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Improving university students' mental health using multi-component and single-component sleep interventions: A systematic review and meta-analysis

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ABSTRACT

University is a time of significant transitions during a young adult's life, with delayed and shortened sleep and poor mental health a common occurrence. This systematic review and meta-analysis examined the effect of both multi-component and single-component sleep interventions on improving university students' sleep and mental health.

Five databases (MEDLINE, PsycINFO, Embase, CINAHL and Cochrane Library) were searched for relevant literature published until April 2022. Treatment studies including university students aged 18–24 years, participating in a sleep intervention (multi-component, e.g., CBT-I, or single-component, e.g., sleep hygiene) were eligible. Comparator groups were either active, i.e., alternative intervention, or passive, i.e., waitlist control or treatment-as-usual, with study outcomes to include measures of sleep *and* mental health.

Of 3435 references screened, 11 studies involving 5267 participants, with and without insomnia symptoms, were included for a narrative synthesis on intervention designs and methodology. Six studies eligible for meta-analyses showed a moderate effect of sleep interventions in reducing sleep disturbance (SMD = −0.548 [CI: −0.837, −0.258]) at post-treatment, alongside a small effect in improving anxiety (SMD = −0.226 [CI: −0.421, −0.031]) and depression (SMD = −0.295 [CI: −0.513, −0.077]). Meta-regression examining study and intervention characteristics identified subpopulation (experiencing insomnia or not) as a significant moderator for effects on sleep ($p = 0.0003$) and depression ($p = 0.0063$), with larger effects in studies with participants experiencing insomnia. Comparison group type (active or passive) was also a significant moderator ($p = 0.0474$), with larger effects on sleep in studies using passive comparison groups. Study type, delivery format, and intervention duration were not identified as significant moderators. At follow-ups, small but significant effects were sustained for anxiety and depression.

Protecting and promoting sleep amongst university students may help safeguard and advance mental health.

1. Introduction

Sleep is vital for both physical and mental health [1] and sleep difficulties are a core component of the diagnostic criteria for several mental health disorders within the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), including depressive disorders and anxiety disorders [2]. Complaints about poor sleep

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quality and sleep disturbances are common amongst university students [3,4] with poor sleep quality associated with increased symptoms of psychological distress, including anxiety and depression [5,6].

Mental health problems are increasing amongst university students [7], with a high proportion of students reporting experiencing symptoms of depression, anxiety, and stress [8–10]. Consequently, there has been an increase in students utilising university mental health services [7]. Concerns reported by students which are associated with mental health problems include academic performance, pressure to be successful in their studies, plans following graduation, financial status, relationships with friends and family, body image, self-esteem, overall health, and poor sleep quality [8].

In one representative study investigating the predictors of well-being amongst university students (18–25 years of age), compared with other factors in the model (physical activity, depression, having received mental health services, and use of tobacco), sleep quality was found to be the strongest predictor of students' well-being [11]. Research also indicates that poor sleep is associated with an increased risk of self-harm and suicidal behaviours amongst university students [12]. With strong evidence for the association between poor sleep and mental health symptoms in university students, it is important to examine the most effective ways to reduce both poor sleep and mental health symptoms in this population.

Cognitive behavioural therapy for insomnia (CBT-I) is a multi-component intervention that targets dysfunctional sleep-related cognitions and behaviours [13]. Stimulus control therapy and sleep restriction alongside sleep hygiene education are often seen as the primary components of CBT-I, with other components such as relaxation techniques and cognitive therapy seen as complementary elements of the treatment [14,15]. The efficacy of CBT-I as a treatment for insomnia disorder has been well established [16–18], and is often recommended as the first-line treatment of insomnia and sleep difficulties [19,20]. To a lesser degree, the efficacy of such sleep treatments in improving mental health in the general population has also been supported [21–23]. With focus on university students, although evidence has shown a positive effect of interventions in improving sleep in this population [24,25], an understanding of the effect on mental health is needed. Understanding efficacy of such interventions in this population can help to protect and improve both the sleep and mental health of young people as they emerge into adulthood, with university settings offering unique opportunities for prevention and treatment for students.

1.1. Rationale, aims of the review and research questions

The aim of the present review was to examine the extent to which sleep interventions, both multi-component e.g., CBT-I and single-component e.g., sleep hygiene, can improve the sleep and mental health of university students. The primary question of this systematic review and meta-analysis was to examine how efficacious psychological and behavioural sleep interventions are, in improving the sleep and mental health of university students.

2. Methods

The specific criteria of the systematic review and meta-analysis including research questions, search strategy, and inclusion/exclusion criteria were developed prior to commencement of the review and followed the PRIMSA (2009) guidelines [27]. The protocol of this systematic review and meta-analysis was registered on the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42020179207).

2.1. Search strategy

The search strategy was developed in close collaboration with an informational specialist (SJ). Following several scoping searches between March and April 2020, five bibliographic databases (MEDLINE, PsycINFO, Embase, CINAHL and Cochrane Library) were searched for relevant literature up to May 11, 2020 (see Supplementary Fig. 1). The reference lists of papers identified for inclusion of full-text screening were hand-searched to identify any further relevant literature, as were the reference lists of related systematic reviews [21–23,26,28,29]. A cited reference search of the included papers was also performed via Web of Science to identify any additional relevant literature. Searches were repeated monthly via the same process as the initial search to identify any relevant newly published literature until April 2022. Search alerts were also received monthly with literature screened in the same way as the initial search.

2.2. Inclusion & exclusion criteria and screening

Studies were considered appropriate for inclusion in the review if they were written in English language; included university/college students between the ages of 18 and 24; were randomised controlled trials (RCTs) or non-RCT intervention studies, all with pre- and post-intervention outcome measures; and included measures of sleep *and* mental health, specifically anxiety and/or depression. Anxiety and depression were identified as the two mental health outcomes of interest due to the high prevalence of both of these within the university student population, and the associations found between poor sleep, anxiety and depression. Studies were excluded if they focused on sleep or circadian disorders other than insomnia; were pharmacological-based, epidemiological, cross-sectional, single case studies, qualitative studies, animal studies; or were systematic reviews. There were no inclusion criteria in regard to insomnia status of students, so that comparisons on the effects of interventions between these sub-populations could be examined. Both RCT and non-RCT interventions were included to gather a more comprehensive picture of sleep interventions, and multi-component e.g., CBT-I, and single-component e.g., sleep hygiene, sleep interventions were eligible so the efficacy of intervention types could be compared.

In the initial screening stage, all identified papers' titles and abstracts were reviewed. Full texts of the papers considered relevant were obtained, where possible. Two reviewers (LC, CP) then independently assessed each paper against the inclusion and exclusion criteria according to the 'screening and selection tool' developed for this review (see Supplementary Fig. 2). Studies that did not meet inclusion criteria were excluded, with reasons provided. Any discrepancies between the reviewers were resolved with input from a third member of the team (NT).

2.3. Data extraction and quality assessment

Data was extracted from the included studies via a data extraction table, which was developed specifically for this review. Extracted data included study characteristics, participant characteristics, and study results. The data extraction table was piloted by three reviewers with experience in performing systematic reviews and knowledge of the topic (LC, LL, CP) to ensure all of the necessary data would be captured.

