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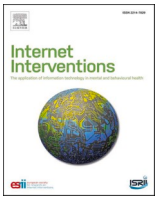

Efficacy of internet-based cognitive-behavioral therapy for depression in adolescents: A systematic review and meta-analysis

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ABSTRACT

Objective: Internet-based cognitive behavior therapy (ICBT) may provide an accessible alternative to face-to-face treatment, but the evidence base in adolescents is limited. This systematic review and meta-analysis aims to comprehensively assess the efficacy of ICBT in addressing depression among adolescents.
Methods: Four electronic databases were searched on June 8, 2023. Randomized controlled trials (RCTs) evaluating the efficacy of ICBT for depression in adolescents were included. The quality of the studies was assessed using the risk of bias tool recommended by the Cochrane Handbook. Furthermore, the GRADE approach was employed to gauge the certainty of the obtained evidence. Meta-analysis was conducted using RevMan 5.4, and Egger's test was implemented through Stata for assessment of potential publication bias.
Results: A total of 18 RCTs involving 1683 patients were included. In comparison to control groups like attention control, waiting list, and treatment as usual, our meta-analysis findings elucidate a significant reduction in depression scores (SMD = −0.42, 95 % CI: [−0.74, −0.11], $p < .05$) as well as anxiety scores (SMD = −0.34, 95 % CI: [−0.60, −0.08], $p < .05$) in adolescents following ICBT interventions. Furthermore, the analysis indicated no notable distinctions in patient's quality of life (QoL) scores. (SMD = 0.12, 95 % CI: [−0.10, 0.34], $p > .05$).
Conclusion: Results provide evidence of the efficacy of ICBT to reduce depressive and anxiety symptoms in adolescents. These research findings are of vital significance for the establishment of evidence-based treatment guidelines in the digital era.
Trial registration: PROSPERO registration: CRD42021277562.

Depression is a profound affective mental disorder primarily characterized by persistent and prolonged feelings of low mood, and anhedonia (Gotlib and Joormann, 2010). Given the inherent instability in psychological development, depressive symptoms often manifest in adolescents (Prieto et al., 2005). By the age of 19, it is estimated that one in five to a quarter of young individuals experience depression (Rohde et al., 2013). The World Health Organization (WHO) reports that depression stands as a leading cause of morbidity and disability among adolescents (Dick and Ferguson, 2015). Moreover, depression during adolescence is linked to adverse outcomes that might extend into adulthood, including suicidal tendencies, susceptibility to mental health disorders, substance misuse, diminished educational attainment, and impaired social functioning (Wickersham et al., 2021a; Wickersham et al., 2021b; Woodward and Fergusson, 2001). Cognitive behavioral therapy (CBT) is widely recognized as the preeminent psychological intervention for addressing adolescent depression (Creswell et al., 2014). Numerous studies have underscored CBT's acceptance and efficacy as an intervention for depressive symptoms in adolescents. A 2019

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meta-analysis by Oud et al. demonstrated CBT's effectiveness for youth with depression (Oud et al., 2019). Similarly, a review conducted by Reddy et al. highlighted the robust impact of CBT on depressive symptoms among adolescents (Reddy et al., 2023). Despite these effective interventions, most adolescents with mental health needs do not receive adequate treatment (Essau, 2005; Mojtabai et al., 2016; Merikangas et al., 2011). This discrepancy can be attributed to limited mental health services, the stigma surrounding mental illness, and a preference for self-help strategies (Gulliver et al., 2010; O'Brien et al., 2016). Consequently, there is an urgent imperative to develop interventions that combine efficacy with ease of implementation.

Internet-based cognitive behavioral therapy (ICBT) was developed through a combination of information technology and psychotherapy (Andersson, 2009). ICBT typically offers treatment content similar to conventional face-to-face CBT, except that ICBT relies on a digital platform to deliver treatment. Moreover, ICBT is available in various delivery formats, including blended, guided, and unguided. It often follows a modular format, encompassing interactive audio, video materials, interactive games, and assignments. Participants access these treatment modules consistently within specified timeframes (Poppelaars et al., 2016). ICBT can be self-directed or therapist-directed. Guidance can refer to any form of support from a coach or therapist, such as automated reminders, asynchronous email communications, brief scheduled phone calls, or live chats (Andersson, 2016; Barak et al., 2009). It can overcome the limitations of some traditional therapies. Compared with face-to-face treatment, ICBT offers more flexibility in terms of time and location; greater privacy; effective cost savings; and more independence (MacDonell and Prinz, 2017; Lin et al., 2013; Calear and Christensen, 2010). Young people are very proficient with the internet and show a positive attitude toward computerized mental health interventions (Sweeney et al., 2019). Therefore, ICBT may be an effective alternative to the original face-to-face treatment (Hollis et al., 2017). Internet interventions for depression are currently being developed that can be used to treat and prevent depression. Our study focuses on the efficacy of Internet-based cognitive behavioral therapy for the treatment of depression in adolescents.

Numerous RCTs and meta-analyses have shown that ICBT can be effectively implemented in adults with anxiety and depression (Karyotaki et al., 2017; Andrews et al., 2018). In recent years, there have also been studies dedicated to exploring the effects of ICBT on depressive symptoms in adolescents. However, compared with adults, research evidence based on ICBT among adolescents is very limited. And these reviews are usually insensitive to age effects, making it difficult to determine whether ICBT is equally effective in children, adolescents, and young adults (Calear and Christensen, 2010; Ebert et al., 2015; Richardson et al., 2010; Vigerland et al., 2016). Hollis et al. (2017) carried out an overview of a systematic review in 2016, aiming to explore the effectiveness of digital health interventions for addressing mental health concerns among children and young individuals. Within their study, they incorporated 21 pertinent meta-analyses and 30 randomized controlled trials (RCTs), with only one of these included studies offering evidence concerning Internet-Based Cognitive Behavioral Therapy (ICBT) as a treatment option for depression in adolescents aged 10 to 19 years. Ebert et al. (2015) stratified the meta-analysis by age group and found that studies that tested ICBT in adolescents achieved better results than studies that targeted children or mixed-age groups. And they looked at studies published six years ago and very few studies with adolescents. In 2016, Vigerland et al. conducted a study (Vigerland et al., 2016) that examined the effects of Internet-delivered cognitive behavioral therapy on children and adolescents aged 0 to 18 years, without imposing limitations on the specific type of illness. Lehtimaki et al.'s Overviews of systematic review (Lehtimaki et al., 2021) uncovered evidence supporting the effectiveness of computerized cognitive behavioral therapy for managing anxiety and depression in adolescents and young adults (0–24 years). Notably, the meta-analyses by Christ et al. (2020) and Wickersham et al. (2022) delved into the efficacy of Computer-Based CBT for adolescents with depression; however, the original studies focused on depressed adolescents were relatively scarce. In recent years, digital health has changed considerably. The prominence of mHealth (mobile health) and the integration of artificial intelligence and machine learning have emerged as essential methodologies within the realm of digital health. In particular, mHealth has shown great potential in the field of psychology (Fatehi et al., 2020; Hollis et al., 2017), (Nicol et al., 2022). Therefore, in contrast to previous studies, (Christ et al., 2020; Wickersham et al., 2022) we focused the intervention on ICBT rather than computer-based cognitive behavioral therapy.

Depression and anxiety are frequently observed in children and adolescents, often manifesting concurrently, with a strong correlation between the two (Brady and Kendall, 1992). Furthermore, multiple studies have underscored the adverse influence of depression on the QoL (Fernandes et al., 2023; Gazibara et al., 2018; Christ et al., 2020). The objective of the present study is to conduct an up-to-date comprehensive systematic review and meta-analysis to evaluate the efficacy of ICBT on the depression of adolescents. We are also planning to undertake a meta-analysis to assess the impact of ICBT on anxiety and quality of life among adolescents. Additionally, our objective involves investigating potential associations between treatment outcomes and factors such as passive control versus positive control groups, as well as short-term follow-up versus long-term follow-up. This will be achieved through conducting subgroup analyses.

1. Methods

1.1. Eligibility criteria

We used the P.I.C.O.S. (Population, Interventions, Comparators, Outcomes, and Study Design) framework to identify relevant studies.

