



Effects of self-guided stress management interventions in college students: A systematic review and meta-analysis

Yagmur Amanvermez^{a,*}, Ruiying Zhao^a, Pim Cuijpers^a, Leonore M. de Wit^a, David D. Ebert^b, Ronald C. Kessler^c, Ronny Bruffaerts^d, Eirini Karyotaki^a

^a Department of Clinical, Neuro and Developmental Psychology, Amsterdam Public Health Research Institute, Vrije Universiteit Amsterdam, the Netherlands

^b Department of Sport and Health Sciences, Technical University of Munich, Munich, Germany

^c Department of Health Care Policy, Harvard Medical School, Boston, MA, USA

^d Universitair Psychiatrisch Centrum, Center for Public Health Psychiatry, Katholieke Universiteit Leuven, Leuven, Belgium

ARTICLE INFO

Keywords:

Self-help
College students
Stress management
Unguided interventions

ABSTRACT

Background: College students face several sources of stress. Self-guided stress management interventions offer an excellent opportunity for scaling up evidence-based interventions for self-management of these stresses. However, little is known about the overall effects of these interventions. Increasing this understanding is essential because self-guided stress management interventions might be a cost-effective and acceptable way of providing help to this important segment of the population during a critical life course stage.

Methods: We carried out a systematic literature search of bibliographical databases (PubMed, PsycINFO, Embase, and Cochrane Library) for randomized controlled trials (RCTs) of self-guided stress management interventions published up through April 2020. We conducted two separate meta-analyses for perceived stress, depression, and anxiety. The first included interventions for general college student samples. The second included studies for students with high levels of perceived stress.

Results: The first meta-analysis included 26 studies with 29 intervention-control comparisons based on a total of 4468 students. The pooled effect size was small but statistically significant ($g = 0.19$; 95% CI [0.10, 0.29]; $p < 0.001$). Results showed moderate heterogeneity across studies [$I^2 = 48\%$; 95% CI (19, 66%)]. The second meta-analysis, included four studies based on a total of 491 students with high levels of stress. The pooled effect size was small but statistically significant ($g = 0.34$; 95% CI [0.16, 0.52]; $p < 0.001$). Results showed no heterogeneity across studies ($I^2 = 0\%$; 95% CI [0, 79%]), but risk of bias was substantial.

Discussion: Our results suggest that self-guided stress management programs may be effective when compared to control conditions, but with small average effects. These programs might be a useful element of a multi-component intervention system. Given the psychological barriers to treatment that exist among many college students, self-help interventions might be a good first step in facilitating subsequent help-seeking among students reluctant to engage in other types of treatment. More studies should be conducted to investigate these interventions, sample specifications, mediating effects, and individual-level heterogeneity of effects.

1. Introduction

College students experience a range of stressors related to this specific phase in life such as leaving home, being more independent, gaining new responsibilities, and overcoming new academic demands (Sussman and Arnett, 2014). A considerable proportion of college students report elevated levels of perceived stress defined as the appraisal of stressors as threats that exceed one's coping abilities and result in a

feeling of being overwhelmed (Cohen et al., 2020; Leppink et al., 2016). Prolonged psychological stress is closely associated with mental disorders (Auerbach et al., 2018; Beiter et al., 2015; Karyotaki et al., 2020; Mortier et al., 2018), and also has consequences for academic performance (Bruffaerts et al., 2018), campus engagement (Salzer, 2012), and college drop-out (Eisenberg et al., 2009). Chronic psychological stress may also lead to more serious mental health disorders later in life (Cohen et al., 2007; De Girolamo et al., 2015). Moreover, the first onset

* Corresponding author at: Department of Clinical, Neuro and Developmental Psychology, Amsterdam Public Health Research Institute, Vrije Universiteit Amsterdam, Van der Boechorststraat 7-9, 1081 BT Amsterdam, the Netherlands.

E-mail address: y.amanvermez@vu.nl (Y. Amanvermez).

<https://doi.org/10.1016/j.invent.2022.100503>

Received 11 May 2021; Received in revised form 7 February 2022; Accepted 9 February 2022

Available online 12 February 2022

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of common mental disorders generally occurs during young adulthood (Kessler et al., 2007). Therefore psychological interventions for college students may play a critical role in prevention and early intervention with these mental disorders (Karyotaki et al., 2020).

Recent evidence suggests that stress management programs and psychological treatments for common mental disorders are both effective in decreasing perceived stress and clinically significant symptoms of anxiety and depression among college students (Amanvermez et al., 2020; Cuijpers et al., 2016; Cuijpers et al., 2021; Harrer et al., 2019b). However, college students' treatment uptake is low (Bruffaerts et al., 2019) and access to psychological treatments for common mental disorders is limited due to several barriers such as system-related and scheduling issues (Leviness et al., 2019; Marsh and Wilcoxon, 2015; Stallman and Shochet, 2009; Watkins et al., 2011). In addition, students can be reluctant to seek professional mental health treatment because of unwillingness to define themselves as having a mental disorder and fear of stigma (Ebert et al., 2019; Marsh and Wilcoxon, 2015). Moreover, mental health needs may not be fulfilled sufficiently at university counseling centers since face-to-face interventions generally require resources such as trained personnel (e.g. therapist or coach) (Leviness et al., 2019). Given these barriers, delivering evidence-based interventions designed to provide help with stress management in a self-help format might be a more practical and psychologically acceptable approach.

A self-help intervention is defined as a standardized intervention in which participants apply the intervention manual independently from a professional guide or therapist (Cuijpers and Schuurmans, 2007). Self-help interventions are sometimes facilitated by a trained practitioner or in a group format to stimulate adherence and use group processes to enhance therapeutic effects. They can also be self-administered by individual users (National Institute for Health and Care Excellence, 2020). Self-help interventions have enormous potential to maximize scalability because of their low cost and flexibility in terms of the times in which they can be used, and their ability to overcome system-related barriers (e.g. long waiting list) and attitudinal barriers (e.g. embarrassment, preference for self-management) (Czyz et al., 2013; Levin et al., 2016; Mains and Scogin, 2003). Moreover, self-administered stress management interventions may be more acceptable to college students than to other segments of the population due to the greater digital literacy of college students (Fairburn and Patel, 2017; Richardson et al., 2009).

Recent controlled studies found that self-help interventions can be effective in reducing depression and anxiety (Andrews et al., 2018; Bennett et al., 2019; Cuijpers et al., 2019; Karyotaki et al., 2021). However, these studies generally focused on clinical or sub-clinical populations with depression or anxiety. Meta-analytical evidence is generally lacking for non-clinical samples who experience elevated levels of perceived stress. In addition, the systematic reviews that exist on this topic combine digital programs with and without human support (Davies et al., 2014; Heber et al., 2017; Lattie et al., 2019). Given that supported self-help interventions are more expensive than their unsupported counterparts, it would be useful to have meta-analytic evidence on the effects of each separately. In the current report, we aimed to present such an analysis of self-help interventions for stress management delivered without human support, which we henceforth refer to as *self-guided*.

To date, the effects of self-guided stress management interventions at a meta-analytic level have generally been examined in samples of people with physical illness (Ugalde et al., 2017) or adults seeking help for the management of work-related stress (Richardson and Rothstein, 2008). However, there is growing literature investigating the effects of self-guided stress management interventions among unrestricted samples of college students. Therefore, we focused on individual self-guided stress management interventions, excluding both self-help groups and guided self-help interventions. In our study, we anticipated differences between college student samples in terms of inclusion characteristics, thus, we investigated the effects of stress management interventions for

two college student samples separately: (1) those who were recruited regardless of their perceived stress scores (hereinafter referred to as *unselected college students*), and (2) those who were recruited into studies delivered exclusively to students with high levels of perceived stress based on a cut-off score on a standardized stress scale (hereinafter referred to as *preselected college students*).

2. Methods

The results of the systematic review and meta-analysis were reported following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) Statement (Liberati et al., 2009).

2.1. Protocol and registration

Methods of the planned search strategy, inclusion criteria, and data analysis were prospectively identified. This study has been preregistered in the Open Science Framework (OSF). The preregistered protocol can be retrieved via <https://osf.io/23vck>.

