toned cognitive activity, selective attention monitoring, sleep behaviours, anxiety, stress, and pre-sleep arousal. There were no within group changes in beliefs about sleep or in sleep quality in the intervention group and no within group changes in any of the selected outcomes in the comparison group. Differences in mean change could not be calculated given the data reported in the study's evidence tables. Unclear methods of randomization and allocation concealment, lack of comparison between groups at baseline, and high attrition contribute to a high risk of bias in these findings.

Discussion

The purpose of this systematic review was to critically appraise and synthesize the quantitative and qualitative evidence on the effectiveness and user experiences of virtually delivered sleep interventions to improve sleep and mental health outcomes in postsecondary students. We synthesized the findings of ten studies (in nine publications) examining the effectiveness of digital sleep interventions within the postsecondary student population. Statistical pooling was not possible in this review due to the variability in study design, outcome selection, and the interventions. The quality assessment of all studies had at least some methodological concerns which likely biased the results to some degree and therefore we are unable to conclude on the effectiveness of digital sleep intervention to improve sleep and mental health outcomes in postsecondary students.

Cognitive-behavioral therapy for insomnia (CBT-I) is recommended as a first line treatment for primary insomnia and has been found to be efficacious in improving sleep outcomes[49-51] and also highly effective in improving sleep in patients with co-morbid psychiatric disorders[52], with acute effects comparable or superior to those found for pharmacotherapy[24,53]. The challenge remains to make it available and accessible to meet population needs. To increase CBT-I outreach while restraining care expenses, CBT-I delivered through digital means such as the internet has been proposed as a first option within a stepped care model[54]. While Freeman's study used on-line CBT-I and demonstrated sustainable improvements in both sleep and mental health outcomes[40], the high attrition rates bias the effects resulting in overestimation of the effect sizes seen[55]. Similarly, Mairs and Mullan's study reported high attrition, skewing the study results in favour of the self-monitoring intervention[44]. Attrition has been suggested to be a potential problem, especially in internet-delivered interventions, showing study non-completion rates ranging from 43% to 99%[56]. There could be a number of possibilities for this. Typically, CBT-I is delivered over the course of 6-8 sessions that occur weekly or every other week for approximately 30-60 minutes each[57]. During the first few weeks of treatment there is often an acute

reduction in total sleep time that can lead to the side effect of increased daytime sleepiness which, for some, is enough to lead them to drop out of treatment. Therefore, this could potentially explain the high dropout rates seen in Freeman et al.'s RCT[40]. Format of CBT treatment (e.g., in-person vs. e-therapies) has been shown to be a significant moderator of dropout[58]. Perhaps those that have in-person therapy have more of a sense of accountability and engagement in the therapeutic process and in-person approaches would provide more encouragement or validation of the daytime sleepiness being part of the process. Furthermore, improvements from CBT-I are typically not seen until 3-4 weeks into treatment, therefore participants may feel that benefits attained are sufficient and that they would not benefit more from continuing with CBT-I. Finally, the CBT-I intervention in Freeman's trial did not tailor the intervention specifically for a postsecondary student population. In Mairs and Mullan's study, participants likely dropped out due to low acceptability of the intervention related to the daily commitment of keeping a diary.

Sleep education programs on sleep, sleep health and sleep hygiene behaviour may be a far-reaching and cost-effective method to increase postsecondary student awareness and knowledge on sleep and sleep hygiene behaviour, and has the potential to facilitate sleep health[59-61]. Our systematic review found insufficient evidence from which conclusions could be drawn on the effectiveness of digital sleep education delivered to the postsecondary student population. The findings identified limited evidence of varying significance and methodological concerns related to the digital delivery of sleep education. A recent review examining the effects of sleep education programs (face-to-face) on sleep hygiene knowledge, sleep hygiene behaviour and/or sleep quality in college students also led to insufficient evidence to support sleep education program in improving sleep outcomes in college students[62]. Their results are based on four included studies (three RCTs, one quasi-experimental study).

Despite the high prevalence rates and the severe consequences of sleep problems within the postsecondary student population, there is limited evidence to support the effectiveness of psychological interventions on sleep and mental health outcomes. A recent systematic review found that CBT was the most effective approach to improve sleep in university students with relaxation techniques, mindfulness and hypnotherapy additionally benefiting mental health outcomes[22]. While we know that CBT-I is effective in treating insomnia, it should be modified for the population targeted – in this case, postsecondary students. Given that previous research has documented great potential of internet-based mental health interventions and areas of application[63,64], more research is needed to determine which types of interventions best fit which population, and in which context, to optimize their effects. We were unable to test the appropriateness of the tested interventions to address those perspectives since we did not find any qualitative studies. Qualitative studies evaluating the end-user (e.g., student, provider) perspective of sleep interventions delivered digitally are needed – especially since acceptability seems to have been an issue in some of the studies we examined. Evaluating the participant's personal experiences by using qualitative methods also allows us to gain insights in implementing improvements recommended by former studies. For example, in Boggs et al. (2014) qualitative investigation of participants' experiences with Mindful Mood Balance – a web-based intervention designed to treat residual depressive symptoms, suggestions for improvement of program content, format, and delivery were sought[65]. For example, participants described the desire for more interaction. Furthermore, the demand for a better integration of personal use devices in the treatment process was met by diary and coaching options. Fleischmann et al. (2018) examined college students' experiences receiving a stress reducing internet and mobile-based intervention (IMI) and found that students expressed the need for more individualization and more content-related support[66]. Students' expectancies concerning digitally delivered interventions and specific needs may differ from those of the general population due to their particularly unstable life circumstances. Phases of postsecondary attendance, exam preparation and thesis writing lead to different problems and stress experiences[66], which may lead to further sleep difficulties and mental health problems. Enhancing the appeal of digitally delivered sleep interventions for

postsecondary students and tailoring its content to their current life circumstance is important and should be made a priority.

Study Strengths and Limitations

Our review has a number of strengths. We utilized an extensive and rigorous search strategy. We pre-defined explicit inclusion and exclusion criteria to identify possibly relevant studies. We used two pairs of independent reviewers to minimize error and potential bias. Furthermore, we used the SIGN tools to standardize the critical appraisal process and inform our scientific judgement on study admissibility. Our review also has some limitations. The critical appraisal process entailed judgement by the reviewers, which may have been subjective. This potential bias was limited by training the reviewers and using standardized critical appraisal methods. Finally, our synthesis did not exclude studies with high risk of bias. Although we summarized findings from all studies, our synthesis and conclusions are reflective of the methodological quality of included studies.

