



A meta-analysis of emotional regulation outcomes in psychological interventions for youth with depression and anxiety

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Difficulties in applying emotional regulation (ER) skills are associated with depression and anxiety symptoms, and are common targets of treatment. This meta-analysis examined whether improvements in ER skills were associated with psychological treatment outcomes for depression and/or anxiety in youth. A multivariate, random-effects meta-analysis was run using metafor in R. Inclusion criteria included studies that were randomized controlled trials (RCTs) of a psychological intervention for depression and/or anxiety in patients aged 14–24, were peer reviewed, were written in English, measured depression and/or anxiety symptoms as an outcome and measured ER as an outcome. Medline, Embase, APA PsycInfo, CINAHL and The Cochrane Library were searched up to 26 June 2020. Risk of bias (ROB) was assessed using the Cochrane Collaboration Risk of Bias 2.0 tool. The meta-analysis includes 385 effect sizes from 90 RCTs with total $N = 11,652$. Psychological treatments significantly reduced depression, anxiety, emotion dysregulation ($k = 13$, Hedges' $g = 0.54$, $P < 0.001$, 95% confidence interval (CI) = 0.30–0.78) and disengagement ER ($k = 83$, $g = 0.24$, 95% CI = 0.15–0.32, $P < 0.001$); engagement ER also increased ($k = 82$, $g = 0.26$, 95% CI = 0.15–0.32, $P < 0.001$). Improvements in depression and anxiety were positively associated with improved engagement ER skills, reduced emotion dysregulation and reduced disengagement ER skills. Sensitivity considered study selection and publication bias. Longer treatments, group formats and cognitive-behavioural orientations produced larger positive associations between improved ER skills and reduced symptoms. ER skill improvement is linked to depression and anxiety across a broad range of interventions for youth. Limitations of the current study include reliance on self-report measures, content overlap between variables and inability to test the directionality of associations.

Depressive and anxiety disorders most often begin in adolescence and young adulthood, before the age of 24 (ref. ¹). Depression and anxiety are common and disabling conditions that often co-occur^{2–4}, increasing the potential for mental-health difficulties and suicidal behaviour in adulthood if not treated^{1,3–5}. Given the substantial and sustained burden caused by these symptoms in young persons, it is critically important to identify effective psychosocial interventions to further advance treatment and prevention efforts. Equally important is the exploration of the specific components of psychological interventions that are associated with successful reduction in clinical symptoms⁶. Here, we examined how three indices of emotional regulation (ER) skills were associated with changes in depression and anxiety symptoms following psychological interventions for youth and young adults aged 14–24.

In daily life, we implement ER skills to change the frequency, intensity and duration of negative emotional experiences (for example, reframing the impact of a poor grade)⁷. ER skills are also used to increase or maintain positive emotional experiences (for example, celebration of a milestone with others). These skills can be intrapersonal, originating from inside a person, and interpersonal, involving an interaction with others. Indeed, many emotions happen in a social context and can be regulated through others as much as our own selves⁸. Skills can have both cognitive and behavioural components, such as physically avoiding an anxiety-provoking situation

or using experiential avoidance to avoid unwanted thoughts, emotions and physical sensations. Thus, ER skills represent a broad set of processes or strategies for monitoring, evaluating and modifying our emotional experiences in the short-term and dynamically over time⁷. From childhood to young adulthood, we are continuously diversifying our ER skills, learning from caregivers and interpersonal relationships⁹, as higher-order cognition develops and new contexts are encountered^{10–12}. We even become willing to experience negative emotions for others in different interpersonal contexts (for example, parenting, social relationships) to serve long-term hedonic or prosocial benefits¹³. As adults, we start to exhibit more stable patterns of ER skills most frequently used and individual differences in how we respond to emotional experiences are linked to a range of interpersonal, psychological and physical well-being indices^{14–16}. Existing research suggests that individual differences in intrapersonal and interpersonal ER skills are transdiagnostic factors that underlie the development and course of depression and anxiety disorders^{17–20}.

Using the process model framework⁷, mental disorders such as depression and anxiety are said to arise from failures to select and implement ER skills effectively. Indeed, evidence suggests that dysfunctional patterns in intrapersonal ER skills in youth and young adults are positively associated with symptoms of depression and anxiety cross-sectionally^{18,21–23}, and prospectively predict anxiety and depressive symptoms over time^{24,25}. Moreover, individual

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	Emotion dysregulation	Engagement ER	Disengagement ER
Definitions	Often defined as a generalized lack of ER skills, difficulties selecting appropriate skills, or difficulties implementing them. One model suggests six facets of skills difficulties such as poor emotional awareness and clarity, and difficulties engaging in goal-directed and non-impulsive behaviors when upset.	These skills typically involve active engagement with an emotional experience or stimulus (for example, accepting a mistake; reframing it as a learning experience, and generating possible solutions to solve it). Other examples include seeking social support and self-compassion. Engagement ER skills are negatively associated with depression and anxiety symptoms.	These skills typically involve disengagement from an emotional experience through avoidance, suppression of thoughts or emotional expression and repetitive thinking (which typically impedes more active responses). Other examples include distraction and self-criticism. Disengagement ER skills are positively associated with depression and anxiety symptoms.
Example measures	<p>Difficulties in Emotion Regulation Scale: example item, 'When I am upset, I believe there is nothing I can do to make myself feel better' (referring to a general lack of skills).</p> <p>Emotion Regulation Skills Questionnaire: 'I was able to influence my negative feelings' (reversed, perceived ability to modulate emotional experiences).</p>	<p>Emotion Regulation Questionnaire (reappraisal subscale): example item, 'I am able to control my emotions by changing the way I think about the situation I'm in'.</p> <p>COPE Inventory, active coping subscale: 'I concentrate my efforts on doing something about it'.</p> <p>Philadelphia Mindfulness Scale acceptance subscale: 'I try to stay busy to keep thoughts or feelings from coming to mind' (reversed).</p>	<p>Acceptance and Action Questionnaire-II: example item, 'Emotions cause problems in my life'.</p> <p>Ruminative Response Scale: '(when sad or down) I think I won't be able to concentrate if I keep feeling this way'.</p> <p>ERQ (suppression subscale): 'I keep my emotions to myself' and 'I control my emotions by not expressing them.'</p>
Hypotheses	Reduced emotion dysregulation will be notably associated with reduced anxiety and depressive symptoms.	Improved engagement ER skills will be notably associated with reduced anxiety and depressive symptoms.	Decreased disengagement ER skills will be notably associated with reduced anxiety and depressive symptoms.