2.2. Eligibility criteria

We included studies that were 1) RCTs in which 2) a self-guided self-help stress management intervention compared to 3) a control condition (care-as-usual, waiting list, or attention control, etc.) in 4) a higher education setting. Included data were based on continuous outcomes for perceived stress, psychological distress, depression, and/or anxiety. Psychological stress/distress is considered a generic concept. In this study, we defined psychological stress/distress as a non-specific emotional and behavioral response resulting from external or internal demands (Cohen et al., 1995, pp. 6–7; Cohen et al., 2016; Ridner, 2004). Therefore, we decided to examine symptoms of depression and anxiety as outcomes next to stress symptoms as they are often reported together and in some cases used interchangeably in studies testing the effectiveness of stress management programs. Further, depressive and anxiety symptoms are two of the most common emotional health problems, and thus, they are conceptually embedded within the definition of psychological distress (Ridner, 2004). Despite their phenomenologically unique characteristics (e.g., depression is characterized as low positive affect, lack of motivation, loss of interest, or hopelessness, while anxiety is characterized by symptoms of physical hyperarousal such as restlessness or irritability), they share substantial non-specific components with each other (Hammen, 2015; Henry and Crawford, 2005; Lovibond and Lovibond, 1995; Monroe, 2008; Watson et al., 1995). Given the strong associations between these emotional problems and the high comorbidity, in this meta-analysis, we included depression and anxiety outcomes to get a more comprehensive overview of the effectiveness of stress management interventions.

We defined two different eligibility criteria for two meta-analyses in terms of the target population. In the first meta-analysis, we only included studies with unselected college students. In the second study, we included studies preselected college students based on a cut-off score on a perceived stress scale. Self-guided stress management intervention is defined as a psychological intervention addressing psychological stress and coping skills in which individuals follow the program without the help of a care provider. We added self-guided stress management programs in any format including web-based, mobile phone applications, book, or audio. We included studies if participants were in contact with the research staff only with the purpose of technical support (e.g. if they had problems in accessing the platform in the online intervention) or data collection. Only RCTs in English were added to our study.

We excluded peer support groups and guided self-help interventions in which a coach/therapist provided personalized feedback on the student's progress. We excluded studies if the recruitment focus was not stress. Following this, we excluded studies addressing interventions for depressive and/or anxiety symptoms, worry, procrastination, sleep

difficulties, or eating behaviors. We also excluded studies if they were not published in peer-reviewed journals (such as conference papers, or dissertations).

2.3. Search strategy

We retrieved publications from the four main bibliographic databases namely, PubMed, PsycINFO, Embase, and Cochrane Library up until 29.04.2020. We had already established this database to be used in another study examining the guided or in-person stress management interventions (Amanvermez et al., 2020). We updated this database using the same search strings. We filtered results by RCTs and according to age groups. Full search strings are presented in Appendix A. We also searched a database which includes psychological interventions in college students that was developed by another research group. Details related to this database can be found at https://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42017068758.

2.4. Selection of studies

After retrieving studies from the databases and removing duplicates, two researchers (YA and RZ) independently screened the studies based on the titles and abstracts. Following the first screening, full-texts of the selected studies were examined for eligibility. Disagreements between the two assessors were discussed with the senior researchers (EK, LDW, or PC).

2.5. Data extraction and classification

Two researchers independently extracted the data including 1) the characteristics of the studies (author, publication year, country), 2) characteristics of the interventions (theoretical background, format, length), 3) characteristics related to the study design (type of control condition, inclusion criteria of the participants, outcomes, time of assessments, compensation, study attrition rate), and 4) characteristics of the participants (age, percentage of the female students, target student population, recruitment strategy, type of the university). We extracted the percentage of female students to describe trends in gender distribution in the included studies because previous studies have shown that female participants were more likely to utilize psychological interventions (Davies et al., 2014; Harrer et al., 2019b).

We classified selected study characteristics to run subgroup analysis. Stress management programs were grouped according to the theoretical background under four categories based on common therapeutic strategies: 1) cognitive-behavioral therapy (CBT), 2) third-wave therapies (TW), 3) skills-training, and 4) mind-body interventions. Stress management programs including components such as cognitive restructuring or stress inoculation strategies were assessed under the CBT-based stress management programs (Ong et al., 2004). Programs including techniques of acceptance or mindfulness concepts in combination with CBT strategies such as acceptance and commitment therapy (ACT), or mindfulness-based cognitive behavior therapy (MBCT) were classified under TW (Hayes and Hofmann, 2017). Skills training programs included components to improve particular skills to manage stress (e.g. improving present control skills). Mind-body interventions were the programs that mainly used mindfulness, meditation, biofeedback, or relaxation techniques (Astin et al., 2003; Ong et al., 2004). We classified the length of the intervention as brief, moderate, and long if they were delivered for 1–4 weeks, 5–8 weeks, and 8+ weeks, respectively. We have classified the modalities if they were delivered in online format (including web-based stress management programs, and/or mobile phone applications) or others (book and/or audio).

The number of participants, mean scores, and standard deviation of control and intervention conditions at post-test were extracted to calculate the effect size. If these data were not available, we extracted other available statistics (i.e., *p*-value, *t* score, or effect size) that allowed

us to calculate the effect size. If no relevant information was reported for calculating effect size, then we contacted the author. If the author did not respond, we excluded this study from our analysis. We could not retrieve relevant data from the published reports of four studies. After contacting the authors, we could obtain the relevant data for three studies (Nguyen-Feng et al., 2015; Nguyen-Feng et al., 2019; Walsh et al., 2019), which allowed us to calculate effect sizes. However, we could not retrieve the relevant data for one study which was excluded.

2.6. Quality assessment

The risk of bias was assessed by the revised Cochrane risk-of-bias tool for randomized trials (RoB 2) (Sterne et al., 2019). RoB 2 includes five domains: (1) bias arising from the randomization process; (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in the measurement of the outcome; and (5) bias in the selection of the reported result (Sterne et al., 2019). However, in the present study, the domain assessing the bias in the measurement of the outcome was omitted as all studies used self-reported measures. This issue inherently precludes the blinding of the outcome assessor. Therefore we assessed only four domains in the RoB 2 tool.

Two independent assessors (YA and RZ) assessed each study for these domains by answering the signaling questions. By doing this, we had results of low risk of bias, some concerns, or high risk of bias at the domain level. Then we determined the overall risk of bias of each study as low, some concerns, and high risk of bias. The overall risk of bias of the study was determined to be low if at least two domains had low risk and no high risk of bias at any domain. The overall risk of bias was considered high if at least two domains had a high risk of bias or all domains had some concerns. The studies that did not meet these criteria were evaluated as containing “some concerns” (e.g. studies having “some concerns” at three domains and low risk of bias at one domain). Discrepancies between assessments were discussed by two assessors. Senior researchers (EK, LDW, or PC) were consulted if discrepancies were not solved as a result of the discussion.

2.7. Meta-analyses

We conducted two separate meta-analyses using the Comprehensive Meta-Analysis (CMA) software package and the meta (Schwarzer, 2007), metafor (Viechtbauer, 2010), and dmetar (Harrer et al., 2019a) packages in R version 4.0.2. We calculated the effect size of each study using the CMA by pooling all continuous outcomes of perceived stress, anxiety, and/or depression within a study. Then we used R to calculate the pooled effect size, perform additional analyses including subgroup analyses, sensitivity analysis, and test publication bias.