Conclusion

Students pursuing postsecondary education are a population at significant risk for both sleep problems and mental health conditions[15,16,18]. As the COVID-19 pandemic continues to evolve, postsecondary students have modified their routines due to the lockdown and social distancing requirements and have been forced to adapt to remote learning. In an already vulnerable population for sleep and mental health problems[6,7], the COVID-19 pandemic has amplified these problems in postsecondary students globally with lower quality sleep and altered mental health including higher levels of depression and anxiety[67-70]. Interventions for prevention and treatment in order to mitigate the pandemic's psychological impacts are needed. While we cannot draw firm conclusions from our systematic review on the effectiveness of digitally delivered sleep interventions, examining sleep interventions digitally warrants further investigation. Given that most college students do not seek mental health treatment[71], sleep may serve as an important gateway topic for intervening on mental health problems within this vulnerable population. Novel delivery mechanisms for evidence-based interventions that are acceptable to this population are needed now more than ever.

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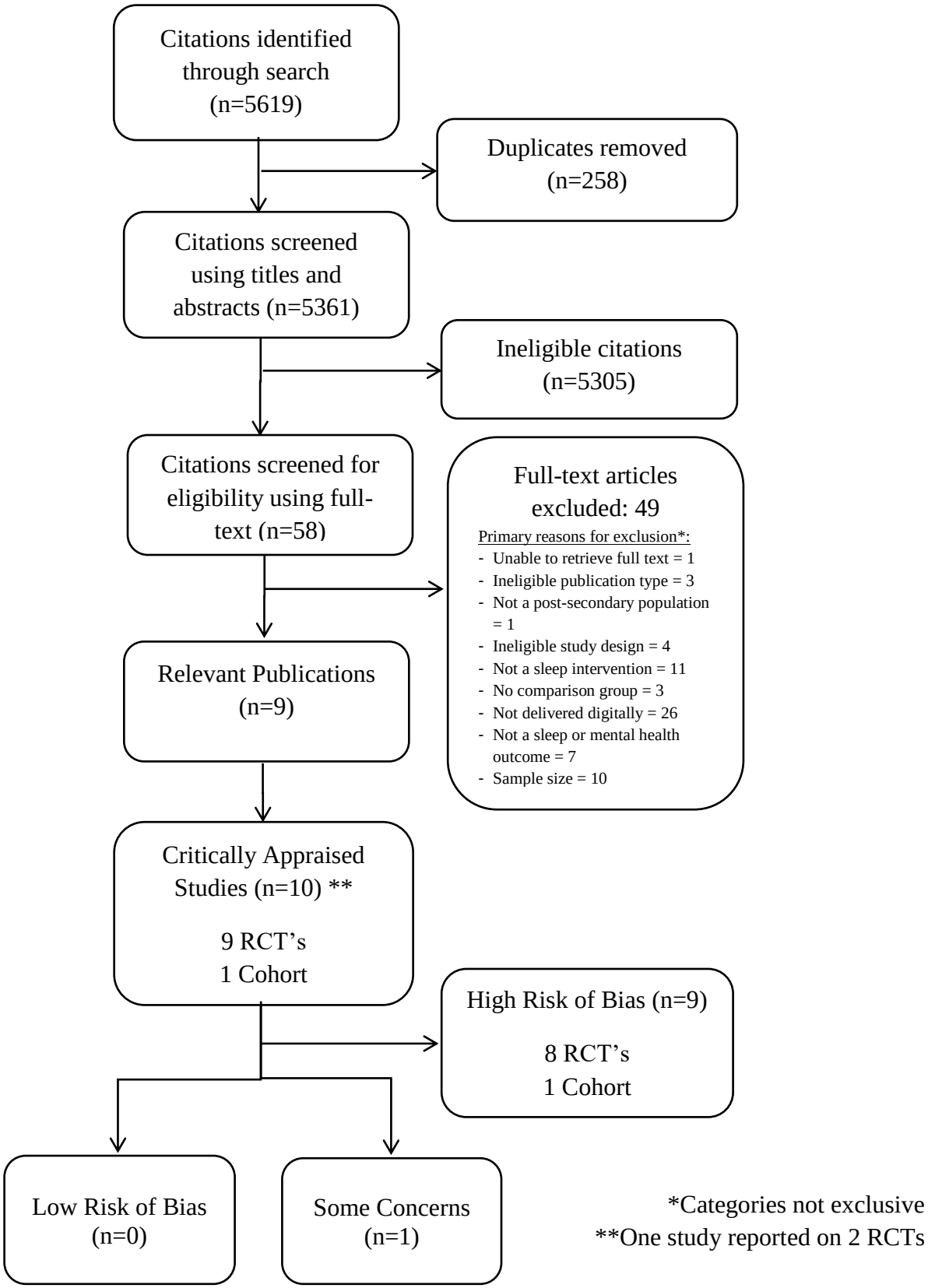
Figure 1: PRISMA Diagram



*Categories not exclusive
**One study reported on 2 RCTs

Figure 2: Sources of Bias – Randomized Controlled Trials (n=9)