Fig. 1 | Three ways of measuring improvements in ER over the course of psychological treatment in the present synthesis. A more detailed review, with additional examples of measures, can be found in the Supplementary Information. References corresponding to scales are as follows: the Difficulties in Emotion Regulation Scale⁸², Emotion Regulation Skills Questionnaire⁸³, Emotion Regulation Questionnaire¹⁴, COPE⁸⁴, Philadelphia Mindfulness Scale⁸⁵, Acceptance and Action Questionnaire II (ref. ⁸⁶) and the Ruminative Response Scale⁶⁶.

differences in interpersonal ER skills, such as becoming dependent on others or social settings to regulate one's own emotions (for example, through excessive reassurance or advice seeking)^{20,26} have been shown to predict depressive and anxiety symptoms in adults^{19,27}. When people exhibit several deficits in intrapersonal ER skills or use skills in a manner that is harmful, impulsive and serves to reinforce the heightened experience of negative emotions, they are typically said to be experiencing emotion dysregulation, which is common to depressive and anxiety disorders^{28–30}. Similar to dysfunctional patterns in ER skills, the experience of emotion dysregulation is also positively associated with depressive and anxiety symptom severity^{31–33}. Thus, accumulating evidence suggests that individual differences in the ability to engage in intrapersonal and interpersonal ER skills may have a transdiagnostic role in the development and course of depressive and anxiety disorder symptoms.

One of the challenges in studying ER skills is the wide range of skills identified and variability in their operational definition and assessment. The current integration was guided by previous reviews and focused on ER skills that have a substantial theoretical and empirical foundation as well as validated self-report measures (Fig. 1)^{34,35}. We organized these ER skills into two broad classes that align closely to a two-factor structure used to evaluate their relationship with psychopathology^{34,36}. We define engagement ER skills as those that involve active engagement with an emotional experience or stimulus (for example, acceptance, cognitive reappraisal and problem solving) and are negatively associated with psychopathology if used habitually. Alternatively, disengagement ER skills are those involving disengagement from an emotional experience or stimulus through avoidance, inhibition of thoughts or overt expression, or the use of repetitive thinking (for example, avoidance, suppression and rumination) and are positively associated with psychopathology if used habitually. To give an example, one can accept or engage with the anxiety that comes with giving a presentation in front of an audience or suppress thoughts about its existence that inhibit an

emotional experience. By accepting its existence (or the potential for its occurrence), it may allow one to then reduce of the feeling of anxiety through relaxation or other methods. We acknowledge that adapting skills to situational demands may be most important to mental well-being^{37,38}. However, contextual use of ER skills remains difficult to measure versus habitual ER skill use. In addition, given its association with depression and anxiety symptoms, we also incorporated measures of emotion dysregulation, because treatments that increase general abilities to regulate emotions may also support insights into the treatment of anxiety and depressive symptoms in young people.

Evidence for ER skill improvements during treatments for depression and anxiety is already accumulating. Several reviews have argued that a range of psychological treatments with varied theoretical orientations improve intrapersonal ER skills in youth and adults with heterogeneous clinical presentations^{39,35}. This effect appears to be transdiagnostic across mental disorders and invariant to the type of psychological intervention used. In the most comprehensive review of the literature so far, 95% of studies (which largely focused on adult samples) found substantial decreases in disengagement ER skills and overall emotion dysregulation, regardless of the specific treatment protocol, the construct of ER examined, or the disorder targeted³⁵. Other research has demonstrated that improvements in ER skills during treatment are associated with positive treatment outcomes for a variety of evidence-based psychological treatments, including cognitive-behavioural therapy (CBT), dialectical behaviour therapy (DBT), acceptance and commitment therapy (ACT) and ER therapy, among others^{40–46}. These results indicate that distinct psychological treatments can produce meaningful changes in intrapersonal ER skills, and that these changes may represent a core process across psychological disorders likely to produce change when targeted in treatment⁴⁷. There is also great potential in examining changes in interpersonal ER skills during treatment, given their importance in maintaining depressive and

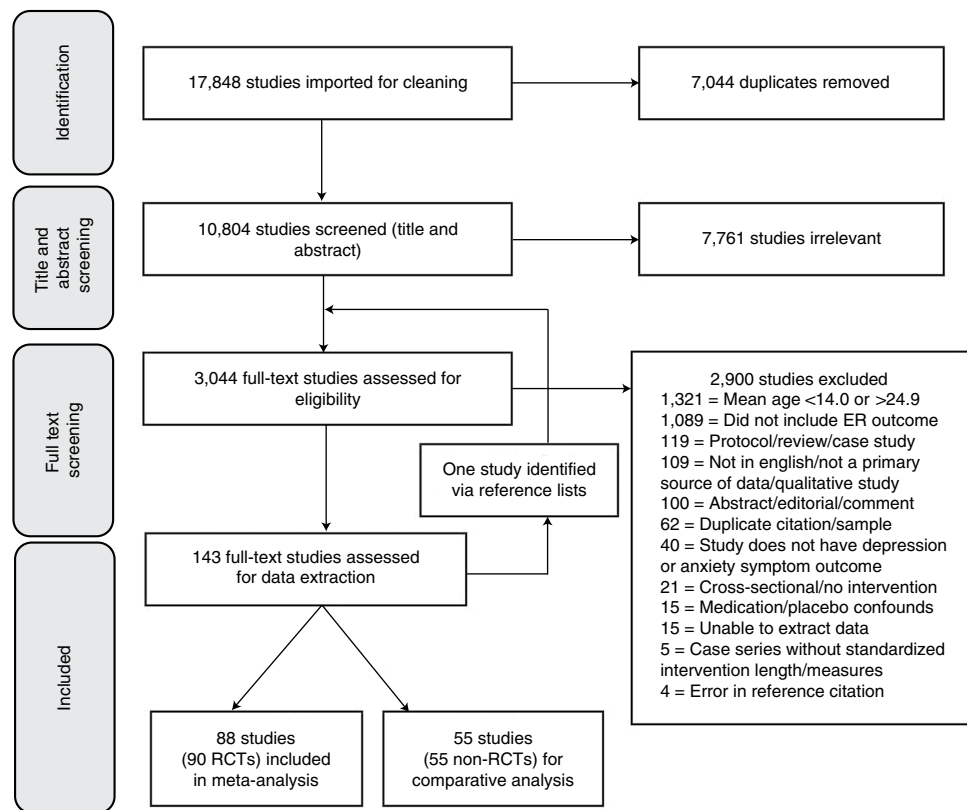


Fig. 2 | PRISMA figure depicting the flow of studies in the present synthesis using a comprehensive search strategy. Two of the 88 studies in the included RCTs section had an additional study reported in their respective paper. Hence, there are a total of 90 RCTs.