We calculated the effect size of each study using the mean, standard deviation, and the number of students in the intervention and control conditions at post-test assessment. If multiple outcomes were reported within one study, first we calculated a synthetic effect size per study. If there is high association between targeted outcomes, this would result in high correlation between errors of these outcomes. In such case, combining outcomes first within the study and generating one effect size per study is recommended (Borenstein et al., 2009). In our main analysis, we pooled the combined effect size from each study by taking into account the high correlation between these outcomes. Therefore we calculated one effect size (Hedges' *g*) for each study separately. Then we pooled the effect sizes. As an additional analysis, we also examined the effect of stress management programs on each outcome separately. We conducted the meta-analyses under the random-effects model due to the wide variability of studies. An effect size of 0.2, 0.5, and 0.8 was interpreted as small, moderate, and large, respectively (Cohen, 1988). We also calculated the number needed to treat (NNT) to improve the understandability of the findings (Kraemer and Kupfer, 2006). Heterogeneity of the effect sizes across studies was calculated using I^2 (Ioannidis et al., 2007). Heterogeneity was deemed to be low, moderate, and

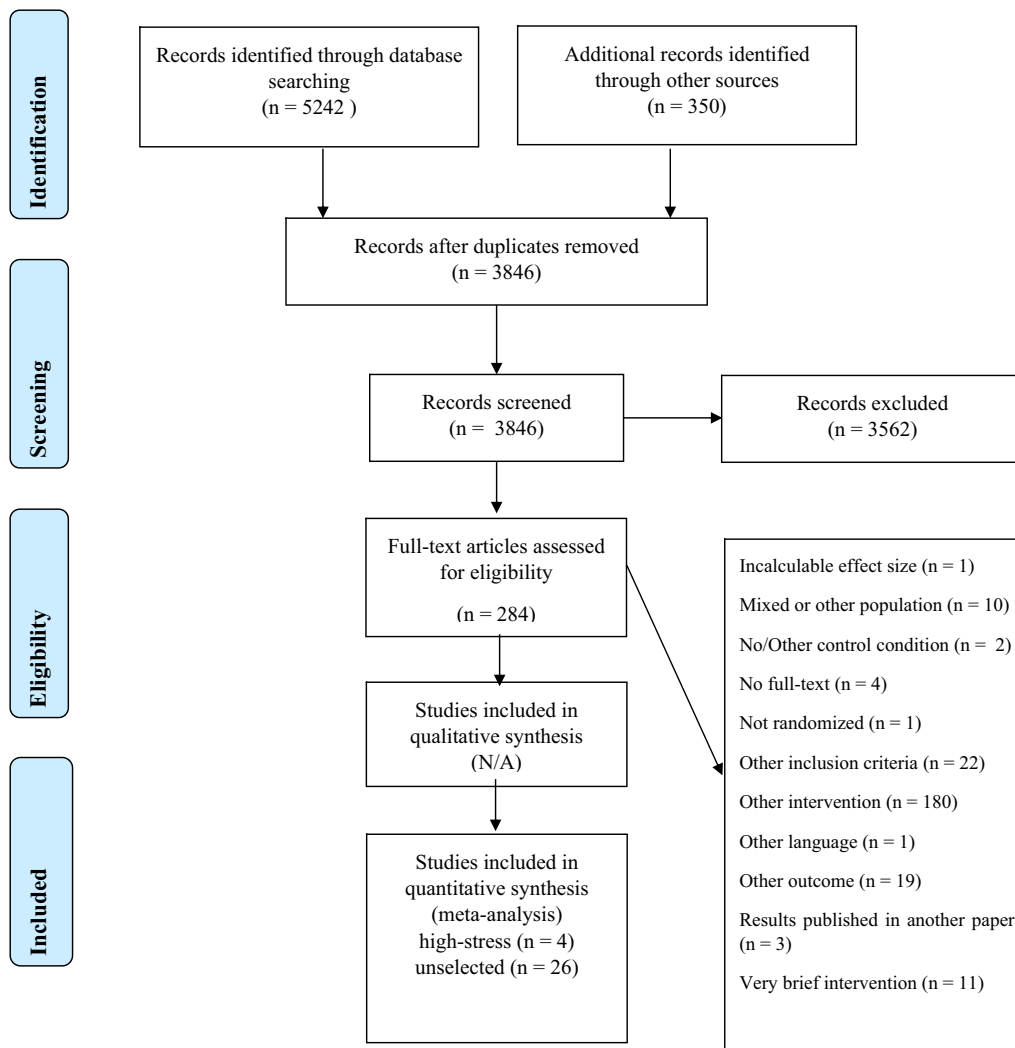


Fig. 1. PRISMA flow diagram.

high if the I^2 value was quantified 25%, 50%, and 75% respectively (Higgins et al., 2003). We also calculated the 95% CI around I^2 .

2.8. Publication bias

Publication bias was assessed by inspection of the funnel plot and testing the asymmetry of the funnel plot performing Egger's test of the intercept (Egger et al., 1997). We estimated the number of missing studies from the funnel plot, and re-calculated the effect size after imputation the missing studies with Duval and Tweedie's trim and fill procedure (Duval and Tweedie, 2000).

2.9. Additional analyses

A series of subgroup analyses using the mixed-effects model was conducted with the studies for unselected college students to examine whether the effects are different in terms of the study or intervention characteristics. We conducted subgroup analyses for the type of control (AC vs. WL vs. CAU), theoretical background (CBT vs. TW vs. skills training vs. mind-body), length of the studies (brief vs. moderate vs. long), intervention format (online vs. others), compensation (yes vs. no), recruitment strategies (campus vs. subject pool vs. online vs. mixed), and risk of bias assessment (high vs. some concerns vs. low). We also conducted a sensitivity analysis including only studies with a low risk of bias to obtain the most accurate findings.

3. Results

3.1. Study selection

Our searches resulted in 5242 studies from the database search and 350 from the other source. After removing the duplicates, we had a total of 3846 studies. The records were screened based on the title and abstract and 3562 studies did not meet inclusion criteria and were excluded. Following this, we screened the full-text of 284 remaining studies for eligibility. As a result, we retrieved 26 studies with 29 comparisons for the unselected college samples and four studies for preselected students. Details of this process and reasons for the exclusion of the studies can be seen in Fig. 1.

3.2. Study characteristics

Studies with unselected college students consisted of 4468 participants in total (intervention groups: $N = 2400$; control groups: $N = 2068$). Fourteen out of 26 studies compared the intervention to a waiting list (WL) group, while comparisons were made with an attention control (AC) in 10 studies, and care-as-usual (CAU) in two studies. Among 29 comparisons, 13 of them were mind-body interventions, seven interventions were based on TW approaches. There were six skills training and three CBT-based programs. Almost all studies were conducted in high-income countries. Half of the studies were conducted in the USA.

Table 1
Study characteristics for studies with unselected college students.