1.1.1. Types of participants

Studies that met the following criteria were included: Adolescents (10–19 years old) (Dick and Ferguson, 2015) with depressive symptoms, with or without anxiety symptoms, have no risk of suicide, have no cognitive impairment or any other mental illness. Depressive symptom Judgment Criteria: Diagnosed by physicians or other qualified mental health professionals according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), the international Classification of diseases(ICD-10), or undiagnosed but assessed as having at least mild depressive symptoms by validated depression scales, such as Children's Depression Rating Scale-Revised (CDRS-R), The Center for Epidemiologic Studies Depression Scale Revised (CESD-R), Beck Depression Inventory (BDI), Beck Depression Inventory-II (BDI-II), Reynolds Adolescent Depression Scale-2(RADS-2), Montgomery-Asberg Depression Rating Scale (MADRS-S), Mood and Feelings Questionnaire (MFQ), Quick Inventory of Depressive Symptomatology for Adolescents (QIDS-A17-SR), and Patient Health Questionnaire-9 (PHQ-9).

1.1.2. Types of studies

In this study, we included only randomized controlled trials (RCTs) that evaluated ICBT as treatment for adolescents with depression symptoms. Studies that did not clearly state study population characteristics, studies for which the full text was not available, and studies with incomplete data reporting were excluded.

1.1.3. Types of interventions

We defined ICBT as intervention via computer or online and using specific CBT-based components. ICBT is delivered over the internet through websites or web applications. Users access therapy materials and tools through web browsers on their computers, tablets, or smartphones. Computerized cognitive behavioral therapy (cCBT) is usually installed and run on the user's computer, which we also included in this study. There were no limitations on the duration and frequency of

interventions. Types of comparisons: treatment as usual, waiting list and attention control.

1.1.4. Types of outcome measures

The primary outcomes of interest were depression symptom severity (e.g., symptom scale scores). The secondary outcomes are anxiety symptoms; quality of life.

1.2. Information sources

Four electronic databases for studies published in English (PubMed, Cochrane Library, Web of Science, and EMBASE) were comprehensively searched from inception to June 8, 2023.

1.3. Search strategy

We did keyword and MeSH searches, and the specific search strategy was shown in Appendix 1. We checked reference lists of relevant reviews for additional studies.

1.4. Selection process

Studies were selected independently by 2 reviewers (Yanan Wu and Meng Xu) and disagreements were resolved in consultation with a third reviewer (Fenfen E). After eliminating duplicates, titles and abstracts were read to exclude irrelevant studies, after which the full text was assessed for final study inclusion.

1.5. Data collection process

Two reviewers (Yanan Wu and Yan Wang) extracted data independently using a standardized study form. Any disagreement was resolved through discussion. If the data were not available, we try to contact the study authors.

1.6. Data items

The content of data extraction mainly included study information (i.e., the year of publication and the first author's name, geographic location, and setting); characteristics of participants (i.e., diagnostic information or relevant inclusion criteria, sample size); intervention characteristics (i.e., website/application name, intervention time, comparison group, and length of follow-up), outcomes (i.e., depression, anxiety, quality of life), and guidance.

1.7. Study risk of bias assessment

The Cochrane collaboration tool (RoB 2) (Sterne et al., 2019; Higgins et al., 2011) was used to assess risk of bias in the studies to be included for review and was done independently by the two review authors (Yan Wang and Fenfen E). For each study, the following items were evaluated: (a) bias arising from the randomisation process; (b) bias due to deviations from intended interventions; (c) bias due to missing outcome data; (d) bias in measurement of the outcome; (e) bias in selection of the reported result. Each item was classified as low, high, or some concerns risk of bias, and the results were displayed by summary plots. A third review author (Meng Xu) was consulted and consensus was reached when there was disagreement on the assessment.

1.8. Synthesis methods

The meta-analysis was performed using RevMan version 5.4 software. Depression was the primary outcomes and secondary outcomes were anxiety symptom, quality of life. In this study, treatment response was measured by improvements in depressive symptoms, anxiety symptoms, and quality of life scores. Depression in the included studies was measured by CDRS-R, CESD-R, BDI, BDI-II, RADS-2, MADRS-S, and MFQ-Child. Anxiety was measured using The Spence Children's Anxiety Scale (SCAS), The Screen for Child Anxiety Related Emotional Disorders (SCARED), and Beck Anxiety Inventory (BAI). Quality was measured by the pediatric version of the Short Form of the quality of Life Enjoyment and Satisfaction Questionnaire (PQ-LES-Q), KIDSCREEN-27, The Pediatric Quality of Life Inventory (PedsQL), and EQ-5D-Y. Depression, anxiety, and quality were measured as continuous variables. If the trials evaluated used different scales to measure the same outcome, standardized mean differences (SMD) with 95 % confidence interval (CI) were used to synthesise the data. We used I-squared (I^2) statistical tests to assess the heterogeneity of the results. If the results indicate significant heterogeneity ($I^2 > 50$ %), the results were considered to be heterogeneous, and we will proceed with using the random-effects model. If $I^2 \leq 50$ %, the random-effects model will be used. In order to better understand the factors that contributed to an effective intervention, we performed subgroup analyses for the outcomes when there were sufficient trials.

1.9. Reporting bias assessment

We performed funnel plots and visually examined the signs of asymmetry to investigate publication bias, and used Egger's test as a formal test of publication bias when the number of the included studies for a given outcome exceeded >10 ($n \geq 10$).

1.10. Certainty assessment

We used Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system (Guyatt et al., 2011) to assess the quality of evidence associated with specific outcomes and to construct a summary table of results. The GRADE approach was used to assess the quality of a set of evidence based on the extent to which one's estimate of an effect or association reflects the degree of certainty of the item being assessed. The quality of the evidence was assessed taking into account the methodological quality, directness of the evidence, heterogeneity of data, precision of effect estimates, and risk of publication bias (Norris et al., 2016).

2. Results

2.1. Study selection

Fig. 1 showed the PRISMA flowchart. A total of 5798 citations were identified in the search strategy, of which 2181 studies were excluded due to duplication, and 3617 studies were screened by browsing titles and abstracts, and after excluding irrelevant literature, a total of 37 full-text studies were assessed for eligibility, with 18 (Fleming et al., 2012; Gladstone et al., 2018; Grudin et al., 2022; Ip et al., 2016; Martínez et al., 2019; Mechler et al., 2022; Merry et al., 2012; Nicol et al., 2022; Poppelaars et al., 2016; Schniering et al., 2022; Smith et al., 2015; Srivastava et al., 2020; Stasiak et al., 2014; Topooco et al., 2018; Topooco et al., 2019; Wright et al., 2017; Wright et al., 2020; Wisman et al., 2023) studies ultimately meeting the inclusion criteria (One of which was unable to obtain usable data, and we contacted its corresponding authors on 22 June 2023, and we received the available information on June 30, 2023. The study (Gladstone et al., 2018) was included). 19 studies were excluded, and the main reasons for excluding studies from this review were shown in Appendix 2.

2.2. Study characteristics

Table 1 summarized the general characteristics of the included studies. Of the selected trials, 88.90 % were distributed in high-income countries, 5.55 % from upper-middle-income countries, and 5.55 % from lower-middle-income countries (World Bank data), all of which

were published between 2012 and 2023. Studies were conducted in schools (33.33 %), communities (27.78 %), and Clinic (38.89 %). The included population ranges in age from 11 to 19 years old. The compliance rate ranges from 54 % to 100 %. Follow-up analyses were conducted in all studies, ranging from 1 month to 24 months. Appendix 3 summarized the additional supplementary features of intervention measures, including specific descriptions of the intervention modality, intervention content, whether parents are involved in the intervention, and whether the intervention is conducted under the guidance of a therapist.

2.3. Risk of bias in studies

Four studies were assessed as having a high risk of bias; six were assessed as some concerns, and eight as having a low risk of bias. The most common sources of high risk of bias were measurement of the outcome; three of the studies were assessed as high risk of bias in this item. In the Missing outcome data, all studies were assessed as low risk of bias. Only one study was assessed as some concerns on the selection of the reported result, the remaining 17 studies were assessed as low risk of bias. A summary of the risk of bias was provided in Fig. 2.