anxiety symptoms^{19,20}. While ER skills training may be a key factor to consider in treatment outcomes for depressive and anxiety disorders, few of these studies or reviews have considered multiple indices of ER for enhanced specificity. Moreover, systematic reviews and meta-analyses have less often examined whether improvement in ER skills are associated with depression and anxiety treatment outcomes in young persons.

The present systematic review investigated whether improvements in ER skills are associated with improvements in symptoms in the psychological treatment of anxiety and depression in young persons aged 14–24. We defined anxiety and depression as dimensional symptom constructs, rather than categorical diagnoses, as assessed by validated self-report measures over time. Measures of depression (for example, the Reynolds Adolescent Depression Scale) assessed symptoms of depressed mood and a loss of interest or pleasure in activities, along with difficulties sleeping, fatigue, diminished concentration and suicidal thoughts. Measures of social and/or generalized anxiety (for example, the Spence Children's Anxiety Scale) assessed feelings of worrisome thoughts that tend to recur intrusively leading to experiential avoidance, social anxiety, along with tension and physical changes in the body. Some measures assess both symptoms of depression and anxiety (for example, the Revised Child Anxiety and Depression Scale). Search criteria were designed to be broad to capture as many interventions as possible that were targeted to this age group. We proposed that improvements in ER skills (that is, decreased emotion dysregulation, decreased disengagement ER skills and increased engagement ER skills) would be positively associated with the reduction of depression and anxiety symptoms in young persons. Following the examination of overall effects, we completed sensitivity analyses to further understand in what contexts, and for whom, under which this association is evident

or enhanced. Individual ER skills were also investigated when sufficient information was available. Notably, these research questions and methodology were informed by youth with lived experience, whose recommendations meaningfully shaped this synthesis.

Results

Search results and characteristics of selected studies. As depicted in Fig. 2, our initial search garnered 10,804 results once 7,044 results were removed as duplicates. Following title and abstract screening by two independent team members, 3,044 articles were selected for full-text review and ultimately 143 articles met inclusion criteria and were assessed for data extraction. Data were extracted and primary analyses were conducted using 385 effect sizes from 88 included studies. Two of these studies contained secondary studies, for a total of 90 randomized controlled trials (RCTs) ($n=11,652$). Half of these RCTs (50%) were from countries where English was not a primary language. As seen in Fig. 3, ROB ratings indicated that 85% of RCTs had low or some concerns. Primary findings were compared to 55 non-RCTs ($n=3,224$) that met criteria for inclusion but were analysed separately. A summary of study characteristics for RCTs and non-RCTs is presented in Table 1, with study reference lists found in the Supplementary Information. As further explained in the Supplementary Information, we were unable to locate any studies that used interpersonal ER measures; we highlight other associated findings there, while focusing exclusively on intrapersonal ER skills in the main text.

Most RCTs delivered between two and ten intervention sessions in either college or high school samples with fewer than 100 individuals. RCTs were relatively equal in distribution across three mean age groups (14–17.9, 18–21.9 and 22–24.9) and females were well represented, often being the majority sex in these interventions.

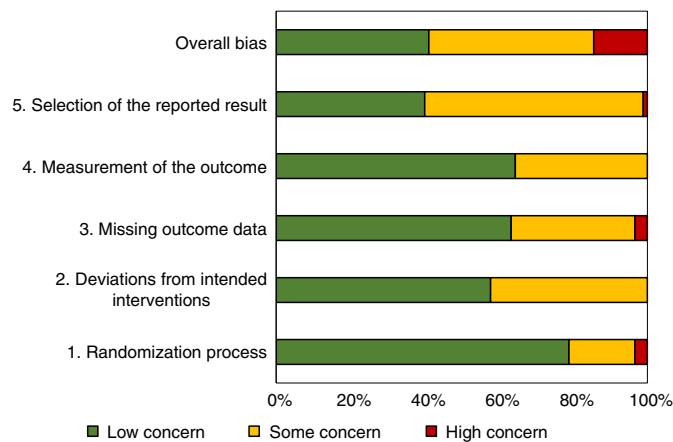


Fig. 3 | Overall and domain-specific Risk of Bias ratings for each of the 90 RCTs included in the meta-analysis. Only the 90 RCTs received ROB ratings as most of the non-RCTs would automatically be rated as having ‘some concern’ owing to lack of randomization and/or random allocation to treatment. Overall ratings are provided with the study characteristics of RCTs in Supplementary Table 1. A full breakdown of ROB ratings per study can be found in Supplementary Table 4.

Almost half of RCTs used an active control (for example, treatment as usual), 42% used an inactive control (for example, waitlist) and 10% used both due to the involvement of multiple intervention arms. Most RCTs used individual or group intervention formats, with fewer online/blended formats (12.5%). There was a wide range of interventions, with CBT-, mindfulness- and acceptance- or ER-based (for example, ACT, DBT) interventions well represented. Categorical analyses indicated several differences between RCT and non-RCT study characteristics (Table 1). For this reason, we conducted supplementary analyses with non-RCTs to ensure that our primary findings could be replicated despite these significant differences in study design and sample features.