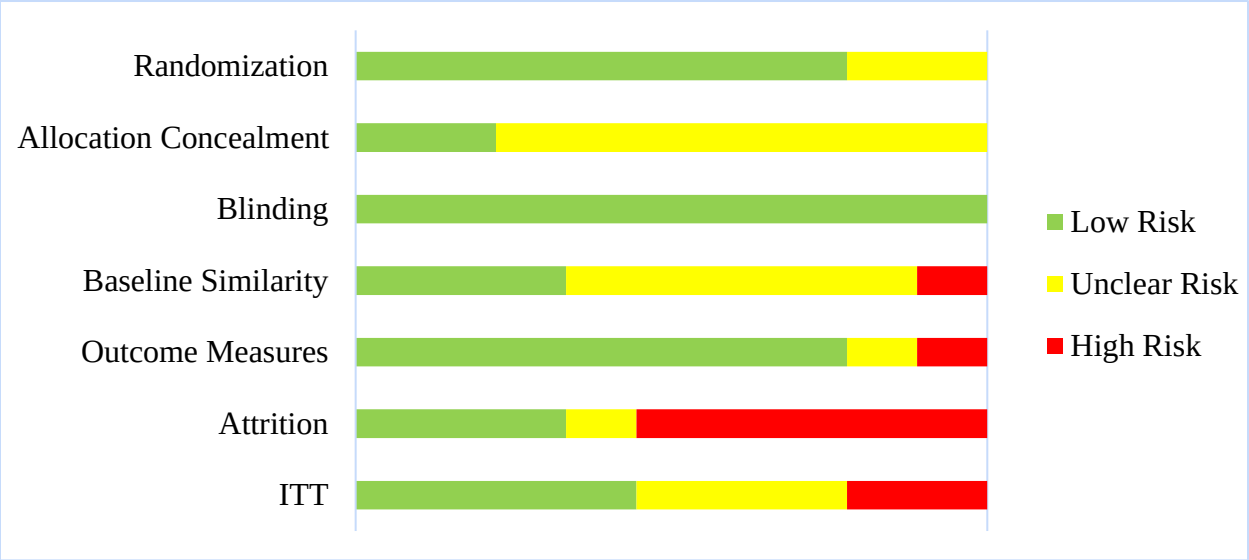


TABLE 1

Evidence Table

Cognitive Behavioural Therapy					
Study	**Population**	**Intervention**	**Comparison**	**Outcomes**	**Key Results**
Freeman (2017) RCT	University students with insomnia from 26 UK universities Inclusion Criteria: 1) Attending university; 2) 18 years or older; 3) Positive screen for insomnia (score of 16 on Sleep Condition Indicator) (n=3755)	Web-based CBT-I (Sleepio): 6 interactive online sessions (20 min each) delivered by an animated therapist and personalized using algorithms driven by initial assessment and daily sleep diaries; behavioural (e.g., sleep restriction, stimulus control, and relaxation); cognitive (paradoxical intention, belief restructuring, mindfulness, imagery, and putting the day to rest); and educational (e.g., information about the processes of sleep and sleep hygiene) components. Participants had access to moderated	Treatment as usual: current care that participants were receiving. (n=1864)	3 weeks (primary outcome only), 10 weeks (end of therapy), 22 weeks post-randomization Primary Outcomes: Insomnia – Sleep Condition Indicator (SCI-8); range 0-32; higher scores indicate better sleep; score of less than 17 identifies probable insomnia disorder Paranoia – Green et al Paranoid Thought Scales (GPTS), part B; 16-items each rated on a scale of 1 (not at all) to 5 (totally); high scores indicate higher levels of paranoia Hallucinations – Specific Psychotic Experiences Questionnaire (SPEQ) - Hallucinations subscale; 9-items - rated on a scale of 0 (not at all) to 5 (more than once per day); higher scores indicate	Difference in mean change (web-based CBT-I – usual care)a 3 weeks: Insomnia (SCI-8): -2.8 (95% CI -3.0; -2.6) [favouring web-based CBT-I] Paranoia (GPTS): 2.6 (95% CI 2.2; 3.1) [favouring web-based CBT-I] Hallucinations (SPEQ): 1.0 (95% CI 0.7; 1.3) [favouring web-based CBT-I] 10 weeks: Insomnia (SCI-8): -5.0 (95% CI -5.2; -4.6) [favouring web-based CBT-I] Paranoia (GPTS): 3.4 (95% CI 2.9; 3.9) [favouring web-based CBT-I Hallucinations (SPEQ): 1.8 (95% CI 1.5; 2.0) [favouring web-based CBT-I] Insomnia (ISI): 3.8 (95% CI 3.6; 4.0) [favouring web-based CBT-I]

		online community and online library of sleep information (n=1891)		greater occurrences of hallucinatory experiences Secondary Outcomes: Sleep – Insomnia (Insomnia Severity Index – ISI; 0-28; higher scores = more severe insomnia); Nightmares (Disturbing Dreams and Nightmare Severity Index – DDNSI; higher score = more severe nightmare disorder) Psychotic Experiences – Prodromal Questionnaire (PQ-16; higher score = more prodromal psychotic symptoms) Affective Symptoms – Depression (Patient Health Questionnaire – PHQ-9; 0-27; higher score = more severe depressive symptoms); Anxiety (Generalized Anxiety Disorder – GAD-7; 0-21; higher scores = more severe symptoms of anxiety); Mania (Altman Self-Rating Mania Scale – ASRM Scale; higher scores = more symptoms of mania)	Nightmares (DDNSI): 1.5 (95% CI 1.2; 1.8) [favouring web-based CBT-I] Psychotic Symptoms (PQ-16): 0.9 (95% CI 0.7; 1.0) [favouring web-based CBT-I] Depression (PHQ-9): 3.0 (95% CI 2.8; 3.3) [favouring web-based CBT-I] Anxiety (GAD-7): 2.2 95% CI 2.0; 2.5) [favouring web-based CBT-I] Mania (ASRM): -0.73 (95% CI -0.9; -0.6) [favouring usual care] Function (WSAS): 4.4 (95% CI 4.0; 4.7) [favouring web-based CBT-I] Wellbeing (WEMWBS): -2.3 (95% CI -2.7; -1.9) [favouring web-based CBT-I] 22 weeks: Insomnia (SCI-8): -5.0 (95% CI -5.2; -4.7) [favouring web-based CBT-I] Paranoia (GPTS): 3.7 (95% CI 3.2; 4.2) [favouring web-based CBT-I Hallucinations (SPEQ): 1.8 (95% CI 1.6; 2.1) [favouring web-based CBT-I]

				Function – Work and Social Adjustment Scale (WSAS); 0-40; higher scores = worse impairment Psychological wellbeing – Warwick–Edinburgh Mental Wellbeing Scale (WEMWBS); 14-70; higher scores = higher level of mental wellbeing Serious Adverse Events – Defined as deaths, suicide attempts, serious violet incidents, admissions to secure units, formal complaints about the online intervention	Insomnia (ISI): 3.7 (95% CI 3.4; 3.9) [favouring web-based CBT-I] Nightmares (DDNSI): 1.9 (95% CI 1.6; 2.2) [favouring web-based CBT-I] Psychotic Symptoms (PQ-16): 0.8 (95% CI 0.7; 1.0) [favouring web-based CBT-I] Depression (PHQ-9): 2.5 (95% CI 2.3; 2.7) [favouring web-based CBT-I] Anxiety (GAD-7): 1.9 (95% CI 1.7; 2.2) [favouring web-based CBT-I] Mania (ASRM): -0.7 (95% CI -0.8; -0.5) [favouring usual care] Function (WSAS): 4.6 (95% CI 4.2; 4.9) [favouring web-based CBT-I] Wellbeing (WEMWBS): -2.6 (95% CI -3.0; -2.2) [favouring web-based CBT-I] Adjusted OR (Control group as reference): 10 weeks: Ultra-high risk of Psychosis (PQ-16 of 6 or more): 0.26 (95% CI 0.15; 0.46) High probability of manic or hypomanic condition (ASRM 6

