



REVIEW

Effects of Internet-Based Acceptance and Commitment Therapy (IACT) on Adolescents: A Systematic Review and Meta-Analysis

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ABSTRACT

Objectives: This study reviewed published randomized controlled trials (RCTs) and evaluated the efficacy of internet-based acceptance and commitment therapy (IACT) on adolescent mental health. **Methods:** Searches were conducted in PubMed, ProQuest, APA (PsycNET/PsycINFO), and Web of Science from inception to January 2022 to identify RCTs evaluating the effects of IACT on adolescents. The included studies were assessed for quality and risk of bias. This study was performed using the standard mean difference and associated 95% confidence interval of effective measures. Review Manager 5.4 software was adopted to calculate the effect size. **Results:** Compared to adolescents in control groups, those in the IACT groups showed some improvement in the efficacy of depression symptoms (SMD = -0.24, 95% CI = [-0.44, -0.05], $p = 0.01$) and had a small but significant effect on reducing experiential avoidance (SMD = -0.24, 95% CI = [-0.46, -0.01], $p = 0.04$). However, the effect size on anxiety did not reach the threshold (SMD = -0.18, 95% CI = [-0.27, -0.09], $p < 0.0001$). In addition, there were no significant differences in stress and well-being compared to those of the control group. Compared with universal adolescents, IACT was found to have a more significant therapeutic effect on targeted adolescents. **Conclusions:** IACT is effective in adolescent mental health interventions, but its clinical reliability and significant efficacy are limited, and more rigorous RCTs are needed in future studies.

KEYWORDS

Internet-based acceptance and commitment therapy; adolescents; mental health; meta-analysis

1 Introduction

Adolescence is a critical period for emotional and behavioral development, and adolescent mental health has received considerable attention. Many serious mental problems are first identified in childhood or adolescence [1], highlighting the importance of early intervention and adolescent mental health services.

Among behavior therapies, cognitive behavioral therapy can effectively promote mental health [2], and acceptance and commitment therapy (ACT) brings behavior therapy into new territory [3]. As the third wave of behavioral therapy, ACT is a promising approach for transdiagnostic prevention efforts [4]. This therapy has been validated in over 100 randomized controlled trials (RCTs) and is proven to be effective in treating depression, anxiety, substance abuse, eating disorders, stress, smoking, academic concerns, stigma, and self-harm [5]. A recent study indicated that ACT is more effective than treatment as usual (TAU) and untreated groups in improving anxiety, depression, and other mental and behavioral disorders [6].



ACT is based on pragmatism, functional contextualism, and relational frame theory [3]. It can reduce patients' struggles and frustrating experiences by accepting and noticing their thoughts and behaviors, rather than eliminating negative thoughts and behaviors through thought replacement and cognitive restructuring [7]. Psychological flexibility (PF) is the core of ACT, defined as "fully contacting the present moment as a conscious human being, and based on what the situation affords, changing or persisting in behaviors in the service of chosen values" [8]. It is a protective factor for various psychological problems [9].

Traditional mental health services are usually provided by face-to-face or group counseling, with relatively fixed time, no privacy guarantee, few audience, and low efficiency. Less help-seeking behavior among adolescents may be due to the shame associated with "seeing a therapist" [10]. With the development of the internet, this problem can be addressed by internet-based psychological intervention and prevention programs [11]. A review showed that users generally had a positive attitude toward mental health apps [12]. For young people spending more time online, technology and mobile devices offer a flexible tool and new opportunities to provide mental health services [13]. The COVID-19 pandemic has led to an increase in mental health problems among adolescents, and the increased levels of stress, depressive thoughts, and anxiety have aroused their interest in online psychotherapy [14,15]. A recent meta-analysis showed that online mental health interventions were effective across different mental health conditions in adolescents [16].

Internet-based acceptance and commitment therapy (IACT) is a novel treatment protocol based on the Internet and ACT. It combines a face-to-face conversation with a mobile application ("app") between sessions to facilitate ACT and self-acceptance practice, and behavior change [17]. This therapy is delivered primarily through video watching, audio listening, animated presentations, written exercises, and telephone consultation based on ACT. Compared to traditional methods, it has many advantages. For example, its flexibility allows clients to access therapeutic content at any time [18]. In addition, the comparison between face-to-face and web-based interventions shows no differences in effectiveness [19]. A transdiagnostic meta-analysis was conducted to examine the efficacy of IACT in relieving anxiety and depression and improving the life quality and PF of adults [20]. Although there are few meta-analyses on the effectiveness of IACT for adolescents, preliminary results indicated that IACT could increase PF. In recent years, many clinical trials on the effectiveness of IACT in adolescent mental health interventions have been conducted, but related meta-analyses were not performed.

This meta-analysis reviewed published RCTs and evaluated the efficacy of IACT on adolescent mental health. The results can provide clinicians and practitioners with evidence-based research to reduce bias in treatment decisions and guide future research. The current review and meta-analysis aim to address the following questions:

1. What is the efficacy of IACT interventions (compared to control groups) in improving adolescent mental health?
2. What are the risks of bias inherent in the relevant studies?