Effects of psychological treatments on symptoms and ER. Our meta-analytic findings revealed that psychological treatments produced small-to-medium effect-size decreases in depression symptoms ($k=117$, $g=0.35$, $P<0.001$, 95% CI=0.24–0.46), anxiety symptoms ($k=90$, $g=0.29$, $P<0.001$, 95% CI=0.12–0.40), emotion dysregulation ($k=13$, $g=0.54$, $P<0.001$, 95% CI=0.30–0.78) and disengagement ER skills ($k=83$, $g=0.24$, $P<0.001$, 95% CI=0.15–0.32); they also produced small effect-size increases in engagement ER skills ($k=82$, $g=0.26$, $P<0.001$, 95% CI=0.15–0.32). Heterogeneity estimates were significant for the moderator ($Q(5)=53.46$, $P<0.001$; $I^2=90.65\%$) and residual model ($Q(380)=1,543.06$, $P<0.001$; $I^2=75.37\%$). As displayed in Table 2, main effects for depression and anxiety symptom reduction were consistent across nearly every sensitivity analysis tested, except for cognitive training interventions (see Supplementary Table 3 for heterogeneity statistics). Additionally, studies with a high overall ROB did not produce significant reductions in anxiety symptoms. Psychological treatments produced improvements in ER skills across almost all sensitivity analyses; however, engagement ER skills did not improve with cognitive training interventions and disengagement ER skills did not improve with acceptance/ER-based interventions. Finally, although emotion dysregulation improvements were significant across all analyses, effect sizes could not be calculated in some areas due to a lack of studies.

Are ER skills associated with youth treatment outcomes? Correlational analyses indicated that reduced emotion dysregulation and reduced disengagement ER skills (note, decreases in

these indices were coded positively) had positive associations with improved depression and anxiety symptoms overall (Table 3). Moreover, improved engagement ER skills had positive associations with improved anxiety and depression symptoms across all studies. Likelihood ratio tests indicated that the full model (that is, all correlations estimated) always retained better fit statistics compared to restricted models in which one correlation was set to zero. The correlations between anxiety and engagement ER, $\chi^2(1)=10.54$, $P=0.012$, anxiety and emotion dysregulation, $\chi^2(1)=13.05$, $P=0.003$ and anxiety and disengagement ER, $\chi^2(1)=20.92$, $P<0.001$, were significantly different compared to restricted models where their correlation was set to zero. A similar pattern was found for correlations between depression and engagement ER, $\chi^2(1)=35.96$, $P<0.001$, depression and emotion dysregulation, $\chi^2(1)=8.50$, $P=0.004$ and depression and disengagement ER, $\chi^2(1)=20.29$, $P<0.001$. Finally, the full model retained better fit statistics compared to a restricted model where all six estimated correlations were set to zero, $\chi^2(6)=53.96$, $P<0.001$. Below, we discuss sensitivity analyses with a focus on sample and intervention characteristics for ease (see Table 3 for results related to analytic approach, ROB rating and type of intervention control).

Compared to overall findings, we observed larger positive associations between improved anxiety symptoms and reduced disengagement ER skills for studies with group delivery, college and community/outpatient samples, large sample sizes, mean ages between 14–17.9 and 22–24.9, briefer treatments of six sessions or fewer and CBT- and Mindfulness-based interventions. Associations in the opposite direction from expectations (that is, improvements in anxiety and ER skills were negatively correlated) were observed for studies with blended/online delivery formats, medium sample sizes, as well as cognitive training and acceptance/ER-based interventions. Compared to overall findings, the observed positive relationship between improved depression symptoms and reduced disengagement ER skills was larger for studies with group delivery, longer treatment lengths (greater than six sessions), mean ages between 14–17.9 and 22–24.9, college and high school samples, small and large sample sizes and CBT- and mindfulness-based treatments. Relationships in the opposite hypothesized direction were observed for studies with blended or online delivery formats, medium sample sizes, as well as cognitive training and acceptance- or ER-based interventions.

Compared to overall findings, the observed positive relationship between improved anxiety symptoms and improved engagement ER skills was larger for studies with longer treatments, group delivery formats, samples with mean ages between 14–17.9 and 22–24.9, small and large sample sizes, high school and community/outpatient samples, and CBT-based treatments. Shorter treatment lengths, blended or online delivery and acceptance- or ER-based interventions produced correlations in the opposite direction of expectations (that is, negative correlations). Improved depressive symptoms were associated with improved engagement ER skills across most sensitivity analyses, although observed correlations were larger compared to overall analyses for studies with all sample types, mean ages between 14–17.9 and 22–24.9, longer treatments, group formats and CBT-based interventions. Negative correlations were observed for briefer treatments and those studies with mindfulness- and acceptance/ER-based interventions.

Compared to overall findings, the observed positive association between improved anxiety and reduced emotion dysregulation was larger for studies with longer treatments, samples with mean ages between 14–17.9 and 22–24.9, individual formats of delivery, college students and small sample sizes. The positive association between improved depression and reduced emotion dysregulation was larger than overall findings for briefer treatments, group formats, high school samples, samples aged 14–17.9 and both CBT- and acceptance- or ER-based interventions. No relationships opposite to

Table 1 | Summary of study characteristics for RCTs (*n* = 90) versus non-RCTs (*n* = 55) studies