Quality assessment of the included studies was performed via the 'Checklist for Measuring Quality' [30]. This tool was chosen as it can be applied to both randomised and non-randomised studies, which allows the quality assessment to remain consistent across all studies included in this review. The checklist contains 27 'yes' or

'no' questions across five sections, providing an overall score for study quality out of 30. The five sections include questions about: Study quality (10 items; the overall quality of the study), external validity (3 items; the ability to generalise findings of the study), study bias (7 items; to assess bias in the intervention and outcome measure), confounding and selection bias (6 items; to determine bias from sampling or group assignment), and power of the study (1 item; to determine if findings are due to chance).

As has been done in previous research [31], question 27 concerning power was modified to award a single point if a study had sufficient power to detect a clinically important effect, where the probability of Type 1 error is less than 5%. The maximum score of the modified version was therefore 28 with the following categories: Excellent quality (24–28 points), good quality (19–23 points), fair quality (14–18 points), and poor quality (≤13 points). Quality assessment was performed independently by two reviewers (LC, LL) to reduce the risk of errors or the influence of bias. Where there were discrepancies, a third reviewer (MG) performed the quality assessment of the specific study to resolve them.

2.4. Methods of synthesis and analysis

2.4.1 Narrative synthesis

A narrative synthesis, which provides a text-based summary of the included studies, was performed to give a comprehensive synthesis of the nature of the included studies and interventions, including study design and methodology.

2.4.2 Meta-analysis

A quantitative synthesis via meta-analysis was performed to investigate the efficacy of the included interventions on sleep, anxiety and depression outcomes. A random effects model was used to calculate the standardised mean differences (SMD) between post-intervention scores for the intervention group and comparison group in each study included, to take into consideration heterogeneity between studies. For a study to be included, they were required to include an intervention and a comparison group, with pre and post means and standard deviations on a sleep, anxiety or depression outcome. Where data was unavailable, authors were contacted to request required data. Four of the 11 studies were not included in the meta-analysis because the required data was unavailable (means & SDs). One of these studies did not have a comparison group. Interpretation of the SMD was via Hedges' g. The I^2 statistic was used to examine heterogeneity. A rough guide to interpretation as outlined by Cochrane [32] is as follows: unimportant heterogeneity (0–40%), moderate heterogeneity (30–60%), substantial heterogeneity (50–90%) and considerable heterogeneity (75–100%). Interpretation of the I^2 statistic should be noted with caution however, due to other factors that can influence heterogeneity [32]. The probability of benefit statistic was also calculated to examine the probability that a randomly selected intervention would show a greater improvement in outcomes compared to a randomly selected comparison group. A SMD equalling zero indicates that the probability that an intervention group outperforms a comparison group is 0.5 (50%). A SMD equalling one, indicates that the probability is 0.76 (76%) [33].

Sources of heterogeneity between the studies included in each meta-analysis was explored via subgroup analyses and meta-regressions. Analyses were performed to investigate how much heterogeneity could be explained by the selected exploratory variables (moderators). Study and intervention characteristics examined included delivery format (digital or in-person), duration of intervention (in weeks), type of study (RCT, non-RCT), type of intervention (multi-component or single-component) and type of comparison group (active [alternative intervention] or passive [e.g., waitlist control or treatment as usual]). Comparisons between the subpopulations of participants (experiencing insomnia or not) were also examined. Separate multivariate regressions for each outcome (sleep, anxiety & depression) were performed. Each regression included the six studies of the respective meta-analysis. Funnel plot asymmetry of each meta-analysis was also visually examined, alongside Egger's Regression tests to investigate possible publication bias. Comprehensive Meta-analysis Software V3 [34] was used to perform the meta-analyses and meta-regressions.

3. Results

3.1. Search, screening and selection

Overall, 3435 references were identified via the bibliographic database search. Fig. 1 provides detailed information of the screening and selection process. A total of 11 papers were identified as relevant for inclusion in the review.

3.2. Participant characteristics

The total number of participants in the studies included in this review was 5267, and the sample sizes ranged between 34 and 3755 participants (Table 1). Nine of the studies (81.8%) consisted of a majority of female participants (over 50%), with one study including only females. The mean age of participants from the 11 studies was 20.7 (SD = 2.066) years. Studies consisted of both undergraduate specific, and more generalised recruitment of university students. Three studies (27.3%) actively recruited participants experiencing increased sleep difficulties such as having a positive screen for insomnia or self-reporting sleep onset latency of at least 30-min for three months. One study recruited participants experiencing symptoms of stress, with seven studies (63.6%) not requiring any specific clinical criteria for inclusion. Baseline mean scores of all studies indicated participants were, on average, experiencing symptoms of insomnia or sleep disturbance at baseline with the exception of Ball and Bax (2002). In this study, 47% of participants indicated achieving 6h of sleep or less per night. In terms of mental health symptoms at baseline, specifically anxiety and depression, studies varied in severity of symptoms. Baseline mean scores indicated the presence of mental health symptoms across all studies with the exception of Ball & Bax (2002), where minimal depression symptoms were reported.

3.3. Study designs and intervention characteristics

Six studies (54.5%) were randomised controlled trials (RCTs) and five (45.5%) were non-RCTs (Table 1). The interventions were divided into two categories. Nine studies investigated multi-component interventions (81.8%). Seven of these were CBT-I-based interventions. The other two consisted of interventions focused on sleep health combined with mental health management. Two studies included single-component interventions of sleep hygiene and sleep health education (18.2%).

Four studies included interventions that were in-person (36.4%), six studies included digital interventions (54.5%) and one study included both methods of delivery (9.1%). The duration of interventions ranged from one single 20-min (approx.) session to covering a whole semester. Three studies delivered interventions across six weeks (27.3%). Three studies dd not include a follow-up. Follow-up lengths ranged between one month and a semester. The most common follow-up length was three months/12 weeks, with three studies reporting this (27.3%). One study did not include a comparator group (9.1%). Six studies included a passive comparison group e.g., waitlist control group or treatment as usual (54.5%). Four