2 Methods

The systematic review and meta-analysis were performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [21] and Cochrane Handbook for Systematic Reviews of Interventions Version 5.4 [22]. The protocol was registered with the PROSPERO number CRD42022323974.

2.1 Search Strategy

After the initial scoping searches, relevant studies were searched by key terms in PubMed, ProQuest, APA (PsycNET/PsycINFO), and Web of Science from inception to January 2022. These terms included:

(Internet Based Intervention, Internet-Based Interventions, Web-Based Intervention, Web-Based Intervention, Online Intervention, Internet Intervention, Internet-Delivered, Web-Delivered, Mobile Applications, Mobile App, Mobile Apps, App) and (Acceptance and Commitment Therapy, IACT, ACT) and (Adolescents, Adolescence, Teens, Teen, Teenagers, Teenager, Youth, Youths, Adolescents, Female Adolescent, Male Adolescent). Search terms were adjusted for each database, including the use of MeSH terms and Cochrane filters as required. Furthermore, the website of the Association of Contextual Behavioral Science (<http://contextualscience.org>) was also retrieved. To minimize potential publication bias, unpublished dissertations were searched, and relevant documents were added according to their reference list. Studies were also manually searched based on their reference lists, systematic reviews, and related article features in databases.

2.2 Study Selection

2.2.1 Studies were Included Based on the Following Criteria

- (a) The study must be an RCT testing the effects of ACT as an intervention before and after the intervention implementation at the group level;
- (b) Study participants must be adolescents (including junior high, high school, and college students);
- (c) The intervention must be performed using IACT;
- (d) The study must have reported pre-test and post-test results of the IACT measurements;
- (e) The study must be peer-reviewed.

2.2.2 Studies with Any of the Following Features Were Excluded

- (a) Reanalysis of data from previously published studies (including reviews and meta-analyses);
- (b) Face-to-face ACT intervention;
- (c) Not published in English;
- (d) Insufficient data were used to calculate the effect size.

Two researchers with database searching skills and ACT expertise independently screened and cross-checked the literature according to the above criteria. A third reviewer was responsible for resolving any discrepancies.

2.3 Data Extraction and Quality Assessment

After reviewing the full text, the following data were extracted: (a) Participants: country, sample size, age, condition, retention rate; (b) Studies: study design, results, online intervention modalities and duration, intervention content, outcome measurement tools, mean and standard deviation after the experiment (statistical significance is represented by p values, and clinical significance is denoted by effect sizes).

All literature quality was evaluated using the Cochrane Risk of Bias Tool endorsed by the PRISMA guidelines [22]. The tool includes seven parts: (a) “random sequence generation”; (b) “allocation concealment”; (c) “blinding of participants and personnel”; (d) “blinding of outcome assessment”; (e) “incomplete outcome data”; (f) “selective outcome reporting”; (g) “other bias”. The risk of bias in each study was classified as low, high, or unclear based on uniform judgment.

2.4 Meta-Analysis

The current meta-analysis was performed using the standard mean difference (SMD) and associated 95% confidence interval (CI) of effective measures and presented in a single forest plot. The effect size of each study was calculated using Hedges' G [23]. According to Cohen's theory, $0.2 \leq SMD < 0.5$ is a small effect, $0.5 \leq SMD < 0.8$ is a medium effect, and $SMD \geq 0.8$ is a large effect [24]. Heterogeneity between results was examined by the I^2 test, and the standard for I^2 reflects the proportion of

heterogeneity in the total effect size variation. If $0 < I^2 < 40$, there is low heterogeneity; if $40 < I^2 < 60$, there is moderate heterogeneity; if $60 < I^2 < 75$, there is substantial heterogeneity; if $75 < I^2 < 100$, there is considerable heterogeneity. If heterogeneity existed between study samples, a random effect model was used to evaluate the effect of IACT. Review Manager 5.4 software was adopted to calculate the effect size.

3 Results

3.1 Selection of Studies

Fig. 1 illustrates the flow diagram from searching to article inclusion based on PRISMA guidelines. A total of 3064 articles were identified through database searching, and 3 articles were found by searching reference lists. After removing duplicates, 489 articles were screened based on title and abstract, of which 440 were excluded for various reasons (e.g., review articles or qualitative research). The eligibility of 49 articles was assessed by reading the full text, and 37 studies were excluded for the reasons listed in Fig. 1. Finally, 12 studies were included that met all criteria.