Variable	Categories	RCT	Non-RCT	Chi square (approximate)
Sample size	1–50	31 (34.4%)	37 (67.3%)	$\chi^2 = 14.78(3)$, $P = 0.002$
	51–100	30 (33.3%)	9 (16.4%)	
	101–200	19 (21.1%)	6 (10.9%)	
	>201	10 (11.1%)	3 (5.5%)	
Mean age (or median if range used)	14–17.9	32 (35.6%)	27 (49.1%)	$\chi^2 = 2.15(2)$, $P = 0.34$
	18–21.9	34 (37.8%)	18 (32.7%)	
	22–24.9	21 (23.3%)	10 (18.2%)	
Percentage female	0–40%	0	4 (7.3%)	$\chi^2 = 6.70(3)$, $P = 0.08$
	41–60%	19 (21.1%)	11 (20.0%)	
	61–80%	37 (41.1%)	23 (41.8%)	
	81–100%	30 (33.3%)	16 (29.1%)	
Type of control	Active (that is, treatment as usual)	44 (48.9%)	8 (14.5%)	$\chi^2 = 1.86(2)$, $P = 0.39^a$
	Inactive (that is, waitlist)	37 (41.1%)	8 (14.5%)	
	Both (that is, study had multiple arms)	9 (10.0%)	0	
	None (that is, single-arm study) ^a	0	39 (70.9%)	
Treatment length	1 session	8 (8.9%)	1 (1.8%)	$\chi^2 = 11.15(4)$, $P = 0.02$
	2–6 sessions	35 (38.9%)	17 (58.2%)	
	7–10 sessions	35 (38.9%)	18 (32.7%)	
	11–14 sessions	9 (10.0%)	10 (18.2%)	
	>14 sessions	3 (3.3%)	8 (14.5%)	
Sample type	High school	23 (25.6%)	10 (18.2%)	$\chi^2 = 17.23(3)$, $P = 0.002$
	College	53 (58.9%)	18 (32.7%)	
	Outpatient	8 (8.9%)	12 (21.8%)	
	Community	10 (11.1%)	15 (27.3%)	
	Other/special (inpatient, military, correctional)	1 (1.1%)	3 (5.5%)	
Modality of intervention	Individual	33 (36.7%)	11 (20.0%)	$\chi^2 = 9.62(3)$, $P = 0.02$
	Group	46 (51.1%)	38 (69.1%)	
	Online/blended	11 (12.2%)	7 (12.7%)	
	Family	0	3 (5.5%)	
Therapeutic orientation	Cognitive training (CBM, ABM and so on)	15 (16.7%)	1 (1.8%)	$\chi^2 = 14.96(3)$, $P = 0.006$
	CBT or CBT-based (or PST, IPT)	35 (38.9%)	17 (30.9%)	
	Acceptance/ER-based (ACT, ABBT, DBT, ERT)	15 (16.7%)	12 (21.8%)	
	Mindfulness-based (MBCT, MSBR)	22 (24.4%)	20 (36.4%)	
	Other (psychodynamic, mentalization, UP, family)	3 (3.3%)	8 (14.5%)	

^aOne row was excluded from categorical analyses as it produced a structural zero. All other zeroes and low values were observed rather than expected, and the large sample of studies ($n > 120$) made chi-square approximation acceptable. Some information was unavailable: mean age/median (three RCTs), percentage female (four RCTs and one non-RCT), treatment length (one non-RCT, where treatment lengths varied per person). Percentage was calculated inclusive of these missing values. Some studies had multiple arms with different therapeutic orientations, therefore sums may be more than the total number of unique studies. ABBT, acceptance-based behaviour therapy; ABM, attention bias modification; CBM, cognitive bias modification; ERT, ER therapy; IPT, interpersonal psychotherapy; MBCT, mindfulness-based cognitive therapy; MSBR, mindfulness-based stress reduction; PST, problem-solving therapy; UP, unified protocol.

expectations were observed for emotion dysregulation in relationship to reduced depression or anxiety, but several correlations could not be calculated due to a lack of information.

Results for individual ER skills. While controlling for shared variance in symptom reduction, psychological treatments for depression and anxiety tended to increase acceptance and problem solving, but not cognitive reappraisal (Table 4). Additionally, psychological treatments reduced avoidance, rumination and suppression. Findings indicate that regardless of diagnostic target or intervention approach, young people's improvements in individual ER skills were in line with expected changes at the specific skills

level, except for cognitive reappraisal. We also observed positive associations between engagement ER skills and reduced depression and anxiety extended to the specific skills of acceptance, problem solving and cognitive reappraisal (Table 5). Similarly, positive associations between reduced disengagement ER skills and reduced depression and anxiety were observed with a decrease in the specific skill of rumination. For avoidance, decreases were positively associated with reduced anxiety symptoms but negatively associated with reduced depression symptoms (the latter finding is opposite to expectations). Finally, decreased suppression was negatively associated with reduced anxiety and depressive symptoms (opposite to expectations).

Table 2 | Sensitivity analyses for the simultaneous effect of psychological treatments on outcome measures

		Symptom outcomes										ER skills outcomes														
		Anxiety symptoms					Depressive symptoms					Engagement ER skills					Disengagement ER skills					Emotion dysregulation				
		No. of studies	k	g	95% CI	P	k	g	95% CI	P	k	g	95% CI	P	k	g	95% CI	P	k	g	95% CI	P				
Mean age		32	31	0.21	0.09, 0.32	<0.001	51	0.27	0.10, 0.44	0.002	27	0.20	0.11, 0.28	<0.001	29	0.25	0.12, 0.39	<0.001	7	0.30	0.15, 0.46	<0.001				
14–17.9																										
18–21.9		34	36	0.39	0.22, 0.57	<0.001	40	0.37	0.23, 0.51	<0.001	32	0.32	0.19, 0.46	<0.001	35	0.27	0.18, 0.38	<0.001	2	0.33	−0.05, 0.71	0.09				
22–24.9		21	21	0.29	−0.04, 0.61	0.08	22	0.39	−0.003, 0.77	0.052	19	0.36	0.06, 0.66	0.02	17	0.09	−0.22, 0.40	0.58	3	0.93	0.40, 1.46	<0.001				
Number of sessions																										
>6		47	47	0.31	0.14, 0.47	<0.001	66	0.38	0.18, 0.58	<0.001	51	0.31	0.18, 0.46	<0.001	37	0.22	0.03, 0.41	0.03	8	0.58	0.25, 0.92	<0.001				
≤6		43	43	0.24	0.13, 0.35	<0.001	51	0.26	0.17, 0.36	<0.001	31	0.25	0.15, 0.35	<0.001	46	0.20	0.14, 0.26	<0.001	5	0.29	0.13, 0.44	<0.001				
Format of delivery																										
Blended/online		12	15	0.31	0.16, 0.45	<0.001	18	0.35	0.19, 0.50	<0.001	12	0.24	0.09, 0.40	0.002	10	0.26	0.08, 0.44	0.005	1	0.40	0.05, 0.76	0.03				
Individual		32	33	0.40	0.18, 0.62	<0.001	44	0.32	0.17, 0.47	<0.001	14	0.31	0.09, 0.52	0.005	37	0.27	0.15, 0.39	<0.001	4	0.76	0.27, 1.25	0.002				
Group		46	42	0.22	0.08, 0.36	0.003	55	0.34	0.15, 0.52	<0.001	56	0.25	0.14, 0.36	<0.001	36	0.20	0.07, 0.33	0.003	8	0.38	0.20, 0.56	<0.001				
Sample type																										
College		53	54	0.32	0.17, 0.48	<0.001	60	0.38	0.21, 0.54	<0.001	48	0.34	0.19, 0.48	<0.001	52	0.24	0.11, 0.37	<0.001	5	0.63	0.29, 0.97	<0.001				
High school		23	25	0.45	0.08, 0.81	0.02	39	0.32	0.08, 0.55	0.008	20	0.19	0.09, 0.30	<0.001	24	0.30	0.08, 0.52	0.007	4	0.32	0.10, 0.55	0.004				
Community/outpatient		17	13	0.32	0.05, 0.59	0.02	20	0.37	0.21, 0.53	<0.001	17	0.31	0.17, 0.45	<0.001	9	0.39	0.18, 0.60	<0.001	4	0.71	0.26, 1.16	0.002				
Type of control arm																										
Active control		55	49	0.20	0.10, 0.30	<0.001	68	0.27	0.15, 0.39	<0.001	43	0.26	0.18, 0.33	<0.001	48	0.19	0.11, 0.28	<0.001	8	0.36	0.07, 0.65	0.02				
Inactive control		45	41	0.49	0.34, 0.65	<0.001	49	0.52	0.37, 0.67	<0.001	39	0.44	0.30, 0.58	<0.001	35	0.37	0.25, 0.49	<0.001	5	0.57	0.30, 0.85	<0.001				
Sample size																										
Large (>100)		25	23	0.20	0.07, 0.34	0.004	41	0.26	0.07, 0.44	0.006	18	0.16	0.07, 0.26	0.001	34	0.18	0.10, 0.26	<0.001	0	-	-	-				
																						Continued				