					or greater): 2.01 (95% CI 1.48; 2.73) Depressive Disorder (PHQ-9): 0.21 (95% CI 0.14; 0.32) Anxiety Disorder (GAD-7): 0.32 (95% CI 0.21; 0.48) 22 weeks: Ultra-high risk of Psychosis (PQ-16 of 6 or more): 0.33 (95% CI 0.18; 0.59) High probability of manic or hypomanic condition (Altman 5.5 or greater): 1.89 (95% CI 1.34; 2.66) Depressive Disorder (PHQ-9): 0.32 (95% CI 0.21; 0.48) Anxiety Disorder (GAD-7): 0.42 (95% CI 0.27; 0.64) No difference between groups in the proportion of participants consulting mental health services, receiving a mental health diagnosis, taking psychiatric medication, or receiving psychological therapy)
Mairs (2015) RCT	Australian university students	Implementation Intentions (delivered online): Day 1: participants guided through process of	Self-monitoring-participants completed daily online sleep diary accessed via an email	2 weeks *Primary outcome not specified	Difference in mean change (implementation intentions – self-monitoring)a 2 weeks:

	(n=104)	formulating 2 implementation intentions for each of the 4 target sleep hygiene behaviours (making the sleep environment restful, avoiding going to bed hungry or thirsty, avoiding stress and anxiety-provoking activities before bed, avoiding caffeine within eight hours of bedtime) and framing each intention in the form "If [insert situation], then I will [insert solution]"; Day 2 and Day 8: participants emailed "if-then" statements, asked to confirm and edit as desired; Total time spent ~30 min. (n=51)	weblink sent on days 1 to 8; regular email reminders provided; diary items from the Pittsburgh sleep diary (bed, sleep and wake times, sleep disturbances/awakenings, overall subjective rating of sleep quality and mood and alertness upon wakening); participants also asked whether they completed the 4 target sleep behaviours the previous day and to reflect upon their influence on waking during the night; identified strengths and areas for improvement in their sleep; reflected on sleep preparation and quality. (n=53)	Sleep hygiene behaviours - number of days during past 2 weeks that participants performed each of the 4 target sleep hygiene behaviours Sleep quality - Pittsburgh Sleep Quality Index (PSQI); range 0-21; higher scores reflect poorer sleep quality; cut-off scores denote "good" (0-5) and "poor" sleepers (>5) Insomnia - Insomnia Severity Index (ISI); range 0-28; cut-offs denote no "clinically signficant insomnia", "sub-threshold insomnia", "moderate" and "severe clinical insomnia"	Behaviour- Restful (number of evenings in past 14 days): 0.2 (95% CI -0.9; 1.2) Behaviour - Hunger/thirst (number of evenings in past 14 days): -0.9 (95% CI -1.7; 0) [favouring implementation intentions] Behaviour - Stress/anxiety (number of evenings in past 14 days): -1.5 (95% CI -2.3; -0.6) [favouring implementation intentions] Behaviour - Caffeine (number of evenings in past 14 days): -0.1 (95% CI -1.2; 1.1) Sleep quality (PSQI): 0.8 (95% CI 0.1; 1.2) [favouring implementation intentions] Insomnia (ISI): 0.9 (95% CI -0.3; 2.1)
Valshtein (2020)	University students who	Mental Contrasting + Implementation	Positive thinking: self-regulation	Post-intervention; 3 weeks	Post-intervention:

[Study 1] RCT	wished to reduce bedtime procrastination; recruited through psychology student online participant pool (US) (n=476)	Intentions (MCII): self-regulation strategy taught online; participants instructed to do the following: 1) make a feasible wish about getting to bed on time; 2) think of a positive outcome resulting from getting to bed on time; 3) think of a personal and internal obstacle to getting to bed on time; 4) think of steps to overcome obstacle; 5) create "if-then" statement (what to do when obstacle encountered). Information derived from the CDC and the Mayo Clinic websites about the importance of sleep and consequences of insufficient sleep. (n=237)	strategy taught online; participants instructed to do the following: 1) think about the top two positive outcome resulting from getting to bed on time; 2) create "if-then" statement (how they will feel as a result of positive outcome). Information derived from the CDC and the Mayo Clinic websites about the importance of sleep and consequences of insufficient sleep (n=239)	Primary Outcomes: Bedtime discrepancy - Timeline follow-back method (TLFB); retrospective report of anticipated bedtime, actual bedtime and wake time for past 7 days; bedtime discrepancy score (intended bedtime – actual bedtime) expressed in minutes; 7 day average; higher scores indicate more discrepant bedtimes Subjective bedtime procrastination - 9-item scale; each item rated on scale of 1 (never) to 7 (always); items averaged Secondary Outcomes: Commitment to reduce bedtime procrastination - 8 statements about commitment rated on scale from 1 (not at all) to 7 (very); responses averaged; higher score indicates stronger commitment to reduce bedtime procrastination	Commitment to reduce bedtime procrastination (mean and SE data not available): Participants randomized to practice MCII reported greater commitment to reduce bedtime procrastination than participants randomized to practice positive thinking (p=0.01) 3 weeks: Bedtime discrepancy (TLFB; minutes): mean change (no SD reported) MCII: 32.94; Positive thinking: 14.10; p=0.001 Subjective bedtime discrepancy (mean and SD data not available): There were no statistically significant differences in subjective bedtime discrepancy between groups. Commitment to reduce bedtime procrastination (mean and SD data not available):

				Sleep quantity - TLFB; time between actual bedtime and wake time expressed in hours; 7 day average	Participants randomized to receive MCII reported greater commitment to reduce bedtime procrastination than participants randomized to practice positive thinking (p<0.001)
Valshtein (2020) [Study 2] RCT	University students who wished to reduce bedtime procrastination; recruited through psychology student online participant pool (US) (n=221)	Mental Contrasting + Implementation Intentions (MCII): self-regulation strategy taught online; participants instructed to do the following: 1) make a feasible wish about getting to bed on time; 2) think of a positive outcome resulting from getting to bed on time; 3) think of a personal and internal obstacle to getting to bed on time; 4) think of steps to overcome obstacle; 5) create "if-then" statement (what to do when obstacle encountered). (n=109)	Sleep hygiene: online written information; 12 tips to achieve better sleep hygiene (Harvard Medical School Division of Sleep Medicine, 2017) (n=112)	Post-intervention; 1 week Primary Outcomes: Baseline bedtime discrepancy - TLFB; retrospective report of anticipated bedtime, actual bedtime and wake time for past 7 days; bedtime discrepancy score (intended bedtime – actual bedtime) expressed in minutes; higher scores indicate more discrepant bedtimes Follow-up bedtime discrepancy (based on daily diary): daily report of planned bedtime, actual bedtime and wake time; intended bedtime – actual bedtime; expressed in minutes; 7-day average; higher scores indicate more discrepant bedtimes Baseline subjective bedtime procrastination - 8-item scale; each item rated on scale of 1	1 week: Sleep discrepancy (mean and SD data not provided): Participants randomized to practice MCII reported significantly lower bedtime discrepancy scores than those randomized to receive online sleep hygiene information (p<0.001, 95% CI -59.79, -15.92). Commitment to reduce bedtime procrastination (mean and SD data not provided): Participants randomized to practice MCII reported significantly greater commitment to reduce bedtime procrastination than those randomized to receive online sleep hygiene information (p=0.01; 95% 0.11, 0.72)