2.4. Result of syntheses

2.4.1. Depression

18 trials including 1683 patients evaluated the efficacy of ICBT for depression in adolescents. Compared to the control group, the meta-analysis results from participant self-reported data indicated that ICBT significantly reduces depression scores in adolescents (SMD = −0.42, 95 % CI: [−0.74, −0.11], $p < .05$; very low certainty). Subgroup analysis of the different control group showed that ICBT significantly reduced depression scores compared to attention control group (SMD = −0.33, 95 % CI: [−0.56, −0.10], $p < .05$), and the pooled effect size was substantially smaller and not significant when the control groups were limited to waiting list and TAU control group (waiting list: SMD = −0.98, 95 % CI: [−2.14, 0.18], $p > .05$; TAU: SMD = −0.24, 95 % CI: [−0.94, 0.46], $p > .05$), as shown in Fig. 3. Subgroup analysis showed that ICBT was effective in improving depression compared to control group at a follow-up time between three and 6 months (SMD = −0.66, 95 % CI: [−1.10, −0.23], $p < .05$), and there was no significant difference between the intervention group and the control group at <3 months or >6 months (≤3 month: SMD = −0.46, 95 % CI: [−1.1.19, 0.27], $p > .05$; >6 month: SMD = −0.27, 95 % CI: [−0.55, 0.02], $p > .05$), as shown in Fig. 4. The subgroup analysis of different guidance elements indicated that the therapist-guided intervention group showed no significant difference in depressive symptoms compared to the control group (SMD = −0.15, 95 % CI: [−0.74, 0.44], p > .05), while the self-guided intervention group significantly improved depressive symptoms in adolescents compared to the control group (SMD = −0.59, 95 % CI: [−0.94, −0.24], $p < .05$), as shown in Fig. 5. The sensitivity analysis showed that results were stable, and no single study significantly affected overall heterogeneity. Meanwhile, our results were

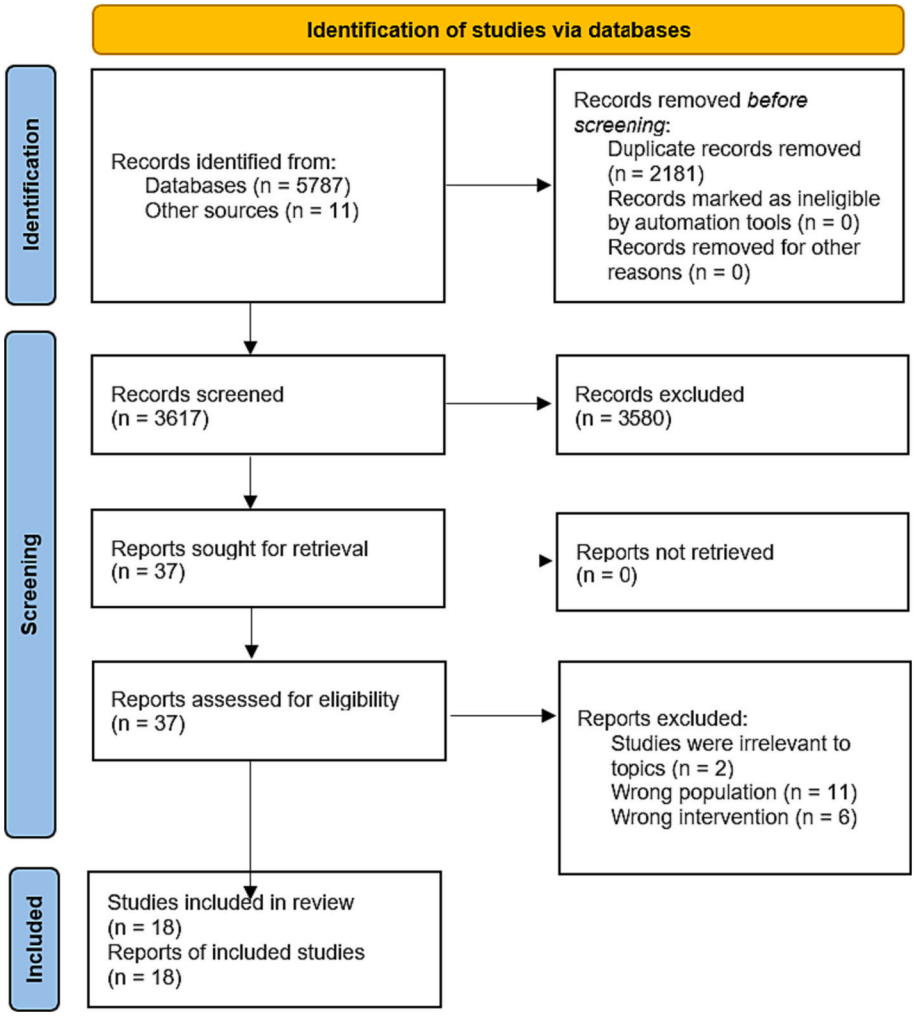

Fig. 1. Flow diagram of the literature screening process and result.

Table 1
The essential characteristics of the included studies.

Study	Country	Setting	Age range	N(I/C)	Inclusion	Intervention		Intervention duration	Follow up	Adherence rate	Outcomes		
						I	C				Self-report	Clinician-rated	Parent-rated
Fleming 2012	New Zealand	School	13–16	19/11	CDRS-R > 29	cCBT SPARX	Waiting list	5 weeks	10 weeks	94 %	①RADS-2 ②Spence ③PQ-LES-Q	①CDRS-R	–
Gladstone 2018	US.	Clinic	13–18	79/103	8 ≤ CES-D_{10} ≤ 17 or CES-D_{20} ≥ 16	ICBT CATCH-IT	attention control	NR	24 months	81 %	①CESD ②SCARED	–	–
Grudin 2022	Sweden	Clinic	13–17	11/11	mild or moderate MDD according to DSM-5	ICBT IBA	TAU	NR	3 months	100 %	①SMFQ-A	①CDRS-R	①SMFQ-P
IP 2016	China	School	13–17	130/127	12 ≤ CESD-R ≤ 40	ICBT CATCH-IT	attention control	2 years	12 months	97 %	①CESD-R	–	–
Martínez 2019	Chile	Clinic	15–19	87/91	BDI > 10	cCBT YPSA-M	EUC	8 weeks	6 months	82 %	①BDI ③KIDSCREEN-27	–	–
Mechler 2022	Sweden	Community	15–19	67/65	QIDS-A17-SR ≥ 9	ICBT	IPDT	NR	10 weeks	96 %	①QIDS-A17-SR	–	–
Merry 2012	New Zealand	Clinic	12–19	94/93	10–19 on the PHQ-9	cCBT SPARX	TAU	NR	3 months	100 %	①RADS-2 ②SCAS ③PQ-LES-Q	①CDRS-R	–
Nicol 2022	US.	Clinic	13–17	10/7	Diagnosed with depression	ICBT	Waiting list	12 weeks	4 weeks	94 %	①PHQ-9 ②GAD-7	–	–
Poppelaars 2016	Netherlands	School	11–16	38/47	RADS-2 score ≥ 59	cCBT SPARX	attention control	5 months	12 months	76 %	①RADS-2	–	–
Schniering 2022	Australia	School	12–17	45/46	Diagnosed with depression according to DSM-5	ICBT	Waiting list	4 h	3 months	78 %	①SMFQ-A ②SCAS-A	–	①SMFQ-P ②SCAS-P
Smith 2015	UK	School	12–16	49/55	MFQ-C ≥ 20	cCBT Stressbusters	Waiting list	8 weeks	6 months	93 %	①MFQ-A ②SCARED-A	–	①MFQ-P ②SCARED-P
Srivastava 2020	India	Clinic	13–19	10/9	Mild/Moderate Depression	cCBT Smartteen	TAU	12 weeks	12 weeks	90 %	①BDI-II	–	–
Stasiak 2014	New Zealand	School	13–18	13/12	CDRS-R > 29, RADS-2 > 75	cCBT Journey	attention control	4–10 weeks	1 month	74 %	①RADS-2 ③PedsQL	①CDRS-R	–
Topooco 2018	Sweden	Community	15–19	22/36	Mild/Moderate Depression (BDI-II ≥ 14 , MINI)	ICBT	attention control	8 weeks	6 months	82 %	①BDI-II ②BAI	–	–
Topooco 2019	Sweden	Community	15–19	31/35	BDI-II ≥ 14, or fulfilled criteria for MDE	ICBT	attention control	8 weeks	12 months	91 %	①BDI-II ②BAI	–	–
Wisman 2023	Netherlands	Clinic	13–18	17/16	Diagnosed with depression	ICBT	TAU	NR	6 months	85 %	①CDI-2 ②SCARED	–	–
Wright 2017	UK	Community	12–18	25/30	MFQ ≥ 20	cCBT Stressbusters	attention control	4–6 h	4 months	60 %	①MFQ-A ②SCAS-A ③EQ-5D-Y	–	–
Wright 2020	UK	Community	12–18	38/37	MFQ ≥ 20	cCBT Stressbusters	attention control	4–6 h	12 months	54 %	①MFQ-A ②SCAS-A	–	–