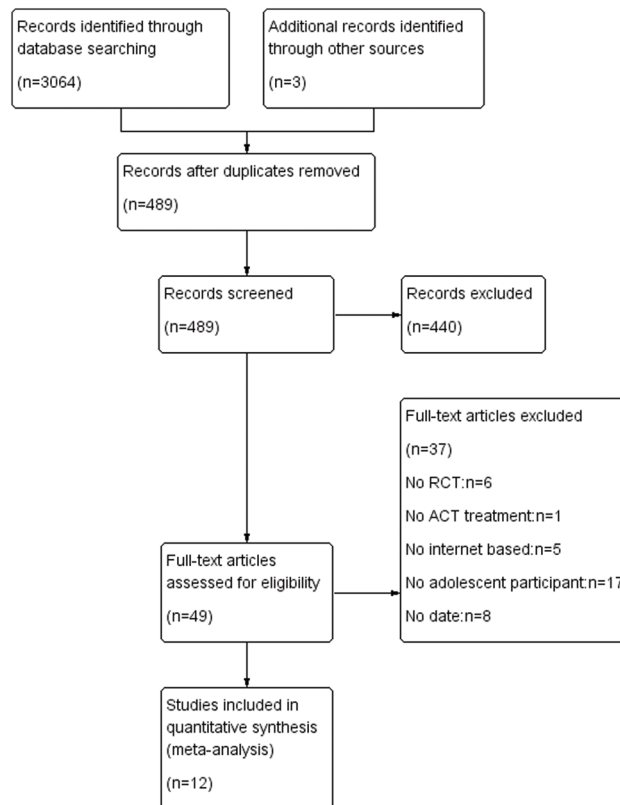


Figure 1: PRISMA flow diagram

3.2 Sample Characteristics and Demographics

Among the included studies, 2588 adolescents were included, of which 2160 were university students [5,9,11,25–30], 367 were secondary school students [31,32], and 61 were indigenous youths [33]. The mean age ranges from 15.27 to 26.85. A total of 5 included studies were in the targeted screening group (suffered from distress or having suicidal thoughts in the past 2 weeks), and 5 were in the universal screening group. In terms of country, 5 of the included studies were from the United States [5,11,25–27], 2 from Australia

[29,33], 3 from Finland [28,31,32], 1 from China [30], and 1 from Ireland [9]. Table 1 illustrates the characteristics of the participants.

Table 1: Demographic details of participants

Author (year)	Country	Sample size	Age	Sample description	Sample condition	Retention rate
Eustis et al. (2018) [11]	USA	156 (T:78/C:78)	M = 25.4	University students	universal	96.2%
Lappalainen et al. (2021) [31]	Finland	162 (T:80/C:82)	M = 15.27	Secondary school students	universal	96.0%
Larsson et al. (2022) [9]	Ireland	113 (T:52/C:61)	M = 25.06	University students	universal	89%
Levin et al. (2014) [25]	USA	76 (T:37/C:39)	M = 18.37	University students	universal	Did not report
Levin et al. (2016) [26]	USA	234 (T:114/C:120)	M = 21.61	University students	universal	65.8%
Levin et al. (2017) [5]	USA	79 (T:40/C:39)	M = 20.51	University students	targeted (suffered from distress)	78.5%
Levin et al. (2020) [27]	USA	90 (T:45/C:45)	M = 22.27	University students	targeted (suffered from distress)	89%
Puolakanaho et al. (2019) [32]	Finland	205 (T:123/C:82)	M = 15.27	Secondary school students	universal	96.0%
Räsänen et al. (2016) [28]	Finland	68 (T:33/C:35)	M = 24.29	University students	targeted (suffered from distress)	100%
Tighe et al. (2017) [33]	Australia	61 (T:31/C:30)	M = 26.25	Youths	targeted (had suicidal thoughts in the previous 2 weeks)	97%
Viskovich et al. (2020) [29]	Australia	1162 (T:596/C:566)	M = 26.85	University students	universal	52%
Zhao et al. (2022) [30]	China	182 (T:95/C:87)	M = 21.76	University students	targeted (being in distress)	92.3%

Note: T = treatment groups; C = control groups; M = mean age; Retention rate = percentage of participants who finished post-intervention/follow-up assessment.

3.3 Study Characteristics

According to the inclusion criteria, all included studies were RCTs, which were divided into 2-arm RCT, 3-arm RCT, and 4-arm RCT based on different research purposes. The experimental group was treated with IACT, while the control group was subject to WLC (waiting list control) or traditional therapy (mental health education).

Online intervention modalities include videos, online self-help platforms and WhatsApp messages from coaches; audio exercises; web-based self-help programs; multimedia sessions; apps; pictures; text; animation; MP3; and Emails. The duration of online intervention was 3 to 12 weeks.

Intervention projects were selected based on the six therapeutic processes of ACT, which include acceptance (embracing internal experiences without altering their form or frequency); cognitive defusion (achieving psychological distance from internal experiences); presence (ongoing, non-judgmental contact with psychological and environmental events as they occur); self-as-context (observing or noticing one's inner/outer world and taking a flexible perspective); values (choosing valued life directions); and committed action (acting in service of one's chosen values) [34].

The primary outcome measures were depression (9 studies; $n = 2111$), anxiety (7 studies; $n = 1888$), and stress (7 studies; $n = 2014$); the secondary were well-being (10 studies; $n = 2307$) and experiential avoidance (6 studies; $n = 1654$). Table 2 summarizes study characteristics and findings for all included studies.