				(never) to 7 (always); items averaged Follow-up subjective bedtime procrastination (based on daily diary)– daily ratings using 8 item scale; each item rated on scale of 1 (never) to 7 (always); 4 momentary items averaged; 7-day average Secondary Outcomes: Baseline commitment to reduce bedtime procrastination - 8 statements about commitment rated on scale from 1 (not at all) to 7 (very); mean of all responses; higher score indicates stronger commitment to reduce bedtime procrastination Follow-up daily commitment to reduce bedtime prograstination (based on daily diary): 4 statements about commitment rated on scale from 1 (not at all) to 7 (very); mean of all responses; higher score indicates stronger commitment to reduce bedtime procrastination	

				Baseline sleep quantity - timeline follow-back method (TLFB); retrospective report of anticipated bedtime, actual bedtime and wake time for past 7 days; time between actual bedtime and wake time expressed in hours; 7 day average Follow-up sleep quantity (based on daily diary) - daily report of anticipated bedtime, actual bedtime and wake time for past 7 days; time between actual bedtime and wake time expressed in hours	
Digital Sleep Education					
Barber (2017) RCT	Undergraduate students enrolled in general psychology courses at Midwestern University (US) (n=78)	Sleep Treatment Education Program for Students including technology management strategies (STEPS-TECH): education on general sleep hygiene behaviours with specific tips on avoiding sleep-disruptive technology use behaviours; delivered	No intervention (n=35)	1 week post-intervention Primary Outcomes: Objective sleep measures (Actigraph GTX+ accelerometer model) Sleep duration - hours per night (7-day average); sleep periods calculated with ActiLife 5 software using Sadeh algorithm developed for ages 10-25. Sleep efficiency - ratio of time asleep to total time in bed (7-	1 week: Objective Sleep Outcomes: mean (SD); p value; Cohen's d Total hours of sleep: STEPS-TECH 6.44 (1.23); Control 5.93 (0.74); 0.018; 0.50 [favouring STEPS-TECH; moderate effect size) Number of awakenings: STEPS-TECH 16.76 (7.83); Control 20.07 (8.31); 0.025; -

		using an automated PowerPoint presentation (22 min, 33 sec) (n=43)		day average); higher scores represent better sleep quality Number of awakenings (7-day average); more awakenings represent poorer sleep quality Secondary Outcomes: Sleep hygiene - Sleep Hygiene Index (SHI); 13-items scored from 1 (Never) to 5 (Always); higher scores represent poorer sleep hygiene behaviours Technology use within 15 minutes of going to sleep - single item scored between 1 (not one day last week) and 8 (every day last week); higher scores represent more technology use Technology use during sleep - single item scored between 1 (not one day last week) and 8 (every day last week); higher scores represent more technology use Subjective sleep quantity – self-reported number of hours per night over past week	0.45 [favouring STEPS-TECH; small to moderate effect size] Sleep efficiency: STEPS-TECH 81.45 (8.81); Control 79.62 (8.31); 0.177; 0.22 Subjective Sleep Outcomes: Adjusted mean (SE); p value; Cohen's d Subjective sleep quantity: STEPS-TECH 7.20 (0.23); Control 7.62 (0.26); 0.116; -0.31 Subjective sleep quality: STEPS-TECH 3.53 (0.24); Control 3.08 (0.26); 0.108; 0.38 Sleep Hygiene (SHI): STEPS-TECH 2.44 (0.05); Control 2.36 (0.05); 0.128; 0.09 Technology use before sleep: STEPS-TECH 6.24 (0.30); Control 6.06 (0.34); 0.343; 0.30 Technology use during sleep: STEPS-TECH 1.87 (0.26); Control 2.78 (0.28); 0.010; -0.47 [favouring STEPS-TECH, small to moderate effect size]

				Subjective sleep quality - how frequently participants experienced trouble falling asleep, trouble staying asleep, waking up several times during the night, waking up after one's usual amount of sleep feeling tired and worn out; response options from 0 (never) to 5 (nearly every night); higher scores indicate poorer sleep quality	
Gipson (2019) RCT	Undergraduate students from one Southwestern university (US) Inclusion Criteria: enrolled as a full-time undergraduate student; age 18-26; currently owned and used a personal mobile device with unlimited text messaging; ability to read and speak	Sleep Hygiene text-messages: bi-weekly (Monday/Thursday; 3pm) text messages about sleep hygiene over 6 weeks; text messages adapted from the National Sleep Foundation (NSF) recommendations for sleep hygiene and written according to the Centers for Disease Control and Prevention (CDC) social media guidelines and best practices.	Healthy Habits text-messages: bi-weekly (Monday/Thursday at 3pm) text messages about healthy habits over 6 weeks; content focused on healthy behaviors; messages included information on nutrition, physical activity, and stress; content was adapted from the CDC recommendations for college health and safety and the United States Department of Agriculture, Choose My Plate.	Post-intervention *No primary outcome specified Sleep knowledge - Sleep Hygiene Awareness and Practice Scale (SHAPS) Knowledge Subscale; 13 items, responses scored 1 point if correct, 2 points if omitted, 3 points if incorrect, scores range from 13-39; higher scores indicate poorer sleep hygiene knowledge Sleep hygiene behaviours - SHI; 14 statements rated on a scale from 1 (never) to 5 (always); scores range from 14-	Difference in mean change (Sleep Hygiene – Healthy Habits)[a] Post-intervention: Sleep knowledge: 0.4 (95% CI -0.5; 1.3) Sleep hygiene (SHI): -2.7 (95% CI -4.1; -1.2) [favouring Healthy Habits] Self-efficacy - time management (SESHI): -2.19 (95% CI -7.1; 2.7) Self-efficacy - sleep influences (SESHI): 1.4 (95% CI -2.8; 5.5) Self-efficacy - disruptive influences (SESHI): 0.17 (95% CI -4.2; 4.5) Sleep quality (PSQI): -0.17 (95% CI -0.7; 0.3)