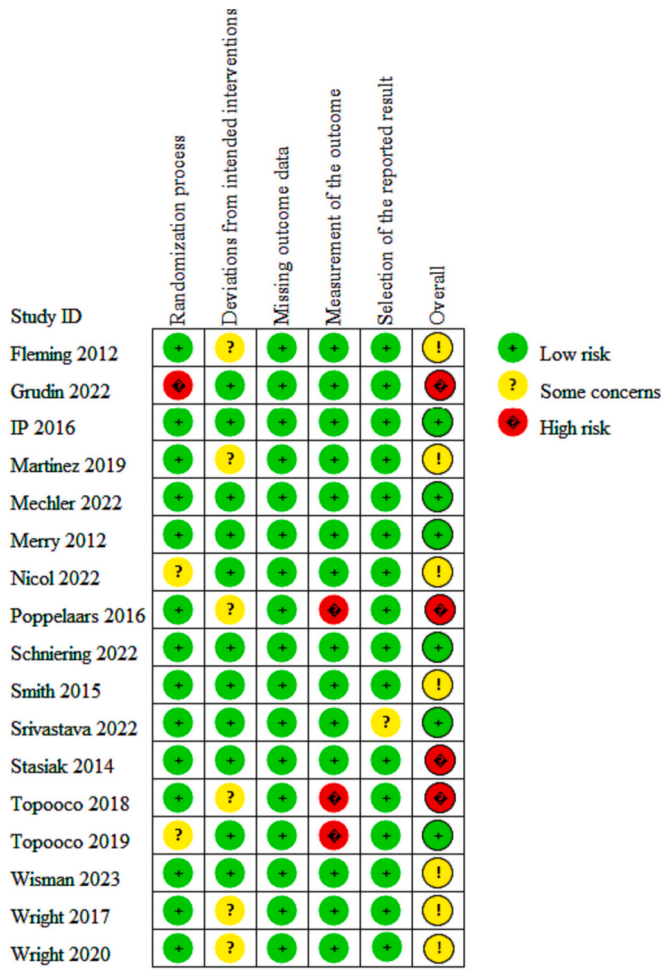

Fig. 2. Summary of review authors' judgements about each risk of bias item.

robust. Compared to the control group, the meta-analysis results from clinician-rated data indicated that ICBT significantly reduces depression scores in adolescents (SMD = −8.09, 95 % CI: [−15.40, −0.77], $p < .05$), as shown in Fig. 6. Compared to the control group, the meta-analysis results from parent-rated data indicated that ICBT significantly reduces depression scores in adolescents (SMD = −0.48, 95 % CI: [−0.81, −0.15], $p < .05$), as shown in Fig. 7.

2.4.2. Anxiety

11 trials including 811 patients evaluated the efficacy of ICBT for anxiety in adolescents. Compared to the control group, the meta-analysis results from participant self-reported data indicated that ICBT significantly reduces anxiety scores in adolescents (SMD = −0.34, 95 % CI: [−0.60, −0.08], p < .05; very low certainty). Subgroup analysis by control group showed no significant difference in the results obtained compared to the different control groups (waiting list: SMD = −0.58, 95 % CI: [−1.27, 0.10], $p > .05$; attention control: SMD = −0.15, 95 % CI: [−0.37, 0.06], $p > .05$; TAU: SMD = −0.26, 95 % CI: [−0.53, 0.00], $p = .05$), as shown in Fig. 8. Subgroup analyses with different follow-up times showed that ICBT did not significantly improve anxiety compared with the control group (≤3 month: SMD = −0.27, 95 % CI: [−0.65, 0.11], $p > .05$; >3 month: SMD = −0.49, 95 % CI: [−1.12, 0.13], $p > .05$; >6 month: SMD = −0.21, 95 % CI: [−0.57, 0.14], $p > .05$), as shown in Fig. 9. The sensitivity analysis showed that one trial significantly affected overall heterogeneity. Meanwhile, after excluding one trial (Smith et al., 2015) our results are robust, indicating the stability of the results. The subgroup analysis of different guidance elements indicated that the self-guided intervention group showed no significant difference in anxiety symptoms compared to the control group (SMD = −0.29, 95 % CI: [−0.70, 0.12], p > .05), while the therapist-guided intervention group significantly improved anxiety symptoms in adolescents compared to the control group (SMD = −0.39, 95 % CI: [−0.63, −0.15], $p < .05$), as shown in Fig. 10. Compared to the control group, the meta-analysis results from parent-rated data indicated that ICBT significantly reduces anxiety scores in adolescents (SMD = −0.49, 95 % CI: [−0.85, −0.14], p < .05), as shown in Fig. 11.

2.4.3. QoL

5 trials including 465 patients evaluated the efficacy of ICBT for QoL in adolescents. Compared with the control group, our meta-analysis results demonstrated that there was no significant difference in the QoL scores of adolescents between the ICBT and control group (SMD = 0.12, 95 % CI: [−0.10, 0.34], $p > .05$; low certainty), as shown in Fig. 12.

2.5. Reporting bias

The funnel plot of depression is presented in Fig. 13. Visual inspection of the plot and Egger's test suggested that no publication bias was observed, with the funnel plot showing a relatively symmetrical distribution (Egger's test, $p > .05$). The funnel plot of anxiety is presented in Fig. 14. Visual inspection of the plot and Egger's test suggested that no publication bias was observed, with the funnel plot showing a relatively symmetrical distribution (Egger's test, $p > .05$).

2.6. Certainty of evidence

Overall, the certainty of the evidence was low, mainly due to high heterogeneity between studies (inconsistency), and the risk of bias. As shown in Fig. 15.

3. Discussion

3.1. Principal findings

This review examined the efficacy of ICBT for depression in adolescents. We included 18 published RCTs including a total of 1683 participants from Sweden (n = 4), New Zealand (n = 3), UK (n = 3), Netherlands (n = 2), US (n = 2), India (n = 1), Australia (n = 1), China (n = 1), and Chile (n = 1). Overall, compared with the control group, the meta-analysis showed that ICBT may be useful in improving depressive symptoms in adolescents. The findings are also similar to those of the adult population, for example, a recent meta-analysis found that ICBT was effective in treating depression in adults (Andrews et al., 2018; Etzelmueller et al., 2020). It's worth noting that the research from Etzelmueller et al. indicates that compared to adolescents; Internet-Based Cognitive Behavioral Therapy (ICBT) has a greater effect size in improving depression and anxiety within the adult population. The results of the subgroup analysis revealed that the ICBT group demonstrated a greater improvement in depressive symptoms compared to the attention control group. However, there were no significant differences in the improvement of adolescent depression between the ICBT group and the treatment as usual group, as well as the waiting list group. Nonetheless, the potential of ICBT cannot be overlooked, given its advantages, such as more flexibility in terms of time and location, more privacy, effective cost savings, and should therefore be recommended. The results of subgroup analysis, considering the duration of follow-up as a moderating factor, demonstrated that the intervention was effective when the follow-up period ranged from 3 to 6 months. However, beyond 6 months, there was no significant improvement compared to the control group. This highlights the importance of not only focusing on post-intervention outcomes but also placing emphasis on the long-term effects on participants. Furthermore, whether it was patient self-reported outcomes, parent-rated assessments, or clinician-rated, the results obtained were consistent. They all indicated that ICBT was