Table 2: Summary of included studies

Author (year)	Study design	Results	Online intervention modalities	Online intervention duration	Intervention project components	Outcome measure tools
Eustis et al. (2018) [11]	2-arm RCT Intervention group: web-based acceptance-based behavioral therapy Control group: WLC	Participants in the SATDS condition had significantly lower stress (general anxiety, $p = 0.04$) scores across time-points.	Videos	4 weeks	(1) Psychoeducation; (2) Mindfulness; (3) Values.	Depression Anxiety Stress Scales (DASS); Brief Fear of Negative Evaluation Scale (BFNE); Acceptance and Action Questionnaire (AAQ); Philadelphia Mindfulness Scale (PHLMS); Quality of Life Inventory (QOLI); Valued Living Questionnaire (VLQ); Experiences Questionnaire (EQ).
Lappalainen et al. (2021) [31]	3-arm RCT Intervention group 1: online intervention with two face-to-face sessions Intervention group 2: online intervention without face-to-face sessions Control group: no treatment	The change in the two intervention groups was not significantly different compared with the control group regarding depressive symptoms ($p = 0.153$); life satisfaction ($p = 0.195$).	Online self-help platform and WhatsApp messages sent by coaches	5 weeks	(1) Direction for Life; (2) Direction for Life; (3) "Stalking Myself"; (4) My Myself; (5) Me and Other People.	Depression Scale (DEPS); Satisfaction with Life Scale (SWLS); Avoidance and Fusion Questionnaire for Youth (ATQ-Y).
Larsson et al. (2022) [9]	2-arm RCT Intervention group: IACT intervention Control group: WLC	The results indicated significant improvements in general mental health in the ACT group compared with the control group ($p = 0.05$, $d = 0.48$) after treatment but not at follow-up.	Audio exercises	3 weeks	(1) Contact with the present moment; (2) Cognitive defusion; (3) Self as context.	General Health Questionnaire (GHQ); Depression Anxiety Stress Scale (DASS); Acceptance and Action Questionnaire (AAQ).

(Continued)

Table 2 (continued)

Author (year)	Study design	Results	Online intervention modalities	Online intervention duration	Intervention project components	Outcome measure tools
Levin et al. (2014) [25]	2-arm RCT Intervention group: web-based ACT program Control group: WLC	For distressed students in the intervention group, their anxiety ($p = 0.033$) and depression ($p = 0.018$) were significantly relieved. Among non-distressed students, no significant differences between the two groups were observed in depression or anxiety.	Web-based self-help program and emails	3 weeks	(1) Exploring your values (Defining what values are, clarifying one's values, reflecting on one's values, defining effective and values-based goals, Goal setting, Wrapping up); (2) Dealing with barriers (Review of the last session, exploring internal barriers to actions, the problem with control strategies, the problem with control strategies, linking willingness to values-based actions, and wrapping up).	Depression Anxiety Stress Scales (DASS); Acceptance and Action Questionnaire (AAQ).
Levin et al. (2016) [26]	2-arm RCT Intervention group: ACT on College Life (ACT-CL) website Control group: mental health education (MHE) website	There were no significant differences ($p < 0.05$) between ACT-CL and MHE programs.	Multimedia sessions and emails	3 weeks	(1) Exploring your values; (2) Dealing with barriers.	Depression Anxiety Stress Scales (DASS); Mental Health Continuum-Short Form (MHC-SF); Avoidance and Fusion Questionnaire for Youth (AFQ-Y); Personal Values Questionnaire-Relationship and Education Subscales (PVQ); Five Facet Mindfulness Questionnaire (FFMQ); ACT Knowledge Questionnaire System Usability Scale (SUS); Program usage.
Levin et al. (2017) [5]	2-arm RCT Intervention group: online intervention Control group: WLC	CCAPS ($p = 0.005$) and MHC ($p = 0.001$) improved from pre-treatment to post-treatment in the ACT condition. No improvements were observed in the waitlist condition ($p > 0.10$).	Emails and web-based survey platform	4 weeks	(1) Costs of experiential avoidance; (2) Defusion; (3) Mindfulness; (4) Acceptance of difficult emotions; (5) Clarifying personal values; (6) Committed action and goal setting.	CCAPS-34 Mental Health Continuum-Short Form (MHC-SF); Acceptance and Action Questionnaire (AAQ); Cognitive Fusion Questionnaire (CFQ); Valuing Questionnaire (VQ); Philadelphia Mindfulness Scale (PHLMS).

(Continued)

Table 2 (continued)