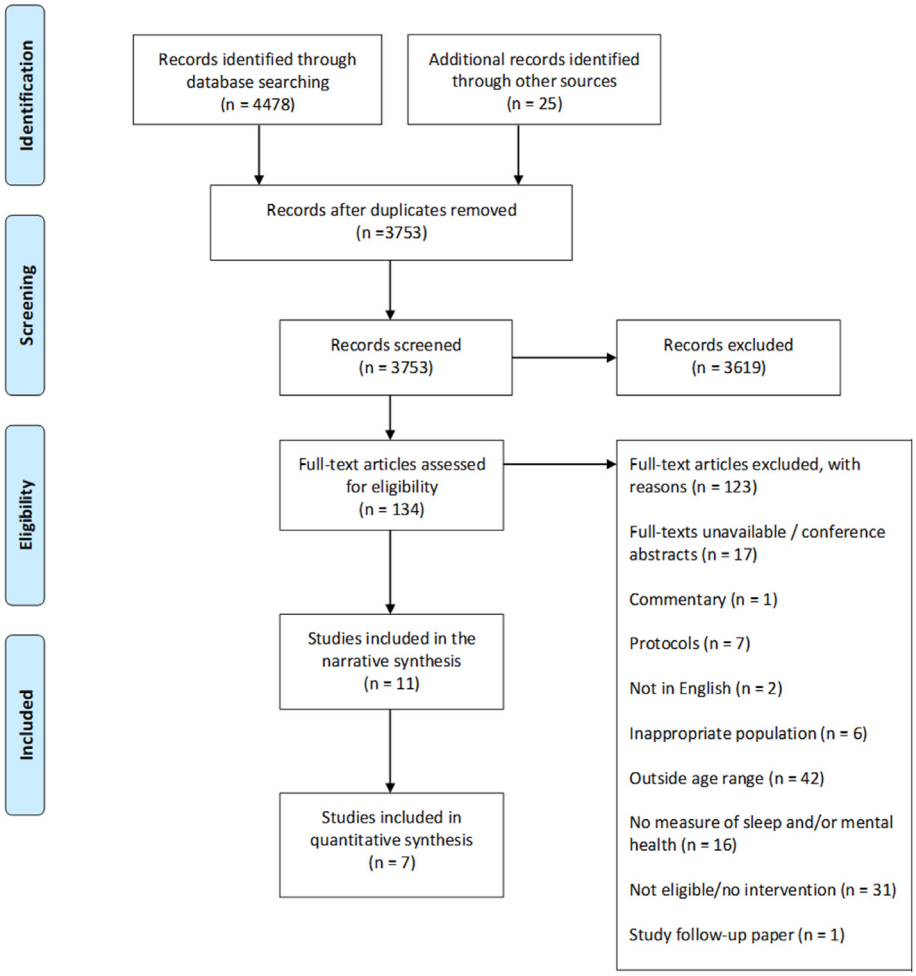

Fig. 1. PRISMA 2009 flow diagram.
Note: the number of studies included in the review reflect the up-to-date results as of April 2022. Each quantitative synthesis (meta-analysis) included only six studies as not all studies reported all outcomes however a combination of seven studies were included across all meta-analyses. Four studies were not eligible for inclusion in the quantitative synthesis as the required data was unavailable.

studies included an active comparison group i.e., an alternative intervention (36.4%).

All 11 studies investigated at least one self-report sleep outcome including sleep quality, sleep onset latency, sleep duration and/or presence of insomnia. Seven studies investigated anxiety (63.6%), with ten studies investigating depression (90.9%). For detailed information about the interventions included in each study see Supplementary Table 1.

3.4. Quality assessment

The overall quality of the studies ranged from 17 to 25 (M = 20.5, SD = 6.273), where 28 was the highest possible score (see Supplementary Table 2). Of the 11 studies, three were rated fair, seven good and one excellent, indicating most studies were of good quality overall. Most studies (72.7%) had a high quality of reporting (M = 9.2, SD = 1.367). The mean external validity for all 11 studies was moderate (M = 2.0, SD = 0.400), the mean study bias was low (M = 4.8, SD = 0.164), and the mean confounding or selection bias was low (M = 4.2, SD = 1.964). In terms of study power, studies were rated as either one or zero, where one indicated sufficient statistical power and zero indicated the lack of statistical power or statistical power not being reported in the paper. Three of the 11 studies were rated as having sufficient statistical power, suggesting caution in interpreting the results of the remaining studies.

3.5. Synthesis of studies

Of the nine studies that included multi-component interventions, five were identified as RCTs and four as non-RCTs. The majority were identified as 'good' quality, with two rated as 'fair', and one 'excellent'. Five were digital interventions, with three delivered in-person, and one a combination of both delivery methods. Two multi-component interventions were a combination of sleep education and mental health management elements. One specifically focused on anxiety whilst the other included both anxiety and depression management techniques. One intervention was a single session with the other including a single session with additional input over the course of one semester. Both of these studies included an active comparison group, an alternative intervention. The remaining seven multi-component studies consisted of CBT-I-based interventions. All interventions included sleep restriction, stimulus control and other components regularly implemented in CBT-I including sleep hygiene, psychoeducation and relaxation techniques. The delivery of these interventions was either via emails or through an online platform, with one delivered in-person through a series of seminars. The length of interventions varied in length from four weeks to over a semester. Two studies

Table 1
Participant characteristics, study design, intervention characteristics and outcomes of all studies.

Authors, year of publication & study type	Participant information				Intervention duration & follow-up	Intervention mode of delivery	Intervention type	Comparison group type•	Outcome measures	Effect of intervention at post-intervention
	Total N & population	Gender (%)	Age (mean years)	Clinical characteristics*						
Ball & Bax (2002) [35] Non-RCT	54 First year medical students	Male 59.3% Female 40.7%	24.02	Baseline: <6h sleep = 47%; minimal depression	Over one semester Follow-up end of second semester	In-person	Sleep hygiene, health & mental health management	Active	Health Habits Survey (incl. sleep habits) ESS BDI-II	Positive effect: sleep disturbance, depression
Trockel et al. (2011) [36] Non-RCT	101 First year students	Male 51.2% Female 48.8%	99: 18 26: 19-22	Subgroups: with/ without sleep disturbance Baseline: with = higher depression symptoms	8 weeks No follow-up	Digital (via email)	CBT-I-based intervention	Active	PSQI CES-D	Positive effect: with sleep disturbance only: sleep disturbance, depression
◆Taylor et al. (2014) [37] RCT	34 University students	Male 41.2% Female 58.8%	19.71	Eligibility: self-reported SOL/WASO 30+ minutes 3x a week for 3 months Baseline: moderate insomnia, anxiety, mild depression	6 weeks 3 month follow-up	In-person	CBT-I-based intervention	Passive	ISI PSQI STAI-T QIDS	Positive effect: sleep, anxiety, depression
◆Asano et al. (2015) [38] Non-RCT	123 University students	Male 40.1% Female 59.9	19.00	Baseline: sleep disturbance, psychological distress	4 weeks 3 month follow-up	In-person and digital (email)	CBT-I-based intervention	Passive	PSQI Kessler-6	Positive effect: sleep, depression
Levenson et al. (2016) [39] Non-RCT	108 University students	Male 3.6% Female 96.4%	20.93	Baseline: above average sleep disturbance, anxiety, depression	4 weeks No follow-up	In-person	Sleep health	None	PSQI STAI-S BDI-II	Positive effect: sleep, depression
◆Morris et al. (2016) [40] RCT	138 Undergraduate students	Male 32.6% Female 67.4%	20.50	Eligibility: stress symptoms Baseline: sleep disturbance, high state anxiety, minimal depression symptoms	6 weeks No follow-up	Digital	CBT-I-based intervention	Passive	PSQI PROMIS	Positive effect: sleep, anxiety, depression
◆Freeman et al. (2017) [41] RCT	3755 University students	Male 27.5% Female 71.5% Other 1.0%	24.7	Eligibility: insomnia via SCI Baseline: moderate insomnia, mild anxiety, moderate depression	10 weeks 12 week follow-up	Digital	CBT-I intervention	Passive	ISI GAD-7 PHQ-9	Positive effect: sleep, anxiety, depression
◆Baroni et al. (2018) [42] Non-RCT	145 Undergraduate students	Male 17.9 Female 82.1%	19.79	Baseline: sleep disturbance, mild anxiety, depression	A semester 2 month follow-up	In-person	CBT-I intervention	Active	PSQI BAI CES-D	Positive effect: sleep, anxiety Negative effect: depression
Hershner & O'Brien (2018) [43] RCT	549 University students	Male 41.7% Female 58.3%	21.90	Baseline: sleep disturbance, mild depression	1 session (approx. 20-min) 8 week follow-up	Digital	Sleep hygiene education	Passive	PSQI PHQ-9	Positive effect: sleep, depression
◆Denis et al. (2020) [44] RCT	199 Psychology students	Female 100%	19.98	Baseline: sleep disturbance, high anxiety, minimal depression	6 weeks 6 month follow-up	Digital	CBT-I intervention	Passive	PSQI STAI MAFQ	Positive effect: sleep favoured comparison: anxiety, depression
◆Short & Schmidt (2020) [45] RCT	61 Undergraduate students	Male 16% Female 84%	19.43	Eligibility: above sample mean on insomnia, anxiety Baseline: subthreshold insomnia, moderate anxiety	1 session (approx. 45-min) 1 month follow-up	Digital (via text)	Sleep education and anxiety treatment intervention	Active	ISI BAI	Positive effect: sleep, anxiety