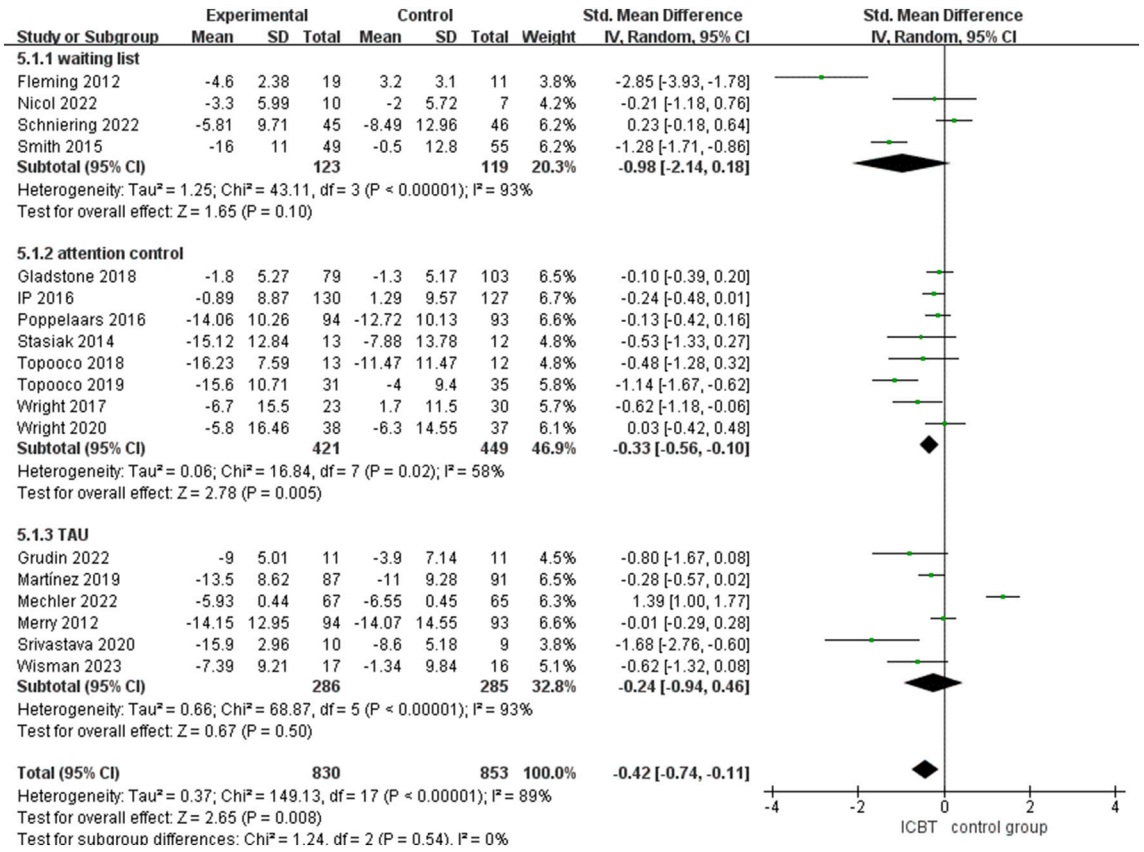

Fig. 3. Effect of the ICBT on the depression scores in adolescents (with different control groups as subgroups).

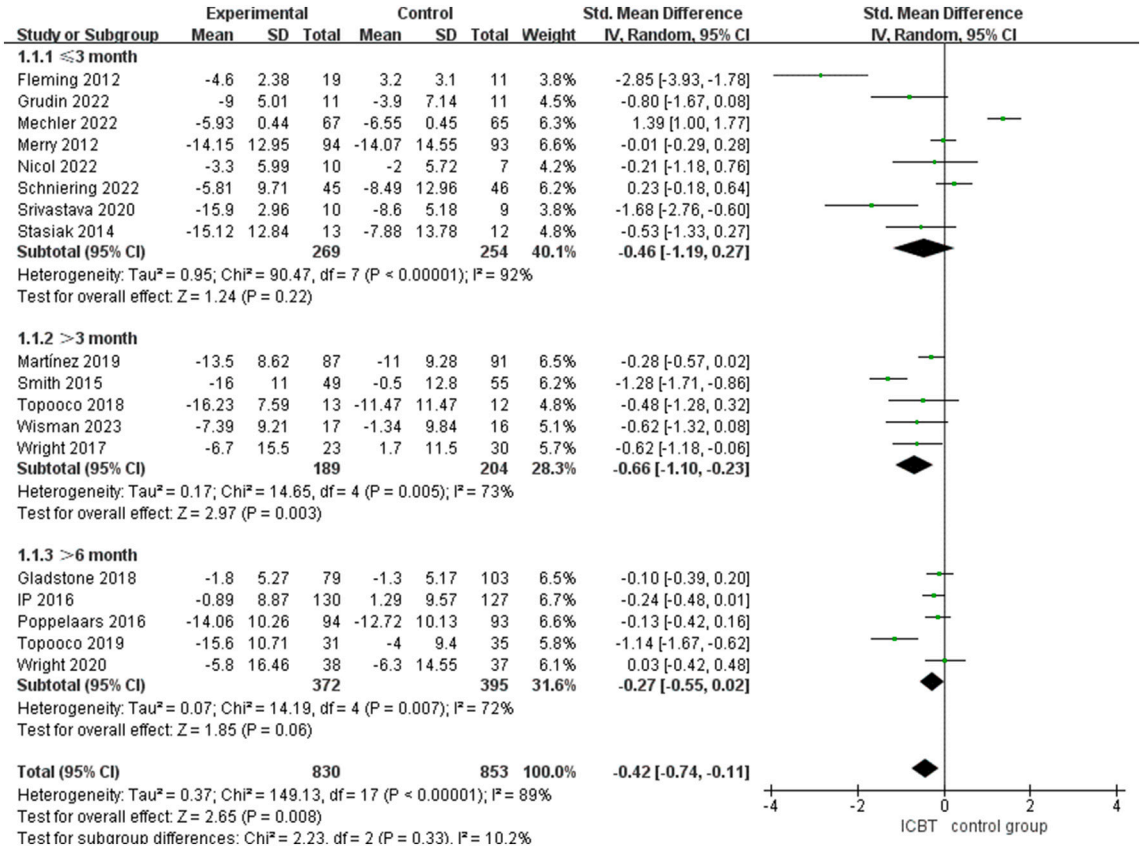

Fig. 4. Effect of the ICBT on the depression scores in adolescents (with different follow-up times as subgroups).