Author (year)	Study design	Results	Online intervention modalities	Online intervention duration	Intervention project components	Outcome measure tools
Levin et al. (2020) [27]	4-arm RCT Intervention group: online intervention Control group: WLC	All three ACT conditions significantly improved over time relative to the waitlist condition on the primary outcome of mental health symptoms (psychological distress: $p < 0.001$; mental health wellbeing: $p < 0.05$).	Web-based self-help programs and phone coaching or email prompts	12 weeks	(1) Noticing experiential avoidance and its short-term and long-term impacts; (2) Introducing acceptance as an alternative and teaching how to break experiential avoidance patterns; (3) Treating unwanted internal experiences as "passengers on the bus," a part of one's experience that does not have to determine action; (4) Identifying cognitive fusion and its negative effects; (5) Practicing meditation exercises to defuse thoughts; (6) Defusing from thoughts with brief skills (e.g., labeling it and saying it backward); (7) Identifying personal values; (8) Connecting values to qualities of action; (9) Exploring and discovering new values; (10) Setting SMART goals; (11) Learning how to make commitments; (12) Noticing when one drifts from commitments and recommitting.	Mental Health Symptoms (CCAPS); Positive Mental Health (MHC-SF); Acceptance and Action Questionnaire (AAQ); Cognitive Fusion Questionnaire (CFQ); acceptance subscale of the Philadelphia Mindfulness Scale (PHLMS); Valuing Questionnaire (VQ-Obs & VQ-Pro); Committed Action Questionnaire (CAQ).
Puolakanaho et al. (2019) [32]	3-arm RCT Intervention groups: (i) IACT face group (web-based interventions plus a face-to-face meeting) (ii) IACT group (only web-based intervention) Control group: TAU	The intervention group showed a small but significant decrease in overall stress ($p = 0.037$).	Web-based self-help platform	5 weeks	(1) Direction for Life ACT-processes: finding personal interests and goals; (2) Me and My Mind ACT-process: promoting awareness of self and acceptance and cognitive defusion skills; (3) "Stalking Myself" ACT-process: being in the present and practicing acceptance; (4) Me and Myself ACT-process: recognizing the self as a context and providing self-compassion; (5) Me and Other People ACT-process: applying important actions to social life and being compassionate toward others.	Overall Stress; School Stress; Academic Buoyancy.

(Continued)

Table 2 (continued)

Author (year)	Study design	Results	Online intervention modalities	Online intervention duration	Intervention project components	Outcome measure tools
Räsänen et al. (2016) [28]	2-arm RCT Intervention group: IACT intervention Control group: WLC	Results indicated that the participants with IACT had significantly improved well-being (between groups, $d = 0.46$), life satisfaction ($d = 0.65$), and mindfulness skills ($d = 0.49$). In the IACT group, participants' self-reported stress ($d = 0.54$) and symptoms of depression ($d = 0.69$) were significantly reduced compared to those in the control group.	MP3, videos	7 weeks	(1) Clarifying values; (2) Taking action; (3) Being present; (4) Watching one's thinking; (5) Awareness and acceptance.	Mental Health Continuum-Short Form (MHC-SF); Perceived Stress Scale-10 (PSS-10); Beck Depression Inventory (BDI-II); Depression Anxiety Stress Scales (DASS); Finnish Descriptive Visual Rating Scale Acceptance and Action Questionnaire (AAQ); Five Facet Mindfulness Questionnaire (FFMQ); Orientation to Life Questionnaire (OLQ-13).
Tighe et al. (2017) [33]	2-arm RCT Intervention group: app-based acceptance-based therapy Control group: WLC	Results indicated that the app, with acceptance-based therapy, reduced depression symptoms ($p < 0.01$) and psychological distress ($p < 0.05$) in the target population but did not significantly change the suicidality or impulsivity tendency.	App	6 weeks	(1) Learning to identify thoughts (including suicidal thoughts), feelings, and behaviors (including suicidal behavior), and learning distancing techniques; (2) Regulating emotions through mindfulness, acceptance, and self-soothing activities that were social; (3) Identifying values important to them.	Depressive Symptom Inventory-Suicidality Subscale (DSI-SS); Patient Health Questionnaire 9 (PHQ-9); Kessler Psychological Distress Scale (K10); Barratt Impulsivity Scale (BIS-11).
Viskovich et al. (2020) [29]	2-arm RCT Intervention group: IACT intervention Control group: WLC	Results indicated that compared with waitlist control, significant results were found for post-intervention wellbeing ($t = 3.58$, $p = 0.001$) and education values success ($t = 4.57$, $p < 0.001$).	Videos	4 weeks	(1) Values and committed action (2) Cognitive Defusion (3) Acceptance (4) Mindfulness and the self-observer.	Depression Anxiety Stress Scales (DASS); Mental Health Continuum Short Form Self-Compassion Scale Short Form Satisfaction with Life Scale Academic performance Acceptance and Action Questionnaire II Cognitive Fusion Questionnaire Education values and general values-based living Mindful Attention Awareness Scale.
Zhao et al. (2022) [30]	2-arm RCT Intervention group: IACT intervention Control group: WLC	The results indicated more significant improvement in depressive symptoms ($d = 1.27$) and positive mental health ($d = 0.59$), both at T1 and T2.	Pictures, text, audio, videos, and animation	6 weeks	(1) Depression is not terrible, and realizing the truth of depression; (2) Refusing avoidance and accepting something when you cannot change it; (3) Cognitive fusion, improving and controlling your life; (4) Self-awareness; becoming a psychological observer of yourself; (5) Living in the present moment and practicing mindfulness; (6) Living according to your values and committing to action.	Depressive symptoms (BDI-II); Mental Health Continuum-Short Form; The Systematic Treatment Selection Self-Report (STS-SR); The Reasons for Depression Questionnaire (RFD).

Note: RCT = randomized controlled trial; IACT = acceptance and commitment therapy; WLC = waitlist control.

