

A systematic review and meta-analysis of Internet-based self-help interventions for mental health among adolescents and college students

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ABSTRACT

Purpose: This meta-analysis aims to evaluate the impact of Internet-based self-help interventions on the mental health of adolescents and college students.

Methods: We conducted a systematic review of randomized controlled trials (RCTs) that investigated Internet-based self-help interventions aiming to mitigate mental health symptoms such as anxiety and depression, as well as managing high levels of stress, among adolescents and college students. Our search spanned databases including Web of Science, PubMed, Cochrane Library, and Embase, up until November 1st, 2022. It is essential to emphasize that our focus was the evaluation of symptoms (continuous outcomes), rather than the diagnosis of specific mental disorders. The meta-analysis was performed using the R version 4.3.1. The effect size measure was the standardized mean difference (SMD), and random-effects models were used to pool data from eligible RCTs. Subgroup analyses were carried out to examine variations in intervention effects based on factors such as sample type, intervention modality, guidance type, and intervention duration.

Results: The meta-analysis was based on 25 comparisons involving a total of 4480 participants. In comparison to the control group ($n = 2125$), participants receiving interventions ($n = 2355$) reported significant reductions in symptoms of anxiety, depression, and stress, along with a significant improvement in quality of life. Specifically, for depression, we observed moderate intervention effects (SMD = -0.42 , 95 % CI: -0.56 , -0.27), and a similar pattern was seen for quality of life (SMD = 0.36 , 95%CI: 0.22 , 0.49). Small intervention effects were found for anxiety (SMD = -0.35 , 95 % CI [-0.48 , -0.22]) and stress (SMD = -0.35 , 95 % CI [-0.51 , -0.20]). Given significant heterogeneity, subgroup analyses were conducted for anxiety and depression, considering factors such as sample type, intervention method, and intervention duration. Notably, college students experienced more significant benefits in both anxiety and depression alleviation compared to adolescents. Longer interventions (>8 weeks) were particularly effective in reducing anxiety and depression. Additionally, third-wave cognitive-behavioral therapy (CBT) showed pronounced intervention effects in both outcome measures, while the presence of guidance did not notably influence results.

Conclusion: This meta-analysis underscores the positive impact of Internet-based self-help programs in alleviating the symptoms of psychological disorders among adolescents and college students. However, it is crucial to acknowledge that the available evidence exhibits inconsistencies and limitations. Therefore, further research utilizing rigorous methodologies is necessary to verify and broaden the findings of this meta-analysis.

1. Introduction

Good mental health is a cornerstone of human well-being and plays a crucial role in fostering positive youth development (World Health, 2021). Adolescents and college students, who are navigating the

transition from adolescence to adulthood, face prevalent mental health challenges (Clarke et al., 2015; Rickwood et al., 2007). This concern is starkly illustrated by recent data from the Australian National Mental Health Survey, which reveals that a striking 39.6 % of individuals aged 16 to 24 grappled with a mental disorder within the past 12 months

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(Australian Bureau of Statistics, 2020-21). Furthermore, recent empirical evidence underscores the exacerbating effect of the COVID-19 pandemic on these challenges, with an evident surge in rates of anxiety, depression, stress, sleep disorders, and adverse behaviors among this demographic (Wang et al., 2020; Chen and Lucock, 2022; Marques de Miranda et al., 2020; Ravens-Sieberer et al., 2022). The research underscores the far-reaching repercussions of mental disorders in adolescents and young adults, with lasting detriment affecting both individual and societal levels, including diminished academic achievement (Eisenberg et al., 2009b; Shankar and Park, 2016), increased school dropout rates (Hjorth et al., 2016; Wang et al., 2015), compromised well-being (Jafari et al., 2010), and impaired psychosocial functioning in adulthood (Power et al., 2020).

What compounds the concern surrounding the mental health of this demographic is the realization that many adult mental health issues trace their origins back to adolescence and early adulthood (Hunt and Eisenberg, 2010; Patel et al., 2007). Notably, the long-term implications of these early mental health challenges often outweigh those of physical health problems during youth (Goodman et al., 2011). Therefore, in this systematic review, we focused on adolescents in secondary education and early adulthood students in higher education.

While a majority of these educational institutions offer complimentary mental health counseling services, a significant number of students remain hesitant to avail themselves of these resources, primarily due to the perception of their non-essential nature (Vidourek et al., 2014; Gulliver et al., 2010), the persistence of negative attitudes such as stigma (Eisenberg et al., 2009a), and the insufficiency of mental health education (Wisdom et al., 2006). For example, adolescents and college-age individuals exhibit heightened sensitivity concerning issues of confidentiality and express reservations about discussing “personal” issues with mental health professionals (Ackard and Neumark-Sztainer, 2001; Ebert et al., 2019). In addition, formidable barriers are impeding access to traditional face-to-face clinical therapy, including elevated costs, limited availability in remote regions, and a shortage of skilled therapists (Hofmann, 2011; Nakao et al., 2021; Hedman et al., 2012). Consequently, there exists a compelling need for innovative strategies aimed at addressing these obstacles to accessing mental healthcare among students.

Recently, the potential of Internet-based self-help interventions in addressing mental health concerns has become increasingly apparent, offering a viable alternative to traditional face-to-face treatment (Andersson et al., 2013; Baumeister et al., 2014). The term “Internet-based self-help interventions” refers to a diverse range of therapeutic approaches where users autonomously engage with therapeutic programs delivered via the Internet (Andersson and Titov, 2014). These interventions utilize diverse modalities, including AI chatbots (Liu et al., 2022), interventions featuring automated feedback websites (Levin et al., 2017), and those with human guidance (Hoek et al., 2012). In contrast to conventional face-to-face therapy, Internet-based self-help interventions empower users to access evidence-based treatments at their own pace, without being bound by time and location constraints. This approach ensures discreet access to therapy, and on the other hand, it reduces the associated burdens of time and finances linked to clinic visits and mitigates the impact of social stigma (J. et al., 2017). Moreover, online interventions offer an affordable and easily accessible avenue for services, particularly benefiting marginalized and minority communities, as well as adolescents and college students residing in geographically remote regions (Barak and Grohol, 2011).

To date, most research on internet-based self-help treatment approaches has predominantly centered on adolescent and college student populations, consistently demonstrating the high efficacy of these interventions (Sethi et al., 2010; Day et al., 2013; Harrer et al., 2018). To inform both clinical practice and future research endeavors, it is important to systematically summarize existing interventions and evaluate their evidence base within the context of adolescents and college students. A growing trend has emerged wherein reviews and meta-

analyses of Internet-based self-help interventions have gained momentum. However, these assessments have been somewhat constrained in scope, often focusing on only one specific condition (such as anxiety or depression), style of self-help (such as guided or unguided), or age group (such as college students). For instance, a meta-analysis of 24 studies conducted among university students (aged 18 to 27 years) concluded that Web-based guided self-help was promising to be a useful strategy for addressing depression symptoms (Ma et al., 2021). Nevertheless, a meta-analysis encompassing a comprehensive range of Internet-based guided self-help interventions among adolescents and college students, considering various types of interventions and a wide array of symptoms, remains notably absent in the literature.

To bridge this gap in research, we undertook a systematic review and meta-analysis of the existing body of literature concerning Internet-based self-help interventions aimed at ameliorating symptoms of common mental disorders among adolescents and college students. Our study not only examined the overall effect size but also calculated and compared the distinct effect sizes for specific subgroups of interest. Previous research has consistently highlighted that internet-based self-help interventions rely on evidence-based techniques to assist individuals in coping with mental health disorders (Newman et al., 2011; Clarke et al., 2009). Established approaches such as traditional cognitive behavioral therapy (CBT) and newer iterations like third-wave CBT, which encompasses mindfulness, acceptance, and commitment therapy, have garnered robust support as evidence-based methods in delivering Internet-based self-help interventions for mental health disorders like anxiety and depression (Waters et al., 2022; Heber et al., 2017). Previous trials have revealed the efficacy of Internet-based self-help treatments in treating a spectrum of mental health conditions affecting children, adolescents, and college students both before and during the pandemic (Karyotaki et al., 2022; Rackoff et al., 2022). Furthermore, evidence suggests that Internet-based self-help interventions are more beneficial when accompanied by guidance (Andersson and Titov, 2014; Berger et al., 2011). Moreover, a meta-analysis focusing on adolescent depression suggested that shorter interventions had superior effects compared to longer interventions (Stice et al., 2009).