Continued

Table 2 | Sensitivity analyses for the simultaneous effect of psychological treatments on outcome measures (Continued)

	Symptom outcomes						ER skills outcomes									
	Anxiety symptoms			Depressive symptoms			Engagement ER skills					Disengagement ER skills				
	No. of studies	k	g	95% CI	P	k	g	95% CI	P	k	g	95% CI	P	k	g	95% CI
Medium	33	38	0.31	0.20, 0.42	<0.001	36	0.44	0.31, 0.56	<0.001	28	0.35	0.24, 0.47	<0.001	26	0.34	0.23, 0.45
Small (<50)	34	29	0.43	0.14, 0.72	0.003	40	0.33	0.08, 0.59	0.01	36	0.40	0.17, 0.62	<0.001	23	0.25	0.01, 0.48
ROB rating																
Low	37	40	0.29	0.10, 0.48	0.003	49	0.30	0.11, 0.49	0.002	34	0.25	0.09, 0.42	0.003	38	0.20	0.02, 0.38
Some concerns	40	36	0.29	0.18, 0.41	<0.001	54	0.30	0.18, 0.41	<0.001	31	0.26	0.16, 0.36	<0.001	34	0.20	0.13, 0.27
High	13	14	0.18	-0.14, 0.51	0.27	14	0.51	0.03, 0.99	0.04	17	0.43	0.22, 0.64	<0.001	11	0.28	0.07, 0.49
Analytic approach																
ITT	64	63	0.26	0.15, 0.37	<0.001	87	0.33	0.20, 0.47	<0.001	53	0.24	0.16, 0.32	<0.001	58	0.20	0.10, 0.30
Completer	26	27	0.39	0.15, 0.62	0.001	30	0.32	0.17, 0.47	<0.001	29	0.34	0.20, 0.47	<0.001	25	0.42	0.24, 0.60
Intervention type																
CBT or PST	36	32	0.37	0.11, 0.63	0.005	53	0.41	0.15, 0.67	0.002	43	0.27	0.11, 0.44	0.001	35	0.32	0.12, 0.52
MSBR or MBCT	21	24	0.36	0.20, 0.53	<0.001	25	0.41	0.30, 0.53	<0.001	27	0.43	0.31, 0.54	<0.001	11	0.40	0.23, 0.56
ABBT, ACT, DBT, UP or other	18	16	0.24	0.08, 0.40	0.004	16	0.41	0.25, 0.57	<0.001	11	0.26	0.05, 0.48	0.02	13	0.13	-0.09, 0.35
CBM, ABM or AMT	15	18	0.13	-0.01, 0.27	0.07	23	0.13	-0.02, 0.27	0.09	1	0.14	-0.21, 0.48	0.44	24	0.11	0.01, 0.22

See Supplementary Table 3 for heterogeneity statistics, most of which were statistically significant. Each line of statistical values was computed from one random effect multivariate meta-analytic model, given the high level of heterogeneity. No. of studies refers to the number of unique studies that contributed to the multivariate analyses. k is the number of unique effect size statistics that contributed to the outcome result. Individual effect sizes were categorized by outcome and nested within the larger study. g is Hedges' g produced from meta-analysis. AMT, autobiographical memory training; ITT, intent-to-treat.

Table 3 | Overall correlations between depression and anxiety symptom reduction and improvement in ER skills along with sensitivity analyses