Note: Studies are presented by year of publication. RCT; randomised controlled trial. N, number of participants; %, percentage; SOL, sleep onset latency; WASO, wake after sleep onset; SCI, sleep condition indicator. *Baseline scores are based on intervention group means. Interventions were categorised as CBT-I if the included stimulus control and/or sleep restriction with at least one additional component often found as part of CBT-I i.e., sleep hygiene, psychoeducation, relaxation strategies. Sleep hygiene, sleep health education-based interventions consisted of components such as providing participants with sleep hygiene recommendations and information about sleep and the effects of sleep on health. •comparison groups were identified as either active (they consisted of an alternative intervention) or passive (e.g., waitlist control or treatment as usual). Only outcome measures and respective outcome data used for analysis in this review are stated. ◆Study included in meta-analyses. BAI; Beck Anxiety Inventory, BDI-II; Beck Depression Inventory-II, BAI; Beck Anxiety Inventory, CES-D; Center for Epidemiologic Studies Depression Scale, ESS; The Epworth Sleepiness Scale, GAD-7; Generalised Anxiety Disorder Assessment-7, ISI; Insomnia Severity Index, MAFQ; Mood and Feelings Questionnaire, PHQ-9; Patient Health Questionnaire-9, PROMIS; Patient Reported Outcomes Measurement Information System, PSQI; Pittsburgh sleep quality index, QIDS; Quick Inventory of Depressive Symptomatology, STAI; State Trait Anxiety Inventory.

had an active comparison group with five including passive comparisons e.g., a waitlist control or treatment as usual.

Two studies were identified as including single-component interventions. Both studies varied greatly in design and methodology. One study was identified as an RCT with a passive comparison group. The intervention was a one-off digital session focused on sleep hygiene, with some of the provided information being specific to the student population. The other study was identified as a non-RCT with no comparison group. The intervention duration was four weeks and was delivered in-person. The content included similar topics such as best sleep practices, with information specific to students however the main focus was sleep health as a broader topic. The synthesis highlights that although interventions of a specific bracket e.g., CBT-I may consist of similar content, the delivery of these interventions and design of the studies tends to vary greatly.

Neither of the single-component intervention studies were appropriate for inclusion in the meta-analyses as the data required (means & SDs) was not available. Both studies found improvements in sleep parameters post-intervention including sleep quality, sleep onset latency and sleep efficiency. Improvements were also seen for symptoms of depression post-intervention. A further two muti-component intervention studies were not appropriate for inclusion in the meta-analyses as the data required (means & SDs) was not available. Both of these studies were identified as having a 'fair' quality rating. Both found improvements in sleep disturbance and depression symptoms post-intervention. However, in one of the studies which analysed subgroups of participants with and without sleep disturbance, these findings were only found for those experiencing sleep disturbance at baseline.

3.6. Meta-analysis

3.6.1. Sleep

The estimates from the random effect meta-analysis for studies investigating multi-component sleep interventions on sleep outcomes are summarised in Fig. 2. From the six interventions with a total of 4310 participants, a positive effect was observed in all (Fig. 2). Overall, there was a considerable amount of heterogeneity between the studies ($I^2 = 80.5\%$). The aggregate effect size was moderate (SMD = −0.548 [CI: −0.837, −0.258], $p < 0.001$). The probability of benefit statistic indicated that individuals from an intervention group were approximately 60% more likely to see a reduction in sleep difficulties compared to a comparison group.

Subgroup analysis and meta-regression. To explore heterogeneity between the studies, subgroup analyses were performed based on delivery format (digital or in-person), type of study (RCT, non-RCT), comparison group type (active or passive) and subpopulation (participants experiencing insomnia or not). Random effects analysis showed that the total between group effect was not significant for delivery format ($p = 0.181$), type of study ($p = 0.835$), comparison group type ($p = 0.351$) or subpopulation ($p = 0.198$), indicating that there were no differences between the subgroups of studies. Further exploration of heterogeneity was performed via meta-regressions.

Delivery format and intervention duration (in weeks) were included as moderator variables in a regression model, examining intervention characteristics. The model, when both moderators were included, explained 35% of the variance in effects between studies. Study type, comparison group type and subpopulation were included in a second regression model. The model, when the three moderators were included, explained 100% of the variance in effects between studies. Comparison group type ($p = 0.0474$) and subpopulation ($p = 0.0003$) made significant contributions to the model, with passive comparison groups and studies with participants experiencing insomnia showing larger effects (see supplementary figures 3a & 3 b).

Follow-up. Three studies' follow-up results were eligible for meta-analysis to explore longer term effects (see supplementary figure 3c). Follow-up lengths of the respective studies were one, three and six months. Overall, there was a considerable amount of heterogeneity between the studies ($I^2 = 88.3\%$). The aggregate effect size was small (SMD = −0.381 [CI: −0.955, 0.192], $p = 0.193$), and not significant.

3.6.2. Anxiety

The estimates from the random effect meta-analysis for studies investigating multi-component sleep interventions on anxiety outcomes are summarised in Fig. 3. From the six interventions with a total of 4332 participants, a positive effect was observed in five (Fig. 3). Overall, there was a moderate amount of heterogeneity between studies ($I^2 = 56.0\%$). The aggregate effect size was small (SMD = −0.226 [95% CI: −0.421, −0.031], $p = 0.023$). The probability of benefit statistic indicated that individuals from an intervention group were between 50% and 60% more likely to see a reduction in anxiety symptoms compared to a comparison group.