	English; no medical diagnosis of primary sleep disorder; no current use of hypnotics, sedatives, or antidepressants; not pregnant, lactating, or have plans to become pregnant during the study (n=120)	Bi-weekly motivational text messages (Tuesday/Wednesday at 3pm). (n=61)	Bi-weekly motivational text messages (Tuesday/Wednesday at 3pm). (n=59)	70; higher scores indicate poorer sleep hygiene Self-efficacy for sleep hygiene - Self-Efficacy for Sleep Hygiene Inventory (SESHI); 24 items, 3 subscales (time management, disruptive influences, sleep influences) each scored 0-100; higher scores indicate higher self-efficacy Sleep quality- Pittsburgh Sleep Quality Index (PSQI); 19 items, global score range 0-21; higher scores (above 5) indicate greater sleep disturbances	
Hershner (2018) RCT	University students from the University of Michigan (US) broadly representative of the student population from freshman to professional students (medicine, dentistry, PhD) and included students living	Sleep to Stay Awake - online sleep education module (20 min duration): sleep personality profile (Epworth Sleepiness Scale, the Morning-Eveningness Questionnaire), two videos (sleep hygiene; effect of sleep deprivation on memory, learning, and driving),	No education (n=295)	1 week and 8 weeks post intervention Sleep Quality – Pittsburgh Sleep Quality Index (PSQI): score of 5 or higher indicates poor sleep quality. Depression – Patient Health Questionnaire (PHQ-9): none (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27)	Difference in mean change (online sleep education – control group) 8 weeks: Sleep Quality (PSQI): -1.09 (95% CI -1.65; -0.51) [favouring online sleep education] Depression (PHQ-9): -1.60 (95% CI -2.67; -0.29) [favouring online sleep education

	on and off campus. Inclusion criteria: all students age 18 years and older (n=549)	information on healthy sleep behaviours; information on studying, daytime alertness, and naps linked to participant's sleep personality profile. (n=254)		Sleep Knowledge – 14 questions related to sleep hygiene, physiology of sleep, effect of technology on sleep, interaction of sleep on learning, memory, and grades Sleep Hygiene – Sleep Hygiene Index (SHI): range of 13-65; higher score indicates worse sleep hygiene. Sleepiness – Epworth Sleepiness Scale (ESS): score of 10 or higher indicates sleepiness. General Health – General Health Questionnaire (GHQ-12): likert scale, 12 items coded as 0, 1, 2, or 3 with a final summary answer. *No primary outcome specified.	Sleep Knowledge: 0.88 (95% CI 0.31; 1.55) [favouring online sleep education] Sleep Hygiene (SHI): -2.10 (95% CI -3.34; -1.00) [favouring online sleep education] Sleepiness (ESS): -0.55 (-1.51; 0.39) General Health (GHQ-12): -0.34 (95% CI -1.00; 0.63) Online Sleep Education group was more likely than the control group to self-report earlier wake times (adjusted OR 2.40 [95% CI 1.30; 4.40]) and less napping (adjusted OR 2.10 [95% CI 1.10; 4.10]) at 8 weeks than the control group. There were no other differences between groups in self-reported behavior changes. *results were not reported for the 1-week follow-up
Robbins (2017) RCT	Students enrolled in college communication and information science courses offering extra	Online Chats: Participants watched an online video about healthy sleep (evidence-based consequences of sleep deprivation;	No chat: sleep hygiene video only (n=88)	Post-intervention Primary Outcome: Sleep intention and behaviour - participant response to 4 statements: 1) "In the next 2	Post-intervention: Behavioural intentions were higher in the positive than negative ($p<0.001$) chat conditions but not higher than the natural ($p=0.805$) or no-chat

	credit for research participation (US) (n=354)	recommendation of 7 to 8 hours of sleep for optimal health; tips for healthy sleep). Following the video, participants followed a weblink for an online chat; research assistants posed as peers and manipulated the tone of online chat to be either: 1) ***positive chat*** (assistants spoke positively about sleep, the video and their self-efficacy to achieve a healthy amount of sleep) **(n=87)**; 2) ***negative chat*** (assistant spoke negatively about sleep, the video, and their self-efficacy to achieve a healthy amount of sleep regularly) **(n=85)**; or 3) ***natural chat*** (no attempt to sway conversation in one		weeks I intend to sleep 7-8 h most nights of the week"; 2) "In the next 2 weeks I will sleep 7-8 hours on most nights of the week"; 3) In the next 2 weeks I am willing to sleep 7-8 h most nights of the week; and 4) "In the next 2 weeks I plan to sleep 7-8 h most nights of the week". Responses rated using 7-point Likert scale ranging from -3 (strongly disagree) to 3 (strongly agree); items averaged Secondary Outcomes: Perceived effectiveness - agreement with series of statements about effectiveness using 7-point Likert Scale ranging from -3 (strongly disagree) to 3 (strongly agree); items averaged Positive emotion - agreement with two statements: 1) "While I was watching the video about sleep, I felt content"; and 2) "While I was watching the video about sleep, I felt joy"; responses rated using 7-point Likert Scale ranging from -3	control (p-0.190) conditions. Intentions were marginally lower in the negative chat condition than the natural chat (p=0.080) but not different than the no-chat control (p=0.372) conditions. Behavioural intentions (7-point Likert) - mean (95% CI): No chat: 1.0, (0.7, 1.4); Natural chat: 1.3, (0.9, 1.7); Negative chat: 0.8, (0.4, 1.2); Positive chat: 1.4, (1.0, 1.66) Perceived Effectiveness: Participants in the negative chat condition perceived the message to be less effective than the natural chat (p<0.001) and positive chat (p<0.001) condition. Perceived effectiveness (7-point Likert) - mean (95% CI): No chat: 0.7, (0.6, 0.9); Natural chat: 0.8, (0.7, 0.9); Negative chat: 0.0, (-0.2, 0.2); Positive chat: 0.8, (0.6, 1.0) Positive Emotion: Participants in the negative chat condition reported lower