In contrast to the existing literature, the primary objective of this study is to furnish a comprehensive literature review of various types of Internet-based self-help treatments geared toward enhancing the mental health of secondary school and college students. We aim to evaluate the effectiveness of these interventions in mitigating mental disorder symptoms among this specific population. This review is geared toward shedding light on Internet-based self-help interventions for mental health and delves into a multitude of factors, including the duration of interventions, the provision of guidance, the characteristics of the study population, and the therapeutic techniques employed. To ensure thoroughness, our study will encompass all identified forms of Internet-based self-help treatments. Understanding important moderating variables within these interventions may aid in guiding the development of Internet-based self-help programs tailored to adolescents and college students. Furthermore, in an era characterized by increasing digitalization, the accessibility, flexibility, and anonymity offered by internet-based self-help interventions hold great promise for reaching a broader segment of the population grappling with mental health issues (Ebert et al., 2018). In particular, the insights derived from this meta-analysis could equip healthcare professionals with the necessary information to make informed choices when incorporating online self-help interventions as part of a stepped-care approach.

2. Material and methods

This meta-analysis was conducted following the PRISMA statement criteria (Hutton et al., 2016; Moher et al., 2010), and the study protocol was registered with PROSPERO (CRD42023403156). Before literature screening, predefined inclusion and exclusion criteria were presented.

2.1. Eligibility criteria

Randomized controlled trials (RCTs) that satisfied the following requirements were included: (i) Intervention type: internet-based self-help interventions (considered eligible if they utilized internet-based platforms like computers, apps, tablets, or mobile devices, and included therapist or coach-guided self-help, or self-help with automated feedback, or chatbots); (ii) Participants were adolescent students (aged 12 to 18 years old; encompassing middle and high school students) and college students (aged 18 years or older; enrolled in college or university); (iii) measurable continuous outcomes were utilized based on established mental health scales, such as Depression Anxiety Stress Scale (DASS); (iv) the studies were published in English; (v) the study compared outcomes in the Internet-based self-help intervention group versus a control group (waitlist, no treatment, or treatment as usual).

Acceptable outcomes were those in which mental health symptoms including anxiety, depression, or stress were either primary or secondary outcomes. Studies were excluded if they were case series, single-case designs, or uncontrolled repeated measures designs (open trials). Studies employing technology-supported treatments without the use of the Internet were also excluded. Studies that did not involve symptomatology testing for mental health were not considered.

2.2. Search strategy

Publications were identified by searching databases including PubMed, Embase, Cochrane, and Web of Science up to November 1st, 2022.

A string of search terms (including text words, MeSH terms, and headings) suggestive of psychological therapies in secondary and post-secondary education settings based on RCT inclusion criteria were utilized for the literature search. Key terms were determined by the researcher after referencing prior search techniques from reviews of online self-help treatments. The following search terms correspond to four key search strategies: (i) Terms related to Internet-based therapy including “internet”, “website”, “interactive”, “computer”, “web”, “e-health”, “e-therapy”, “internet therapy”, or “technology”; (ii) terms related to self-help therapy including “self-direct”, “self-help”, “self-manage”, “self-administered”, “self-act”, “self-guided”, “CBT”, “MCT”, or “mindful”; (iii) terms related to mental health including “mental health”, “health, mental”, “anxiety”, “depression”, “pressure” or “stress”; (iv) terms related to adolescent and college students including “student”, “youth”, “teenager”, “teens”, or “adolescent”.

2.3. Study selection

Duplicate publications were first removed before the initial screening. Then, the first authors independently screened the titles and abstracts of the remaining articles based on the aforementioned eligibility criteria. To ensure inter-rater reliability, each author independently assessed articles from one randomly selected database (PubMed, $n = 654$). The level of agreement between raters during this process was assessed using Kappa values (Landis and Koch, 1977). There was an 84 % agreement rate (Kappa = 0.62) in the selection of studies, indicating substantial inter-rater agreement. Disagreements were settled through discussion among the authors. Following the initial screening, all full-text publications were reviewed and evaluated. The reasons for discarding full-text publications that did not fulfill eligibility criteria were documented. A discussion was held in the event of disagreements on assessment results. Ultimately, three authors independently identified 25 publications potentially eligible for inclusion in the meta-analysis. The outcome revealed a 93 % agreement rate (kappa = 0.84), indicating a robust level of inter-rater agreement.

2.4. Data extraction

Following the instructions of the Cochrane Library, data were systematically collected from studies that satisfied all the criteria for inclusion. To facilitate this process, a standardized coding sheet was employed, which systematically recorded the following information: (i) Study ID, citation details, authors' names, (ii) country, (iii) participant characteristics (including sample size, sample type, mean age, and the gender distribution within the sample), (iv) attributes of the experimental group and control group (comprising details about the intervention content, type of contact, duration of intervention, and the specific intervention techniques employed), and (v) outcome measures. This data extraction process was carried out by the first author and subsequently cross-verified by the second author.

The sample type was classified as college students if the intervention was administered in college, university, or a similar post-secondary higher education setting, and was categorized as adolescent students if the intervention was delivered in middle school, high school, or a comparable secondary education environment. The types of intervention were classified as cognitive behavioral therapy (CBT), third-wave cognitive behavioral therapy (CBT), and problem-solving therapy (PST). CBT is a therapeutic approach founded on the premise that mental disorders and psychological distress are linked to cognitive factors (Hofmann et al., 2012). It targets maladaptive cognitions that contribute to emotional distress and behavioral issues, emphasizing thought-emotion-behavior interplay for psychological well-being (Beck, 2011). Third-wave CBT represents an evolution of CBT, incorporating mindfulness techniques, acceptance-based approaches, cognitive defusion, values exploration, and processes linked to psychological flexibility (Hayes and Hofmann, 2017). PST focuses on enhancing problem-solving attitudes and skills, particularly in addressing daily life challenges (Bell and D'Zurilla, 2009). The duration of the intervention was classified in line with recent meta-analyses (Ma et al., 2021; Harrer et al., 2019) into “brief” (4 weeks), “moderate” (4–8 weeks), and “long” (8 weeks).

2.5. Quality assessment

The quality of included studies was evaluated using the Cochrane Collaboration's Risk of Bias Assessment Tool (RoB 2) (Sterne et al., 2019), which addresses the following domains: (i) bias arising from the randomization process, (ii) bias due to deviations from intended interventions, (iii) bias due to missing outcome data, (iv) bias in measurement of the outcome, and (v) bias linked to the selection of the reported result. The included studies were rated as having “low risk”, “some concerns” or “high risk” of bias in each domain as well as overall.

2.6. Statistical analysis

Data were analyzed using R version 4.3.1. The effects of the intervention were gauged by examining the differential mean change scores in mental health outcomes between the intervention and control groups after the intervention. Given that the included studies used different scales and measurement techniques, we opted for the standardized mean difference (SMD) as the effect size to enable the integration and comparison of results across studies. For each continuous outcome, SMD was computed along with corresponding 95 % confidence intervals (CI). Given the small sample sizes and differing units of measurement among the studies, we calculated Hedgen's g as the effect size to adjust for potential small sample bias (Larry V. Hedges, 2014). Effect sizes of 0.5 or lower were considered small, those falling between 0.5 and 0.8 were seen as moderate, and values exceeding 0.8 were classified as large (Cohen, 2013).

The I^2 index was utilized for assessing statistical heterogeneity or variation in effect sizes across trials. According to Higgins and Thompson (2002), I^2 represents the proportion of overall variation among studies that can be attributed to heterogeneity, with values of 25 %, 50

%, and 75 % denoting low, moderate, and high heterogeneity, respectively. The fixed-effects model was employed if $p \geq 0.1$ with an $I^2 < 50$ % indicating the existence of statistical homogeneity across studies; otherwise, the random-effects model would be utilized. Moreover, the prediction interval was utilized to provide an estimate of where the true effect size might fall in future studies.

To explore potential moderating factors, subgroup analyses were conducted based on participant types, intervention content, and treatment duration to identify sources of heterogeneity.