Study	Recruitment	Student sample	Conditions	Drop out %	Theoretical background	Format	Reminder	Length	Age	Female %	Compensation	University type	Country
Barry et al., 2019	Online	Graduate	1. Mindfulness program 2. WL	12.00%	TW	Audio	No	8-week	38	81.50%	No	Public	AUS
Burger and Lockhart, 2017	Subject Pool	Undergraduate	1) Mindfulness meditation 2)WL	13.33%	TW	Online	No	4-week	ns	72.00%	No	ns	USA
Cavanagh et al., 2013	Mixed	General	1). Mindfulness program 2) WL	44.00%	TW	Online	Yes	2-week	24.7	88.46%	No	ns	UK
Fehring, 1983	Campus	General	1) Benson's relaxation technique (BRT) 2) Benson's relaxation technique augmented with GSR biofeedback (BAR) 3) CAU	13.33%	MB	Book + Audio + GSR II recorder	No	8-week	22.8	78.20%	No	Private	USA
Flett et al., 2019	Subject Pool	Undergraduate	1) Mindfulness meditation (Headspace) 2) Mindfulness meditation (Smiling Mind) 3) AC	0.09%	TW	Online	Yes	10-day	20.08	ns	Yes	Public	NZ
Flett et al., 2020	Online	Undergraduate	1) Mindfulness meditation (Headspace) 2) WL	22.00%	TW	Online	Yes	3-month	17.87	67.60%	Yes	Public	NZ
Frazier et al., 2015	Subject Pool	Psychology	1) Present control intervention 2) AC (stress information only)	43.20%	ST	Online	Yes	2-week	ns	75.00%	Yes	ns	USA
Hazlett-Stevens and Oren, 2017	Mixed	General	1) MBSR bibliotherapy 2) WL	26.00%	TW	Book + Audio	Yes	10-week	22.1	75.00%	Yes	ns	USA
Hockemeyer and Smyth, 2002	Campus	General	1) Stress management workbook 2) AC	10.00%	CBT	Book + Audio	No	4-week	20.7	53.70%	Yes	ns	USA
Kanekar et al., 2010	Online	International	1) Skills training 2) AC (wellness intervention)	35.00%	ST	Online	Yes	2-month	24.67	12.80%	Yes	ns	USA
Kvillemo et al., 2016	Campus	General	1) Internet-based mindfulness training 2) AC	45.56%	TW	Online	Yes	8-week	29	73.68%	Yes	ns	SWE
Lee and Jung, 2018	Campus	Undergraduate	1. Destressify 2. WL	20.87%	TW	Online	Yes	4-week	20.6	63.00%	Yes	Public	CAN
Levin et al., 2014	Mixed	Undergraduate	1) ACT on college life 2) WL	2.61%	TW	Online	Yes	3 week	18.37	53.90%	Yes	ns	USA
Levin et al., 2016	Mixed	Undergraduate	1) ACT-CL website 2) AC (mental health education website)	23.50%	TW	Online	Yes	3-week	21.61	76.90%	Yes	ns	USA
Melnyk et al., 2015	Online	Undergraduate	1) COPE 2) AC	23.14%	CBT	Online	No	7-week	18.6	86.40%	Yes	Public	USA
Muto et al., 2011	Mixed	International	1) Get Out of Your Mind and Into Your Life book 2) WL	12.85%	TW	Book	No	8-week	23.6	62.86%	Yes	Public	USA
Nguyen-Feng et al., 2015	Campus	Psychology	1) Web-based stress management intervention 2) WL	16.86%	ST	Online	No	5-week	ns	62.00%	Yes	ns	USA
Nguyen-Feng et al., 2017	Campus	Psychology	1) A mindfulness plus present control intervention 2) A mindfulness only intervention 3) AC (stress information)	30.13%	ST	Online	Yes	4-week	ns	75.00%	Yes	ns	USA
Nguyen-Feng et al., 2019	Campus	Undergraduate	1) Ecological momentary intervention	16.23%	ST	Online	Yes	2-week	21.3	77.00%	Yes	ns	USA

(continued on next page)

Table 1 (continued)

Study	Recruitment	Student sample	Conditions	Drop out %	Theoretical background	Format	Reminder	Length	Age	Female %	Compensation	University type	Country
O'Driscoll et al., 2019	Mixed	Undergraduate	2) AC (ecological momentary assessment) 1) Online mindfulness 2) WL	62.59%	TW	Online	Yes	4-week	ns	76.90%	No	Mixed	IRE
Paholpak et al., 2012	Campus	Undergraduate	1) Breathing meditation 2) CAU	0.00%	MB	Audio	No	4-week	23.28	50.00%	No	Public	TH
Saleh et al., 2018	Mixed	General	1) I'm managing my stress 2) WL	57.03%	CBT	Online	Yes	4-week	22.54	81.25%	Yes	Public	FR
Taylor et al., 2014	Campus	General	1) MBCT-SH book 2) WL	5.00%	TW	Book + Audio	Yes	8-week	28.61	81.00%	No	ns	UK
Viskovich and Pakenham, 2020	Mixed	General	1) YOLO Program 2) WL	41.99%	TW	Online	Yes	4-week	26.85	67.80%	No	ns	AUS
Walsh et al., 2019	Mixed	General	1) Wildflowers 2) AC	20.37%	TW	Online	No	3-week	20.01	84.00%	Yes	Public	CAN
Yang et al., 2018	Online	Undergraduate	1) Headspace 2) WL	7.95%	TW	Online	No	4-week	25.11	64.00%	No	Private	USA

Note. AC: active control; AUS: Australia; CAN: Canada; CAU: care-as-usual; CBT: cognitive behavior therapy; FR: France; IRE: Ireland; MB: mind-body; NZ: New Zealand; ST: skills training; SWE: Sweden; TH: Thailand; TW: third wave therapy; UK: United Kingdom; USA: United States of America; WL: waiting list.

Two studies were in the UK, New Zealand, Canada, and Australia. The rest were conducted in Sweden, France, Ireland, and Thailand. Study characteristics can be seen in Table 1.

In the meta-analysis of studies with preselected students, a total of 491 participants were included (intervention groups: $N = 235$; control groups: $N = 256$). Of four studies, two studies used AC as a comparison group and the other two studies used WL. Two interventions were based on skills training, one incorporated CBT techniques, and one was designed based on TW principles. With regard to the inclusion criteria of the participants, two studies used a cut-off score based on the Perceived Stress Scale (PSS-10) (Cohen and Williamson, 1988). One study used the Depression Anxiety and Stress Scale (DASS-21) stress or anxiety subscale (Lovibond and Lovibond, 1995), and one study used the Perceived Control Over Stressful Events Scale (PCOSES) (Frazier et al., 2011). Three studies were conducted in the USA, and one study was in the UK. Study characteristics can be seen in Table 2.

The study dropout rate was calculated using the number of participants who were included in the study but lost to post-test assessment. Overall, 27.77% (ranging from 0% to 62.59%) of the unselected college students, and 28.8% (ranging from 2.08 to 55.72%) of the pre-selected college students did not provide complete data.

3.3. Quality assessment

The overall risk of bias in all studies was considerable. Studies with unselected college students showed that the randomization process was handled/reported adequately in only five out of 26 studies. The risk of bias arising from the deviations from intended interventions showed that fourteen studies fulfilled the criteria for low risk. In fifteen studies, missing outcome data were properly managed or reported in a detailed way. We assessed only five studies as having a low risk of bias for the selection of the reported results. In total, eleven studies were judged to have an overall low risk of bias, ten studies had some concerns, and five studies had an overall high risk of bias. The visual demonstration of the risk of bias assessments can be seen in Figs. 2 and 3.

Among the studies with preselected college students, the randomization process was either not reported elaborately or had some concerns. We assessed only one study having a low risk of bias in the domain of deviations from the intended interventions. Two out of four studies were assessed as having a low risk of bias for missing outcome data. Two studies were deemed to be having a low risk of bias for the selection of the reported result. Overall, there was a low risk of bias in one study, some concerns in two studies, and a high risk of bias in one study. The risk of bias assessments of the studies with preselected college students can be seen in Figs. 4 and 5 in detail.

3.4. Main analyses

The overall effect size of the self-guided stress management program in comparison to a control condition at post-test was small but statistically significant for the unselected student samples ($g = 0.19$; 95% CI [0.10, 0.29]; $p < 0.001$; $n = 29$) with moderate heterogeneity across studies ($I^2 = 48\%$; 95% CI [19–66%]). NNT was 9.43. Based on inspection of the forest plot (Fig. 6), we found two outliers (Nguyen-Feng et al., 2017, mindfulness intervention, and Paholpak et al., 2012). After removing the outliers, the effect size was still low ($g = 0.23$; 95% CI [0.14, 0.31]; $p < 0.001$; $n = 27$; $I^2 = 30\%$; 95% CI [0–56%]). As a result of separate analyses for each outcome, we found a small effect size for stress ($g = 0.25$; 95% CI [0.15–0.35]; $p < 0.001$; $n = 26$), depression ($g = 0.14$; 95% CI [0.03–0.26]; $p = 0.016$; $n = 19$), and anxiety ($g = 0.11$; 95% CI [0.00–0.21]; $p = 0.045$; $n = 19$). Heterogeneity across studies was moderate for stress ($I^2 = 53\%$), depression ($I^2 = 59\%$), and anxiety ($I^2 = 46\%$). The prediction interval ranged from -0.15 to 0.54 . All details are presented in Table 3. We also found an indication of publication bias for studies with unselected samples based on the inspection of the funnel plot (Fig. 8). Egger's test of the intercept was not significant

Table 2
Study characteristics for studies with preselected college students.

