Let's talk about sleep: a systematic review of psychological interventions to improve sleep in college students

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SUMMARY
Sleep problems are a common occurrence in college students. Insomnia, nightmares and impaired sleep quality lead to several mental health issues, as well as impaired academic performance. Although different sleep programmes exist, a systematic overview comparing their effectiveness is still missing. This systematic review aims to provide an overview of psychological interventions to improve sleep in college students. Seven databases were searched from November to December 2016 (MEDLINE, EMBASE, PsycINFO, Cinahl, Cochrane Library, PubMed, OpenSigle). The search string included search terms from three different topics: sleep, intervention and college students. Outcome measures included subjective as well as objective measures and focused on sleep, sleep-related and mental health variables. Twenty-seven studies met the inclusion criteria. They were assigned to four intervention categories: (1) sleep hygiene, (2) cognitive–behavioural therapy (CBT), (3) relaxation, mindfulness and hypnotherapy and (4) other psychotherapeutic interventions. Fifteen studies were randomized controlled trials. While sleep hygiene interventions provided small to medium effects, the CBTs showed large effects. The variability of the effect sizes was especially large in the relaxation category, ranging from very small to very large effect sizes. Other psychotherapeutic interventions showed medium effects. CBT approaches provided the best effects for the improvement of different sleep variables in college students. Five studies included insomnia patients. The other three intervention categories also showed promising results with overall medium effects. In the future, CBT should be combined with relaxation techniques, mindfulness and hypnotherapy. Furthermore, the interventions should broaden their target group and include more sleep disorders.

INTRODUCTION

The life of college students is filled with challenges in all areas. As emerging adults, they face changes in their living arrangements (e.g. flatmates), social life (e.g. new circle of friends, substance abuse), biological developments (e.g. chronotype) and financial situation (e.g. independence from parents, part-time work). Academic demands such as examination periods, term papers and deadlines add further to these potential stressors. Considering these challenges, it is not surprising that sleep problems are a common occurrence in college students. Up to 60% report bad sleep quality (Lund *et al.*, 2010); 14.9% indicate difficulties falling asleep, 25.9% report waking up frequently at night and 7.7% fulfil all general criteria for insomnia, according to the International Classification for Sleep Disorders (ICSD-II), second edition (Schlarb *et al.*, 2012). Nightmares are reported by 4.5% of undergraduate men and by 8.3% of undergraduate women (Abdel-Khalek, 2010).

These relatively high prevalence rates are alarming, because sleep is related closely to academic success and general health in college students. Sleep habits, particularly wake-up times, and sleep length predict the grade-point average significantly in college students (Gaultney, 2010; Kelly *et al.*, 2001; Lund *et al.*, 2010; Trockel *et al.*, 2000). In addition, an impaired sleep–wake cycle leads to lower academic performance (Medeiros *et al.*, 2001). In detail, sleep loss in college students results in reduced learning

capacity, poor declarative and procedural learning and general reduced neurocognitive functioning (Curcio *et al*., 2006). Correspondingly, bad sleep quality leads to more stimulant use (Lohsoonthorn *et al*., 2013). Besides academic concerns, bad sleep habits and impaired sleep quality are connected strongly with health risk behaviours such as fighting, suicide ideation, smoking and alcohol use (Trockel *et al*., 2000; Vail-Smith *et al*., 2009). While Kelly found that sleep length is correlated positively with life satisfaction (Kelly, 2004), insomnia symptoms and nightmares increase the risk for suicidal ideation, mental health problems and lower self-efficacy (Nadorff *et al*., 2011; Schlarb *et al*., 2012; Taylor *et al*., 2011). All in all, not only sleep disorders but even sleep problems and reduced sleep duration impair college students' lives and their academic career significantly.

Several reviews have addressed the question of therapy in patients with sleep disorders. Smith and colleagues found that behaviour therapy (BT) and pharmacotherapy both improve sleep, although BT is superior in respect of sleep latency (Smith *et al*., 2002). Correspondingly, cognitive–behavioural therapy for insomnia (CBT-I) improves sleep, as shown by several reviews (e.g. Koffel *et al*., 2015; Okajima *et al*., 2011), and is more efficient than pharmacotherapy (Mitchell *et al*., 2012). Montgomery compared three non-pharmacological interventions (CBT, bright light, exercise) for sleep problems in later life and found that CBT has a positive effect on sleep maintenance, while exercise enhances sleep in general (Montgomery, 2004). Even though these reviews concern themselves with the non-pharmacological treatment of sleep problems, they have several limitations. First, these reviews included only randomized controlled trials (RCT), which severely limited the variety of the included studies. Secondly, most of them focused on insomnia disorder and disregard other sleep disorders or impaired sleep quality. Lastly, none of the studies focused on students but rather on (older) adults.

A recent review examined the effects of sleep education programmes on sleep knowledge and sleep quality in college students (Dietrich *et al*., 2016). However, they focused only on sleep education and had a very narrow scope of only four included studies (three RCTs, one quasi-experimental). These limitations lead to insufficient evidence to determine whether sleep education programmes improve sleep in college students.

There is a severe lack of broader reviews that examine the effectiveness of psychological interventions to improve sleep in college students.

OBJECTIVES AND METHODS

The primary objective of this study is to assess the availability and effects of psychological interventions to improve sleep in college students. At present, there have been some reviews and meta-analyses that investigate the effects of non-pharmacological treatments (especially CBT) in patients with insomnia and other sleep disorders. However, none of the reviews focused on college students as a vulnerable population. The current review aims to rectify this situation by providing an overview of psychological interventions that are devised to improve sleep in college students. The methods were derived from the *Cochrane Handbook for Systematic Reviews* of interventions (Higgins and Green, 2008).

Criteria for considering studies for this review

Eligibility/inclusion criteria

As this was the first review, to our knowledge, to target psychological interventions to improve sleep in college students, the inclusion and eligibility criteria were selected with the focus on sensitivity rather than specificity.

This review included randomized controlled trials as well as quasi-experimental studies. Participants were college and university students. The term 'university students' was included in the search strategy to increase search sensitivity. The age range was not limited, as American studies, in particular, often included students who are younger than 18 years. The sample sizes had to exceed 10 participants per study.

The treatments consisted of psychological components, e.g. psychoeducation, behaviour therapy or relaxation techniques. The examined interventions were not restricted to a specific dose, frequency, intensity, duration or trainer qualification.

All types of outcome measures were analysed including subjective (questionnaires, sleep logs, etc.) and objective measures (actigraphy, polysomnography, etc.). Adverse effects were monitored if they were reported. Publication years or publication languages were not restricted, although the search terms were formulated in English.

Exclusion criteria

All studies with breathing-related sleep disorders were excluded due to the fact that they cannot be treated solely with psychological interventions. This criterion referred to all studies that included either self-reported or diagnosed breathing-related sleep disorders in the title or abstract. Furthermore, studies that did not investigate the effect of a specific intervention but focused on correlations or prevalence rates were excluded. The same applied to reviews.

Search methods for identification of studies

Search strategy and information sources

Seven databases were searched [MEDLINE, EMBASE, PsycINFO, CINAHL, Cochrane library trials, PubMed and OpenSIGLE (grey literature)] from 10 November 2016 to 12 December 2016. For the first search in MEDLINE, the

Table 1 Study search table

Database	Search date	Reports found	Relevant reports	Precision (%)
MEDLINE	10.11.2016–2.11.2016	6523	95	1.46
EMBASE (without MEDLINE)	6.12.2016–7.12.2016	4648	74	1.59
Psychinfo	22.11.2016	1424	54	3.79
CINAHL	7.12.2016	559	18	3.22
Cochrane library	6.12.2016	804	5	0.62
PubMed	8.12.2016–9.12.2016	1672	34	2.03
OpenSIGLE	12.12.2016	56	3	5.36
Total		15 686	283	1.80

following search string was used: (sleep OR sleep problem OR sleep disorder OR insomnia OR nightmare*) AND (intervention* OR treatment OR therapy OR training OR psychotherapy OR pharmacotherapy OR program*) AND (student* OR college* OR university* OR academic OR academia OR young adult*).

This search string led to very unspecific results that often included studies with obstructive sleep apnea. To further specify the search, breathing disorders were excluded explicitly in a new search string: (sleep OR sleep problem OR sleep disorder OR insomnia OR nightmare*) AND (intervention* OR treatment OR therapy OR training OR psychotherapy OR pharmacotherapy OR program*) AND (student* OR college* OR university* OR graduate*) NOT (apnea* OR breathing).