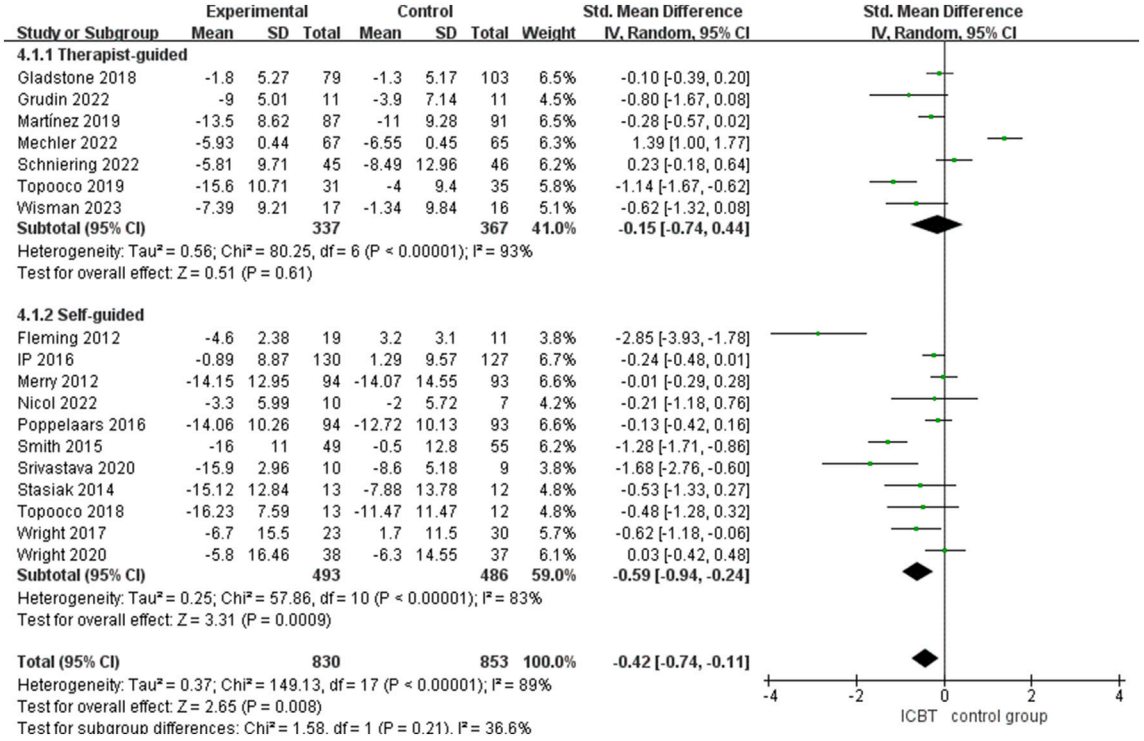

Fig. 5. Effect of the ICBT on the depression scores in adolescents (with different guidance as subgroups).

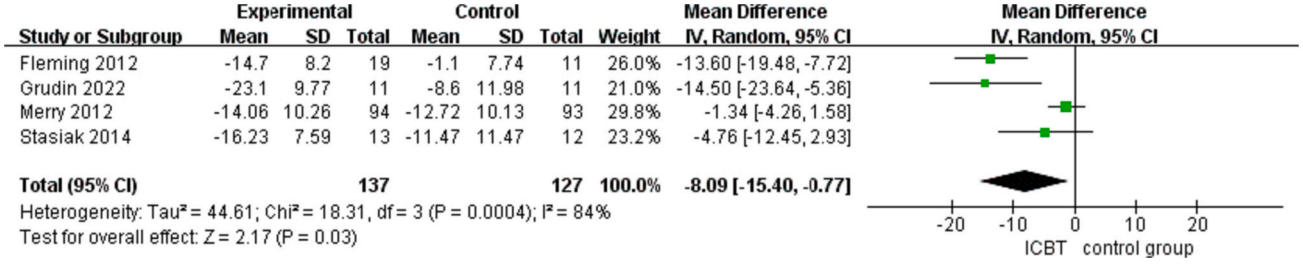

Fig. 6. Effect of the ICBT on the depression scores in adolescents (clinician-rated).

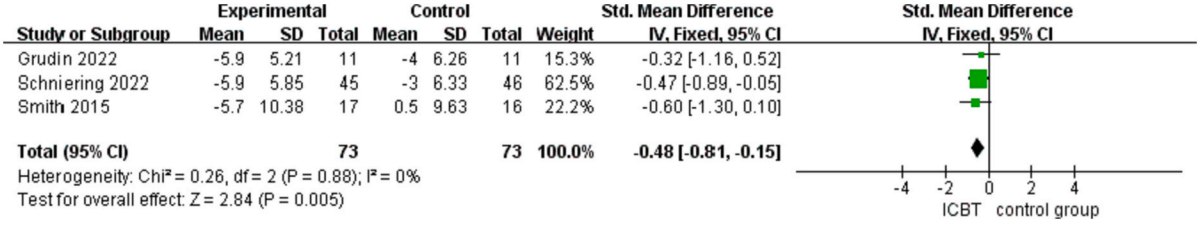

Fig. 7. Effect of the ICBT on the depression scores in adolescents (parent-rated).

effective in improving patient's depressive symptoms compared to the control group. This distinction also sets our study apart from previous research: we have reported outcomes from multiple perspectives, providing a comprehensive depiction of the effects of ICBT on participants.

Compared with the control group, the meta-analysis showed that ICBT may be useful in improving anxiety symptom in adolescents. This result is similar to the findings of Wickersham et al. (2022). Notably, analysis of subgroups with different guidance elements showed that the self-guided intervention did not significantly improve participants' anxiety symptoms compared to the control group. The therapist-guided intervention significantly improved the participants' anxiety symptoms compared to the control group. It can be seen that whether the therapist intervenes or not, as well as the supervision and guidance of the participants have a significant impact on the intervention effect. Moreover, the findings of the study by Ebert et al. also revealed a significant moderating effect of age on treatment outcomes. They observed that, in comparison to adolescents, Internet-Based Cognitive Behavioral Therapy (ICBT) had a more pronounced therapeutic effect on childhood anxiety. Therefore, future research could delve deeper into the association between age and the effectiveness of ICBT interventions for depression and anxiety symptoms.

Moreover, the evidence showed that there was no significant difference in the QoL scores of adolescents between the ICBT and control

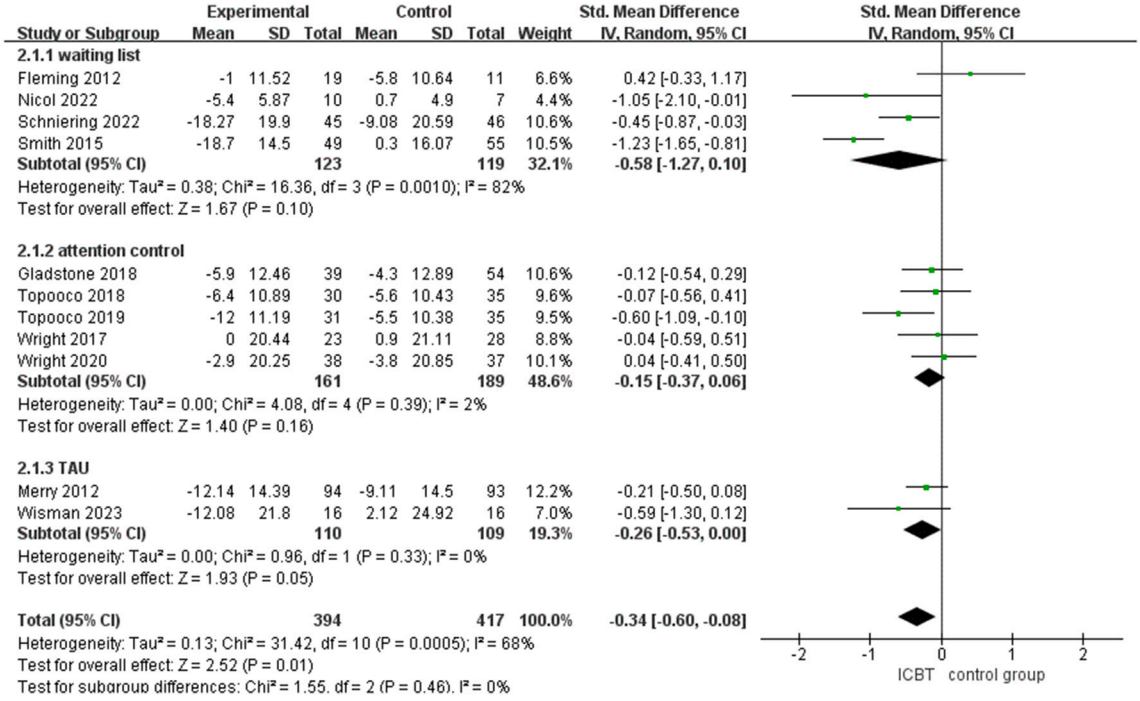

Fig. 8. Effect of the ICBT on the anxiety scores in adolescents (with different control groups as subgroups).