Subgroup analysis and meta-regression. To explore heterogeneity, subgroup analyses were performed based on delivery format (digital or in-person), type of study (RCT, non-RCT), comparison group type (active or passive) and subpopulation (participants experiencing insomnia or not). Random effects analysis showed that the total between group effect was not significant for delivery format ($p = 0.904$), type of study ($p = 0.714$), comparison group type ($p = 0.666$) or subpopulation ($p = 0.400$), indicating that there

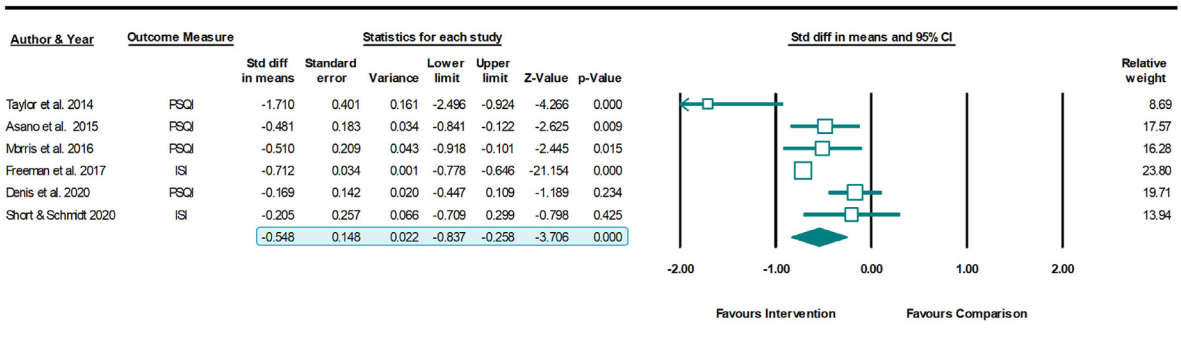

Fig. 2. Forest plot of meta-analysis for sleep outcomes.
Note: ISI, Insomnia Severity Index; PSQI, The Pittsburgh Sleep Quality Index; Std diff in means, standardised difference in means; CI, confidence interval.

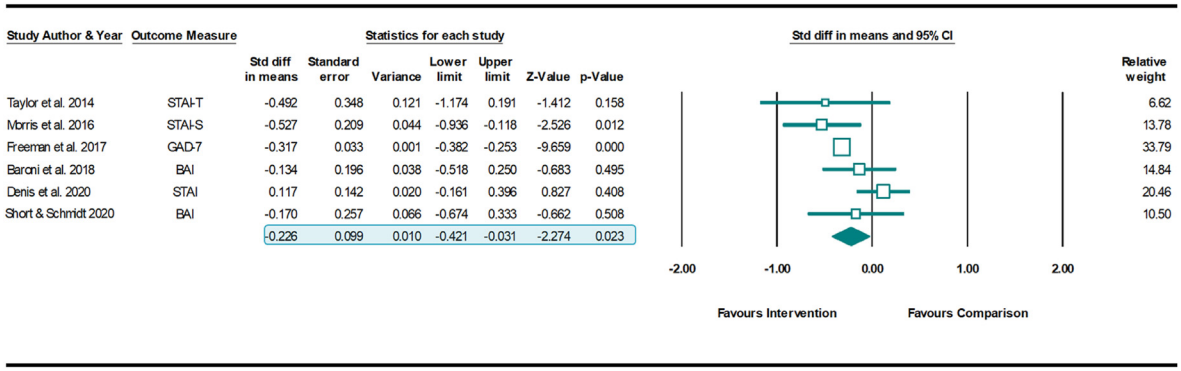

Fig. 3. Forest plot of meta-analysis for anxiety outcomes.
Note: BAI, Beck Anxiety Inventory; GAD-7, Generalised Anxiety Disorder Assessment; STAI-S, State-Trait Anxiety Inventory-State; STAI-T, State-Trait Anxiety Inventory-Trait; Std diff in means, standardised difference in means; CI, confidence interval.

were no differences between the subgroups of studies. Further exploration of heterogeneity was performed via meta-regressions.

Delivery format and intervention duration (in weeks) were included as moderator variables in a regression model, examining intervention characteristics. The model, when both moderators were included, did not explain any of the variance in effects between studies. Study type, comparison group type and subpopulation were included in a second regression model. The model, when the three moderators were included, explained 100% of the variance in effects between studies (see supplementary figures 4a & 4 b).

Follow-up. Four studies' follow-up results were eligible for meta-analysis to explore longer term effects (see supplementary figure 4c). Follow-up lengths of the respective studies were one, two, three and six months. Overall, there was no heterogeneity identified between the studies ($I^2 = 0.0\%$). The aggregate effect size was small (SMD = −0.245 [CI: −0.340, −0.151], $p < 0.001$).

3.6.3. Depression

The estimates from the random effect meta-analysis for studies investigating multi-component sleep interventions on depression outcomes are summarised in Fig. 4. From the six interventions with a total of 4394 participants, a positive effect was observed in five (Fig. 4). Overall, there was a substantial amount of heterogeneity between the studies ($I^2 = 68.6\%$). The aggregate effect size was small (SMD = −0.295 [CI: −0.513, −0.077], $p = 0.008$). The probability of benefit statistic indicated that individuals from an intervention group were between 50% and 60% more likely to see a reduction in depression symptoms compared to a comparison group.

Subgroup analysis and meta-regression. To explore heterogeneity, subgroup analyses were performed based on delivery format (digital or in-person), type of study (RCT, non-RCT), comparison group type (active or passive) and subpopulation (participants experiencing insomnia or not). Random effects analysis showed that the total between group effect was not significant for delivery format ($p = 0.931$), type of study ($p = 0.643$), comparison group type ($p = 0.404$) or subpopulation ($p = 0.131$), indicating that there were no differences between the subgroups of studies. Further exploration of heterogeneity was performed via meta-regressions.

Delivery format and intervention duration (in weeks) were included as moderator variables in a regression model, examining intervention characteristics. The model, when both moderators were included, explained 16% of the variance in effects between studies. Study type, comparison group type and subpopulation were included in a second regression model. The model, when the three moderators were included, explained 100% of the variance in effects between studies. Subpopulation ($p = 0.0063$) made a significant contribution to the model, with participants experiencing insomnia showing larger effects (see supplementary figures 5a & 5b).

Follow-up. Three studies' follow-up results were eligible for meta-analysis to explore longer term effects (see supplementary figure 5c). Follow-up lengths of the respective studies were two, three and six months. Overall, no heterogeneity was identified between the studies ($I^2 = 0.0\%$). The aggregate effect size was small (SMD = −0.340 [CI: −0.436, −0.243], $p < 0.001$).