Search process

Table 1 shows the references retrieved by electronic searches. Precision rates for each database were calculated using the formula: $\text{precision} = \frac{\text{relevant reports}}{\text{reports found}}$. Precision rates range from 0.62 to 5.36%, with an average precision of 1.80 and 1.19% after duplicates were removed.

After the duplicates were removed from the original 283 studies, 185 studies remained (Fig. 1). A further 153 studies were excluded for the following reasons:

- The sample did not (only) include students [53 studies (38 adults, 13 high school students, two war veterans)],
- there was no intervention at all (23),
- there was no psychological intervention (19),
- outcome measures did not supply sufficient information about sleep (16),
- it was a review (15),
- the studies were not accessible (12),
- the intervention was only pharmacological (six),
- it was a study protocol or trial registration (five),
- it was a sleep education programme for health-care practitioners (three) or
- the paper was in Chinese (one).

The remaining 32 studies were evaluated, and again five studies were excluded (see Table S1). Twenty-seven studies were included in this review.

Data collection and analysis

Data collection process and data extraction and management

The titles and abstracts of all possible studies were screened by one author (AF) for the eligibility criteria. If the titles and abstracts met all eligibility criteria, the whole paper was read and integrated into a structured form. In line with Bovanie and colleagues (Bovanie *et al.*, submitted), this form contained (a) the aim and design of the study, (b) sample characteristics, (c) details of the intervention, (d) outcome details and (e) effects (Bovanie *et al.*, submitted). The details of the intervention were derived from the Template for Intervention Description and Publication (TIDieR Checklist, see Supporting information, Appendix 1) (Hoffmann *et al.*, 2014). All interventions were clustered by both authors into different categories according to content.

Assessment of risk of bias in included studies

The risk of bias was assessed in a table format recommended by Higgins and colleagues. It included the six categories sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other bias (Higgins *et al.*, 2011). All six categories were assessed for each study on a three-point scale indicating a low risk of bias ('yes'), a high risk of bias ('no') or an unclear risk of bias ('unclear').

Additionally, the limitations of each study were collected in the table of included studies. If there were similar limitations (e.g. studies failed to provide the sample characteristics), they were discussed separately.

Measures of treatment effect

Qualitative treatment effects were listed and included sleep as well as mental health outcomes. Quantitative treatment effects were presented using Cohen's d. If other effect sizes were reported in the studies, they were converted to Cohen's *d*.[1] Effect sizes larger than $d > 0.20$ were considered small, $d > 0.50$ medium and $d > 0.80$ large.

[1]https://www.psychometrica.de/effect_size.html#transform

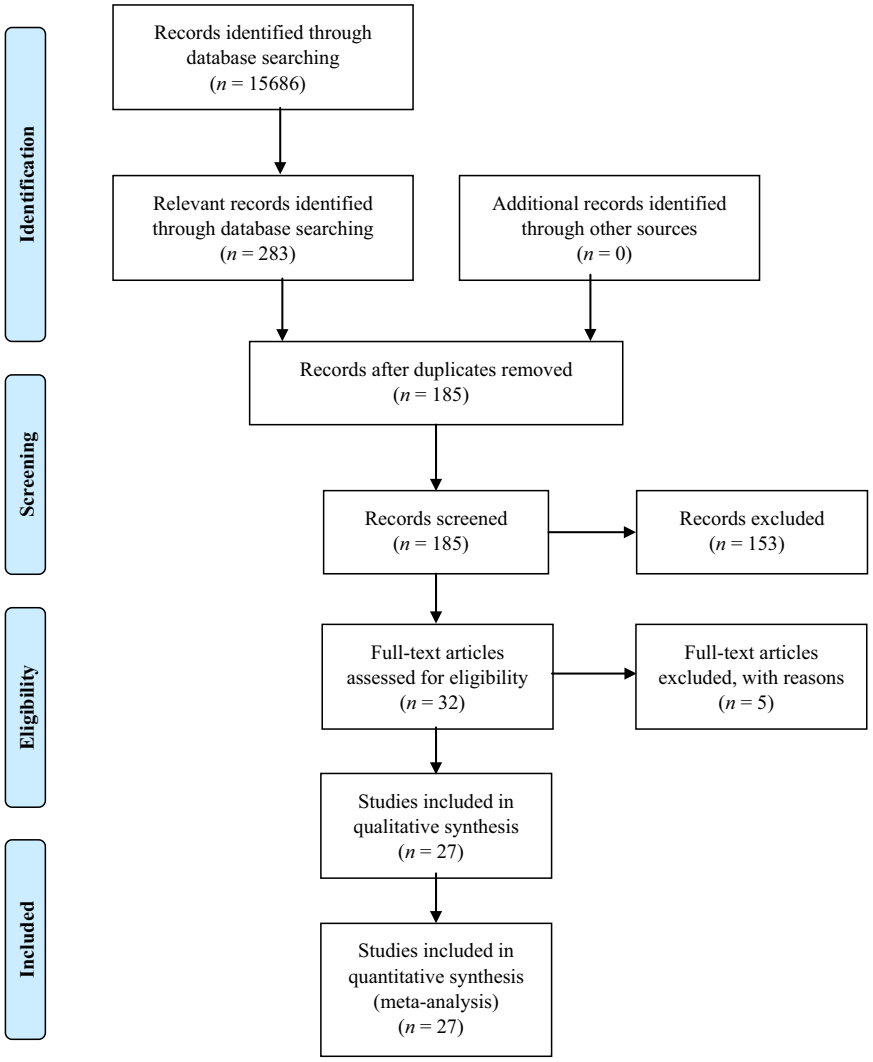

Figure 1. Review flowchart. Derived from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart.

Missing data

Three possibilities of missing data were identified a priori: missing full texts, missing outcome measures (means, standard deviations, effect sizes, etc.) and missing effect sizes.

If the full text of a paper was not available, the authors were contacted once and asked to provide the full text. Papers that were not provided by the authors were not included in this review.

If important outcome measures were not available, the authors were contacted again and asked to provide those data. Furukawa and colleagues recommended data imputation from similar reviews or similar studies in the same review to deal with missing values (Furukawa *et al.*, 2006). However, there were no similar reviews from which to impute data. Additionally, the studies in this review differed greatly concerning design and investigated interventions. Therefore, data imputation was deemed unfeasible in this review.

Missing effect sizes were calculated by the authors of this review if the necessary data were given. The practical meta-analysis effect size calculator provided by the Campbell collaboration was used.[2]

Assessment of reporting biases

This review included many different outcomes: subjective and objective measures, sleep quality, sleep duration, sleep efficiency, etc. Therefore, the traditional funnel plots or forest plots were not appropriate to illustrate reporting or publication biases, as they were designed for only one outcome variable across all studies.

To assess publication and reporting biases in this review, each outcome variable was examined separately.

[2]https://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php

All studies were sorted into one of three categories: the study did not investigate the outcome variable, the study investigated the outcome variable but found no significant effects and the study investigated the outcome variable and found significant effects. This approach should prevent the usual confusion between 'no evidence of effect' and 'evidence of no effect'.

RESULTS

Included studies

The 27 included studies are listed in Table 2. All the analysed studies were published in English. Correspondingly, most were conducted in the United States (66.70%). The earliest study was from 1979, the latest from 2016.

Sample

Overall, 2776 students were included in this review, with an average of 103 participants per study; 66.74% of the participants were female (missing: 14.80%). The mean age was 21.37 years [standard deviation (SD) = 3.49] ranging from 17 to 59 (missing: 33.30%). The sample's mean ages ranged from 18.90 to 25.40, SD from 1.12 to 7.18.

In 63.00% of the studies, students were healthy, in 18.50% they reported bad sleep quality or symptoms of sleep disorders, and in 18.50% of the studies students had a diagnosed sleep disorder; 51.90% of the studies recruited students from all disciplines, while 33.30% focused on psychology students and 11.10% focused on medical students (missing: 3.70%).

Design

More than half the studies were randomized controlled trials (55.60%). The authors decided to group the treatments into four categories: sleep hygiene (33.30%), CBT (33.30%), relaxation, mindfulness, hypnotherapy (22.20%) and other psychotherapeutic approaches, such as Gestalt therapy or imagery rehearsal therapy (11.10%). Most studies comprised individual sessions (66.70%) with a face-to-face design (55.60%). On average, the interventions consisted of 4.56 sessions with a range of one to 21 sessions. The average duration of a session was 44.76 min (10–100 min). The programmes lasted 2.76 weeks, with a span of 1 day to 15 weeks. More than half the studies employed either a waiting-list control group (29.60%) or alternative treatments (29.60%). The remaining studies used placebo interventions (18.50%) or lacked a control group (22.20%).