	Anxiety symptoms						Depressive symptoms						≥Corr. versus overall Percentage
	Engagement ER		Emotion dysregulation		Disengagement ER		Engagement ER		Emotion dysregulation		Disengagement ER		
	Corr.	n	Corr.	n	Corr.	n	Corr.	n	Corr.	n	Corr.	n	
All studies overall	0.54	39	0.88	10	0.72	37	0.92	47	0.94	10	0.82	45	-
Mean age													
14-17.9	>0.99	10	0.96	5	0.91	9	0.96	17	>0.99	6	0.98	14	100%
18-21.9	0.21	16	-	-	0.08	16	0.81	17	-	-	0.55	20	0%
22-24.9	0.80	12	>0.99	3	0.78	10	0.99	11	-	-	0.93	10	83%
Number of sessions													
>6	0.98	23	0.93	8	0.66	16	0.97	30	0.92	7	0.83	21	67%
≤6	-0.99	16	-	-	0.84	21	-0.11	17	>0.99	3	0.59	24	33%
Format of delivery													
Blended/online	-0.05	7	-	-	-0.88	6	0.54	8	-	-	-0.93	6	0%
Individual	0.21	7	0.98	3	0.20	18	0.90	9	-	-	0.77	21	33%
Group	0.76	25	0.85	6	0.97	13	0.99	30	0.99	7	0.86	18	83%
Sample type													
College	0.52	25	0.97	4	0.69	27	0.93	26	0.79	3	0.84	30	50%
High school	>0.99	8	-	-	>0.99	8	>0.99	12	>0.99	3	>0.99	11	83%
Community/outpatient	0.84	8	0.37	4	0.76	3	0.92	11	0.83	4	0.57	5	50%
Type of control arm													
Active control	0.51	21	0.87	6	0.77	22	0.77	28	>0.99	7	>0.99	28	50%
Inactive control	0.42	23	0.92	5	0.18	21	0.91	25	0.38	4	0.55	25	17%
Sample size													
Large (>100)	0.61	9	-	-	0.98	11	0.90	13	-	-	0.97	16	50%
Medium	0.02	13	0.46	6	-0.13	15	0.90	16	0.97	7	-0.22	16	17%
Small (<50)	0.65	18	0.97	4	0.64	13	0.90	19	0.63	3	0.94	15	50%
ROB rating													
Low	0.67	20	0.98	3	0.63	17	0.93	19	-	-	0.95	17	83%
Some concerns	0.75	15	0.72	7	0.63	15	0.92	19	0.94	8	0.57	22	50%
High	0.22	4	-	-	0.54	5	0.91	9	-	-	0.92	6	17%
Analytic approach													
ITT	0.90	26	0.88	8	0.67	26	0.97	32	0.87	8	0.83	34	67%
Completer	0.29	13	-	-	0.81	11	0.66	15	-	-	0.80	11	17%
Intervention type													
CBT or PST	0.65	14	-	-	0.90	14	0.95	21	>0.99	3	0.91	15	83%
MSBR or MBCT	0.26	17	-	-	0.88	4	-0.33	18	-	-	>0.99	6	33%
ABBT, ACT, DBT, UP or other	-0.91	7	0.64	6	-0.99	10	-0.12	7	>0.99	5	-0.65	10	17%
CBM, ABM or AMT	-	-	-	-	-0.61	9	-	-	-	-	-0.93	14	0%

Correlations (Corr.) show the estimated correlation between two random effects, which are assumed to follow a multivariate normal distribution and therefore is not simply the product-moment correlations between two variables. Each line of statistical values was computed from one random effect multivariate meta-analytic model, given the high level of heterogeneity. Positive correlations are consistent with our hypotheses, whereas negative correlations are inconsistent with our hypotheses. ≥Corr. versus overall refers to the percentage of correlations produced by a sensitivity variable that were larger (in magnitude) than the main overall finding, inclusive of missing values.

Consideration of publication bias. Egger's test was significant for subgroupings of studies focused on outcomes for anxiety, $t(65)=4.25$, $P<0.001$ and depression, $t(78)=4.79$, $P<0.001$, due to a skew towards underestimating the magnitude of positive intervention findings. Using the trim-and-fill procedure under random-effects assumptions, seven studies were estimated as missing to the right of the mean for the anxiety outcome studies, with an adjusted random-effects Hedges' $g=0.42$, $P<0.001$, 95% CI=0.32–

0.51, favouring larger intervention effects than estimated. For depression outcome studies, 13 studies were estimated as missing to the right of the mean under random-effects modelling, with an adjusted random-effects Hedges' $g=0.48$, $P<0.001$, 95% CI=0.38–0.58, again favouring larger intervention effects. Funnel plots for the anxiety and depression RCTs subgroupings with graphical imputation of the missing studies can be found in Supplementary Figs. 1 and 2.

Table 4 | Results for individual ER skills using a multivariate meta-analytic approach

	No. of studies	Meta-analytic outcomes											
		Individual ER skill				Anxiety symptoms				Depression symptoms			
		<i>k</i>	<i>g</i>	95% CI	<i>P</i>	<i>k</i>	<i>g</i>	95% CI	<i>P</i>	<i>k</i>	<i>g</i>	95% CI	<i>P</i>
Acceptance	32	41	0.32	0.07, 0.42	<0.001	37	0.24	0.07, 0.42	0.007	39	0.32	0.14, 0.51	<0.001
Problem solving	17	22	0.31	0.14, 0.47	<0.001	11	0.81	0.23, 1.39	0.006	28	0.50	0.17, 0.83	0.003
Cognitive reappraisal	16	19	0.23	−0.01, 0.47	0.06	15	0.27	−0.08, 0.63	0.13	19	0.44	−0.004, 0.88	0.052
Avoidance	18	19	0.18	0.03, 0.32	0.02	13	0.21	0.04, 0.39	0.02	19	0.35	0.14, 0.55	<0.001
Rumination	32	53	0.18	0.06, 0.30	0.002	39	0.12	0.04, 0.26	0.08	48	0.22	0.04, 0.39	0.02
Suppression	9	11	0.26	0.03, 0.50	0.03	7	0.16	−0.39, 0.70	0.58	12	0.13	−0.04, 0.30	0.14

Each line of statistical values was computed from one random effect multivariate meta-analytic model according to the specific ER skill, given the high level of heterogeneity. No. of studies refers to the number of unique studies that contributed to the multivariate analyses. *k* is the number of unique effect size statistics that contributed to the outcome result. Individual effect sizes were categorized by outcome and nested within the larger study.