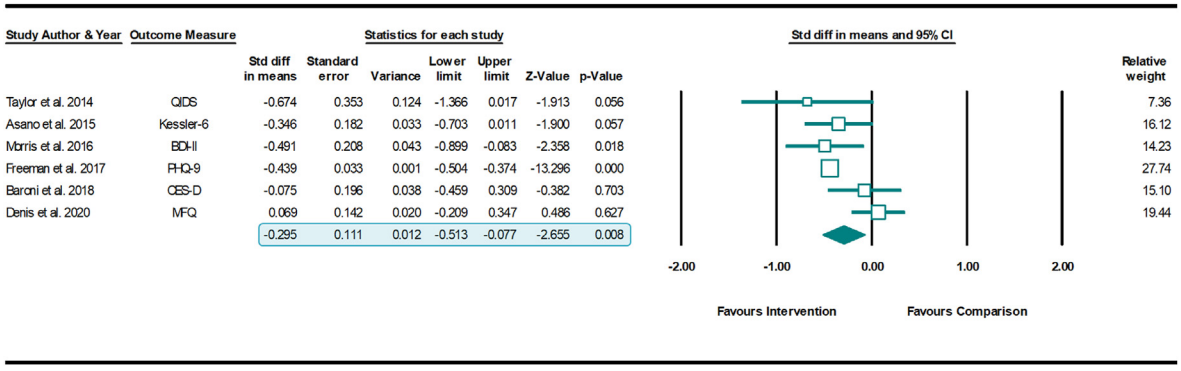

Fig. 4. Forest plot of meta-analysis for depression outcomes.
Note: BDI-II, Beck Depression Inventory; CES-D, Centre for Epidemiologic Studies Depression Scale; MFQ, Mood and Feelings Questionnaire; PHQ-9, Patient Health Questionnaire; QIDS, Quick Inventory of Depressive Symptomatology; Std diff in means, standardised difference in means; CI, confidence interval.

3.7. Publication bias

Egger's regression tests were performed to assess potential publication bias in each meta-analysis via funnel plot asymmetry. The tests did not reveal asymmetry in effect sizes for sleep ($t = 0.819$ [CI: −2.577, 4.734], $p = 0.459$), anxiety ($t = 0.668$ [CI: −1.884, 3.077], $p = 0.541$) or depression ($t = 1.037$ [CI: −1.759, 3.857], $p = 0.358$), indicating an absence of significant publication bias (see supplementary figures 6a, 6b & 6c).

4. Discussion

4.1. Summary

The aim of this systematic review and meta-analysis was to examine how efficacious psychological sleep interventions are, in improving the sleep and mental health of university students. The review identified 11 studies that, overall, provide positive evidence for improving university student sleep and mental health. The narrative synthesis identified many differences in the study and intervention characteristics used by researchers. Meta-analyses found that multi-component sleep interventions showed a moderate effect in improving symptoms of sleep and a small effect in improving symptoms of anxiety and depression against a comparison group at post-treatment. Heterogeneity was found to be high between studies. Subgroup analyses and meta-regressions explored heterogeneity via moderator variables of delivery format, intervention duration, study type, comparison group type and subpopulation. Meta-regressions examining delivery format and intervention duration did not account for significant variance in effects between studies for any outcome. When examining study type, comparison group type and subpopulation, subpopulation made a significant contribution for sleep and depression but not anxiety, with comparison group also making a significant contribution for sleep. Studies that included participants with insomnia, and studies with passive comparison groups showed larger effects. Follow-up analyses showed that small, significant effects were sustained for both anxiety and depression, but not for sleep.

The findings of this review support findings of previous reviews looking at the effect of sleep interventions on sleep and mental health. Small to moderate effects on sleep in adults both with and without sleep disorders [46,47] have been found. Additionally, small to moderate effects for anxiety [21] and depression [22] in adults with insomnia and mental health problems respectively, as well as young adults [23] have also been found. The findings of this review are also somewhat comparable to previous research examining the effect of psychological interventions on mental health in students with and without mental health problems. Interventions showed no (when compared to an active control) to moderate (when compared to WLC) effects for anxiety and small (active control) to large (WLC) effects for depression [48]. Sustained small effects have also been found for both anxiety and depression symptoms at follow-up [48,49], in line with the findings of this review. With improvements in sleep quality found to lead to moderate improvements in mental health [26], and insomnia improvements found to mediate the effects on depression following a CBT-I intervention [50], research shows promise for the causal role of sleep interventions in improving mental health symptoms in university students.

Moderators examined in this review found that delivery format and intervention duration did not explain variance in effects between studies. Whether the intervention included an active or passive comparison group was a significant moderator in explaining variance in effects on sleep outcomes, with larger effects seen against passive comparison groups. This is not surprising considering the content of active comparison groups was often related to well-being, including components related to sleep. Whether participants were experiencing insomnia at baseline or not was also a significant moderator for sleep and depression but not for anxiety, with greater effects seen for those experiencing insomnia.

Students with clinical mental health problems were not specifically recruited in the studies included in this review, with, in general, mild to moderate symptoms observed at baseline. Although this review shows positive effects of sleep interventions on improving sleep and mental health symptoms, with greater effects seen for those experiencing insomnia, further research could establish the difference in effects between university students with and without mental health problems.

This review further adds to the literature by examining the use of sleep interventions on improving the sleep and mental health of university students as a specific population. Increasing our understanding of effective interventions in this population may lead to changes in the infrastructure of universities to better support sleep and subsequently mental health.

4.2. Strengths and limitations of the review

Substantial heterogeneity was found across studies included in this review, which is consistent with previous work [22,23]. Random-effects meta-analyses were performed to take this into consideration as well as subgroup analyses and meta-regressions to explore possible causes of heterogeneity. Although only six studies were included in each meta-analysis and meta-regression, all studies were rated as being of good quality, with one study rated as 'excellent'. Most studies were also identified as RCTs, which adds to the robustness of the findings. However, caution should be noted when interpreting meta-regressions due to the small number of studies included. As studies did not specifically recruit individuals experiencing mental health symptoms, it is unclear what the differences in effect are between those who are experiencing mental health and those who are not. That said, mental health symptoms were reported across studies with varying severity. Future research should distinguish between individuals who are and are not experiencing mental health problems, to identify any differences in intervention efficacy. Although Egger's regression tests did not identify significant publication bias, the number of data points is too low to draw strong conclusions about the absence of a publication bias. The papers were also limited to those in the English language and so other relevant studies in alternative languages may have been missed. The quality assessment of studies included in the review was performed using the 'Checklist for Measuring Quality' [30]. This tool was chosen as it can be applied to both randomised and non-randomised studies, which allowed the quality assessment to remain consistent across all studies included. Although a valid tool, an alternative tool such as the Cochrane ROB tool, may have been a more reliable measure for the assessment of the RCT studies. Many of the outcomes reported in the included papers were based on self-reported data. Whereas this is unavoidable for mental health outcomes, alternatives exist for sleep. This would be beneficial as objective data can provide more reliable data rather than relying on self-report.

Despite these limitations this review provides support from the included studies for the efficacy of multi-component sleep interventions in improving sleep and symptoms of anxiety and depression in university students. The inclusion of both RCTs and non-RCTs was able to provide a more comprehensive picture of the literature, with overall quality remaining good as identified in the quality assessment. Meta-regression analyses also provided preliminary evidence for which covariates may have an influence on treatment effects in the university student population.