The studies investigated the following outcome measures: sleep hygiene, sleep quality, sleep duration, sleep onset latency, sleep efficiency, wake after sleep onset, sleep rhythm, daytime sleepiness, sleep problems, dysfunctional beliefs about sleep and mental health.

Effects of interventions

Effects of the different interventions on the sleep variables are displayed in Fig. 2. All studies are included, regardless of whether they investigated students with healthy, impaired or disordered sleep. Missing bars indicate that the outcome measure was not assessed in this intervention category. While all studies are described in detail in Table 2, exemplary studies are discussed for each intervention category.

Sleep hygiene-based studies provided small effects for sleep duration and medium effects for sleep onset latency. In a randomized controlled trial by Kloss *et al.* (2016), 120 healthy psychology students discussed case vignettes, a sleep hygiene handout and sleep logs in two 90-min sessions. The control group received only the sleep hygiene handout. Comparisons between intervention and control condition revealed fewer maladaptive beliefs, increased sleep hygiene knowledge and reduced sleep onset latency after 4 weeks. Insomnia severity, sleep quality and sleep duration did not change significantly in this healthy sample, indicating an educative effect of sleep hygiene. While other RCTs in the sleep hygiene section revealed less significant changes, the controlled trials without randomization showed various improvements. Brown *et al.* (2006) found that even a short lecture (30 min) on sleep hygiene and stimulus control improved sleep quality significantly, reduced sleep disturbances and the use of sleep medication and improved sleep hygiene in 122 healthy psychology students after 6 weeks. A more recent study in 138 healthy college students compared the effects of sleep hygiene and sleep restriction with a placebo lecture about the perception of dreams (Farias, 2012). In this study, only the sleep hygiene knowledge and the negative affect improved significantly after 2 weeks, while sleep quality, daytime sleepiness and sleep hygiene practices remained unchanged.

CBT-based studies showed large effect sizes in all investigated outcome variables, which included sleep duration, sleep onset latency, sleep efficiency and wake after sleep onset. However, only two of the CBT-based studies included insomnia patients; most addressed healthy students ($n = 5$) or students with insomnia symptoms ($n = 2$). An Iranian RCT investigated the effects of eight CBT sessions (50 min) in 21 healthy women (Azar and Asadnia, 2013). Compared to a waiting-list control condition (WLC), those in the CBT condition showed significantly improved subjective sleep quality, reduced sleep onset latency and longer total sleep time after 8 weeks. However, the total sleep quality, sleep disturbances, daytime dysfunction and sleep medication did not differ from the WLC. Last year, Morris and colleagues conducted an RCT that examined the feasibility of six sessions of online CBT in 48 healthy college students (Morris *et al.*, 2016). After 6 weeks, the students in the online CBT condition reported significantly improved sleep quality when compared to the WLC, although the anxiety did not differ between the two conditions. Due to the fact that the authors examined only the students' sleep quality and anxiety, the effect of online CBT on other sleep (-related)

Table 2 Characteristics of included studies

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	*M_{age} SD_{age} Range*	*Study course (Semester) Sleep†*	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
Sleep hygiene—RCT: healthy participants									
Ball and Bax (2002); USA	RCT (3 m FU)	54 41	24.02 (3.42) ?-?	Med (1) 0	Self-care: sleep lecture, written sleep information, group discussion /face-to-face + group/1×, ? min, 1D versus *self-awareness: written feedback to sleep test scores*	Comparison between intervention and control condition after 7 weeks: not sign.: sleepiness (ESS), consistency of wake times, trouble falling asleep (sleep log), depression (BDI–II), alcohol use (AUDIT) Helpfulness (not helpful): treatment 50%; control: 20.8%	–	–	No obj. data No blinding No sleep disorder Only alcohol use, no other substances Lack of anonymity—reporting bias
Kloss *et al.* (2016); USA	RCT	120 61	21.11 (2.43) 18–28	Psy (all) 0	Case vignettes, SH handout, sleep logs/face-to-face + group/2×, 90 min, 1×/W versus *SH handout*	Comparison between intervention and control condition after 4 weeks: fewer maladaptive beliefs (DBAS-SF)increased SH knowledge (SHAPS-SHK) Reduced SOL (sleep log) Not sign.: insomnia severity (ISI), SQ (PSQI), sleep duration (sleep log)	0.001 0.001 0.01	$d = 0.58$ $d = 0.46$ $d = 0.54$	No obj. data No blinding No sleep disorder No requirement testing No adverse effects No FU
Lamberti (2012); USA	RCT (1 m FU)	56 76	? (?) ?–?	All (1) 0	Sleep discussion, psychoeducation/face-to-face + group (discussion) and online + individually (psychoeducation)/1×, ? min, 1×/W versus *general health discussion, psychoeducation*	Comparison between intervention and control condition after 4 weeks: not sign.: SQ (PSQI), SH (SHPS)	–	–	No obj. data No blinding No sleep disorder No sample characteristics Social support rather than intervention effect?
Mairs and Mullan (2015); Australia	RCT	72 74	20.70 (5.80) 17–49	All (?) 0	Implementation intention: SH + 8 targets for four health behaviours/ online + individually/1×, 30 min, 1D versus *self-monitoring: SH + sleep log*	Comparison between intervention and control condition after 1 week: not sign.: SQ (PSQI), insomnia severity (ISI) Sign. improved stress/ anxiety	 0.024	 $d = 0.39$	No obj. data No participant blinding No sleep disorder Smaller sample size than power analysis recommended Confounded between SM and SH No FU No control of positive or negative framing
Sleep hygiene – other: healthy participants									
Arora *et al.* (2007); USA	T (12 m FU)	58 ?	? (?) ?–?	Med (1–2) 0	Sleep, Alertness and Fatigue Education in Residency (SAFER): lecture about sleep during lunchtime, explaining results of ESS/face-to-face + group/1×, 60–90 min, 1D	Comparison between pre- and post-test 12 weeks after the training: not sign.: changes for sleep duration during on-call duty or recovery sleep in medical students (due to shift work) (actigraphy)	–	–	No subj. data No control group No sleep disorder Special sample (medical students only) Large amount of missing data Theoretical background

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender %*	*Mage SDage Range*	*Study course (Semester) Sleep†*	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
									indicates that training is too short
Brown *et al.* (2006); USA	CT	122 59	19.51 (2.73) ?–?	Psy (1) 0	Lecture: Sleep Treatment and Education Program for Students (STEPS) = SH + SC/ face-to-face + group/1×, 30 min, 1D versus *lecture on importance of scientific method*	Comparison between intervention and control condition after 6 weeks: improved SQ (PSQI)			No obj. data No blinding possible No sleep disorder Baseline differences regarding sleep hygiene practices (treatment group sign. Lower sH-practice scores) No FU
						fewer sleep disturbances (PSQI)	0.017	$d = 0.46$	
						lower sleep latency (PSQI)	0.001	$d = 0.63$	
						less sleep medication (PSQI)	0.0001	$d = 0.67$	
						better sleep hygiene (SHAPS)	0.03	$d = 0.41$	
						fewer naps (SHAPS)	0.0001	$d = 0.84$	
						less hunger before bedtime (SHAPS)	0.01	$d = 0.46$	
						not sign.: other PSQI scales, caffeine knowledge, hygiene practice	0.01	$d = 0.46$	
Farias, (2012); USA	CT	138 78	20.05 (3.73) 18–40	All (1–3) 0	SH: sleep, good SH-practices, SR/ online + individually/1×, 10–15 min, 1D versus *SH placebo about perception of dreams*	Comparison between intervention and control condition after 2 weeks: improved SH knowledge (self-developed questionnaire)	< 0.05	$d = 0.41$	No obj. data No sleep disorder Wrong PSQI cut-off score (≥ 5 instead of > 5) PSQI time-frame not adapted (4 w original, 3 w study, 1 w overlap) No FU
						baseline diff. and post-test diff. in negative effect (PANAS)	< 0.05	$d = 0.46$	
						not sign.: SQ, daytime sleepiness, SH-practices, positive affect	< 0.01	$d = 0.41$	
Tsai and Li (2004); Taiwan	CT	241 46	20.70 (1.70) 18–28	all (all) 0	Sleep education: classroom lectures, discussions, sleep questionnaires, home assignments, sleep logs, paper, information about SH, PMR, SC, SR / face-to-face + group/15×, 100 min, 1×/W versus *waiting-list control group*	Comparison between intervention and control condition after 18 weeks:			No obj. data No blinding No sleep disorder Old data (1998) No sample characteristics for control group Only theoretical, no practical application Very small effect sizes No FU
						improved SQ (sleep log)	0.03	$d = 0.29$	
						reduced nap time for women in the course (sleep log) not sign.: bed/rise times, TIB, TST, SOL, awakenings, SE	0.007	$d = 0.41$	
Quan *et al.* (2013); USA	CT (3 m FU)	250 ?	? (?) ?–?	Psy (all) 0	Supplemental sleep (SS) module: lecture + online sleep sections about SH/ lecture: face-to-face + group and SH: online individually/lecture: 1×, 50 min, 1D versus *standard instruction (SI): lecture + link to general health homepage*	Comparison between intervention and control condition after 10 weeks: sign. improved sleep habits: improved SH	< 0.01 < 0.05	*d = 0.22* *d = 0.37*	No obj. data No blinding No sleep disorder Effect sizes not reported –> calculated Not all data reported Baseline differences concerning worse sleep knowledge in the SS group Effect of repetitive quizzing?
						consistent wake times more/better sleep	< 0.05	*d = 0.32*	