3. Results

3.1. Study identification

After removing duplicate publications, we reviewed the titles and abstracts of 2608 articles, generating 71 articles that generally met the inclusion criteria and underwent full-text examination. Of these, 46 were excluded for the following reasons: Not RCT studies ($n = 8$); studies lacking internet-based self-help interventions for participants ($n = 15$); outcomes focused on physical disorders of participants rather than mental health ($n = 11$); participants not belonging to the adolescent or college students category ($n = 12$). At last, 25 RCTs were included in the present meta-analysis. Fig. 1 illustrates the literature screening process.

3.2. Overview of included studies

All 25 RCTs involving 4480 participants were published in English. Table 1 presents the baseline information for these studies. The primary inclusion criteria entailed both adolescent students and students diagnosed with mental health conditions.

These studies focused on four different outcomes associated with mental health disorders: anxiety ($n = 18$), depression ($n = 18$), stress ($n = 10$), and the quality of life ($n = 7$). They were carried out across various countries (Australia, Sweden, UK, USA, Netherlands, Canada, France, India, Ireland, Queensland, Germany, and Norway), with the majority of them conducted in Australia. The participant counts in each study ranged from 19 to 1477, with notable gender imbalances in most studies. Data on the ethnicity or race of participants were limited and therefore not summarized.

Several intervention approaches were identified, including Mindfulness Virtual Community (MVC), online mindfulness-based intervention, Internet-based self-help programs, online Acceptance, and Commitment Therapy (ACT) program, and Internet-based CBT (iCBT). All of these interventions were delivered via Internet, computer, or web-based platforms. The duration of the interventions spanned from 3 to 16 weeks.

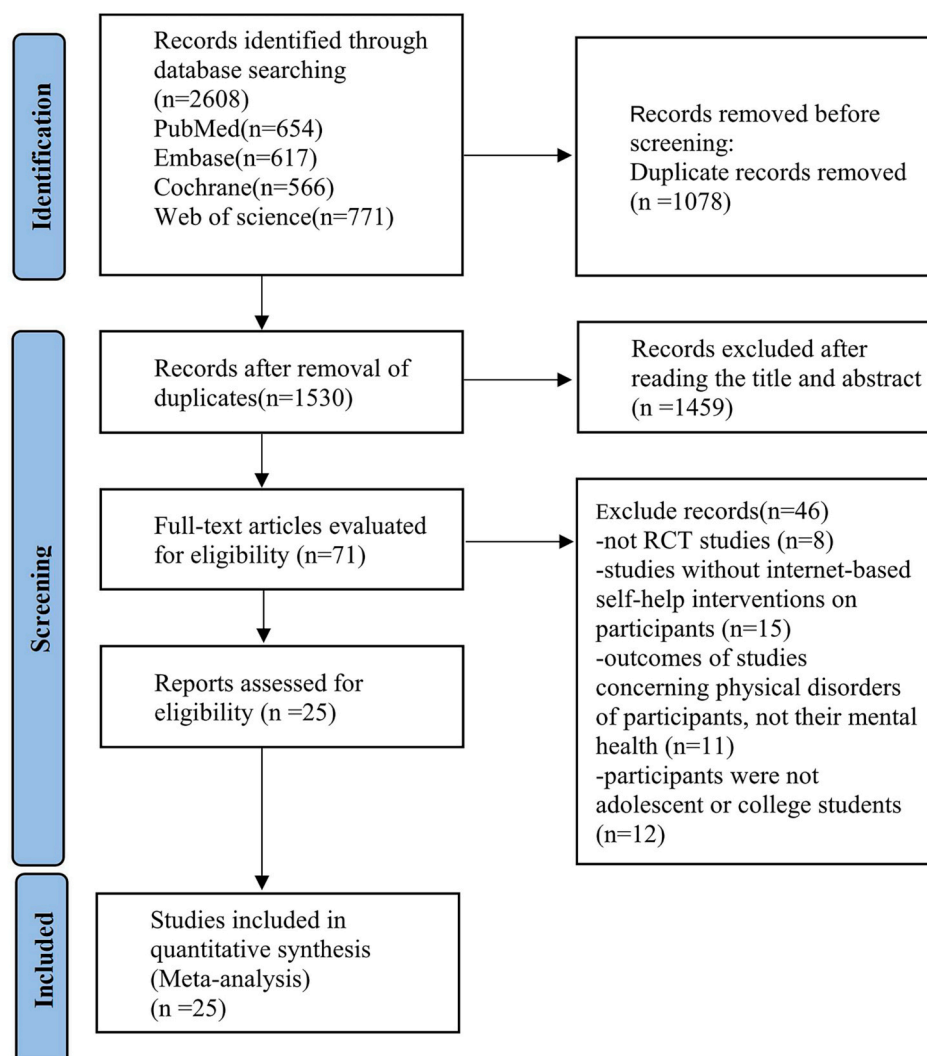


Fig. 1. PRISMA flow diagram of the study screening process.

Table 1
Study characteristics.

Study	Country	Sample size		Type of sample	Gender (m/f)	Mean age (years)		Conditions				Follow-up	Outcome
		EG	CG			EG	CG	EG	CG	Duration	Technique		
G. N. Rackoff 2022	USA	301	284	College students	117/433	20.24	20.65	1. iCBT (<i>The Space for Resilience</i>) 2. Unguided	TAU	4 weeks	CBT	3-month	A3(DASS-str)
E. Karyotaki 2022	Netherlands	48	52	College students	19/81	21.75	22.06	1. iCBT (<i>ICare Prevent</i>) 2. Guided: with coach	TAU	7 weeks	CBT	6-month 12-month	A4(EQ-5D) A1(GAD) A2(PHQ)
M. G. Newman 2021	USA	117	105	College students	153/69	20.10	19.70	1. Online self-help intervention 2. Guided: with coach	WLC	12 weeks	CBT	/	A1(GAD) A2(DASS-dep)
C. El Morr 2021	Canada	79	80	College students	32/125	22.8	22.3	1. MVC (<i>Mindfulness virtual community</i>) 2. Guided: with peer-to-peer communities	WLC	8 weeks	3rd wave	/	A1(BAI) A3(PSS)
J. Chung 2021	Australia	279	148	College students	70/351	/	/	1. Online mindfulness-based intervention 2. Unguided	WLC	18 weeks	3rd wave	/	A3(PSS) A4 (WEMWBS)
P. Srivastava 2020	USA	11	10	Adolescent students (year9,10,11,12)	16/5	16.0	16.1	1. iCBT (<i>Smartteen</i>) 2. Unguided	TAU	12 weeks	CBT	/	A2(BDI) A2(CRDS-R)
F. Kählke 2019	Germany	100	100	College students	76/124	26.71	26.68	1. Internet-based self-help intervention (<i>StudiCare SAD</i>) 2. Unguided	WLC	24 weeks	CBT	3.3-month	A1(SIAS) A2(BDI) A4(AQoL)
D. Saleh 2018	France	64	64	College students	24/104	/	/	1. Internet-based self-help program (<i>I'm managing my stress</i>) 2. Unguided	WLC	8 weeks	CBT	3-month	A3(PSS)
H. C. McCall 2018	Canada	30	35	College students	18/47	21.53	22.14	1. Web-based social anxiety intervention (<i>Overcome Social Anxiety</i>) 2. Unguided	WLC	16 weeks	CBT	4-month	A1(SIAS) A4(Q-LES-Q)
M. Harrer 2018	Germany	75	75	College students	38/112	24.0	24.1	1. Internet-based self-help (<i>StudiCare Stress</i>) 2. Guided: with coach	WLC	7 weeks	3rd wave	3-month	A3(PSS) A2(CESD)
E. H. Eustis 2018	USA	78	78	College students	29/123	25.87	24.94	1. Web-based ABBT (<i>SATDS</i>) 2. Guided: with therapist	WLC	4 weeks	CBT	1 month	A1(DASS-anx) A3(DASS-str) A2(DASS-dep) A4(QOLI)
R. Choubisa 2018	India	104	50	College students	42/135	23.62	24.26	1. Web-delivered positive psychological intervention (<i>SWBEP</i>) 2. Guided: with e-mail reminders	WLC	16 weeks	3rd wave	/	A3(ESAP)
M. E. Levin 2017	USA	40	39	College students	27/52	20.51	20.51	1. Web-based ACT 2. Unguided	WLC	2 semesters	3rd wave	/	A2(CCAPS-Depression) A1(CCAPS-Anxiety)
D. Richards 2016	Ireland	70	67	College students	31/106	23.19	23.24	1. iCBT (<i>The Calming Anxiety</i>) 2. Guided: with supporters	WLC	6 weeks	CBT	3-month	A1(GAD) A2(BDI) A6(PSWQ)
P. Räsänen 2016	Finland	33	35	College students	10/58	24.61	24	1. Online guided ACT intervention programme (<i>Student Compass</i>) 2. Guided: with coach	WLC	7 weeks	3rd wave	12-month	A3(PSS) A2(BDI)
P. Smith 2015	UK	55	57	Adolescent students	/	12–16	12–16	1. CBT (<i>Stressbusters</i>) 2. Unguided	WLC	8 weeks	CBT	3-month 6-month	A1(SCARED)
S. Sethi 2013	Queensland	23	23	College students	14/32	20.78	19.47	1. iCBT (<i>MoodGYM</i>) 2. Guided: with therapist	WLC	5 weeks	CBT	/	A1(DASS-anx) A2(DASS-dep)
V. Day 2013	Canada	33	33	College students	7/59	24.12	22.97	1. Online-based self-help program 2. Guided: with coach	WLC	6 weeks	CBT	6-month	A1(DASS-anx) A2(DASS-dep) A3(DASS-str)
K. Cavanagh 2013	UK	50	54	College students	12/92	25.28	24.08	1. The online mindfulness-based intervention (<i>Learning Mindfulness Online</i>) 2. Unguided	WLC	2 weeks	3rd wave	/	A3(PSS)