3.4 Results of Risk of Bias

Five studies were at low risk of selection bias (“allocation concealment”) because the random numbers generated by computers were used [5,26,27,30,33,34]. Three studies also had low risk because the assignment of these RCTs was performed by an independent researcher [28,31] or by the lead investigator using a random number table the conditional assignment of participants [9]. Four studies were considered to have unclear risks due to insufficient information [11,25,29,32]. Details of the literature evaluation are shown in Fig. 2.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Eustis 2018	+	?	-	+	+	?	?
Lappalainen 2021	+	+	-	?	+	+	?
Larsson 2022	+	+	-	+	-	-	?
Levin 2014	+	?	-	+	+	+	?
Levin 2016	+	+	-	+	+	+	?
Levin 2017	+	+	-	+	+	+	?
Levin 2020	+	+	-	+	+	+	?
Puolakanaho 2018	+	?	-	+	+	+	?
Räsänen 2016	+	+	-	+	+	+	?
Tighe 2017	+	+	-	+	+	+	?
Viskovich 2020	+	?	-	+	+	+	?
Zhao 2022	+	+	-	?	+	+	?

Figure 2: Risk of bias graph

3.5 Effects of IACT on Depression, Anxiety, and Stress

The primary outcome measures were depression, anxiety, and stress. The effects of IACT on depression were investigated in 9 RCTs (N = 2111 participants). According to the evaluation criteria, 9 RCTs revealed that IACT had significant efficacy on depression compared to control groups (SMD = -0.24, 95% CI = [-0.44, -0.05], $p = 0.01$; Fig. 3). Notably, there was a great heterogeneity ($I^2 = 71%$) among these studies. Based on 7 RCTs (N = 1880 participants), there was no significant improvement in anxiety in IACT group compared to the control groups (SMD = -0.18, 95% CI = [-0.27, -0.09], $p < 0.0001$; Fig. 3). There was a low heterogeneity among the studies ($I^2 = 0%$). In 7 RCTs (N = 2014 participants), the group with IACT interventions showed a smaller and non-significant effect on stress compared to control groups (SMD = -0.16, 95% CI = [-0.35, 0.03], $p = 0.10$; Fig. 3). There is great heterogeneity among these studies ($I^2 = 68%$).