Author	Recruitment	Student sample	Inclusion criteria	Conditions	Drop out %	Theoretical background	Format	Reminder	Weeks	Age	Female	Compensation	University type	Country
Chiauszi et al., 2008	Campus	Undergraduate	PSS-10 > 14	1) MyStudentBodyStress 2) AC	2.08%	ST	Online	Yes	2- week	ns	51.46%	No	Mixed	USA
Hintz et al., 2015	Subject pool	Psychology	PCOSES ≤ 3	1) Present control intervention, 2) The present control intervention plus feedback, 3) AC	30.00%	ST	Online	Yes	2- week	ns	70%	Yes	ns	USA
Huberty et al., 2019	Mixed	Undergraduate	PSS-10 ≥ 14	1) Mindfulness meditation (CALM) 2) WL	19.26%	TW	Online	Yes	8- week	21.13	88%	Yes	Public	USA
Ponzo et al., 2020	Mixed	General	DASS-21-S > 14 or DASS-21-A > 7	1) Biobase program 2) WL	55.72%	CBT	online	Yes	4- week	19.87	63.01%	Yes	ns	UK

Note. AC: active control, CAU: care-as usual, CBT: cognitive behavior therapy; DASS: Depression Anxiety Stress Scale; PCOSES: Perceived Control over Stressful Events Scale; PSS: Perceived Stress Scale; ST: skills training; TW: third wave therapy; UK: United Kingdom; USA: United States of America; WL: waiting list.

(intercept: 0; 95% CI: -1.14–1.14, $t = 0$, $p = 0.99$) yet Duval and Tweedie's trim and fill procedure resulted in one imputed study. Adjusted effect size was small ($g = 0.18$, 95% CI [0.09; 0.28], $p < 0.001$).

Meta-analysis of the studies with preselected college students yielded a low effect size ($g = 0.34$; 95% CI [0.16–0.52]; $p < 0.001$; $n = 4$) with zero heterogeneity ($I^2 = 0\%$; 95% CI [0–79%]). NNT was 5.26. We found no outlier based on the inspection of the forest plot (Fig. 7). We performed the separate analyses for outcomes and found a non-significant small effect size for stress ($g = 0.27$; 95% CI [-0.04, 0.58]; $p = 0.087$; $n = 3$), significant small effect for depression ($g = 0.29$; 95% CI [0.10–0.49]; $p < 0.001$; $n = 3$), and anxiety ($g = 0.38$; 95% CI [0.18–0.58]; $p = 0.003$; $n = 3$). Our results yielded moderate heterogeneity for stress ($I^2 = 56\%$), zero heterogeneity for depression ($I^2 = 0\%$) and anxiety ($I^2 = 0\%$). The prediction interval ranged from -0.05 to 0.73. The results can be seen in Table 4. Following the evaluation of the funnel plot in studies for preselected samples, findings did not suggest an indication of publication bias (Fig. 9). Egger's test was significant (intercept: 6.173, 95% CI [3.92– 8.42], $t = 5.375$, $p = 0.033$) which suggest a publication bias. After performing Duval and Tweedie's trim and full procedure, we found no imputed studies.

3.5. Subgroup analyses, and sensitivity analysis

We performed several subgroup analyses for the studies with unselected samples. We found no significant associations between the theoretical background, control condition, length of the intervention, ITT, recruitment strategies, sending reminders, and the intervention format. We found a significant association ($p = 0.04$) between the effect size and compensation in favor of no compensation ($g = 0.34$; 95% CI [0.16–0.51]; $n = 10$) versus presence of compensation ($g = 0.13$; 95% CI [0.03– 0.23]; $n = 19$). All results are presented in Table 3. We could not perform any subgroup analysis with the studies for preselected samples due to a lack of a sufficient number of studies to run such analysis.

Sensitivity analysis for studies only having an overall low risk of bias showed that effect size was low ($g = 0.17$; 95% CI [0.06–0.28]; $p = 0.003$; $n = 12$). The number of studies with preselected samples did not permit us to run sensitivity analysis.

3.6. Meta-analyses of longer-term outcomes

Few studies assessed follow-up outcomes of the self-guided stress management programs, and follow-up time points varied widely across studies. Nevertheless, we pooled the findings of long-term effects up to 6-month follow-up for unselected samples, and found a non-significant effect ($g = 0.01$; 95% CI [-0.10–0.12]; $p = 0.821$; $n = 12$, $I^2 = 24\%$). Similarly, we ran the analysis only with studies assessing the outcomes up to 3-months follow-up and found no significant effect for unselected samples ($g = 0.00$; 95% CI [-0.13–0.13]; $p = 0.963$; $n = 9$, $I^2 = 36\%$). We calculated the long-term effects of self-guided stress management interventions up to 3-month in the preselected samples, and we found small and statistically significant effect size ($g = 0.31$; 95% CI [0.08–0.53]; $p = 0.007$; $n = 3$, $I^2 = 0\%$).

4. Discussion

We conducted two meta-analyses of the RCTs, one with unselected college samples and one with preselected college students with high levels of perceived stress, investigating the effectiveness of self-guided stress management interventions for college students. We included 26 studies with 29 comparisons for the unselected college students in the first meta-analysis and four studies for preselected students in the second meta-analysis. We found a small and statistically significant effect size of the self-guided stress management interventions for perceived stress, depression, and anxiety for the unselected student populations in comparison to the control condition. We also found a small and statistically significant effect size for the preselected students. The risk of bias

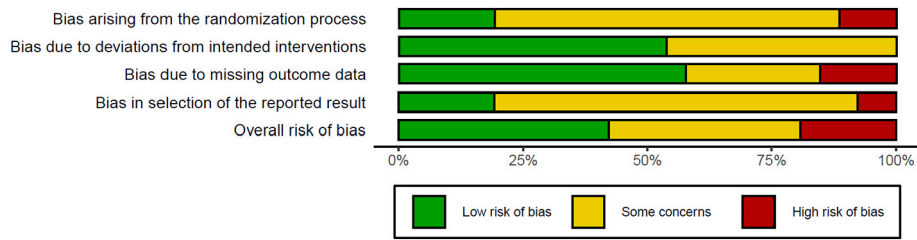


Fig. 2. Risk of bias summary for studies with unselected college students.

Study	Risk of bias domains					Overall
	D1	D2	D3	D5		
Barry et al., 2018	-	-	-	-	X	
Burger et al., 2017	X	-	+	-	-	
Cavanagh et al., 2013	-	+	-	-	-	
Fehring, 1983	-	-	-	-	X	
Flett et al., 2019	-	-	+	+	+	
Flett et al., 2020	-	+	+	+	+	
Frazier et al., 2015	-	+	-	-	-	
Hazlett-Steven & Oren, 2017	X	-	+	-	-	
Hockemeyer & Smyth, 2002	+	-	+	-	+	
Kanekar et al., 2010	-	-	X	X	X	
Kvillemo et al., 2016	X	+	-	+	-	
Lee et al., 2018	-	-	+	-	-	
Levin et al., 2014	-	+	+	-	+	
Levin et al., 2016	+	+	+	-	+	
Melnyk et al., 2015	-	-	X	-	X	
Muto et al., 2011	+	+	+	-	+	
Nguyen-Feng et al., 2015	-	+	+	-	+	
Nguyen-Feng et al., 2017	-	+	-	-	-	
Nguyen-Feng et al., 2019	-	+	+	+	+	
O'Driscoll et al., 2019	-	-	X	-	X	
Paholpak et al., 2012	-	+	+	X	-	
Saleh et al., 2018	-	-	X	+	-	
Taylor et al., 2014	+	+	+	-	+	
Viskovich et al., 2019	-	+	+	-	+	
Walsh et al., 2019	+	-	-	-	-	
Yang et al., 2018	-	+	+	-	+	

Domains:
D1: Bias arising from the randomization process.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing outcome data.
D5: Bias in selection of the reported result.

Judgement
X: High
-: Some concerns
+: Low

Fig. 3. Risk of bias summary for studies with unselected college students.

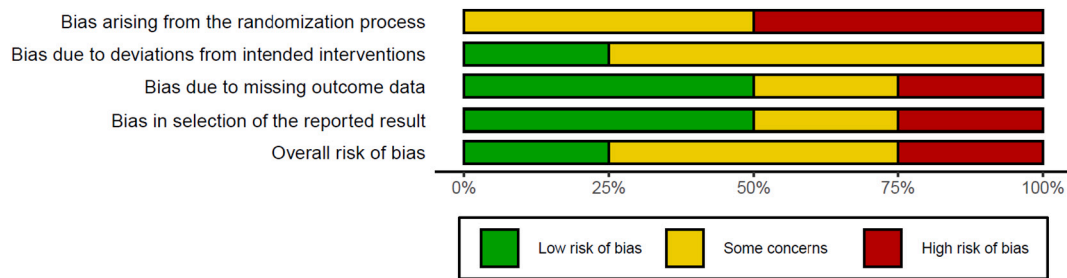


Fig. 4. Risk of bias summary for studies with preselected college students.