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Table 1 (continued)

Study	Country	Sample size		Type of sample	Gender (m/f)	Mean age (years)		Conditions				Follow-up	Outcome
		EG	CG			EG	CG	EG	CG	Duration	Technique		
S. N Merry 2012	New Zealand	94	93	Adolescent students	64/123	15.6	15.6	1. A computerized self-help intervention (SPARX)			3-month	A2(CDRS-R) A1(SCAS) A4(PQ-LES-Q)	
								TAU	4-7 weeks	CBT			
W. Hoek 2012	Australia	22	23	Adolescent students	11/34	15.78	16.36	1. Internet-based PST 2. Guided: with e-mail			/	A1(HADS) A2(CESD)	
M. Tillfors 2011	Sweden	10	9	Adolescent students	/	16.5	16.5	1. iCBT 2. Guided: with therapists			12-month	A1(BAI) A2(MADRS-S) A4(QOLI)	
S. Sethi 2010	Australia	9	10	College students	15/4	19.47	19.47	1. iCBT (MoodGYM) 2. Guided: with therapists			6-month	A1(DASS-anx) A2(DASS-str)	
R. O'Kearney 2009	Australia	67	90	Adolescent students (year 10)	/	/	/	1. iCBT (MoodGYM) 2. Guided: with therapists			6-month	A2(CESD)	
A. L. Callear 2009	Australia	563	914	Adolescent students (year 9, 10, 11)	651/826	14.34	14.34	1. iCBT (MoodGYM) 2. Guided: with therapists			6-month	A1(RCMAS) A2 (CED-D)	

EG: experimental group; CG: control group; iCBT: internet-based cognitive behavior therapy; ABBT: acceptance-based behavioral therapy; MVC: mindfulness virtual community; ACT: acceptance and commitment therapy; PST: problem-solving therapy; WLC: waitlist control; TAU: treat as usual.

A1(anxiety): SIAS = Social Interaction Anxiety Scale; GAD = the Generalized Anxiety Disorder scale; BAI = Beck Anxiety Inventory; DASS-anx = Depression Anxiety and Stress Scales-Anxiety subscale; CCAPS-Anxiety = Counseling Center Assessment of Psychological Symptoms-Anxiety subscale; HADS = Hospital Anxiety and Depression Scale; SCAS = Spence Children's Anxiety Scale; SCARED = Screen for Child Anxiety Related Disorders; RCMAS = Revised Children's Manifest Anxiety Scale.

A2(depression): DASS-dep = Depression Anxiety and Stress Scales-Depression subscale.; BDI = Beck Depression Inventory; CESD = Center for Epidemiological Studies' Depression Scale; CCAPS-Depression = Counseling Center Assessment of Psychological Symptoms-Depression subscale; CRDS-R = Children's Depression Rating Scale Revised; PHQ = the Patient Health Questionnaire.

A3(stress): PSS = Perceived Stress Scale; DASS-str = Depression Anxiety and Stress Scale-Stress Subscales; ESAP = Emotional Skills Assessment Process-Stress management dimension.

A4(quality of life): EQ-5D = EuroQol-5 Dimensions; WEMWBS = Warwick-Edinburgh Mental Wellbeing Scale; AQoL = The Assessment of Quality of Life; Q-LES-Q = Quality of Life Enjoyment and Satisfaction Questionnaire; QOLI = Quality of Life Inventory; PQ-LES-Q = Pediatric Quality of Life Enjoyment and Satisfaction Questionnaire.

3.3. Risk of bias assessment

Figs. 2 and 3 provide an overview of risk of bias summary for the 25 included studies. The quality assessment tool comprised five criteria in total. Twelve studies (48 % of the total) were rated as having a low overall risk of overall bias. Therefore, they were classified as higher-quality studies. Eleven studies (44 %) reached “some concerns” regarding overall bias, indicating a moderate level of overall quality. Two studies (8 %) exhibited a high risk in at least one domain and were categorized as having a high risk of bias. Among the specific domains assessed, three studies exhibited bias in the reported outcome measurement, while three studies had a risk of bias derived from the randomization process. Two studies had a risk of bias arising from missing outcome data. One study presented a risk of bias concerning the selection of the reported result. It's worth noting that achieving blinding of participants and personnel is particularly challenging in psychotherapy outcome research (Munder and Barth, 2018). Thus, the most prevalent issue pertained to deviations from intended interventions, including 10 studies and often involving a lack of information about blinding of participants and personnel.

3.4. Meta-analysis outcomes

3.4.1. Anxiety

The effects of Internet-based self-help programs on the management of anxiety were evaluated in eighteen studies (Karyotaki et al., 2022; Newman et al., 2021; El Morr et al., 2021; Kählke et al., 2019; McCall et al., 2018; Harrer et al., 2018; Levin et al., 2017; Richards et al., 2016; Rasanen et al., 2016; Smith et al., 2015; Sethi, 2013; Day et al., 2013; Merry et al., 2012; Hoek et al., 2012; Tillfors et al., 2011; Sethi et al., 2010; Calear et al., 2009; Eustis et al., 2018), involving 2972 participants in total (1303 in the experimental group and 1669 in the control group). Moderate heterogeneity was found across most of these studies ($p < 0.01$, $I^2 = 57\%$). Therefore, a random-effects model was utilized for data analysis whose results illustrated that symptom of anxiety was significantly reduced in the experimental group compared to the control group (SMD = -0.35 , 95 % CI [-0.48 , -0.22]; the 95 % CI did not overlap zero), as shown in Fig. 4. The prediction interval for the meta-analysis is [-0.78 , 0.09], suggesting that the effect size in future studies could range from a notable benefit (as indicated by -0.78) to a slight potential effect or no effect (as indicated by 0.09).

3.4.2. Depression

For eighteen studies (Levin et al., 2017; Hoek et al., 2012; Sethi et al., 2010; Day et al., 2013; Harrer et al., 2018; Karyotaki et al., 2022; Newman et al., 2021; Kählke et al., 2019; Richards et al., 2016; Rasanen et al., 2016; Smith et al., 2015; Sethi, 2013; Merry et al., 2012; Tillfors et al., 2011; Calear et al., 2009; Eustis et al., 2018; Srivastava et al., 2020; O'Kearney et al., 2009), involving 2944 students (1285 in the

experimental group and 1659 in the control group). We assess how Internet interventions affected depressive symptoms in contrast to control groups. As illustrated by Fig. 5, significant heterogeneity was evident across most of these studies ($p < 0.01$, $I^2 = 67\%$). Therefore, we employed the random-effects model and the results of the meta-analysis demonstrated that participants receiving online self-help therapy reported significantly reduced depression compared to those in the control group (SMD = -0.42 , 95 % CI [-0.56 , -0.27]; the 95 % CI did not overlap zero). Additionally, the prediction interval was [-0.90 , 0.07], suggesting that the effect sizes of future studies would fall within these boundaries.