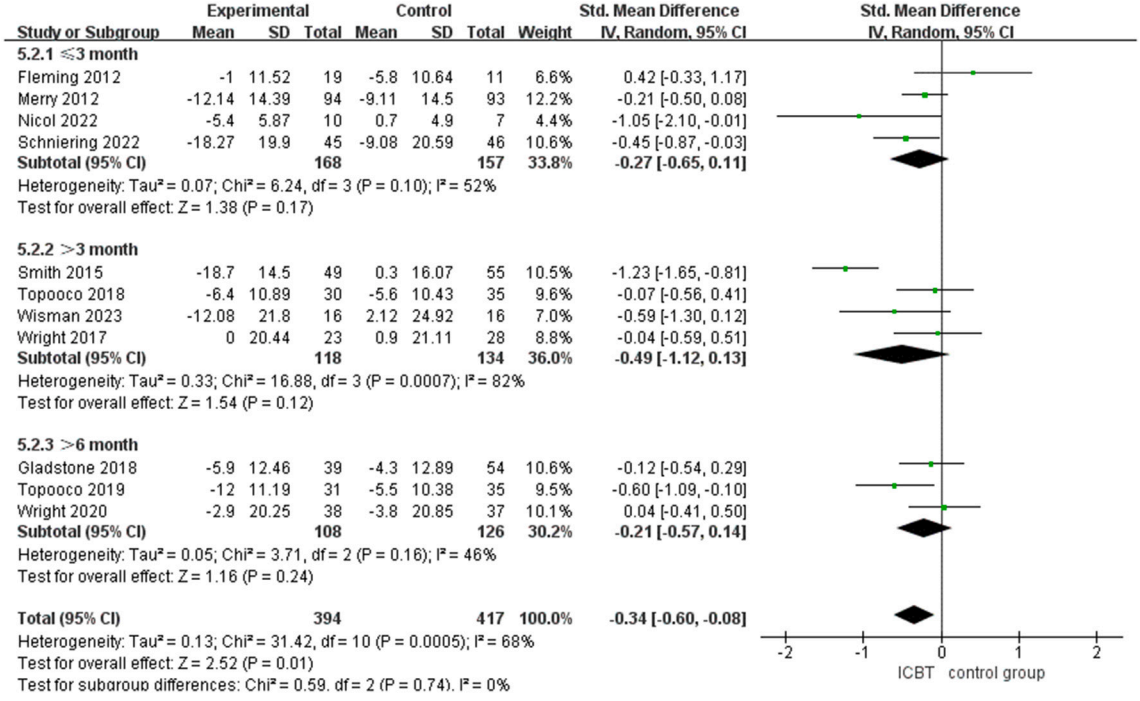

Fig. 9. Effect of the ICBT on the anxiety scores in adolescents (with different follow-up as subgroups).

group. In fact, only 5 of the 18 studies included reported quality of life outcomes. The results may therefore have been limited by the number of studies included. A study by Elfghi also suggested that the underpowered studies may be due to insufficient sample size (Elfghi et al., 2020). Therefore, further high-quality evidence is needed to elucidate the impact of ICBT on QoL in adolescents.

Some statistical heterogeneity was found in our meta-analysis on depression and anxiety. Statistical heterogeneity is the variation in individual study effect sizes. This may be due to differences in study population, study design, interventions or outcome assessment (clinical heterogeneity) or risk of bias (statistical heterogeneity) (Lau et al., 1998). To explore sources of heterogeneity in depression outcome, we did subgroup analyses with separate subgroups for control measures, follow-up time, and guidance elements, and none of the heterogeneity was significantly reduced. It can be seen that none of the above factors was a major source of heterogeneity. Research indicates that a small sample size could be a potential source of heterogeneity. In this study, all three included studies have sample sizes below 30. Consequently, we

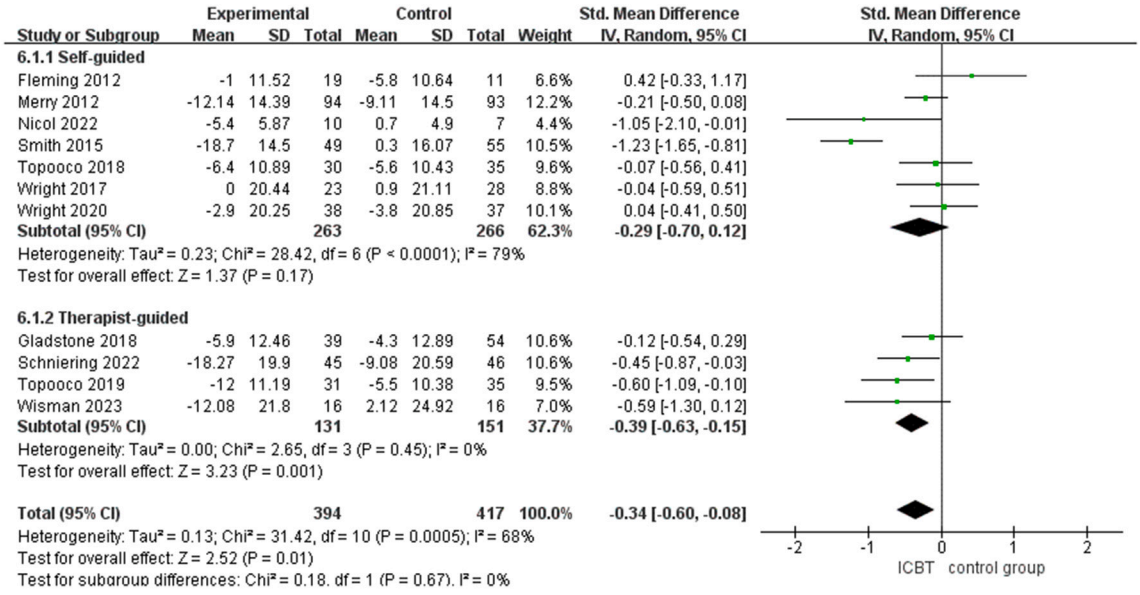

Fig. 10. Effect of the ICBT on the anxiety scores in adolescents (with different guidance as subgroups).

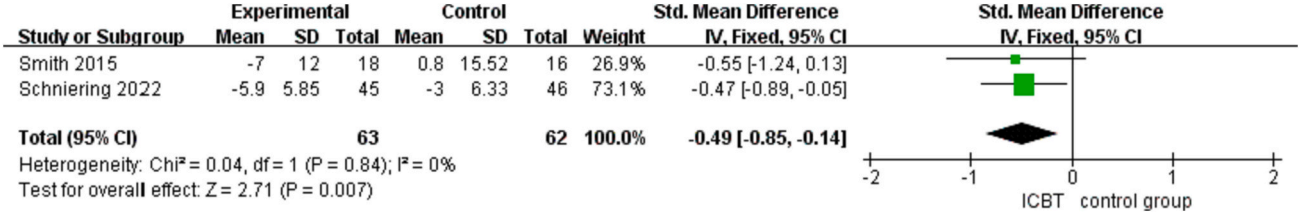

Fig. 11. Effect of the ICBT on the anxiety scores in adolescents (parent-rated).

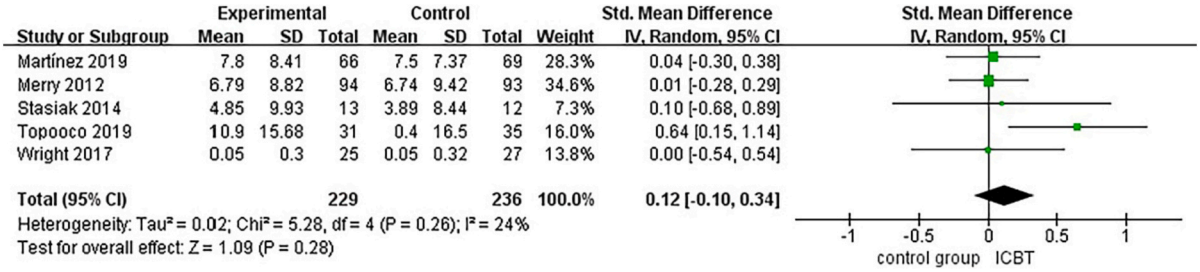

Fig. 12. Effect of the ICBT on the QoL scores in adolescents.

postulate that the significant heterogeneity observed in the statistical results may be attributed to the relatively small sample sizes (Ishaque et al., 2018). In addition, risk of bias is also a possible source of heterogeneity.