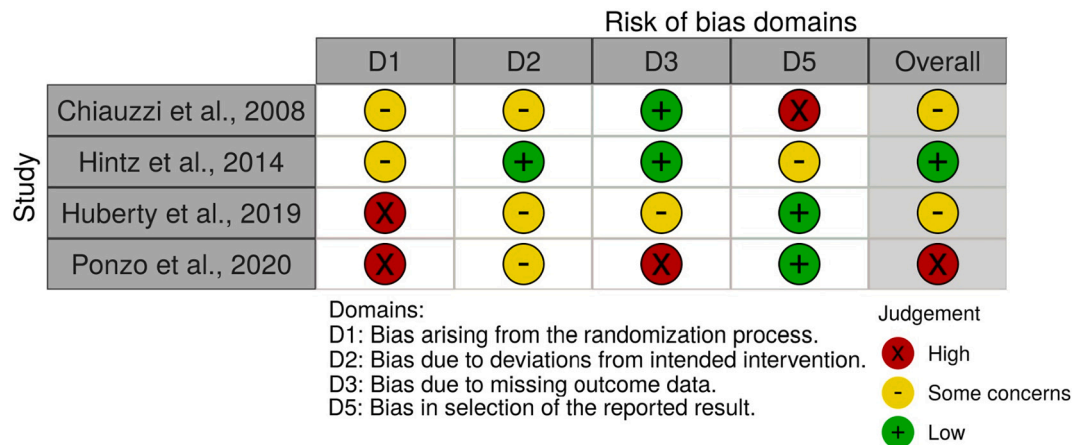


Fig. 5. Risk of bias summary for studies with preselected college students.

was considerable in the included studies.

Systematic assessments of psychological interventions among college students have been studied for several mental health problems, however, to our knowledge, this is the first study pooling the results of all self-guided stress management interventions specifically for college students. Previous meta-analyses of self-guided programs found small effects in working populations (Carolan et al., 2017; Stratton et al., 2017) and in general populations (Heber et al., 2017) on stress and psychological distress. Although evidence of self-guided stress management programs for the non-clinical college student populations is limited, one meta-analysis of digital interventions reported a low effect size on stress, anxiety, and depression (Harrer et al., 2019b). Our results also align with other meta-analytic studies examining the internet-based interventions for non-clinical or subclinical depression/anxiety (Deady et al., 2017; Zhou et al., 2016).

A possible explanation behind the low effects of self-guided interventions may be related to the lack of human reciprocal contact. Several studies have demonstrated the superiority of guided interventions over self-guided programs in improving symptoms of common mental disorders (Baumeister et al., 2014; Domhardt et al., 2019; Karyotaki et al., 2021). Human support has been seen as a possible mechanism of change, as it was found to be associated with higher numbers of completed sessions and increased completer rates (Domhardt et al., 2019; Karyotaki et al., 2021; Nixon et al., 2021), which could be related to better intervention outcomes (Karyotaki et al., 2021). The superior effects of guided interventions may be related to the concept of supportive accountability defined as the social presence and/or dynamic interaction that stimulates the motivation to continue the intervention (Mohr et al., 2011). In addition, as noted earlier, the therapeutic relationship has been suggested as a crucial common factor, which can stimulate behavioral change in psychological interventions (Graves et al., 2017; Wampold, 2015). Thus, the lack of reflective processes and feedback while transferring the knowledge from the

intervention to everyday life might limit the effects of the self-guided interventions (Conley et al., 2016; Pleva and Wade, 2006; Rosen, 1993; Rozental et al., 2014).

However, we should note that most of the existing evidence around the relative effectiveness of guided and unguided interventions is derived from studies focusing on changes in depressive and anxiety symptoms. Therefore, it remains unclear whether guided and self-guided stress management programs produce differential effects. Future studies should examine this comparison in a head-to-head fashion to shed light into the differential effectiveness of guided and self-guided interventions for psychological stress/distress. It is also plausible that the effectiveness of self-guided stress management programs may be increased by the provision of on-demand support or personalized automated messages. For instance, individuals with high levels of stress may find guidance on-demand more beneficial than regular guidance as they can maintain control over the intervention and request social support whenever it is necessary. Previous studies on psychological problems, such as stress or perfectionism, showed that internet-based interventions with guidance on-demand yielded similar effects with guided interventions (Zarski et al., 2016; Zetterberg et al., 2019). Moreover, in these studies, individuals contacted coaches rarely possibly due to the lack of perceived need for additional support. These findings do not necessarily imply lack of need for guided interventions because close monitoring and individualized feedback may be particularly relevant for certain groups like those who are at high risk of experiencing negative effects (Rozental et al., 2014). Therefore, different types and intensities of guidance in stress management programs, as well as predictors of differential response with regard to different guidance formats should be investigated thoroughly in future studies. Moreover, technological advancements could offer innovative tools to increase the effects of self-guided interventions. Persuasive technology strategies, particularly using automated reminders may be another cost-effective strategy to improve intervention outcomes by