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	M_{age} SD_{age} *Range*	*Study course (Semester) Sleep*†	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
Cognitive behaviour therapy—RCT: healthy participants									
Azar and Asadnia (2013); Iran	RCT	21 100	? (?) 18–23	All (all) 0	1. CBT: SH, psychoeducation, sleep schedule, relaxation, cognitive therapy versus 2. Gestalt therapy (GT): become present, dialogue, acceptance, empty chair technique/ face-to-face + group/8×, 50 min (CBT) or 60 min (GT), 1×/W versus *waiting-list control group*	Comparison between CBT intervention and control condition after 8 weeks: subj. SQ (PSQI) SOL (PSQI) TST (PSQI) not sign: total SQ, sleep disturbances, daytime dysfunction, sleep medication	 0.001 0.001 0.007	 $d = 2.35$ $d = 2.21$ $d = 1.77$	No obj. data No blinding No sleep disorder Special sample: all had tension-type headache Baseline differences concerning sleep medication + trend for worse SQ in CBT group No information about the providers No FU
Morris *et al.* (2016); UK	RCT	48 60	20.69 (2.61) ?–?	All (all) 0	'Insomnia relief" (iCBT): psychoeducation, guided imagery, relaxation, SH, SC, SR, PMR/online + individually/6×, ? min, 1×/W *versus waiting-list control group*	Comparison between intervention and control condition after 6 weeks: improved SQ (PSQI) not sign.: anxiety	< 0.001	$d = 0.51$	No obj. data No sleep disorder Intervention groups receive more payment than control group Underpowered No screening procedure for baseline symptomatology No FU
Werch *et al.* (2008); USA	RCT (3 m FU)	303 60	19.20 (1.12) 18–21	All (all) 0	Image based multi-behaviour intervention (MBI): 1× consultation, brochure, goal plan/face-to-face + individually/1×, 15 min, 1Dversus *standard brochure on health behaviour*	Comparison between intervention and control condition after 12 weeks: increased TST in both groups, no intervention effect on health behaviours	–	–	No obj. data No blinding No sleep disorder Not enough guidance in implementing the health behaviour goals
Cognitive behaviour therapy—RCT: participants with sleep disorders									
Taylor *et al.* (2014); USA	RCT (3 m FU)	34 59	19.71 (2.10) 18–27	All (all) 2‡	CBT-I: SC, SR, SH, relaxation, cognitive restructuring/face-to-face + group/6×, ? min, 1×/W (= 6W) versus *waiting-list control group*	Comparison between intervention and control condition after 6 weeks: sign. improved SQ (sleep log) higher SE (sleep log) shorter SOL (sleep log) less number of waking up (sleep log) less WASO (sleep log) lower insomnia severity (ISI) higher SQ (PSQI) fewer dysf. beliefs about sleep (DBAS) less general fatigue (MFI) not sign.: all objective data (actigraphy), daytime sleepiness, other fatigue symptoms, life enjoyment, anxiety, depression, stress, substance abuse	 0.012 0.009 0.026 0.009 0.003 0.003 0.012 0.002 0.007	 $d = 1.02$ $d = 1.06$ $d = 0.91$ $d = 1.09$ $d = 1.23$ $d = 1.20$ $d = 1.01$ $d = 1.27$ $d = 1.10$	No blinding No statistical requirement testing

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	M_{age} SD_{age} *Range*	*Study course (Semester) Sleep*†	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
Cognitive behaviour therapy—other: healthy participants									
Asano *et al.* (2015); Japan	CT	101 55	19.00 (1.59) ?–?	Psy (1–3) 0	CBT: lecture + e-mails with SH, SR, SC, sleep schedule, relapse prevention/face-to-face + group (lecture) and online + individually (e-mails)/ 1× lecture, ? min, 1D and 4 weekly e-mails versus *waiting-list control group*	Comparison between intervention and control condition after 16 weeks: improved SQ (PSQI) mental health (Kessler 6)	 0.0004 0.0003	 *d* = 0.59 *d* = 0.61	No obj. data No blinding No sleep disorder Not all outcome measures are reported (e.g. sleep log data are missing) Baseline gender differences (more women in intervention group) Medications not considered No FU
Kushner *et al.* (2011); USA	T	343 50	? (?) ?–?	med (2) 0	Behaviour change plans: presentation, breakout activity, reading assignments + electronic BCP / face-to-face + group (BCP) and online + individually (iBCP)/6×, ? min (1 class), 1×/W	Only post-test measurements were conducted –> no pre–post comparison possible sleep goals achieved in the intervention group: 14/ 52 (26.9%)		–	No obj. data No blinding No sleep disorder No sample characteristics No control condition? Only categorical outcome (goal achieved or not) Only post-test No FU
Cognitive behaviour therapy—other: participants with impaired sleep									
Funderburk *et al.* (2015); USA	T	17 ?	22.10 (3.80) 18–30	All (all) 1§	SC/face-to-face + individually/1×, 33 min, 1D	Comparison between pre- and post-test after 2 weeks: sign. reduction of sleep problems after 2 weeks (ISI)	 < 0.05	 *d* = 1.30	No obj. data No blinding Small sample No sleep disorder No gender characteristics for the sample No FU
Trockel *et al.* (2011); USA	CT	125 49	? (?) 18–22	All (1) 0/1¶	Refresh: psychoeducation, SR, relaxation, mindfulness, SC, cognitive strategies/ online + individually/8×, ? min, 1×/W versus *breathe: DBT, MBSR*	Comparison between intervention and control condition after 8 weeks: sign. improved SQ (PSQI) -> in those with good SQ depression (CES-D) not sign.: differences in bad SQ group	 0.034 0.036	 *d* = 1.33 *d* = 0.57	No obj. data No sleep disorder Highly selective private university No sample characteristics Baseline differences between groups concerning depression and gender No FU
Cognitive behaviour therapy—other: participants with sleep disorders									
Petrov *et al.* (2014); USA	T	53 87	18.90 (1.70) 17–25	Psy (1–3) 2**	CBT: SC, SR, SH/face-to-face + group/1×, 90 min, 1D	Comparison between pre- and post-test after 2 weeks: good adherence for SC: 77% and SH: 85% ad adherence for SR: on average 82 min discrepancy from recommended wake time sign. reduction in insomnia severity (ISI)	 0.001	 *d* = 0.58	No obj. data No control condition Trainers not blinded No effect sizes No FU