		way or another, brief discussion of video, general talk about life in college) **(n=85)**		(strongly disagree) to 3 (strongly agree); items averaged Psychological reactance - agreement with 4 statements regarding their affective responses to the video (e.g. feeling annoyed, feeling irritated); responses rated using a 7-point Likert Scale ranging from -3 (strongly disagree) to 3 (strongly agree); items averaged	positive emotion than the positive chat ($p<0.001$) condition. Positive emotion (7-point Likert) - mean (95% CI): No chat: -0.3, (-0.6, -0.1); Natural chat: -0.5, (-0.8, -0.2); Negative chat: -1.0, (-1.3, -0.7); Positive chat: -0.3, (-0.5, 0.0) Psychological Reactance: Participants in the positive chat experienced less psychological reactance than in the negative chat ($p=0.008$) condition. Psychological reactance (7-point Likert) - mean, (95% CI): No chat: -1.5, (-1.7, -1.2); Natural chat: -1.4, (-1.7, -1.1); Negative chat: -0.9, (-1.2, -0.6); Positive chat: -1.6, (-1.98, -1.3)
Quan (2013) Cohort	Students enrolled in introductory psychology at the University of New Mexico (US) 1767 eligible to participate (889	Supplemental Sleep Website: In-class instruction on sleep (approx. 50 minutes) as part of standard course content; participants informed of extra-credit sleep module; content derived from	Standard Instruction: In-class instruction on sleep (approx. 50 minutes) as part of standard course content; participants informed of availability of extra-credit sleep module; participants only	Post-intervention (Gateway Test and Sleep Test); End of semester (Post-test) Primary Outcome: Sleep knowledge - Sleep quiz; 28-item test; items derived from instructional points covered in the educational module	Difference in mean change (Supplemental Sleep Website – Standard Instruction)[a] Post-intervention (Gateway Test): Sleep Knowledge: -6.2 (95% CI -6.5; -5.8) [favouring the Supplemental Sleep Website group]

	students from 2 course sections eligible to receive intervention; 878 students from 2 course sections eligible to receive comparison) (n=1092)	Harvard Medical School Division of Sleep Medicine's Sleep and Health Education Program's educational website (www.understanding sleep.org); delivery of supplemental sleep content was structured and interactive and involved multiple choice quizzes that generated feedback and opportunity for content mastery (n=664)	provided with the link to a general sleep information website (www.understanding sleep.org) (n=428)	Secondary Outcome: Sleep behaviours - Self-report survey instrument; items regarding participation in extra-credit activities and changes in sleep habits as a result of participation	Post-intervention (Sleep Test): Sleep Knowledge: -4.7 (95% CI -5.0; -4.4) [favouring the Supplemental Sleep Website group] End of semester (Post-test): Sleep Knowledge: -1.1 (95% CI -1.4; -0.8) [favouring the Supplemental Sleep Website group] Relative risk of reporting change in sleep behaviours in the Supplemental Sleep Website Group (reference – Standard Instruction): Change in sleep habits: RR 1.4 (95% CI 1.2; 1.5) [favouring Supplemental Sleep Website group] More consistent wake time: RR 1.7 (95% CI 1.3; 2.2) [favouring Supplemental Sleep Website group] Trying to get more or better sleep: RR 1.9 (95% CI 1.3; 2.9) [favouring Supplemental Sleep Website group]
Music Listening					
Oxtoby (2013)	Queensland University Technology	Music: participants provided with links to download	Control: participants instructed to maintain usual night-	Post-intervention	Median (IQR): baseline; post-intervention; p value

RCT	(QUT) students enrolled in a variety of courses (e.g. psychology, nursing, business). (n=127)	approximately 3 hours of instrumental music edited to maintain consistent volume (3 sets: classical piano and guitar, ambient, and meditative tracks); participants instructed to listen for minimum 20 minutes per night after 6pm at a "relaxing" volume and could engage in usual night activities while listening as long as they were stationary; recommended (but optional) to listen to music while falling asleep. (n=89)	time habits (including listening to music) (n=38)	*No primary outcome identified Beliefs about sleep - Dysfunctional Beliefs and Attitudes about Sleep scale - (DBAS-10); 10-item scale) Sleep quality - Pittsburgh Sleep Quality Index (PSQI) Negatively toned cognitive activity - Glasgow Content of Thoughts Inventory (GCTI) Selective attention monitoring - Sleep Associated Monitoring Index (SAMI) Sleep behaviours - Sleep-Related Behaviour Questionnaire (SRBQ) Anxiety and stress - Depression Anxiety Stress Scale (DASS); Anxiety and Stress subscales Arousal and distress - Pre-Sleep Arousal Scale (PSAS)	Beliefs about sleep (DBAS-10): Music: 6.7 (2.48); 5.9 (2.90); p=0.067 [no statistically significant difference] Control: 7.2 (1.92); 6.7 (1.15); p=0.103 [no statistically significant difference] Sleep quality (PSQI): Music: 5.0 (4.00); 5.0 (3.00); p=0.173 [no statistically significant difference] Control: 5.5 (4.50); 6.0 (5.50); p=0.751 [no statistically significant difference] Negatively toned cognitive activity (GCTI): Music: 41.0 (15.75); 36.5 (17.75); p<0.001 [statistically significant improvement] Control: 50.0 (19.25); 48.0 (14.50); p=0.067 [no statistically significant difference] Selective attention monitoring (SAMI): Music: 68.0 (27.50); 56.0 (29.50); p<0.001 [statistically significant improvement] Control: 72.0 (26.75); 71.5 (31.25); p=0.940 [no

					statistically significant difference] Sleep behaviours (SRBQ): Music: 34.5 (18.75); 29.0 (27.75); p=0.002 [statistically significant improvement] Control: 39.5 (15.00); 38.5 (17.25); p=0.287 [no statistically significant difference] Anxiety (DASS-Anxiety): Music: 8.0 (9.50); 2.0 (6.00); p<0.001 [statistically significant improvement] Control: 6.0 (7.50); 2.0 (7.50); p=0.091 [no statistically significant difference] Stress (DASS-Stress): Music: 10.0 (8.00); 8.0 (11.00); p=0.031 [statistically significant improvement] Control: 12.0 (12.00); 12.0 (10.50); p=0.567 [no statistically significant difference] Pre-Sleep Arousal Scale (PSAS): Music: 33.0 (14.75); 28.0 (15.25); p<0.001 [statistically

					significant improvement] Control: 33.0 (15.50); 31.0 (11.75); p=0.395 [no statistically significant difference]

[a] Difference in mean change or confidence interval calculations performed by systematic review team