3.4.3. Stress

Ten studies (Rackoff et al., 2022; El Morr et al., 2021; Chung et al., 2021; Saleh et al., 2018; Harrer et al., 2018; Eustis et al., 2018; Choubisa and Singh, 2018; Rasanen et al., 2016; Day et al., 2013; Cavanagh et al., 2013), comprising 1490 participants (752 in the experimental group and 738 in the control group), accessed changes in participants' stress symptoms after treatment. We utilized the random-effects model for data analysis due to moderate significant heterogeneity across the studies ($p = 0.10$, $I^2 = 39\%$). As demonstrated in Fig. 6, the results of the meta-analysis indicated that the intervention group experienced reduced stress symptoms than the control group, with this difference being statistically significant (SMD = -0.35 , 95 % CI [-0.51 – 0.20]; the 95 % CI did not overlap zero). The prediction interval ranged from -0.76 to 0.05 , indicating that future study effect sizes would lie within this range.

3.4.4. Quality of life

The effects of interventions on the quality of life were explored in seven studies (Karyotaki et al., 2022; Chung et al., 2021; Kählke et al., 2019; McCall et al., 2018; Eustis et al., 2018; Merry et al., 2012; Tillfors et al., 2011), involving 858 subjects (429 in the experimental group and 429 in the control group). A fixed-effects model was utilized given the absence of considerable heterogeneity among these studies ($p = 0.26$, $I^2 = 22\%$). The meta-analysis results revealed that the quality of life among participants in the experimental group was significantly improved compared with that in the control group (SMD = 0.36 , 95%CI [0.22 , 0.49], the 95 % CI did not overlap zero) (Fig. 7). The prediction interval, spanning from [-0.22 , 0.72], anticipates that future study effect sizes would lie within this range.

3.4.5. Subgroup analysis

To explore potential sources of heterogeneity, subgroup analyses were undertaken for outcomes with a sufficient number of studies ($I^2 > 50\%$), specifically anxiety and depression. These analyses considered sample type (adolescent students, college students), treatment technique (CBT interventions, third-wave CBT), guidance (unguided, guided), and intervention duration (≤ 4 weeks, 4–8 weeks, ≥ 8 weeks).

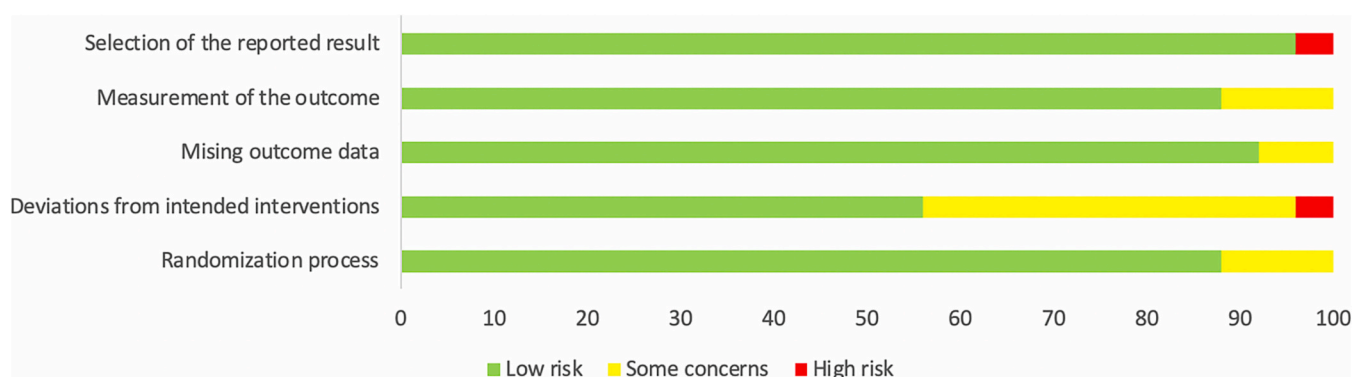


Fig. 2. Risk of bias graph.

	D1	D2	D3	D4	D5	Overall
G. N. Rackoff 2022	+	+	+	+	+	+
E. Karyotaki 2022	+	+	+	+	+	+
M. G. Newman 2021	+	+	+	+	+	+
C. El Morr 2021	+	+	+	?	+	?
J. Chung 2021	?	+	+	+	+	?
P. Srivastava 2020	+	?	+	+	+	?
F. Kahlke 2019	+	?	?	+	+	?
D. Saleh 2018	+	?	?	+	+	?
H. C. McCall 2018	?	?	+	+	+	?
M. Harrer 2018	+	+	+	?	+	+
E. H. Eustis 2018	+	?	+	+	+	+
R. Choubisa 2018	+	+	+	+	+	+
M. E. Levin 2017	+	?	+	+	+	?
D. Richards 2016	+	+	+	+	+	+
P. Räisänen 2016	+	+	+	?	+	?
P. Smith 2015	+	?	+	+	+	+
S. Sethi 2013	+	?	+	+	+	?
V. Day 2013	+	+	+	+	+	+
K. Cavanagh 2013	+	?	+	+	+	?
S. N Merry 2012	+	+	+	+	+	+
W. Hoek 2012	+	+	+	+	+	+
M. Tillfors 2011	?	?	+	+	+	?
S. Sethi 2010	+	+	+	+	+	+
R. O’Kearney 2009	+	+	+	+	+	+
A. L. Callear 2009	+	+	+	+	+	+

+	Low risk
?	Some concerns
+	High risk

D1	Randomization process
D2	Deviations from intended interventions
D3	Missing outcome data
D4	Measurement of the outcome
D5	Selection of the reported result

Fig. 3. Risk of bias summary.

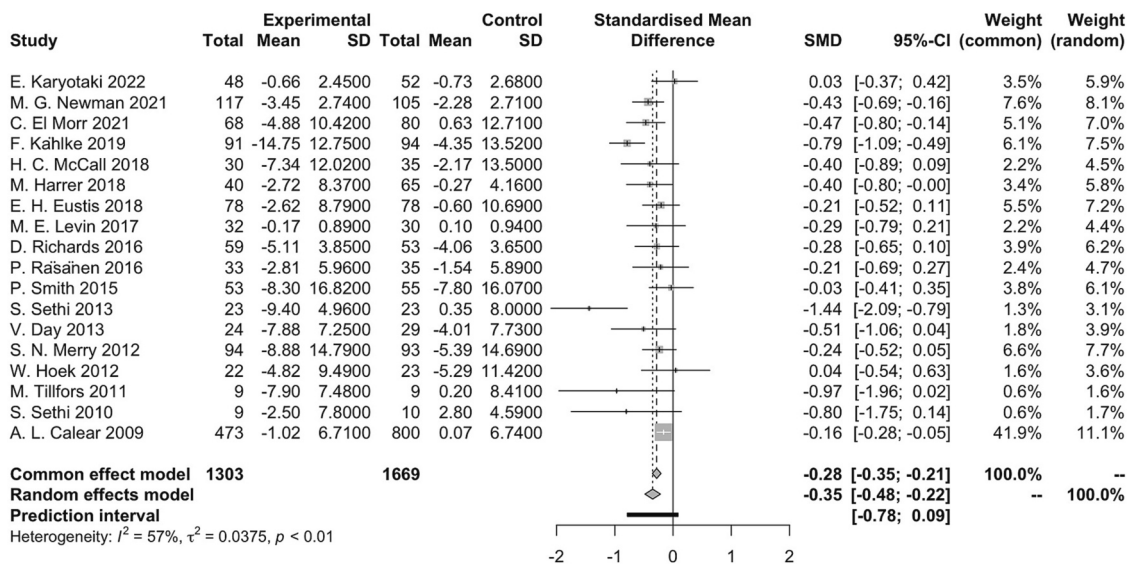


Fig. 4. Forest plot for anxiety outcomes.