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	*M_{age} SD_{age} Range*	*Study course (Semester) Sleep*†	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
Relaxation, mindfulness and hypnotherapy—RCT: healthy participants									
Greeson *et al.* (2014); USA	RCT	90 66	25.4 (5.70) 18–59	all (all) 0	'Koru': mindfulness programme: abdominal breathing, guided imagery, insight meditation/face-to-face + group/4×, 75 min 1×/Wversus *waiting-list control group*	Comparison between intervention and control condition after 4 weeks: improved stress (PSS) sleep problems (MOS SLP9) mindfulness (CAMS) self-compassion (SCS) not sign.: differences in gratitude	 0.04 0.03 0.01 0.00	 *d* = 0.45 *d* = 0.52 *d* = 0.95 *d* = 0.75	No obj. data No sleep disorder Baseline differences in TST (treatment group slept 30 min less) No FU
Oxtoby *et al.* (2013); Australia	RCT	56 77	23.31 (7.18) ?–?	All (all) 0	Relaxing music (3 h classical or ambient, meditative) after 18:00 hours/online + individually/14×, 20 Min, 1×/D versus *control group: no treatment*	Comparison between intervention and control condition after 2 weeks: relaxing music versus control: Less anxiety (DASS) Less presleep arousal (PSAS) Improved attention (SAMI) Not sign.: dysfunctional beliefs, SQ, sleep-related behaviours, stress	 0.022 0.035 0.024	 *d* = 0.63 *d* = 0.59 *d* = 0.63	No obj. data No blinding No sleep disorder PSQI duration not adjusted to 2W Very low power No fixed listening time ('at bedtime') Ceiling effect regarding SQ No FU
Relaxation, mindfulness and hypnotherapy—RCT: participants with impaired sleep									
Borkovec *et al.* (1979); USA	RCT (12 m FU)	29 ?	? (?) ?–?	Psy (1–3) 1††	Muscle relaxation (MR): 5–7 s tension –> 30 s relaxation, 14–4 muscle groups + practice at home: 2×/D/tapes + individually/8×, 15–20 min, 2×/W versus *relaxation: same as MR but without tension versus waiting-list control group*	Comparison between intervention, alternative intervention and control condition after 1 week: MR showed sign. reduced subj. SOL (sleep log) and reduced obj. SOL (EEG) actual practice at home: 1.44×/day FU: positive effects maintained	 < 0.025 < 0.024	*Not computable*	No information about blinding No sleep disorder Old study No effect sizes –> not computable No sample characteristics
Harmat *et al.* (2008); Hungary	RCT	94 78	22.60 (2.83) 19–28	All (all) 1¶	Classical music 2 CDs/at home + individually/21×, 45 min, 1×/D versus audiobooks, 11 short stories versus *waiting-list control group*	Comparison between intervention group, alternative intervention and control group after 3 weeks: classical music showed improved SQ (PSQI) and lower depression when compared to audiobooks or wait-list control group not reported: ESS	 0.0001 0.0001	 *d = 0.75* *d = 1.43*	No obj. data No blinding No sleep disorder No effect sizes –> calculated Short stories might induce other emotions than classical music No FU
Relaxation, mindfulness and hypnotherapy—RCT: participants with sleep disorders									
Means *et al.* (2000); USA	RCT	118 72	21.20 (5.20) 17–44	Psy (1–3) 0/2‡‡	Progressive muscle relaxation with therapist and at home for students with insomnia/face-to-	Comparison between intervention and control condition after 6 weeks:			No obj. data No effect sizes –> calculated (SQ not computable)

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	M_{age} SD_{age} *Range*	*Study course (Semester) Sleep*†	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
					face + individually/with therapist: 3×, 15–20 min, 2W and at home: 2×/D for 2W versus *untreated control group with insomnia versus untreated healthy control group*	adherence: 1×/D sign. compared to untreated insomniacs: improved WASO (sleep log)			Ethics: not all insomniacs received treatment
							< 0.01	*d = 0.47*	Randomization not described
						improved SE (sleep log) better SQ (sleep log)	< 0.01	*d = 0.45*	Only insomniacs received intervention
							< 0.05	*?*	No FU
						sign. compared to untreated healthy:			
						worse WASO (sleep log) worse SE (sleep log) worse SQ (sleep log)	?§§	*d = 0.90*	
							?	*d = 1.61*	
						not sign.: SOL	?	?	
Relaxation, mindfulness and hypnotherapy—other: healthy participants									
Cordi *et al.* (2014); Switzerland	CT	70 100	23.27 (3.17) 18–35	? (?) 0	High suggestibility (HS): 1. deep hypnosis, 2. shallow hypnosis, low suggestibility (LS): deep hypnosis/ tape + individually/1×, 13 min tape + 90 min sleep, 1D versus HS: learning text versus *LS: hypnosis simulate*	Comparison between intervention group, alternative interventions and control group after 1 week:			No sleep disorder Special sample (highly suggestible women) Nap study (effect on night-time sleep?) Only interventions—no free control No FU
						deep hypnosis in the HS group led to			
						more slow wave sleep (EEG) and	0.013	*d* = 0.77	
						less WASO (EEG) not sign.: LS or TST	0.065	*d* = 0.54	
Other psychotherapeutic approaches – RCT: participants with sleep disorders									
Carrera and Elenewski, (1980); USA	RCT	71 44	? (?) ?–?	Psy (1–3) 2¶¶	1. Implosive therapy referring to death 2. General implosion: loss of self-control, social dilemmas, psychosis 3. Ocean sounds / tape recording + individually/ 2×, 45 min, 1D (1 session) versus *waiting-list control group*	Comparison between intervention condition, two alternative interventions and control condition after 4 weeks: all conditions showed decreased SOL (self-report)SOL only sign. reduced when comparing implosive therapy and waiting-list control group experimental conditions (1–3) reduced anxiety	< 0.05	*Not computable*	No obj. data No blinding No effect sizes –> not computable (missing SD) No sample characteristics Very old study No FU
							< 0.05		
Gellis *et al.* (2013); USA	RCT	51 65	? (?) ?–?	Psy (1-3) 2***	Cognitive refocusing treatment for insomnia: identifying three engaging, but non-arousing topics to focus on + SH/face-to-face + individually/1×, 30 min, 1D versus *SH only*	Comparison between intervention and control condition after 4 weeks:			No obj. data No information about sleep medication/ treatment No sample characteristics No FU
						comparable adherence in both groupslower insomnia severity (ISI)			
						less presleep arousal (PSAS)	0.03	*d* = 0.60	
						not sign.: somatic arousal	0.07	*d* = 0.48	

Table 2 *Continued*

Publication Authors (year) country	*Design (FU)*	*Participants* n ♀ *gender* %	*M_{age} SD_{age} Range*	*Study course (Semester) Sleep*†	*Intervention/mode of delivery/number of sessions, duration, time-frame versus* control condition	*Outcomes**	P	*Effect sizes*	*Limitations*
Other psychotherapeutic approaches—other: participants with impaired sleep									
Digdon and Koble (2011) Canada	T	41 78	23.22 (6.11) ?–?	All (all) 1	1. Constructive worry: write out worry that interferes with sleep and find solutions (before 8 p.m.) 2. Imagery distraction: imagine interesting + relaxing situations (in bed) 3. Gratitude: write down positive experiences (before 20:00 hours)/ online + individually/7×, 15 min, 1×/D	Comparison between three alternative interventions after 1 week: all interventions showed reduced somatic arousal (PSAS) reduced cognitive arousal (PSAS) reduced bedtime worry (sleep log) higher SQ (sleep quality scale) Longer TST (sleep log) Not sign.: SOL, bedtime planning, bedtime thinking, bedtime anxiety	< 0.05 < 0.01 < 0.001 < 0.001 0.02	*d* = 0.48 *d* = 0.60 *d* = 1.11 *d* = 0.60 *d* = 0.61	No obj. data No sleep disorder No control Low power (small sample size) No FU

Means, standard deviations and ranges are provided for the age of the samples. Effect sizes in italics indicate that they were not provided by the study and had to be calculated by the authors of this review. All effect sizes that were converted into Cohen's *d* are underlined. All abbreviations are explained at the bottom of the table.

AUDIT: Alcohol Use Disorders Identification Test; BDI: Beck Depression Inventory; CES-D: Center for Epidemiological Studies—Depression Scale; CAMS: Cognitive and Affective Mindfulness Scale; CT: controlled trial; D: day; DASS: Depression Anxiety Stress Scale; DBAS: Dysfunctional Beliefs and Attitudes about Sleep; DBT: Dialectical Behaviour Therapy; ESS: Epworth Sleepiness Scale; FU: follow-up; ISI: Insomnia Severity Index; M: month; MBSR: mindfulness-based stress reduction; Med: Medical students; MFI: Multidimensional Fatigue Inventory; MOS SLP9: Medical Outcome Study Sleep Scale; PANAS: Positive Affect Negative Affect Scale; PMR: Progressive Muscle Relaxation; PSAS: Presleep Arousal Scale; PSS: Perceived Stress Scale; PSQI: Pittsburgh Sleep Quality Index; Psy: Psychology Students; RCT: randomized controlled trial; SAMI: Selective Attention and Monitoring Index; SC: stimulus control; SCS: Self-compassion Scale; SE: sleep efficiency; SH: sleep hygiene; SHPS: Sleep Hygiene Practice Scale; SOL: sleep onset latency; SR: sleep restriction; SQ: sleep quality; T: trial (no control group, only intervention group); TIB: time in bed; TST: total sleep time; W: week(s); WASO: wake after sleep onset.