CDC – Cognitive Behavioural Therapy for Insomnia (CBT-I); Centers for Disease Control and Prevention; CI – Confidence Interval; Disturbing Dreams and Nightmare Severity Index (DDNSI); Epworth Sleepiness Scale (ESS); General Health Questionnaire (GHQ-12); Generalized Anxiety Disorder (GAD-7); Green et al. Paranoid Thought Scales (GPTS); Insomnia Severity Index (ISI); MCII – Mental Contrasting + Implementation Intentions; NSF – National Sleep Foundation; Odds Ratio (OR); Patient Health Questionnaire (PHQ-9); PSQI – Pittsburgh Sleep Quality Index; Prodromal Questionnaire (PQ-16); Sleep Condition Indicator (SCI-8); SD – Standard Deviation; SESHI – Self-efficacy for Sleep Hygiene Inventory; SHAPS – Sleep Hygiene Awareness and Practice Scale; SHI – Sleep Hygiene Index; STEPS-TECH – Sleep Treatment Education Program for Students including technology management strategies; TLFB – Timeline Follow Back; Warwick Edinburgh Mental Wellbeing Scale (WEMWBS); Work and Social Adjustment Scale (WSAS)

TABLE 2

Risk of Bias – Randomized Controlled Trials

Study	2.1 RQ	2.2 Random-ization	2.3 Allocation Conceal-ment	2.4-2.5 Blinding	2.6 Baseline Similarity	2.7 Differences Between Groups	2.8-2.9 Outcome Measures	2.10 Attrition	2.11 ITT	2.12 Site Compar-ison	3.1 Overall Risk of Bias
Hershner (2018)	Y	Y	Y	Subjects NP Treatment provider Y Outcome assessor Y Bio-statistician CS	Similarity at baseline: Y Adjusted analysis: NA	CS	Outcomes are measured in a reliable way. Y Outcomes are measured in a valid way. Y	**1 week:** Online Education group: 43% Control: 31% **8 weeks:** Online Education: 37% Control: 34%	Y	NA	Some Concerns
Freeman (2017)	Y	Y	Y	Subjects NP Treatment provider Y Outcome assessor Y	Similarity at baseline: Y Adjusted analysis: NA	Y	Outcomes are measured in a reliable way. Y Outcomes are measured	**3 weeks:** Web-based CBT-I: 45% Control: 25% **10 weeks:** Web-based CBT-I: 61% Control: 39% **22 weeks:**	Y	NA	High

				Bio-statistician CS			in a valid way. Y	Web-based CBT-I: 68% Control: 48%			
Mairs (2015)	Y	Y	N	Subjects Y Treatment provider Y Outcome assessor Y Bio-statistician CS	Similarity at baseline: Y Adjusted analysis: NA	CS	Outcomes are measured in a reliable way. Y Outcomes are measured in a valid way. Y	**2 weeks:** Implement-ation Inten-tions: 8% Sleep Diary: 30%	Y	NA	High
Barber (2017)	Y	CS	N	**Subjects** NP **Treatment provider** NP **Outcome assessor** CS **Bio-statistician** CS	**Similarity at baseline:** CS **Adjusted analysis:** CS	CS	**Outcomes are measured in a reliable way.** Y **Outcomes are measured in a valid way.** Y	Not reported Overall: 2.6% (on primary outcome); 2.6% (on self-report outcomes)	Y	NA	High

Gipson (2019)	Y	Y	Y	**Subjects** NP **Treatment provider** CS **Outcome assessor** CS **Bio-statistician** CS	**Similarity at baseline:** CS **Adjusted analysis:** N	Y	**Outcomes are measured in a reliable way.** Y **Outcomes are measured in a valid way.** Y	**1 week:** Sleep Hygiene: 15% Healthy Habits: 25%	N	NA	High
Oxtoby (2013)	Y	CS	N	**Subjects** NP **Treatment provider** Y **Outcome assessor** Y **Bio-statistician** CS	**Similarity at baseline:** CS **Adjusted analysis:** NA	CS	**Outcomes are measured in a reliable way.** Y **Outcomes are measured in a valid way.** Y	**Baseline:** Music: 45% Control: 32% **Post-intervention:** Music: 60% Control: 47%	N	NA	High
Robbins (2017)	Y	Y	N	**Subjects** CS	**Similarity at baseline:**	CS	**Outcomes are measured**	**Post-intervention:**	CS	NA	High

				Treatment provider NP **Outcome assessor** CS **Bio-statistician** CS	CS **Adjusted analysis:** Cannot say		**in a reliable way.** CS **Outcomes are measured in a valid way.** CS	Positive chat: 7% No chat: 6% Natural chat: 28% Negative chat: 21%			
Valshtein (2020) [Study 1]	Y	Y	CS	**Subjects** Y **Treatment provider** Y **Outcome assessor** Y **Bio-statistician** CS	**Similarity at Baseline:** N **Adjusted analysis:** N	N	**Outcomes are measured in a reliable way.** Y **Outcomes are measured in a valid way.** Y	**3 weeks:** MCII: 18% Positive Thinking: 21%	NA	NA	High
Valshtein (2020) [Study 2]	Y	Y	CS	**Subjects** CS **Treatment provider** Y	**Similarity at baseline:** CS **Adjusted analysis:**	CS	**Outcomes are measured in a reliable way.**	**1 week:** MCII: 19% Sleep Hygiene: 20%	CS	NA	High

				Outcome assessor Y **Bio-statistician** Y	CS		N **Outcomes are measured in a valid way.** N				

Risk of bias assessed using the Scottish Intercollegiate Guidelines Network (SIGN) Criteria for Randomized Controlled Trials.
BCT: Behaviour Change Technique (Implementation Intentions); CBT-I: Cognitive Behavioural Therapy for Insomnia; CS: Cannot Say; ITT: Intention-to-treat; MCII: Mental Contrasting with Implementation Intentions; N: No; NA: Not Applicable; NP: Not Possible; RQ: Research Question; Y: Yes

TABLE 3

Risk of Bias – Cohort Studies

Study	1.1 RQ	1.2 Similarity of Source Populations	1.3 Participation Rate	1.4 Outcome Status at Enrollment	1.5 Attrition	1.6 Drop out Comparison	1.7 Defined Outcome	1.8 Blinding	1.9 Recognition Where Blinding Not Possible	1.10 Reliability of Exposure Assessment	1.11 Validity/ Reliability of Outcome Assessment	1.12 Multiple Exposure Assessments	1.13 Confounders	1.14 CI's	Overall Risk of Bias
Quan (2013)	Y	CS	Y	Y	**Sleep test:** SS: 78% SI: 57% **Post-test:** SS: 19% SI: 11%	CS	Y	NA	CS	Y	CS	NA	CS	N	High

CS: Cannot say; N: No; NA: Not Applicable; RQ: Research Question; SI: Standard instruction plus access to informational website; SS: Standard instruction plus access to a supplemental sleep module website; Y: Yes