4.3. Implications for future research

From this review, it is evident that sleep interventions, specifically multi-component sleep interventions, show positive effects in improving university student sleep and mental health. Studies delivering sleep interventions showed many differences in design and methodology. Intervention characteristics including delivery format and intervention duration did not appear to explain the effects between studies. Further research could examine which specific characteristics may have a role to play in intervention efficacy. This could lead to future trials improving the design of interventions to improve efficacy, whilst making them as concise and accessible as possible to reduce the burden and increase the uptake. Additionally, there is still a need to identify the efficacy of sleep interventions in subgroups including university students with and without underlying mental health difficulties.

5. Conclusions

This review provides evidence from 11 studies for the efficacy of sleep interventions in improving the sleep and mental health of university students. With evidence for the role of improving sleep leading to improving mental health [26,50], both assessment of sleep and introducing sleep-focused services for students at university may be beneficial to both their sleep and mental health. University settings can offer unique opportunities for both prevention and treatment of sleep disturbance and mental health symptoms amongst their students. Although services are available in university settings, mental health problems are still high in this population, and accessibility and engagement are still an issue. Sleep is a less stigmatised route to treatment and may help improve engagement with services. Possible avenues include adding to existing well-being services and providing services through university apps and/or campus accommodation.

Declarations of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2022.09.003.

References

[1] Chattu VK, Manzar D, Kumary S, Burman D, Spence DW, Pandi-Perumal SR. The global problem of insufficient sleep and its serious public health implications. Healthcare 2018;7(1). https://doi.org/10.3390/healthcare7010001.
[2] American Psychiatric Association. Diagnostic and statistical manual of mental disorders. fifth ed. 2013. https://doi.org/10.1176/appi.books.9780890425596.
[3] Becker SP, Jarrett MA, Luebbe AM, Garner AA, Burns GL, Kofler MJ. Sleep in a large, multi-university sample of college students: sleep problem prevalence, sex differences, and mental health correlates. Sleep Health 2018;4(2):174–81. https://doi.org/10.1016/j.sleh.2018.01.001.
[4] Schlarb AA, Claßen M, Hellmann SM, Vögele C, Gulewitsch MD. Sleep and somatic complaints in university students. J Pain Res 2017;10:1189–99. https://doi.org/10.2147/JPR.S125421.
[5] Milojevich HM, Lukowski AF. Sleep and mental health in undergraduate students with generally healthy sleep habits. PLoS One 2016;11(6):e0156372. https://doi.org/10.1371/journal.pone.0156372.
[6] Gadie A, Shafto M, Leng Y, Cam-Can, Kievit RA. How are age-related differences in sleep quality associated with health outcomes? An epidemiological investigation in a UK cohort of 2406 adults. BMJ Open 2017;7:e014920. https://doi.org/10.1136/bmjopen-2016-014920.
[7] Oswalt SB, Lederer AM, Chestnut-Steich K, Day C, Halbritter A, Ortiz D. Trends in college students' mental health diagnoses and utilization of services, 2009–2015. J Am Coll Health 2020;68(1):41–51. https://doi.org/10.1080/07448481.2018.1515748.
[8] Beiter R, Nash R, McCrady M, Rhoades D, Linscomb M, Clarahan M, et al. The prevalence and correlates of depression, anxiety, and stress in a sample of college students. J Affect Disord 2015;173:90–6. https://doi.org/10.1016/j.jad.2014.10.054.
[9] Lovell GP, Nash K, Sharman R, Lane BR. A cross-sectional investigation of depressive, anxiety, and stress symptoms and health-behavior participation in Australian university students. Nurs Health Sci 2015;17:134–42. https://doi.org/10.1111/nhs.12147.
[10] Macaskill A. The mental health of university students in the United Kingdom. Br J Guid Counsell 2013;41(4):426–41. https://doi.org/10.1080/03069885.2012.743110.
[11] Ridner SL, Newton KS, Staten RR, Crawford TN, Hall LA. Predictors of well-being among college students. J Am Coll Health 2016;64(2):116–24. https://doi.org/10.1080/07448481.2015.1085057.
[12] Russell K, Allan S, Beattie L, Bohan J, MacMahon K, Rasmussen S. Sleep problem, suicide and self-harm in university students: a systematic review. Sleep Med Rev 2019;44:58–69. https://doi.org/10.1016/j.smrv.2018.12.008.
[13] Pigeon WR. Treatment of adult insomnia with cognitive-behavioral therapy. J Clin Psychol 2010;66(11):1148–60. https://doi.org/10.1002/jclp.20737.
[14] Perlis ML, Jungquist C, Smith MT, Posner D. Cognitive behavioral treatment of insomnia: a session by session guide. New York: Springer Publishing; 2005.
[15] Siebern AT, Manber R. New developments in cognitive behavioral therapy as the first-line treatment of insomnia. Psychol Res Behav Manag 2011;4:21–8. https://doi.org/10.2147/PRBM.S10041.
[16] Davidson JR, Dickson C, Han H. Cognitive behavioural treatment for insomnia in primary care: a systematic review of sleep outcomes. Br J Gen Pract 2019;69(686):e657–64. https://doi.org/10.3399/bjgp19X705065.
[17] Murawski B, Wade L, Plotnikoff RC, Lubans DR, Duncan MJ. A systematic review and meta-analysis of cognitive and behavioral interventions to improve sleep health in adults without sleep disorders. Sleep Med Rev 2018;40:160–9. https://doi.org/10.1016/j.smrv.2017.12.003.
[18] Zachariae R, Lyby MS, Ritterband LM, O'Toole MS. Efficacy of internet-delivered cognitive behavioral therapy for insomnia – a systematic review and meta-analysis of randomized controlled trials. Sleep Med Rev 2016;30:1–10. https://doi.org/10.1016/j.smrv.2015.10.004.
[19] Insomnia NICE. Management. National Institute for Health and Clinical Excellence; 2021. https://cks.nice.org.uk/topics/insomnia/management/.
[20] Riemann D, Baglioni C, Bassetti C, Bjorvatn B, Dolenc Groselj L, Ellis JG, et al. European guideline for the diagnosis and treatment of insomnia. J Sleep Res 2017;26(6):675–700. https://doi.org/10.1111/jsr.12594.
[21] Belleville G, Cousineau H, Levrier K, St-Pierre-Delorme M. Meta-analytic review of the impact of cognitive-behavior therapy for insomnia on concomitant anxiety. Clin Psychol Rev 2011;31:638–52. https://doi.org/10.1016/j.cpr.2011.02.004.
[22] Gee B, Orchard F, Clarke E, Joy A, Clarke Reynolds S. The effect of non-pharmacological sleep interventions on depression symptoms: a meta-analysis of randomised controlled trials. Sleep Med Rev 2019;43:118–28. https://doi.org/10.1016/j.smrv.2018.09.004.
[23] Kodsi A, Bullock B, Kennedy G, Tirlea L. Psychological interventions to improve sleep in young adults: a systematic review and meta-analysis of randomized controlled trials. Behav Sleep Med 2021. https://doi.org/10.1080/15402002.2021.1876062.
[24] Saruhanjan K, Zarski AC, Bauer T, Baumeister H, Cuijpers P, Spiegelhalder K, et al. Psychological interventions to improve sleep in college students: a meta-analysis of randomized controlled trials. J Sleep Res 2021;30(1). https://doi.org/10.1111/jsr.13097.
[25] Lubas MM, Szklo-Coxe M. A Critical review of education-based sleep interventions for undergraduate students: informing future directions in intervention development. Adolescent Res Rev 2019;4:249–66. https://doi.org/10.1007/s40894-018-0100-9.
[26] Scott AJ, Webb TL, Martyn-St James M, Rowse G, Weich S. Improving sleep quality leads to better mental health: a meta-analysis of randomised controlled trials. Sleep Med Rev 2021;60. https://doi.org/10.1016/j.smrv.2021.101556.
[27] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372. https://doi.org/10.1136/bmj.n71.
[28] Friedrich A, Schlarb AA. Let's talk about sleep: a systematic review of psychological interventions to improve sleep in college students. J Sleep Res 2018;27(1):4–22. https://doi.org/10.1111/jsr.12568.
[29] Dietrich SK, Francis-Jimenez CM, Knibbs MD, Umali IL, Truglio-Londrigan M. Effectiveness of sleep education programs to improve sleep hygiene and/or sleep quality in college students: a systematic review. JBI Database System Rev Implement Rep 2016;14(9):108–34. https://doi.org/10.11124/JBISRIR-2016-003088.
[30] Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies