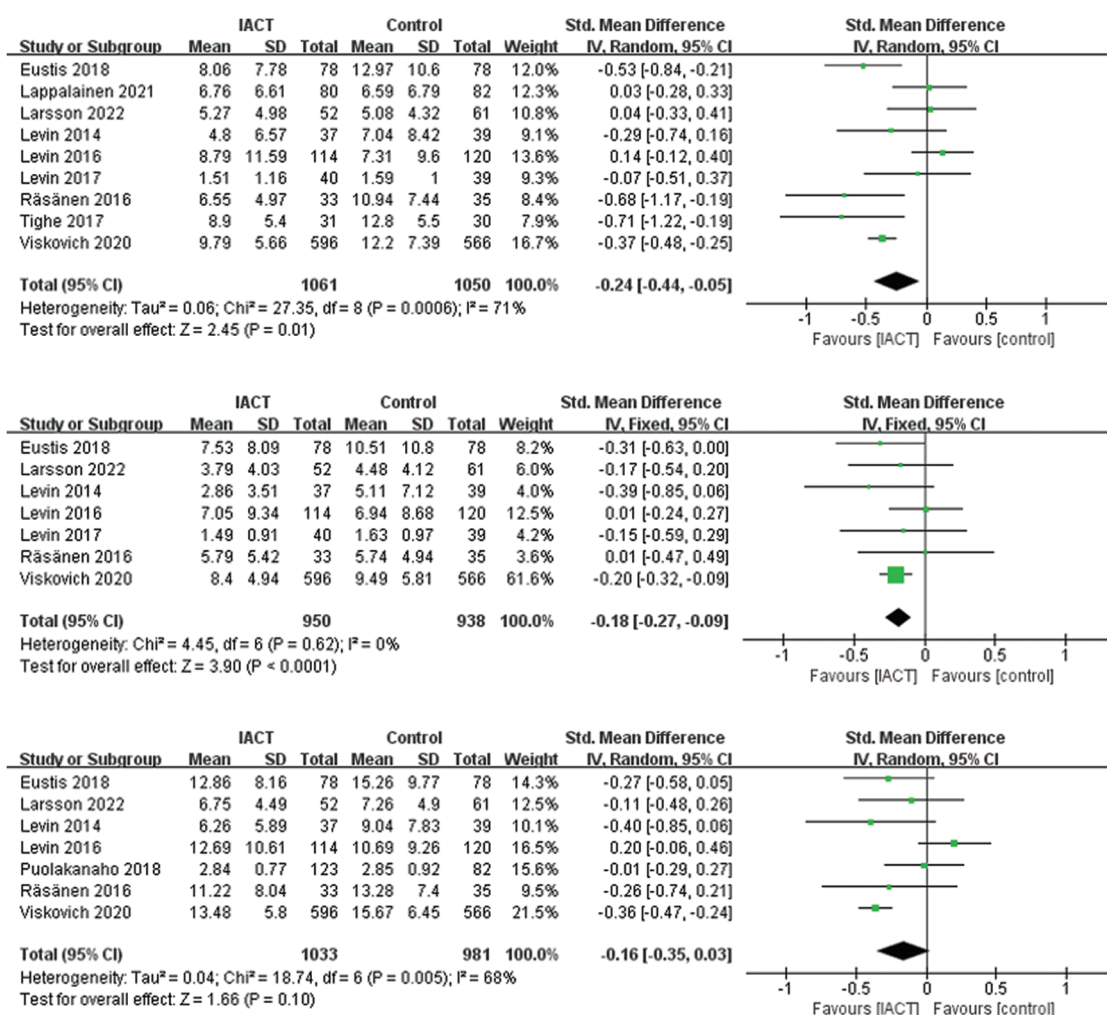


Figure 3: Effects of IACT on depression, anxiety, and stress

Despite insufficient studies on other outcome measures for subgroup analysis, we performed a subgroup analysis of depression outcome measures to assess whether groups with different conditions (universal/targeted) produced different treatment effects. A total of 9 RCTs reported sample conditions of depression outcome measures, including 1903 universal adolescents and 208 targeted adolescents (suffered from

distress or having suicidal thoughts in the past 2 weeks). Meta-analysis of the random-effects model showed no significant difference between the universal and targeted groups in improving the efficacy of IACT. However, the therapeutic effect on depression was mainly shown in the targeted group (SMD = -0.47, 95% CI = [-0.89, -0.05], $p = 0.03$; Fig. 4).

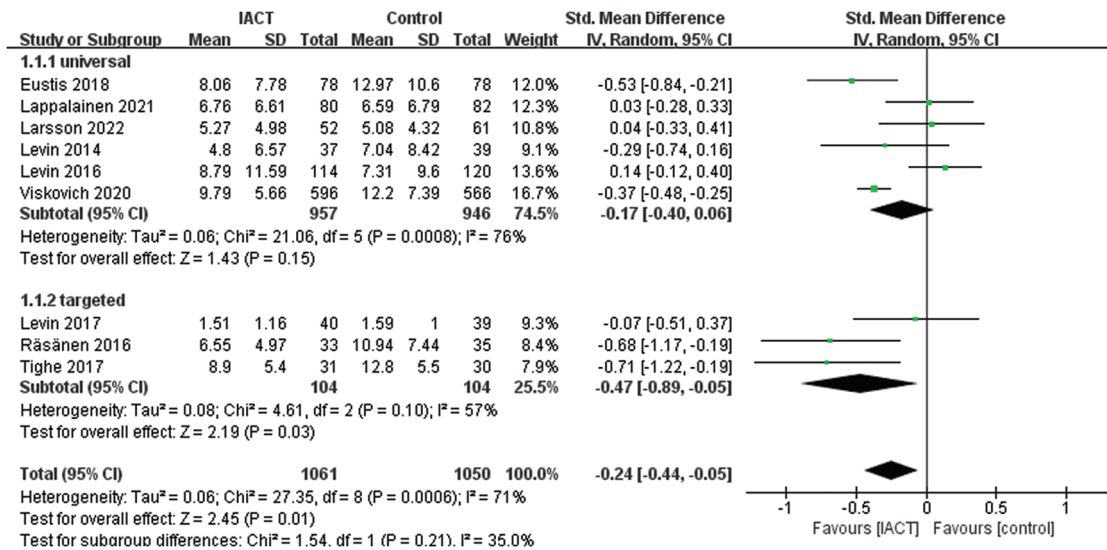


Figure 4: Effects of IACT on depression in different groups

3.6 Effects of IACT on Well-Being

The secondary outcome measure was well-being. A meta-analysis of 10 RCTs (N = 2307 participants) showed that the overall effect of IACT interventions on well-being was not statistically significant (SMD = 0.09, 95% CI = [-0.16, 0.33], $p = 0.49$; Fig. 5). In addition, this analysis showed the highest degree of heterogeneity among studies (I² = 84%).

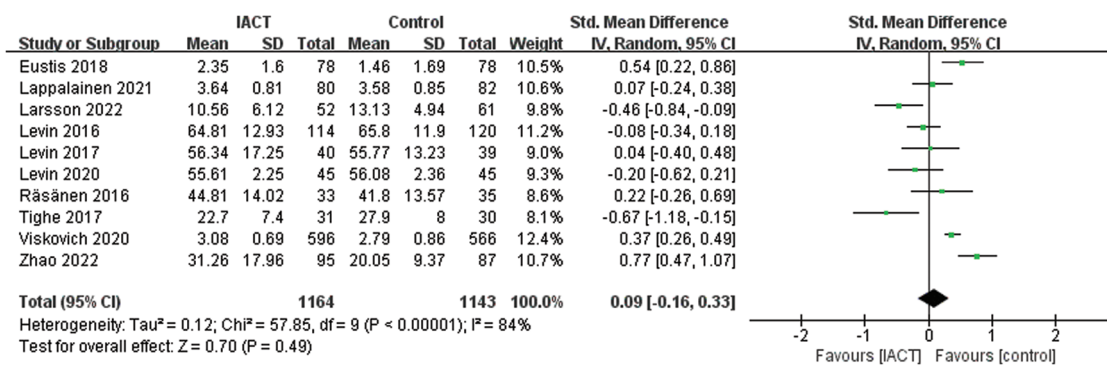


Figure 5: Effects of IACT on well-being

3.7 Effects of IACT on Experiential Avoidance

As mentioned above, a meta-analysis was conducted on the effect of IACT on experiential avoidance. In 6 RCTs (N = 1654 participants), the groups with IACT interventions showed less effect on experiential avoidance than the control groups (SMD = -0.24, 95% CI = [-0.46, -0.01], $p = 0.04$; Fig. 6). There is a great heterogeneity (I² = 65%) among studies.