*If an intervention condition was compared to a control condition, the outcomes were always phrased from the perspective of the intervention condition (e.g. 'fewer maladaptive beliefs' = 'the intervention condition showed fewer maladaptive beliefs than the control condition').

†Sleep: did the students have sleep problems? 0 = no sleep problems; 1 = bad sleep quality/sleep disorder symptoms; 2 = diagnosed sleep disorder.

‡Insomnia according to DSM-5.

§Symptoms of insomnia according to ISI.

¶Bad sleep quality according to PSQI.

**Insomnia according to ICSD-2.

††Insomnia symptoms (students with the highest SOL).

‡‡Insomnia disorder according to ICSD.

§§*P*-values not provided and not computable.

¶¶Insomnia according to own diagnostic criteria (> 45 min SOL, not rested, no psychotherapy, no medication).

***Insomnia according to DSM-IV (no daytime impairment when compared to DSM-5).

variables remains unclear. Taylor *et al.* (2014) compared the effects of six weekly CBT sessions with a WLC in 34 college students who suffered from insomnia according to DSM-5. Significant interaction effects were found for various sleep variables, including a better sleep quality, higher sleep efficiency, shorter sleep onset latency, less wake after sleep onset, lower insomnia severity, less dysfunctional beliefs about sleep and less general fatigue in the CBT condition after 6 weeks. Only the mental health outcomes (life enjoyment, anxiety, depression, stress, substance abuse) did not differ between CBT and WLC.

Relaxation interventions had small effects for sleep efficiency and medium effects for wake after sleep onset. In a RCT with 90 healthy college students, Greeson and colleagues evaluated the effectiveness of 'Koru', a mindfulness programme (Greeson *et al.*, 2014). In four sessions (75 min), the students learned about abdominal breathing, guided imagery and insight meditation. After 4 weeks, the 'Koru' students had fewer sleep problems, less stress, more mindfulness and more self-compassion than the WLC students, although gratitude did not change significantly. Hungarian researchers compared 21 sessions of listening to

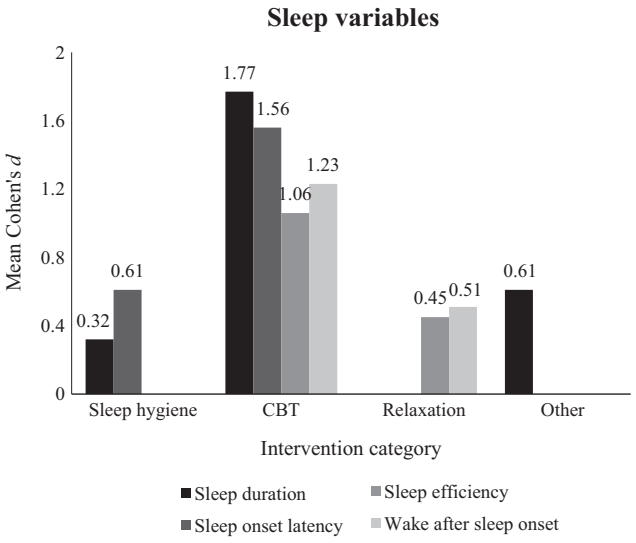

Figure 2. Mean effect sizes (Cohen's *d*) for the sleep variables in the four intervention categories.

classical music to audiobooks, and a WLC in 94 college students with bad sleep quality according to the Pittsburgh Sleep Quality Index (PSQI) (Harmat *et al*., 2008). After 3 weeks, students in the music condition showed significantly improved sleep quality and lower depression than the students in the audiobook condition or the WLC. Finally, Means and colleagues investigated the effectiveness of progressive muscle relaxation (PMR) in students with insomnia (ICSD) when compared to an untreated control group with insomnia and to an untreated healthy control group (Means *et al*., 2000). After 6 weeks, the students with insomnia in the PMR condition reported significantly reduced wake after sleep onset, better sleep efficiency and better sleep quality than the students in the insomnia control group and the students in the healthy control group. The sleep onset latency did not differ between the three groups.

The other psychotherapeutic approaches solely improved sleep duration with a medium effect. Gellis and colleagues examined the effects of cognitive refocusing treatment (CRT) for insomnia versus a sleep hygiene control condition in 51 psychology students with insomnia according to DSM-IV (Gellis *et al*., 2013). In the CRT condition, the students identified three engaging but non-arousing topics to focus on while falling asleep. In addition, they received sleep hygiene instructions. Students in the CRT condition showed significantly lower insomnia severity and less presleep arousal than the control condition after 4 weeks. The students' somatic arousal did not improve significantly. In another approach, Digdon and Koble applied a constructive worry intervention, imagery distraction and a gratitude intervention to 41 sleep-impaired college students (Digdon and Koble, 2011). In the worry intervention, the students had to write down worrying thoughts and corresponding solutions that interfered with their sleep every evening for 1 week. The imagery distraction included imagining interesting but relaxing situations while falling asleep. In the gratitude intervention, students wrote down positive experiences. All three interventions reduced the students' somatic and cognitive arousal and their tendency to worry during bedtime. Furthermore, the interventions improved the students' sleep quality and total sleep time. Sleep onset latency, bedtime planning, bedtime thinking and bedtime anxiety did not change significantly.

Fig. 3 displays the effects of the four intervention categories on the sleep-related variables. Small effects regarding sleep hygiene, sleep quality, sleep rhythm and sleep problems were found for the sleep hygiene studies. Again, CBT showed the largest effects, in this case for sleep quality, daytime sleepiness and sleep problems. Relaxation and other psychotherapeutic approaches both provided medium effects for sleep quality and sleep problems.

Finally, the effects of the different interventions on dysfunctional beliefs about sleep and mental health were investigated (Fig. 4). The studies measured different aspects of mental health, most commonly anxiety and depression. Only one study implemented a comprehensive assessment battery for comorbid mental health issues (Asano *et al*., 2015).

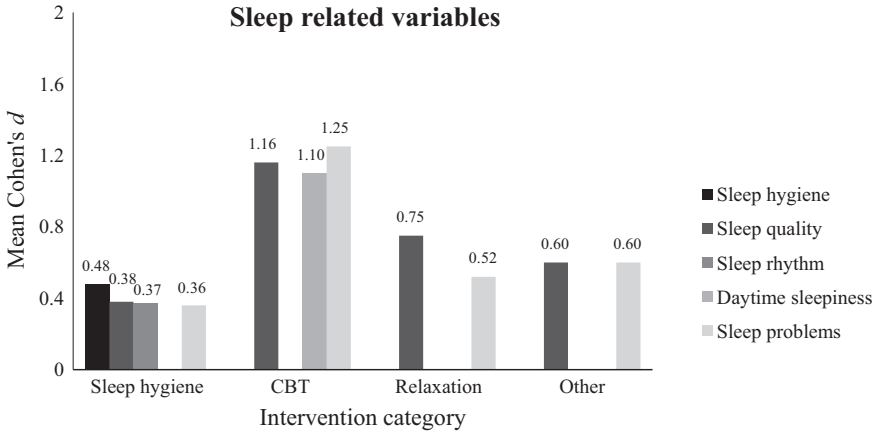

Figure 3. Mean effect sizes (Cohen's *d*) for the sleep related variables in the four intervention categories.

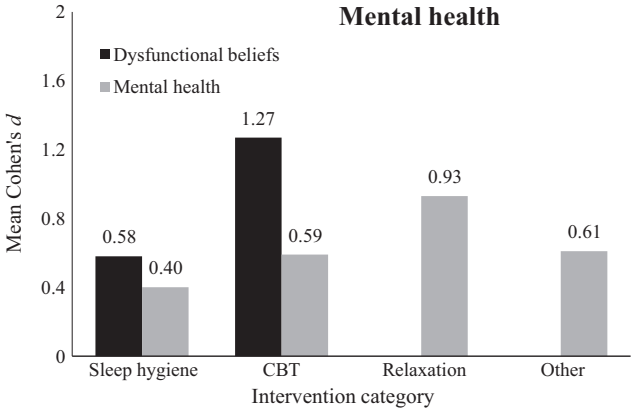

Figure 4. Effects of the four intervention categories on dysfunctional beliefs about sleep and mental health.