As presented in Table 2, several significant differences between subgroups were discovered. For anxiety, intervention effects were more pronounced in college students (SMD = -0.40, 95 % CI [-0.54, -0.25]) compared to adolescent students (SMD = -0.15, 95 % CI [-0.26, -0.04]). Significant effects were observed for therapies lasting longer than 8 weeks (SMD = -0.44, 95 % CI [-0.65, -0.24]) and interventions employing CBT (SMD = -0.38, 95%CI [-0.57, -0.20]) and third-wave CBT (SMD = -0.38, 95 % CI [-0.58, -0.17]). However, interventions lasting <4 weeks did not reach statistical significance (SMD = -0.33, 95 % CI [-0.81, 0.15]).

For depression, the results showed more favorable outcomes in

college students (SMD = -0.49, 95 % CI [-0.61, -0.37]) compared to adolescent student groups (SMD = -0.42, 95 % CI [-0.76, -0.08]). Additionally, the most significant effects were found with therapies lasting longer than 8 weeks (SMD = -0.66, 95 % CI [-0.94, -0.39]) compared to those of medium duration (SMD = -0.29, 95 % CI [0.43, -0.14]). Third-wave CBT therapies exerted greater effects (SMD = -0.52, 95 % CI [-0.82, -0.22]), but there was no statistical significance for shorter intervention durations (SMD = -0.10, 95 % CI [-1.13, 0.94]).

For both target outcomes, there was no evidence to suggest that guidance significantly impacted effect size.

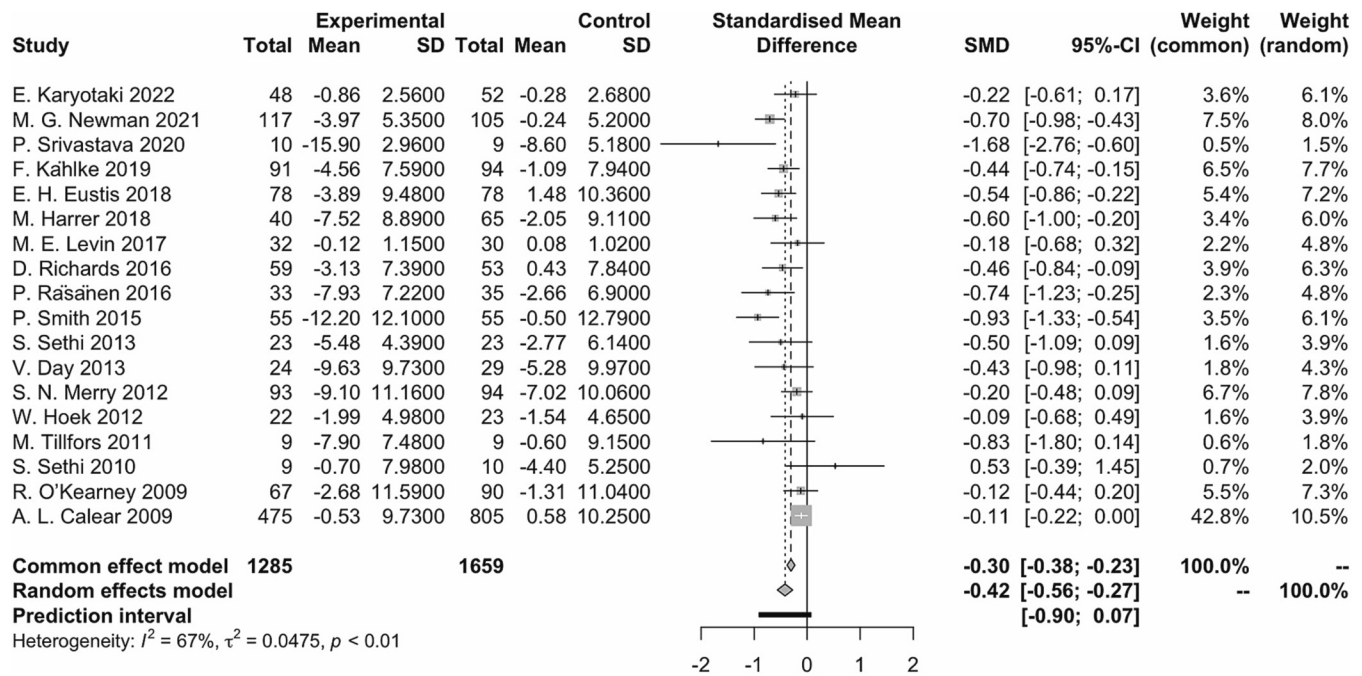


Fig. 5. Forest plot for depression outcomes.

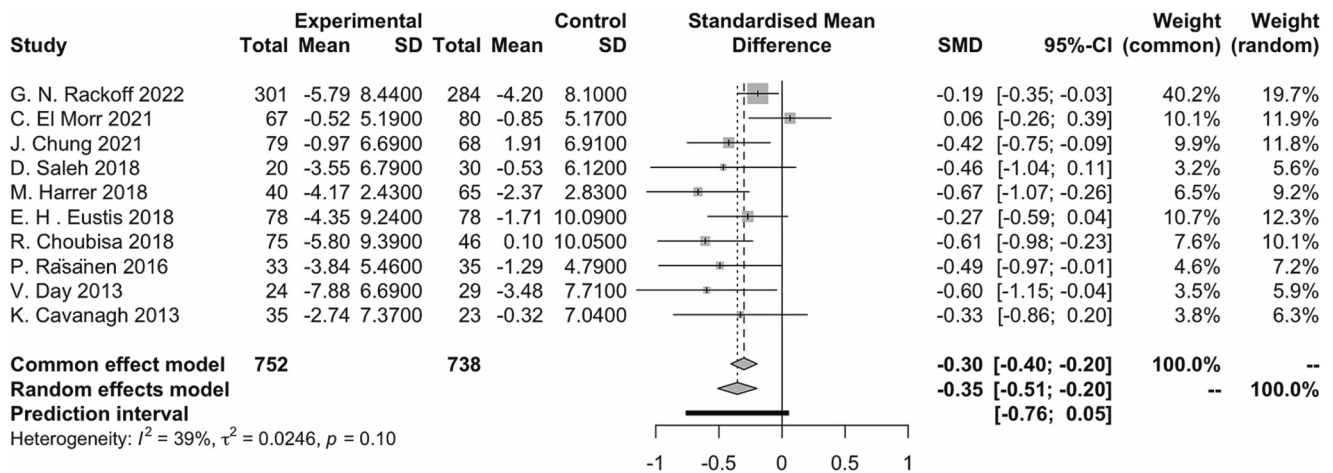


Fig. 6. Forest plot for stress outcomes.

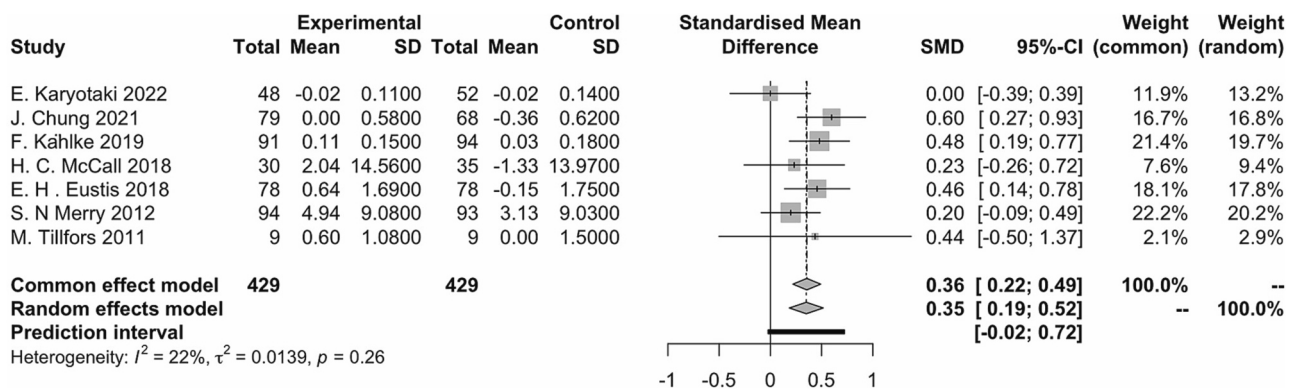


Fig. 7. Forest plot for quality of life outcomes.