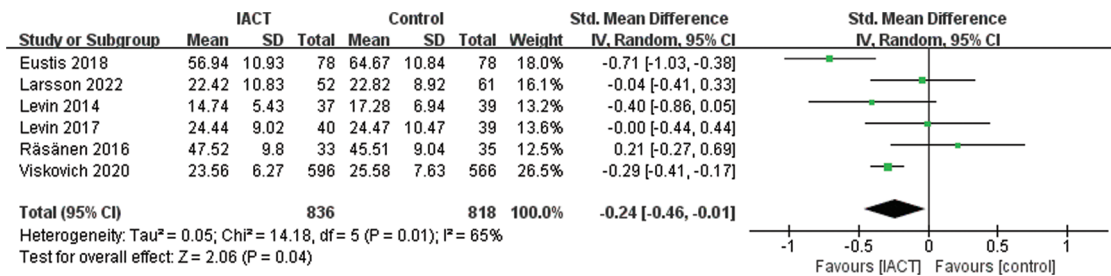


Figure 6: Effects of IACT on experiential avoidance

4 Discussion

As far as we know, this is the first meta-analysis regarding the efficacy of IACT in adolescents. IACT is likely to be an effective and popular method for promoting the well-being of adolescents [31]. Although existing RCTs demonstrate the efficacy of IACT, there is no meta-analysis on the application of IACT in adolescents and its development. A transdiagnostic meta-analysis confirmed the effectiveness of IACT in relieving anxiety and depression and improving life quality and PF in adults [20]. However, there was no particular discussion of the adolescent population. In the current study, some of these studies and the latest RCTs were selected. Adolescents were considered as the research objects because they are proficient in internet operation and willing to accept online psychological intervention. The results verified our hypothesis, with a high retention rate for most studies.

The systematic review included 12 studies examined the effects of IACT interventions on the mental health of adolescents. Afterward, meta-analyses were separately conducted for primary and secondary outcome measures using standardized mean deviations. Although there were few studies on the effect of IACT on adolescents, preliminary results suggested that IACT had some efficacy for depression (SMD = -0.24) and a small effect on anxiety (SMD = -0.18), while there were no statistically significant differences in its impact on stress and well-being. These results can be compared with another meta-analysis that examined the role of ACT in improving the well-being of college students [35]. It revealed a significant, small pooled effect size ($d = 0.29$) of ACT on university students' well-being. Differences between face-to-face and online interventions may explain this slight difference. Regarding PF, IACT had a small but significant effect on experiential avoidance (SMD = -0.24). Subgroup analysis showed that IACT was more effective in treating targeted adolescents than universal adolescents because of the higher baseline levels of mental health and poorer improvement from psychological interventions. The findings of the present study partially support previous meta-analyses of other populations [20,36–39].

The high heterogeneity in this study may be caused by the differences in the included studies, with the main differences possibly arising from the different measurement instruments. As for the primary outcome indicators, most studies used the DASS to measure depression, anxiety, and stress, and some adopted the DEPS scale, CCAPS scale, HBSC scale, PHQ scale, and BDI scale. Among 12 studies, 5 different indicators were applied to measure well-being. Most studies used the MHC-SF [40], followed by the QOLI scale, SWLS scale, GHQ scale, and K10 scale, reflecting the difference between psychological studies.

The high risk of performance bias for “blinding of participants and personnel” across all studies reflected the universality of psychotherapy research. Blinding of participants and therapists was not feasible in intervention trials of this nature [41]. It is difficult to blind subjects and outcome evaluators based on the nature of online psychological research. In each study, participants were randomly assigned to different conditions, and the “random sequence generation” was assessed as ‘low risk’ in all included studies. Most articles reported all pre-specified outcomes, such as M and SD, which had good psychometric properties and were considered low risk. Only one study was assessed as high risk [9]. Because of the

insufficient data, we contacted the authors and obtained the data. In addition, the risk of other biases was assessed as unclear in all studies.

The results of this review suggest that IACT can improve depression, anxiety, and experiential avoidance in adolescents. In addition, subgroup analyses show that IACT is more effective for adolescents with psychological problems. Since the number and quality of included research are limited, the results as mentioned earlier must be supported by more high-quality studies. However, the practical significance of IACT needs to attract more attention because it breaks through the limitations of traditional face-to-face ACT. It can be carried out at any time and space and is worthy of promotion on campus. In future studies, more high-quality RCTs are needed to verify the intervention effect of IACT.

5 Limitations

There are still some limitations in this study. First, the number of RCTs included in this study is limited because only adolescents are involved. In addition, the quality of the included studies is low. Because subjects and bureau assessors in all RCTs are not blinded, the risk of implementation and measurement bias is high, partially affecting the credibility of the study results. Finally, the measurement tools in these studies are different, resulting in a high degree of heterogeneity in research findings.

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