Sleep hygiene improved dysfunctional beliefs and, to a lesser extent, the mental health of college students. CBT provided large effects for the dysfunctional beliefs but only medium effects for mental health. While the relaxation category had a large impact on mental health, the other psychotherapeutic approaches showed a medium effect. The dysfunctional beliefs were not investigated in the last two categories.

Limitations

As mentioned above, most studies did not address students with severe sleep problems or diagnosed sleep disorder. Fig. 5 provides an overview of the number of studies that recruited healthy participants, participants with sleep problems and participants with a sleep disorder. Only five of the studies included college students that suffered from a diagnosed sleep disorder: two of these studies belonged in the CBT category, one study in the relaxation category and two studies in the category with other psychotherapeutic approaches. The remaining 22 studies examined either healthy college students or college students with impaired sleep quality.

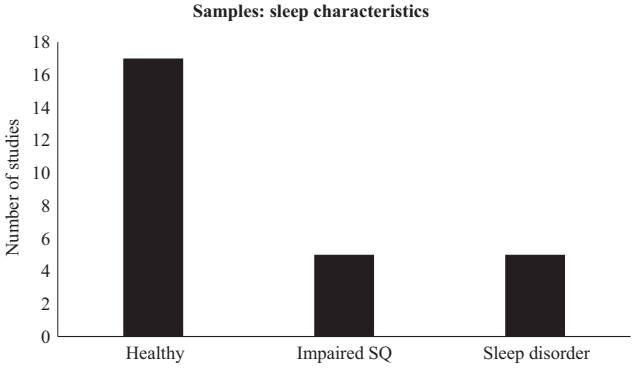

Figure 5. Number of studies that included students with healthy sleep, impaired sleep quality (SQ) or a diagnosed sleep disorder.

Two other common limitations were a lack of objective data and follow-up measurements; 88.89% of the studies did not use objective measures and relied only on subjective questionnaires or sleep log data. Regarding follow-up, most of the studies (74.07%) did not assess long-term outcomes. In the seven studies (25.93%) that did use a follow-up design, the average time-frame between post-measurement and follow-up was 5.29 months.

Assessment of reporting bias

The studies in the four intervention categories investigated different outcome measures. In order to differentiate between outcome variables that were not significant and those that were not investigated, Fig. 6 displays the percentage of (in)significant results for each outcome measure. Approximately half the studies in this review examined the students' sleep quality and mental health. The outcome measures sleep hygiene, sleep duration, sleep onset latency and sleep problems were investigated in at least one-fifth of the studies. The outcome measures sleep efficiency, wake after sleep onset, sleep rhythm, daytime sleepiness and dysfunctional beliefs were included in fewer than one-fifth of the studies.

Risk of bias in included studies

Table 3 provides an overview of the risk of bias in the included studies. Information about (1) sequence generation, (2) allocation concealment and (3) blinding were provided only for those studies that were randomized (1, 2) or compared the treatment group to other groups (3). The last category, 'other bias', consisted of different forms of bias, for example baseline differences between the groups, reporting bias due to a lack of anonymity, wrong cut-off scores for questionnaires, old data, missing effect sizes, comorbid disorders or different compensations for treatment and control group.

Fig. 7 gives a graphical overview of the six risk of bias categories. Overall, the outcome data received a favourable evaluation: the incomplete outcome data category and the selective outcome reporting category had a low risk of bias in approximately 90% of the studies. The randomization and allocation process was unclear in more than half the studies. However, the studies in which the sequence generation and allocation was reported revealed a low risk of bias. Potential bias was identified in two categories: blinding and other bias.

Excluded studies

All excluded studies are listed in Supporting information, Table S1. These studies were excluded because the samples did not (only) consist of students (2), the outcomes lacked sleep variables (2) or it was a sleep curriculum programme for medical students that taught medicine students to diagnose sleep difficulties.

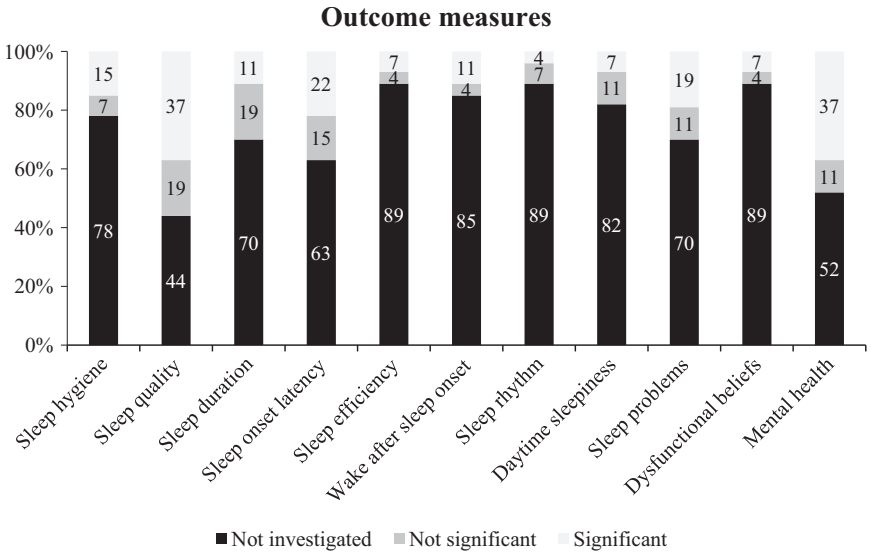

Figure 6. Percentages of outcome measures that were not investigated, not significant or significant.

DISCUSSION

Summary of main results

This systematic review investigated the effects of psychological interventions that improve sleep in college and college students. Only five studies addressed severe sleep problems or sleep disorders, whereas all other studies included healthy students or students with mild sleep problems. Four categories of psychological interventions were identified: sleep hygiene, CBT, relaxation and other psychological interventions. Sleep hygiene had mainly small effect sizes regarding sleep and sleep-related variables. Dysfunctional beliefs about sleep improved, with medium effects and mental health with small effects in the sleep hygiene category. While CBT showed large effects concerning all sleep variables and dysfunctional beliefs about sleep, the effects on mental health were medium. Relaxation provided small to medium effects for sleep variables and large effects for mental health variables. Other psychological interventions (e.g. cognitive refocusing) had overall medium effect sizes.

The effect sizes for the outcome measures differed across the studies. The interventions showed overall medium to large effect sizes for the outcome measures sleep onset latency, sleep efficiency, wake after sleep onset, sleep hygiene, sleep quality, daytime sleepiness, sleep problems and dysfunctional beliefs about sleep. Small to medium effect sizes were found for sleep duration, sleep rhythm and mental health outcomes. Overall, the proportion of significant results compared to insignificant results was larger for the outcome variables sleep hygiene, sleep quality, sleep onset latency, sleep efficiency, wake after sleep onset, sleep problems, dysfunctional beliefs and mental health. The inverse relation (more insignificant than significant results) was found for sleep duration, sleep rhythm and daytime sleepiness.

Overall completeness and applicability of evidence

Participants included undergraduate and graduate students from all disciplines. Sample limitations stem from a focus on health sciences (psychology students: 33%; medical students: 11%), a larger proportion of female participants (66%) and American study origin (66%). Additionally, most studies investigated healthy students or students who had impaired sleep quality. Therefore, the amount of evidence regarding students with sleep disorders is limited.

Many psychological interventions were identified (sleep hygiene, CBT, relaxation, hypnotherapy, mindfulness, cognitive refocusing treatment, Gestalt therapy, implosive therapy, worry/gratitude interventions). The relevant outcomes (e.g. sleep duration) were not investigated in all studies and will be discussed further in the Limitations section.

Overall, the broad range of participants and disciplines as well as the identification of various psychological interventions show that insomnia in students and its treatment is extremely complex, as many different types of variables, a huge number of missing data and a low number of students with sleep disorders have been treated. Further studies are needed to examine the percentage of students suffering from insomnia according to diagnostic criteria (DSM-5; ICSD-3). Furthermore, future studies addressing treatment of insomnia disorders in students are clearly necessary.

Quality of evidence

With 27 included studies and a total sample size of 2776 college students, the amount of evidence in this review was acceptable. The percentages of RCTs (56%) and studies with control groups (78%) indicated good quality of evidence.