Table 2
Subgroup analysis.

Subgroup	Anxiety			Depression				
	n _c	Effect sizes SMD (95 % CI)	Heterogeneity	p-Value between subgroups	n _c	Effect sizes SMD (95 % CI)	Heterogeneity	p-Value between subgroups
Type of sample								
College students	16	-0.40(-0.54, -0.25)	I ² = 48 %, p = 0.02	p < 0.01	11	-0.49(-0.61, -0.37)	I ² = 16 %, p = 0.29	p = 0.71
Adolescent students	2	-0.15(-0.26, -0.04)	I ² = 0 %, p = 0.51		7	-0.42(-0.76, -0.08)	I ² = 76 %, p < 0.01	
Treatment technique								
CBT	13	-0.38(-0.57, -0.20)	I ² = 67 %, p < 0.01	p = 0.38	14	-0.42 (-0.58, -0.25)	I ² = 72 %, p < 0.01	p = 0.44
Third wave CBT	4	-0.37(-0.58, -0.17)	I ² = 0 %, p = 0.83		3	-0.52 (-0.82, -0.22)	I ² = 25 %, p = 0.26	
PST	1	0.04(-0.54, 0.63)	-		1	-0.09 (-0.68, 0.49)	-	
Treatment length								
4-8 weeks	9	-0.28(-0.46, -0.10)	I ² = 57 %, p = 0.02	p = 0.51	10	-0.29 (-0.43, -0.14)	I ² = 39 %, p = 0.10	p = 0.05
≥8 weeks	7	-0.44(-0.65, -0.24)	I ² = 46 %, p = 0.08		6	-0.66 (-0.94, -0.39)	I ² = 55 %, p = 0.05	
≤4 weeks	2	-0.33(-0.81, 0.15)	I ² = 28 %, p = 0.24		2	-0.10 (-1.13, 0.94)	I ² = 78 %, p = 0.03	
Type of contact								
Guided	13	-0.34(-0.48, -0.19)	I ² = 54 %, p = 0.01	p = 0.88	13	-0.38 (-0.54, -0.22)	I ² = 64 %, p < 0.01	p = 0.43
Unguided	5	-0.36(-0.648, -0.08)	I ² = 65 %, p = 0.02		5	-0.55 (-0.94, -0.16)	I ² = 73 %, p < 0.01	

n_c.: number of comparisons; SMD: standardized mean difference; CBT: cognitive-behavioral therapy, PST: problem-solving therapy.

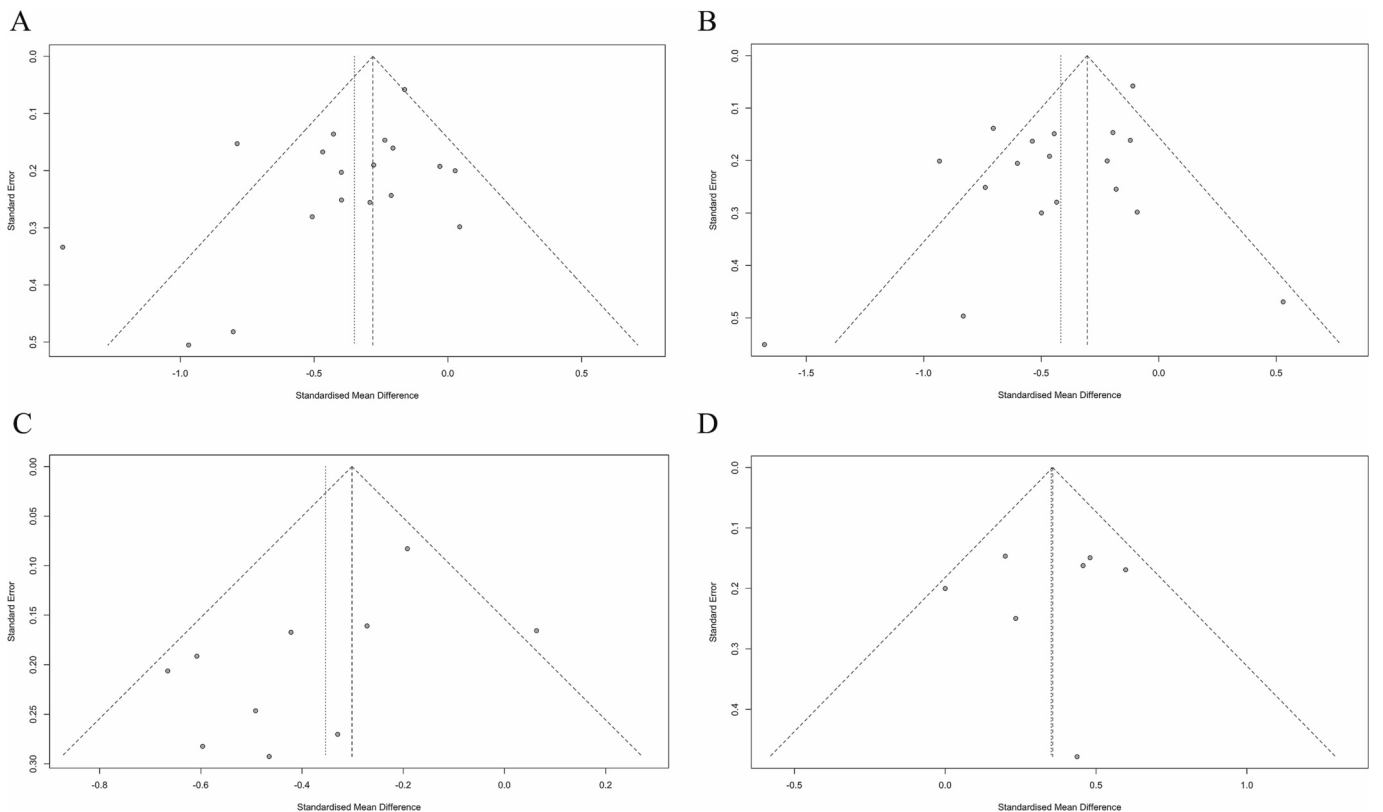


Fig. 8. Funnel plot to assess for publication bias. (A) Funnel plot of anxiety outcomes. (B) Funnel plot of depression outcomes. (C) Funnel plot of stress outcomes. (D) Funnel plot of quality of life outcomes.

3.4.6. Sensitivity analysis and examination of publication bias

We visually assessed the potential for publication bias using funnel plots, which display the effect sizes of the studies against their standard errors. A symmetrical distribution of studies around the combined effect size suggests the absence of publication bias, whereas an asymmetrical distribution might indicate a potential bias. The funnel plots for anxiety, depression, stress, and quality of life can be seen in Fig. 8A, B, C, and D. We further quantified the potential for publication bias using Egger's test. The results indicated that anxiety ($p = 0.057$), stress ($p = 0.072$), and quality of life ($p = 0.786$) had p -values >0.05 , indicating no evidence of publication bias. However, depression ($p = 0.029$) had a p -value <0.05 , suggesting the presence of publication bias.

Despite significant heterogeneity observed in the forest plot for depression and anxiety symptom scores, sensitivity analyses, which involved removing studies one by one, did not alter the results, suggesting minimal bias from any single study and reinforcing the robustness of our meta-analysis results.

4. Discussion

This meta-analysis examined the impact of Internet-based self-help interventions on mental health conditions among adolescents and college students, based on the evaluation of 25 studies with a total of 4480 participants.

4.1. Summary of findings

Our analysis results indicated that compared to those who received no intervention, participants engaging in online self-help programs experienced notable reductions in anxiety, depression, and stress, along with an improvement in their overall quality of life. These findings echo the findings of a meta-analysis by Harrer and Adam (Harrer et al., 2019), which similarly demonstrated the effectiveness of Internet-based interventions in addressing depression, anxiety, and stress among college students. This effectiveness can be attributed to the accessibility, scalability, and cost-effectiveness of such interventions (Buntrock et al., 2017).