of health care interventions. J Epidemiol Community 1998;52:377–84. https://doi.org/10.1136/jech.52.6.377.
[31] O'Connor SR, Tully MA, Ryan B, Bradley JM, Baxter GD, McDonough SM. Failure of a numerical quality assessment scale to identify potential risk of bias in a systematic review: a comparison study. BMC Res Notes 2015;8(224). https://doi.org/10.1186/s13104-015-1181-1.
[32] Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors. Cochrane handbook for systematic reviews of interventions. second ed. Chichester (UK): John Wiley & Sons; 2019.
[33] Faraone SV. Interpreting estimates of treatment effects: implications for managed care. P T : a peer-reviewed journal for formulary management 2008;33(12):700–11.
[34] Borenstein M, Hedges L, Higgins J, Rothstein H. *Comprehensive meta-analysis version 3*. 2013. Biostat, Englewood, NJ.
[35] Ball S, Bax A. Self-care in medical education: effectiveness of health-habits interventions for first-year medical students. Acad Med 2002;77(9):911–7. https://doi.org/10.1097/00001888-200209000-00023.
[36] Trockel M, Manber R, Chang V, Thurston A, Tailor CB. An e-mail delivered CBT for sleep-health program for college students: effects on sleep quality and depression symptoms. J Clin Sleep Med 2011;7(3):276–81. https://doi.org/10.5664/JCSM.1072.
[37] Taylor DJ, Zimmerman MR, Gardner CE, Williams JM, Grieser EA, Tatum JI, et al. A pilot randomized controlled trial of the effects of cognitive-behavioral therapy for insomnia on sleep and daytime functioning in college students. Behav Ther 2014;45(3):376–89. https://doi.org/10.1016/j.beth.2013.12.010.
[38] Asano K, Ishimura I, Abe H, Nakazato M, Nakagawa A, Shimizu E. Cognitive Behavioral Therapy as the basis for preventive intervention in a sleep health program: a quasi-experimental study of e-mail newsletters to college students. Open J Med Psychol 2015;4:9–16. https://doi.org/10.4236/ojmp.2015.41002.
[39] Levenson JC, Miller E, Hafer B, Reidell MF, Buysse DJ, Franzen PL. Pilot study of a sleep health promotion program for college students. Sleep health 2016;2(2):167–74. https://doi.org/10.1016/j.sleh.2016.03.006.
[40] Morris J, Firkins A, Millings A, Mohr C, Redford P, Rowe A. Internet-delivered cognitive behavior therapy for anxiety and insomnia in a higher education context. Hist Philos Logic 2016;29(4):415–31. https://doi.org/10.1080/10615806.2015.1058924.
[41] Freeman D, Sheaves B, Goodwin GM, Yu L-M, Nickless A, Harrison PJ, et al. The effects of improving sleep on mental health (OASIS): a randomised controlled trial with mediation analysis. Lancet Psychiatr 2017;4(10):749–58. https://doi.org/10.1016/S2215-0366(17)30328-0.
[42] Baroni A, Bruzzese J, Di Bartolo CA, Ciarleglio A, Shatkin JP. Impact of a sleep course on sleep, mood and anxiety symptoms in college students: a pilot study. J Am Coll Health 2018;66(1):41–50. https://doi.org/10.1080/07448481.2017.1369091.
[43] Hershner S, O'Brien LM. The impact of a randomized sleep education intervention for college students. J Clin Sleep Med 2018;14(3):337–47. https://doi.org/10.5664/jcsm.6974.
[44] Denis D, Eley TC, Rijsdijk F, Zavos H, Keers R, Espie CA, et al. Is digital cognitive behavioural therapy for insomnia effective in treating sub-threshold insomnia: a pilot RCT. Sleep Med 2020;66:174–83. https://doi.org/10.1016/j.sleep.2019.10.007.
[45] Short NA, Schmidt NB. Developing and testing a novel, computerized insomnia and anxiety intervention to reduce safety aids among an at-risk student sample: a Randomized Controlled Trial. Behav Ther 2020;51(1):149–61. https://doi.org/10.1016/j.beth.2019.05.012.
[46] Cheung JMY, Jarrin DC, Ballot O, Bharwani AA, Morin CM. A systematic review of cognitive behavioral therapy for insomnia implemented in primary care and community settings. Sleep Med Rev 2019;44:23–36. https://doi.org/10.1016/j.smrv.2018.11.001.
[47] Murawski B, Wade L, Plotnikoff RC, Lubans DR, Duncan MJ. A systematic review and meta-analysis of cognitive and behavioral interventions to improve sleep health in adults without sleep disorders. Sleep Med Rev 2018;40:160–9. https://doi.org/10.1016/j.smrv.2017.12.003.
[48] Barnett P, Arundell LL, Saunders R, Matthews H, Pilling S. The efficacy of psychological interventions for the prevention and treatment of mental health disorders in university students: a systematic review and meta-analysis. J Affect Disord 2021;280(Pt A):381–406. https://doi.org/10.1016/j.jad.2020.10.060.
[49] Winzer R, Lindberg L, Guldbrandsson K, Sidorchuk A. Effects of mental health interventions for students in higher education are sustainable over time: a systematic review and meta-analysis of randomized controlled trials. PeerJ 2018;6. https://doi.org/10.7717/peerj.4598.
[50] Henry AL, Miller CB, Emsley R, Sheaves B, Freeman D, Luik AI, Littlewood DL, Saunders KEA, Kanady JC, Carl JR, Davis ML, Kyle SD, Espie CA. Insomnia as a mediating therapeutic target for depressive symptoms: a sub-analysis of participant data from two large randomized controlled trials of a digital sleep intervention. J Sleep Res 2021;30(1). https://doi.org/10.1111/jsr.13140.