If the studies provided significant effects, the effect sizes between the studies were consistent. However, there were

Table 3 Risk of bias

Publication	*Sequence generation*	*Allocation sequence concealed*	*Blinding*	*Incomplete outcome data*	*Selective outcome reporting*	*Other bias*
Sleep education—RCT						
Ball and Bax (2002)	U	U	N	Y	Y	N
Kloss *et al.* (2016)	U	U	N	Y	Y	N
Lamberti (2012)	U	N	N	Y	Y	N
Mairs and Mullan (2015)	Y	Y	Y	Y	Y	N
Sleep education—other						
Arora *et al.* (2007)	–	–	–	Y	Y	N
Brown *et al.* (2006)	–	–	Y	Y	Y	Y
Farias (2012)	–	–	Y	Y	Y	N
Tsai and Li (2004)	–	–	N	Y	Y	Y
Quan *et al.* (2013)	–	–	N	Y	Y	N
Cognitive behaviour therapy—RCT						
Azar and Asadnia (2013)	U	U	N	Y	N	N
Morris *et al.* (2016)	Y	Y	U	Y	Y	N
Taylor *et al.* (2014)	Y	Y	N	Y	Y	Y
Werch *et al.* (2008)	U	U	N	Y	Y	N
Cognitive behaviour therapy—other						
Asano *et al.* (2015)	–	–	N	N	N	N
Funderburk *et al.* (2015)	–	–	–	Y	Y	U
Kushner *et al.* (2011)	–	–	–	Y	Y	N
Petrov *et al.* (2014)	–	–	–	N	Y	Y
Trockel *et al.* (2011)	–	–	N	Y	Y	N
Relaxation, mindfulness and hypnotherapy—RCT						
Borkovec *et al.* (1979)	Y	Y	U	Y	Y	N
Greeson *et al.* (2014)	Y	Y	Y	Y	Y	N
Harmat *et al.* (2008)	Y	U	N	N	Y	Y
Means *et al.* (2000)	N	U	N	Y	Y	Y
Oxtoby *et al.* (2013)	U	U	N	Y	Y	Y
Relaxation, mindfulness and hypnotherapy—other						
Cordi *et al.* (2014)	–	–	U	Y	Y	Y
Other psychotherapeutic approaches—RCT						
Carrera and Elenewski (1980)	U	U	N	Y	Y	N
Gellis *et al.* (2013)	U	U	U	Y	Y	U
Other psychotherapeutic approaches—other						
Digdon and Koble (2011)	–	–	–	Y	Y	N

Y: yes, there is a low risk of bias; N: no, there is a high risk of bias; U: unclear; there is an unclear risk of bias; RCT: randomized controlled trial.

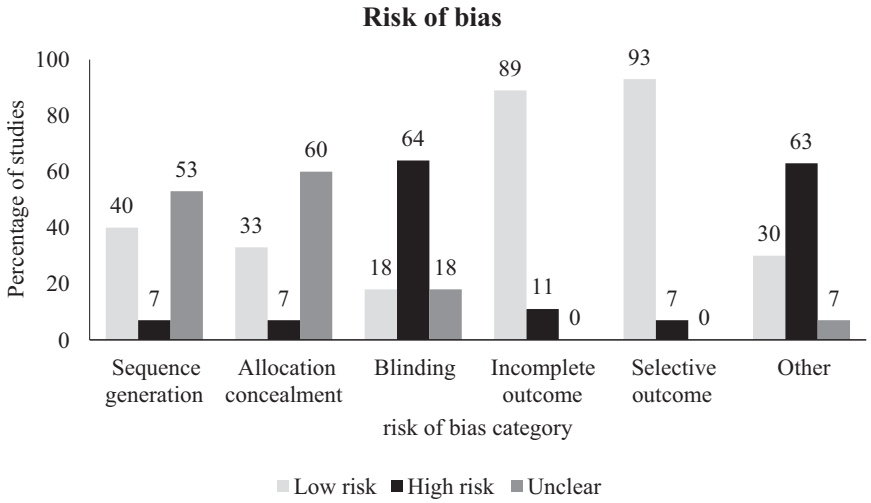

Figure 7. Risk of bias for included studies.

inconsistencies regarding the proportion of significant and insignificant results across the different outcome measures. The outcome variable daytime sleepiness had similar proportions of significant (7%) and insignificant results (11%), impeding a clear interpretation due to the supposed heterogeneity of this condition with respect to its causes.

Potential biases in the review process

The methods of this review were derived from the *Cochrane Handbook for Systematic Reviews*, which implies a high methodological quality. Although the sensitivity of the search was somewhat low with 1.19%, the inversely related probability that all relevant studies were identified was high. Thirteen possibly relevant studies were not included in this review, because the full text papers were not accessible (n = 12) or the paper was written in Chinese (n = 1). Another bias may occur because the studies were selected by only author and not by two authors, as recommended. A strength of this review was the inclusion of non-RCTs, which led to a broader scientific picture.

Limitations

Several limitations have to be named. First, and most importantly, the samples included healthy students as well as students with sleep problems or sleep disorders. Only five studies addressed college students with sleep disorders. The other 22 studies examined healthy students (n = 17) or students who only had impaired sleep quality (n = 5). This might cause a ceiling effect, thereby limiting the effectiveness of the examined interventions.

Secondly, the studies varied extremely concerning the different outcome measures. This circumstance hinders the interpretation of the five outcome variables that were investigated in fewer than one-fifth of the 27 studies: sleep efficiency, wake after sleep onset, sleep rhythm, daytime sleepiness and dysfunctional beliefs about sleep. Therefore, results of the four intervention categories concerning these outcome variables should be interpreted with caution.

Another limitation concerns the definition of the psychological interventions. The separation of the four categories is not always clear, as CBT often includes elements of relaxation and sleep hygiene. Furthermore, the definition of sleep hygiene as a psychological intervention is problematic. However, nine studies investigated only the effects of sleep hygiene alone, which implies that it is often practised and needs to be evaluated scientifically.

In addition, two common limitations were a lack of objective data and no follow-up measurement. This impedes the validity of the results, as insomniacs have a distorted subjective perception of sleep and long-term effects of the interventions could not be assessed.

Furthermore, three smaller sources for risk of bias were identified. First, the blinding of personnel and participants was not ensured, leading to potential expectation effects. Adverse effects were generally not reported. Therefore, the safety of the interventions and negative side effects could not be determined in this review. Lastly, a small risk of bias was present for the effect sizes, as those could not be calculated for two of the 27 included studies.

Finally, other sleep disorders such as narcolepsy, and other psychological disorders such as depression, were not considered in this review. They may cause symptoms of the investigated sleep disorders, e.g. daytime sleepiness, leading to heterogenous results.

Despite these limitations, the overall completeness, the high quality of evidence, and the low risk of bias in the review process support the results of this review.

(Dis-)Agreements with other studies and reviews

Generally, this review supports the results of similar reviews and meta-analyses, as CBT was an effective intervention for the treatment of sleep disorders in adults (e.g. Koffel *et al*., 2015). The positive effects of sleep education on sleep quality found by Dietrich and colleagues could be replicated with small to medium effect sizes (Dietrich *et al*., 2016). However, the comparability of this review is limited, as it is the first review to compare different psychological interventions for sleep problems in college students.

Noteworthy were the large effects of relaxation, mindfulness and hypnotherapy on mental health outcomes, which were larger than the effects of all other interventions, even CBT. Therefore, relaxation techniques seem to be a promising approach to improve comorbid mental health problems that was not investigated in other reviews.

CONCLUSIONS

Implications for future research include a stronger focus on non-RCTs, as they are an important source of information and often show a good quality of evidence including control groups and follow-up measurements. Another important aspect is the investigation of outcome measures. Most reviews only examine the significant effect sizes and disregard the insignificant results or results that were not investigated.

In line with reviews that focused on (older) adults, this review recommends CBT to improve sleep in college students. Relaxation techniques, mindfulness and hypnotherapy should be combined with CBT to enhance the effects on comorbid mental health problems.

Future interventions should consider the challenges of the college students' lives by incorporating chronobiology, academic demands (e.g. examination periods) and living conditions into their schedule. They should also include other sleep disorders than insomnia disorder (e.g. nightmare disorder) to provide scientific health-care interventions for a greater variety of college students.

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AUTHOR CONTRIBUTIONS

AF conducted and wrote this review. AAS had the idea, supervised the process (e.g. inclusion and exclusion criteria, categorizing, decision making, etc.) and intensely corrected the manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Characteristics of excluded studies.