Forest Plots

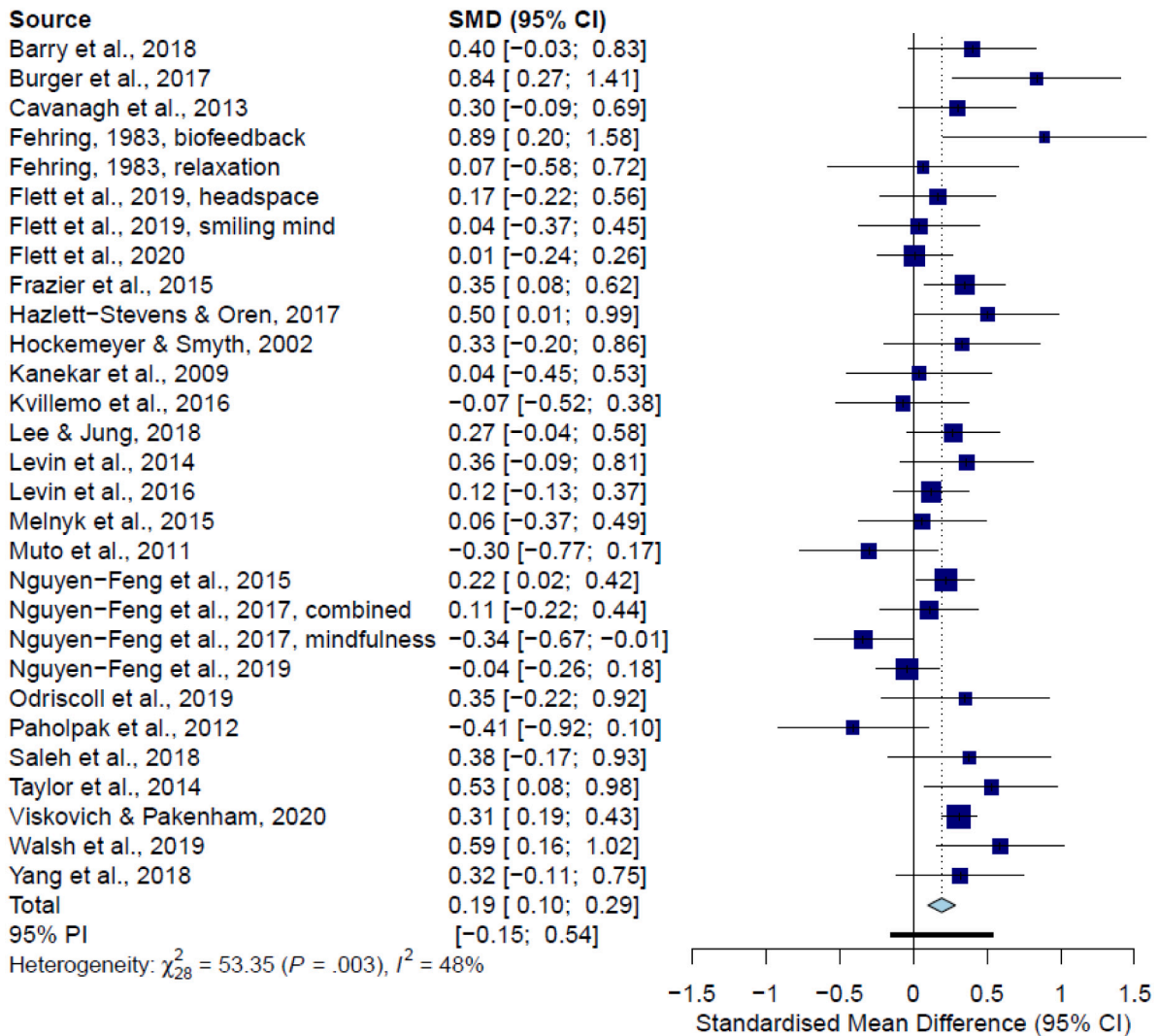


Fig. 6. Forest plot for comparisons of self-guided stress management programs for unselected college students to control conditions at posttest.

increasing engagement (Kelders et al., 2012; Brouwer et al., 2011). However, timing, frequency, content, and format (i.e., SMS, push notification, or email) of the automated reminders should be investigated with careful consideration since some participants may perceive them as stressful (Dennison et al., 2013). Last but not least, it is possible that some individuals benefit equally from guided and self-guided interventions as we have seen in the case of depression (Karyotaki et al., 2021). Such hypothesis, however, remains to be investigated in future research.

The low effect size could also be explained by sample characteristics. Our results showed that little improvement is possible in unselected student samples. In addition, studies targeting students with high levels of perceived stress yielded a slightly higher effect size than unselected student samples. Previously, higher baseline stress scores were found to be associated with the larger effect size of a web-based stress management program (Coudray et al., 2019). Studies also provided evidence on the larger effects in preselected student samples than unselected ones (Amanvermez et al., 2020; Conley et al., 2016; Harrer et al., 2019b). However, there are still unanswered questions about which students benefit most from self-guided stress management programs, as we did not directly test or compare this in the present study. Besides, it is not clear if stress management programs are also effective for people with

subthreshold depression or anxiety, although recent RCT studies showed promising results (Harrer et al., 2021; Weisel et al., 2018).

In this study, the study dropout rates were comparable to those reported by studies on internet-based interventions for common mental health problems (Christensen et al., 2009; 1–50%; Harrer et al., 2019b; 2–50%; Melville et al., 2010; 0–82%). Nevertheless, it is important to differentiate between study dropout and intervention dropout. Intervention dropout refers to the situation in which the participant stops following the intervention before receiving the recommended dose (Donkin et al., 2011). It would have been important to investigate the possible impact of intervention dropout as it can be associated with the intervention outcomes (Karyotaki et al., 2017). However, the substantial variability of measuring/reporting the intervention adherence across the included studies prevented us from investigating this issue. This has been found as a general problem in similar interventions (Beintner et al., 2019). Future research should establish consensus about reporting criteria on adherence in digital intervention trials and investigate predictors and consequences of intervention dropout in self-guided stress management programs.

A large number of college students are experiencing stresses in several domains and scalable stress management interventions for college students are needed at universities (Karyotaki et al., 2020). The

Table 3
Pooled effects of self-guided stress management programs for unselected college students on target outcomes compared with control groups.

	n	Effect size			p	Heterogeneity		NNT
		g	95% CI	p		I ²	95% CI around I ²	
Overall effects	29	0.19	0.10–0.29	0.000		48	19–66	9.43
Removing two outliers	27	0.23	0.14–0.31	0.000		30	0–56	7.69
Symptom outcomes								
Stress	26	0.25	0.15–0.35	0.000		53	28–70	7.14
Anxiety	19	0.11	0.00–0.21	0.045		46	8–69	16.13
Depression	19	0.14	0.03–0.26	0.016		59	33–75	12.82
Only low risk of bias	12	0.17	0.06–0.28	0.003		41	0–70	10.42
Only low and some concerns	23	0.18	0.08–0.29	0.001		54	26–71	9.80
Subgroup analyses								
Theoretical background								
CBT	3	0.23	–0.06–0.51	0.60	0.41	0	0–80	7.69
Mind-body	13	0.21	0.05–0.37	0.06		41	0–69	8.47
Skills training	6	0.07	–0.12–0.26	0.02		61	6–84	25
TW	7	0.29	0.11–0.46	0.07		48	0–78	6.17
Comparison group								
Attention control	12	0.10	–0.03–0.23	0.08	0.11	39	0–69	17.86
CAU	3	0.16	–0.59–0.90	0.01		78	27–93	11.11
Waiting list	14	0.28	0.17–0.38	0.19		24	0–60	6.41
Length								
Brief	18	0.20	0.08–0.32	<0.01	0.99	53	20–72	8.93
Moderate	9	0.18	0.00–0.37	0.10		41	0–73	9.80
Long	2	0.21	–0.26–0.68	0.08		67	0–93	8.47
ITT								
Yes	15	0.15	0.04–0.27	<0.01	0.24	56	21–75	11.90
No	14	0.27	0.11–0.43	0.08		37	0–67	6.58
Recruitment								
Campus	11	0.13	–0.07–0.32	<0.01	0.23	58	18–79	13.51
Mixed	9	0.28	0.20–0.37	0.64		0	0–054	6.41
Online	6	0.10	–0.09–0.30	0.27		22	0–66	17.86
Subject pool	3	0.33	–0.06–0.72	0.02		75	17–92	5.43
Format								
Online	21	0.18	0.09–0.28	0.02	0.72	43	4–66	9.80
Other	8	0.24	–0.06–0.53	0.01		62	17–82	7.46
Reminder								
Yes	18	0.17	0.07–0.27	0.03	0.47	43	0–67	10.42
No	11	0.25	0.05–0.46	<0.01		57	16–78	7.14
Compensation								
Yes	19	0.13	0.03–0.23	0.06	0.04	36	0–63	13.51
No	10	0.34	0.16–0.51	0.08		41	0–72	5.26
Risk of bias								
High	6	0.26	0.03–0.49	0.02	0.74	12	0–78	6.85
Some concerns	11	0.21	0.01–0.42	0.04		65	34–82	8.47
Low	12	0.17	0.06–0.28	0.00		41	0–70	10.42

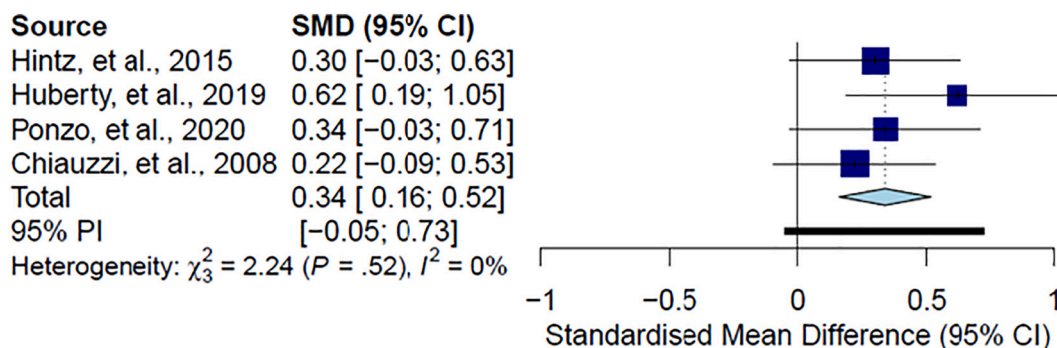


Fig. 7. Forest plot for comparisons of self-guided stress management programs for preselected college students to control conditions at posttest.