Due to the risk of bias of the included studies, the results of this review should be interpreted with caution. There was a high risk of bias for measurement of the outcome in our meta-analysis. The high risks of bias may significantly reduce the reliability of the results (Zeng et al., 2008). In addition, it has been noted that the quality and reporting of RCTs needs to be improved, particularly with regard to reporting methods and outcomes (Li et al., 2022; Li et al., 2021). Therefore, according to the Cochrane quality assessment tool, researchers need rigorous training to clearly understand the importance of study quality and to improve the reliability of RCTs (Yao et al., 2016; Tian et al., 2017).

3.2. *Strengths and limitations*

This is a meta-analysis of this type specifically for the adolescent age group to determine the efficacy of ICBT in this different developmental period. There are few studies that have specifically explored the effects of ICBT on adolescent depression. Existing studies such as Ebert; (Ebert et al., 2015) Vigerland; (Vigerland et al., 2016) Christ; (Christ et al., 2020) et al. identified the study population as adolescents and young adults and did not examine the specific group of adolescents. Given the unique biological and social transitions associated with adolescence, and the associated prevalence of mental health disorders in this age group, this is an important addition to the literature (Costello et al., 2003; Merikangas et al., 2010). While Wickersham et al. (2022) systematically evaluated the efficacy of ICBT for adolescent depression. However, we added to their study by including five articles that explored the efficacy of ICBT in treating depression in adolescents. In addition, we used a comprehensive and systematic search strategy to ensure the

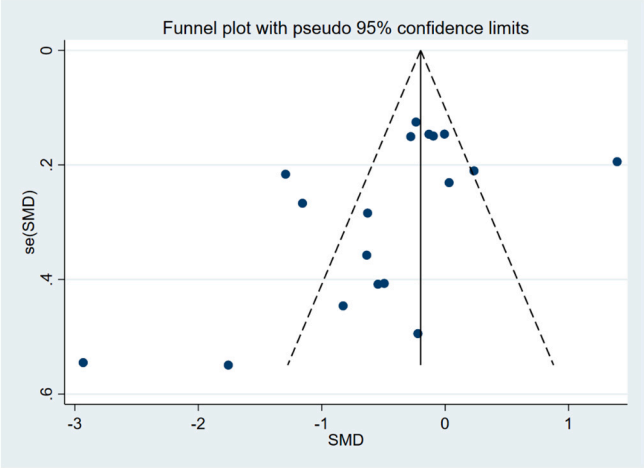

Fig. 13. Funnel plot of depression.

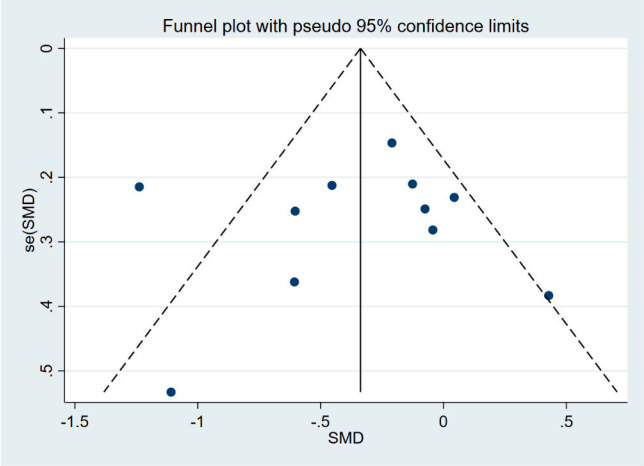

Fig. 14. Funnel plot of anxiety.

validity of the results obtained. Moreover, we included studies from a wide range of countries, suggesting that ICBT may be an effective intervention in a variety of cultural settings. Some limitations of this study should also be mentioned. We focused on participants aged 10 to 19 years but acknowledge that the age of adolescents is widely disputed and therefore some of the studies excluded from this review due to the age of the participants may have produced findings relevant to the adolescent population. Second, some studies were not included due to data availability limitations, although we did our best to search for access database resources and references. Third, this study focused on the effects of ICBT on depression, with limited inclusion of evidence on anxiety and quality of life as outcomes. Therefore, more high-quality trials are still needed to further elucidate the effects of ICBT on adolescents.

3.3. Clinical implications

This article systematically reviews the existing randomized controlled trials of ICBT in the treatment of adolescent depression to provide clarity for clinical decision-making. Nevertheless, the influence of the trials' overall low quality impedes the formation of definitive conclusions. Our findings do suggest that ICBT could potentially yield a favorable impact on adolescent depression, a notion that merits consideration among clinicians. Particularly, ICBT displays promise, especially in alleviating depressive and anxiety symptoms in adolescents. Notably, the positive influence of clinician guidance on intervention effects is significant. Hence, it is advisable to employ cognitive behavioral therapy as an intervention for adolescents with depression and anxiety symptoms, guided by therapists. Moreover, owing to the constrained number of included studies, the existing evidence is inadequate to conclusively demonstrate the clinical value of ICBT in enhancing the quality of life. Consequently, further rigorous trials of high quality are imperative to comprehensively unveil the effects of ICBT.

3.4. Future directions

Among the eighteen studies included, sixteen were conducted in high-income countries, one in upper-middle-income countries, and one in lower-middle-income countries. It is evident that there remains a

Internet-based Cognitive-behavioral Therapy for Depression adolescents

Patient or population: Depression adolescents
Settings:
Intervention: Internet-based Cognitive-behavioral Therapy

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk Control	Corresponding risk Internet-based Cognitive-behavioral Therapy				
Depression		The mean depression in the intervention groups was **0.42 standard deviations lower** (0.74 lower to 0.11 higher)		1683 (18 studies)	⊕⊖⊖⊖ **very low**[1,2]	
Anxiety		The mean anxiety in the intervention groups was **0.34 standard deviations lower** (0.60 to 0.08 lower)		811 (11 studies)	⊕⊖⊖⊖ **very low**[1,2]	
QoL		The mean qol in the intervention groups was **0.12 standard deviations higher** (0 to 0.34 higher)		465 (5 studies)	⊕⊕⊖⊖ **low**[1]	

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval;

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

[1] We downgraded quality due to a lack of clarity about blinding of participants and outcome assessors, and incomplete outcome data
[2] We downgraded for inconsistency due to studies having hige heterogeneity

Fig. 15. Summary of findings.

substantial need for future research that investigates the feasibility and effectiveness of ICBT in low- and middle-income countries. Secondly, the prevailing studies in this domain predominantly comprise pilot projects characterized by modest sample sizes and diminished quality. This underscores the necessity for researchers to persist in conducting large-scale, high-quality trials in the forthcoming endeavors. Thirdly, the variances observed in intervention effects across different follow-up periods underscore the importance of focusing not solely on post-intervention effects but also on the enduring impact of interventions on participants. Fourthly, forthcoming research could delve deeper into the potential negative effects encompassing participants' mood deterioration and inclinations toward self-harm during the intervention. Fifthly, this study centers on the efficacy of ICBT for adolescent depression. Future strides in machine learning and intelligent algorithms hold the potential to pave the way for more nuanced and pertinent intervention strategies. Thus, upcoming research can continue to explore the efficacy of more advanced interventions that result from the synergy between the Internet and machine learning, as well as intelligent algorithms.

4. Conclusion

The meta-analysis suggests that ICBT may be an effective intervention to help improve depression and anxiety symptoms in adolescents, showing a statistically significant effect. Furthermore, our results suggest that ICBT is similar to control groups in terms of improving quality of life in adolescents. Researchers must have a clear understanding of the importance of study quality and be committed to self-checking study design against the Cochrane Quality Assessment Tool through. Importantly, this study also demonstrates the need for higher quality methodological research in this population.

Registration and protocol

Our findings were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Ziegler et al., 2011) and detailed analysis protocol was registered on the International Prospective Register of Systematic Reviews (PROSPERO registration number: CRD42021277562). The PRISMA guideline can be found in Appendix 4.

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Declaration of competing interest

The authors have no conflicts of interest to declare, have all read and approved the manuscript, and agree with its submission.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.invent.2023.100673.

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