In our subgroup analysis, higher efficacy of these interventions was found in college students compared with adolescents. One possible explanation for this can be gleaned from the study by Hoek and Schuurmans (Hoek et al., 2012), which highlighted the challenges of involving adolescents in Internet-based self-help programs. Parental consent requirements, high time commitment, the (un)attractiveness of the self-help format, and a lack of support from parents and friends may have negative impacts on dropout rates and the efficacy of online self-help programs among adolescent participants. College students, on the other hand, are typically more familiar with using the Internet to access mental healthcare information and have greater flexibility to complete online programs. Moreover, these two age groups exhibit distinct developmental and experiential differences (Steinberg, 2005), which can influence their engagement with and benefit from Internet self-help treatments. For instance, college students, in contrast to adolescents, might possess greater independence and maturity in terms of self-regulation and internet use (Lenhart et al., 2010), potentially making them more receptive to self-help interventions.

Another noteworthy finding of this study is the absence of a significant difference between guided online self-help interventions (e.g., those guided by coaches, therapists, or emails) and unguided online self-help interventions, which is consistent with previous meta-analyses (Harrer et al., 2019; Baumeister et al., 2014). However, studies also suggest that participants benefit more from Internet-based interventions when guidance is provided for common mental disorders (Andersson and Titov, 2014; Johansson and Andersson, 2012). Therefore, the result needs to be interpreted cautiously, especially given the limited number of unguided intervention groups included in the trials. Clinicians should not disregard the potential advantages of guidance based solely on our

findings, and additional research is warranted to explore the efficacy of Internet-based therapies involving varying levels of interaction for addressing mental health conditions among young students.

Furthermore, subgroup analyses indicated that interventions lasting >8 weeks had a significant impact on mental health symptoms, whereas interventions lasting <4 weeks did not attain statistical significance. The finding aligns with the consensus among researchers that individuals suffering from mental distress require longer therapy (Smit et al., 2012; Leichsenring and Rabung, 2008). Longer programs may have a more enduring positive influence on participants who have ample time to engage with program content and practice skills for attitude and behavior modification. However, this finding diverges from some other systematic reviews, which indicated notably stronger effects for online interventions lasting 4 to 8 weeks (Heber et al., 2017; Harrer et al., 2019). Also, it contradicts the conclusions drawn by Ma and Huang (Ma et al., 2021), which found no significant differences among interventions of varying durations. On the contrary, ample time to engage with programs may deter young people due to their unattractiveness, potentially leading to higher dropout rates and diminished intervention outcomes. Hence, considering that intervention intensity and treatment techniques can significantly affect intervention outcomes, the generalizability of this finding is constrained, necessitating further research to elucidate this complex relationship.

Moreover, this meta-analysis found no significant differences in depression outcomes between standard CBT and third-wave CBT. These results are consistent with a previous review by Ma and Huang focused on mental health disorders in university students (Ma et al., 2021). Moreover, the review also found that third-wave CBT was more effective in addressing anxiety among students, aligning with previous research indicating that adapted mindfulness-based interventions may be more helpful than CBT for depression symptoms, while CBT could be more effective for individuals experiencing anxiety (Arch and Ayers, 2013; Wolitzky-Taylor et al., 2012; Wang et al., 2023). However, it's crucial to interpret the findings of the subgroup analysis cautiously, given the high heterogeneity observed, calling for replication in other research with minimal risk of bias. Future analyses should delve into specific intervention strategies for distinct forms of CBT, such as ACT or mindfulness.

4.2. Practical implications

Despite the varied results presented in this review and the necessity for further research to arrive at definitive conclusions, Internet-based self-help interventions hold substantial promise in addressing mental health symptoms among young students.

Recognizing their inherent benefits, it becomes imperative to enhance the accessibility of online-based self-help interventions for this demographic, enabling them to access healthcare via these platforms, either directly or as part of a stepped-care approach (Andersson and Titov, 2014). As research in this area advances, online interventions could potentially serve as initial steps in a therapeutic journey or complement traditional interventions, especially for individuals in the early stages of symptom development or those experiencing milder symptoms. This aligns with recommendations from researchers like Espie (2009), who advocated for evidence-based online interventions as the primary accessible step for most individuals, reserving in-person services for those requiring intensified support. In light of this, professionals like school counselors, general practitioners, and youth workers, who often act as gatekeepers to mental health services for young students (Rickwood et al., 2007), should familiarize themselves with these online self-help techniques to broaden the reach of early and impactful interventions.

Furthermore, prior research has underscored the importance of recognizing individual variability in psychotherapy outcomes (Kaiser et al., 2022). This observation resonates with our findings, particularly in the subgroup analysis revealing that some college students were more likely than adolescent students to respond to Internet interventions.

Given this understanding, we hope to explore the development of artificial intelligence-based personalized treatment within the online clinical setting. Such an approach could aid in matching students in need of treatment with optimal Internet interventions, ultimately enhancing their therapeutic experiences.

4.3. Limitations

Firstly, While our intention was to pre-register this meta-analysis, we encountered delays in the formal registration process, including the issuance of a registration number. It's important to note that our study adhered to the pre-planned methodology and analysis, preserving its integrity, despite these registration-related challenges. Secondly, the moderate heterogeneity observed across the included studies may potentially impact the analysis results. This is partly attributed to the broad scope of the study, encompassing mental disorders across both adolescent and college student populations, leading to inherent data variability. While we made concerted efforts to address this issue through subgroup analyses, it's imperative to exercise caution when interpreting the findings. Thirdly, our meta-analysis shed limited insights into the effects of long-term interventions. Only a subset of the included studies provided data on the long-term effects of interventions, and there were discrepancies in the duration of follow-up. Fourthly, the collective classification of middle and high school students as "adolescent students" may obscure the variations in developmental characteristics within different stages of adolescence, including early, middle, and late adolescence. Fifthly, some studies excluded young individuals with intellectual and developmental disabilities. Consequently, the generalizability of related analysis results may be restricted for this specific population, even though they exhibit a notably high prevalence of common mental health disorders. Sixthly, there are limitations pertaining to the clinical significance of the results. While we observed statistically significant reductions in symptoms, we did not explore the relationship between these results and clinical cut-off values. As a result, the practical clinical implications of this meta-analysis should be interpreted with caution. Finally, it is worth noting that all the RCTs included in the analysis were conducted in high-income countries, potentially limiting the generalizability of the results to low-income countries.

5. Directions for future research

In conclusion, Internet-based self-help interventions hold significant promise for addressing a wide range of mental health conditions among adolescents and college students. Nevertheless, a deeper understanding of their efficacy necessitates further research. Future research could benefit from more nuanced student classifications to explore potential variations in the impact of Internet-based self-help interventions across these developmental stages, including early, middle, and late adolescence. Comparative studies should explore varying levels of guidance in Internet-based self-help therapies in relation to unguided interventions or traditional face-to-face treatments, specifically focusing on alleviating anxiety, depression, and stress, as well as improving the overall quality of life. Moreover, investigations into intervention duration and methodologies are warranted to identify factors associated with improved outcomes. Additionally, there is a critical need for more extensive research on the utilization of Internet-based self-help interventions among young individuals who are currently underrepresented in the existing literature, such as those with intellectual and developmental disabilities and those from low- and middle-income countries. Expanding the scope of research to encompass these diverse groups will contribute to a more comprehensive understanding of the effectiveness and accessibility of such interventions. Looking ahead, we anticipate significant developments in the clinical realm. These developments encompass the integration of clinical significance assessments alongside statistical analysis, addressing lingering questions regarding the characteristics of individuals most likely to benefit from

Internet-based interventions, determining the most effective methods for incorporating these interventions into existing healthcare services, and devising optimal strategies for merging Internet-based interventions with medication. By addressing these areas of inquiry, we can further enhance the impact of Internet-based self-help interventions in the realm of mental health treatment.

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Ethics approval

Not applicable.

CRediT authorship contribution statement

Conceptualization: Qing Wang; Methodology: Qing Wang, Senbo An; Formal analysis and investigation: Qing Wang, Weixin Zhang; Senbo An; Writing original draft preparation: Qing Wang; Writing review and editing: Senbo An; Funding acquisition: Senbo, An; Resources: Senbo An; Supervision: Senbo, An and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Consent for publication

Not applicable.

Declaration of competing interest

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

Data availability

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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