Table 4
Pooled effects of self-guided stress management programs for preselected college students on target outcomes compared with control groups.

	n	Effect size			Heterogeneity		NNT
		g	95% CI	p	I ²	95% CI around I ²	
Overall effects	4	0.34	0.16–0.52	0.000	0	0–79	5.26
Symptom outcomes							
Stress	3	0.27	–0.04–0.58	0.087	56	0–88	6.58
Anxiety	3	0.38	0.18–0.58	0.000	0	0–20	4.72
Depression	3	0.29	0.10–0.49	0.003	0	0–66	6.17

present study indicated that unselected student samples and students with pre-existing stress symptoms can benefit in the aggregate from self-guided stress management programs. These results allowed us to advance our knowledge of the effects of these programs in more detail.

Despite these strengths, some limitations should be emphasized while interpreting our results. First, we could only retrieve four studies targeting preselected samples and the number of participants was small in this meta-analysis. These results are underpowered and more studies should be conducted with large sample sizes to confirm our findings. Second, the risk of bias was substantial in the included studies. This limits the reliability of our results. Also, we modified the RoB 2 tool by removing one domain related to bias in outcome measurement and altering the criteria for assessing the overall risk of bias in each study, as this tool did not fit perfectly with the psychotherapy research. Third, the ecological validity of our study is unclear because individuals in RCTs

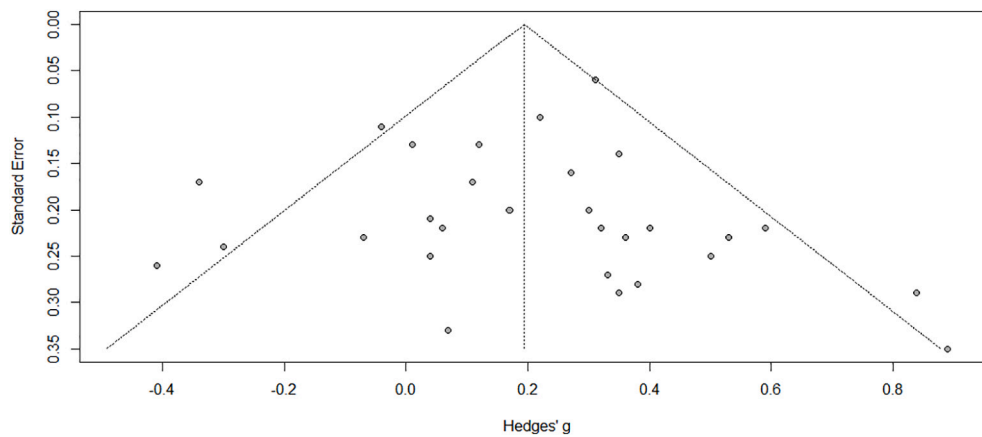


Fig. 8. Funnel plot of studies with unselected college students.

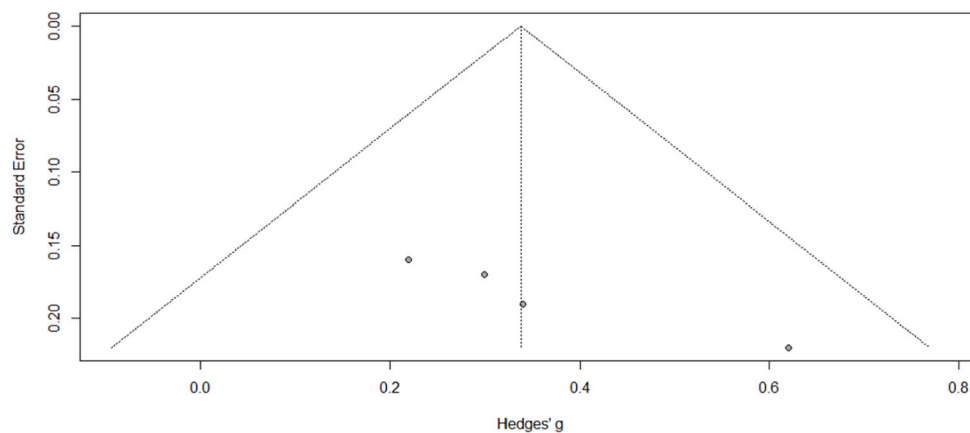


Fig. 9. Funnel plot of studies with preselected college students.

may be more motivated to follow the intervention compared to real-world users of self-help (Cuijpers et al., 2010; Furmark et al., 2009). Moreover, we were not able to generalize our results to different (cultural) contexts. Our results generally were retrieved from the studies including predominantly female students pursuing a 4-year college education. This limits the representativeness of our results in students other than female, and non-college attending peers. Similarly, included studies were mainly conducted in high-income western countries, and our results may not be applicable for college students in low and middle-income countries, because there may be differences in sources of stress and contextual issues relating to the implementation of the interventions (Evans-Lacko and Thornicroft, 2019). Fourth, we are not aware of research on individual participant differences in response to self-guided stress management interventions. We still do not know whether these aggregate effects represent small homogeneous effects across all students or if there is a subset of students for whom these interventions have substantial effects and a larger subset for whom the interventions have no effects or possibly even negative effects. Investigation of this individual-level heterogeneity is critical for advancing our understanding of the most appropriate role for self-help interventions among college students. Such knowledge may help us in targeting the interventions to those who are most likely to benefit. Fifth, all studies used self-report measurements for stress, depression, and anxiety. Therefore, we could not investigate the effects of self-guided stress management programs on the biological measurement of stress such as cortisol. Sixth, the field of self-help has changed dramatically as more interventions have been developed based on information and communications technology (Haug et al., 2012; Rosen, 1993). Self-help tools

such as books, websites, or mobile phone applications are used by large populations and barely evidence-based (Rosen, 1993; Walsh et al., 2019). Therefore, the effects of the self-help tools apart from the ones used in RCTs are unclear.

Despite these limitations and the need for more high-quality research, our study showed that self-guided stress management interventions are potentially beneficial for college students in general and college students with elevated levels of stress. These results are important from the public health standpoint, as several implications can be addressed for both implementations of the programs in higher education and future research. Self-guided stress management programs are offering great promise for college students because a large group of students may benefit from psychological interventions at a low cost. Although self-guided stress management programs yielded a small effect size, and possibly will not be a substitute for in-person interventions for more severe cases, such programs can be offered for college students as first-line mental health support within a stepped care framework.

Self-help approaches can be successful to prevent or alleviate the high stress and associated mental problems among college students. Although we found small effects of these programs, the effects might be larger for specific subgroups of students. Students may have different responses to these programs based on their characteristics (e.g. pre-existing symptoms). To this end, an in-depth investigation should be done addressing the preferences, needs, and opinions of subgroups within college students. This also requires further research inquiring into the effects of these programs using individual-participant data. Exploring the changing mechanisms in these programs will also contribute to the implementation of these programs.

Lack of human support has been repeatedly mentioned as a limitation in similar programs. On the other hand, self-help may increase willingness to seek professional help among college students. Therefore, innovative methods are worth investigating such as the different ways of increasing adherence and transferring common factors associated with improvement in face-to-face/guided programs into self-guided interventions. Internet-based interventions may be preferable since more personalized and scalable interventions can be designed based on the unique goals and needs of individuals. As a result, the most accurate strategies can be developed to outreach college students who are in the need of mental health help but do not access the relevant resources due to barriers.

Funding

The first author of this manuscript is funded for her doctoral studies by the Ministry of National Education, the Republic of Turkey.

CRediT authorship contribution statement

Yagmur Amanvermez: Conceptualization, Writing – original draft, Writing – review & editing, Validation. **Ruiying Zhao:** Writing – review & editing, Validation. **Pim Cuijpers:** Conceptualization, Writing – review & editing, Validation. **Leonore M. de Wit:** Conceptualization, Writing – review & editing, Validation. **David D. Ebert:** Writing – review & editing, Validation. **Ronald C. Kessler:** Writing – review & editing, Validation. **Ronny Bruffaerts:** Writing – review & editing, Validation. **Eirini Karyotaki:** Conceptualization, Writing – review & editing, Validation.

Declaration of competing interest

In the past 3 years, Dr. Kessler was a consultant for Datastat, Inc., Holmusk, RallyPoint Networks, Inc., and Sage Therapeutics. He has stock options in Mirah, PYM, and Roga Sciences.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.invent.2022.100503>.

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