Given the significant differences in study characteristics between RCTs and non-RCTs, we completed supplementary analyses on the extracted intervention data using the single-arm and active intervention arms if the study had multiple arms (that is, no study controls were present in this secondary analysis). Results from 186 effect-size extractions across 55 non-RCT studies largely converged with the above. After simultaneous entry of all outcome variables in a multivariate format, results indicated medium-to-large main effects in reducing symptoms of depression ($k=55$, $g=0.61$, $P<0.001$, 95% CI=0.46–0.75), anxiety ($k=44$, $g=0.53$, $P<0.001$, 95% CI=0.40–0.66), disengagement ER skills ($k=33$, $g=0.56$, $P<0.001$, 95% CI=0.32–0.60) and emotion dysregulation ($k=10$, $g=0.83$, $P<0.001$, 95% CI=0.58–1.08). Small-to-medium increases in engagement ER skills were also found pre- to posttreatment ($k=44$, $g=0.48$, $P<0.001$, 95% CI=0.37–0.59). The larger effects of treatment found for non-RCTs compared to RCTs relates to the lack of control arm data and supports our underestimation of treatment effect above. Heterogeneity remained significant for the moderators ($Q(5)=111.87$, $P<0.001$; $I^2=95.53\%$) and the residual model ($Q(181)=806.08$, $P<0.001$; $I^2=77.55\%$). Reduced anxiety symptoms exhibited positive associations (that is, estimated correlations between random effects, ρ) with reduced disengagement ER skills ($n=21$, $\rho=0.85$; $\chi^2(1)=5.48$, $P=0.019$) and improved engagement ER skills ($n=29$, $\rho=0.60$; $\chi^2(1)=9.39$, $P=0.002$), with likelihood ratio tests indicating better fit statistics compared to restricted models where their correlations were set to zero. Reduced depression symptoms exhibited positive associations with reduced disengagement ER skills ($n=25$, $\rho=0.90$; $\chi^2(1)=31.13$, $P<0.001$) and improved engagement ER skills ($n=31$, $\rho=0.58$; $\chi^2(1)=22.29$, $P<0.001$), with similar likelihood ratio test findings. Reduced emotion dysregulation was associated with reduced symptoms of anxiety ($n=6$, $\rho=0.87$; $\chi^2(1)<0.1$, $P>0.99$) and depression ($n=9$, $\rho=0.64$; $\chi^2(1)=2.33$, $P=0.13$) in a positive direction, but likelihood ratio tests indicated that these models were statistically equivalent to restricted models where the above correlations were set to zero. Finally, the full model retained better fit statistics compared to a restricted model where all six estimated correlations were set to zero, $\chi^2(6)=40.60$, $P<0.001$.

Discussion

Our goal was to synthesize the associative changes between ER skills and emotion dysregulation during psychological interventions targeting depression and anxiety in youth and young adults. The current study extends other reviews^{39,35} by focusing on dimensional depressive and anxiety symptoms in young persons aged 14–24,

incorporating ER skills to broaden previous reviews and involving a panel of youths with lived experience to support study design and knowledge dissemination. Our youth advisory informed the interpretation of the results and commentary outlined below.

Psychological treatments reduced anxiety, depression, disengagement ER skills and emotion dysregulation, and improved engagement ER skills. Results for depression and anxiety were robust across almost all sensitivity analyses conducted and consistent at the individual skill level, with the two engagement ER skills increasing, and three disengagement skills decreasing, over the course of treatments for anxiety and/or depression symptoms. Moreover, significant reductions in anxiety and depression symptoms during treatment were positively associated with significant reductions in emotion dysregulation and disengagement ER skills, as well as significant increases in engagement ER skills. Our findings are consistent with discussions regarding the importance of ER in treatment^{48,49}, the general effectiveness of various psychological treatments for depression and anxiety symptoms^{50,51} and the discussion of common factors that may underlie them^{52,53}. Improvements in intrapersonal ER skills may represent a common ‘active’ ingredient across psychological interventions for young people, consistent with a substantial treatment literature in adult samples demonstrating a similar effect^{40–46}. Findings indicate that a common goal across psychological interventions for depression and anxiety symptoms in youth and young adults may be to increase and diversify the types of intrapersonal ER skill used to regulate emotions. However, future work will want to examine this question empirically using mediation analyses and determine whether this relationship remains true during follow-up.

With respect to anxiety symptoms, positive treatment outcomes produced relatively larger positive associations with reduced disengagement (versus improved engagement) ER skills during treatment. One possible explanation for this finding is the central role in reducing the experiential avoidance and anxious arousal common in anxiety through exposures and cognitive restructuring across several intervention approaches^{54,55}. Young people with anxiety are often explicitly taught to accept rather than suppress their feared thoughts or situations in treatments, which may facilitate a reduction in disengagement ER skills (that is, avoidance, ruminative negative thinking and suppression) that may have maintained their anxiety^{54,55}. Nevertheless, increases in engagement ER and reductions to emotion dysregulation were also associated with reduced anxiety symptoms during treatment. Our youth advisory board highlighted the use of framing depression and anxiety as problems with ER to reduce the stigma regarding the disorders; moreover,

Table 5 | Output from multivariate meta-analysis showing heterogeneity statistics and associations between individual ER skills and anxiety and depression symptoms

	Heterogeneity statistics						Associations between individual ER skills and symptoms over treatment			
	Moderator			Residual			Anxiety symptoms		Depression symptoms	
	Q	I ²	P	Q	I ²	P	Corr.	N	Corr.	N
Acceptance	14.59	79.4%	0.002	462.78	75.4%	<0.001	0.80	27	0.85	27
Problem solving	19.85	84.9%	<0.001	302.75	80.8%	<0.001	>0.99	9	>0.99	17
Cognitive reappraisal	3.92	23.5%	0.27	337.12	85.2%	<0.001	0.67	10	0.90	12
Avoidance	35.16	91.5%	<0.001	146.71	67.3%	<0.001	0.87	6	−0.79	7
Rumination	9.36	67.9%	0.03	635.36	78.4%	<0.001	0.72	23	0.88	29
Suppression	10.74	72.1%	0.01	92.23	70.7%	<0.001	−0.71	12	−0.07	15

Each line of statistical values was computed from one random effect multivariate meta-analytic model according to the specific ER skill, given the high level of heterogeneity. Q is the Cochran Q, a statistic to determine heterogeneity in meta-analyses. Moderator Q is the Cochran test of moderator heterogeneity. Residual Q is the Cochran test for residual heterogeneity once moderator heterogeneity is removed. I² is the heterogeneity statistic describing the percentage of variation across studies that is due to heterogeneity rather than chance. Corr. represents the estimated correlation between two random effects, which are assumed to follow a multivariate normal distribution and therefore is not simply the product-moment correlation between two variables.

they felt that it would be valuable to increase awareness of the relationships between ER skills and depression/anxiety symptoms to the broader youth audience.

Positive outcomes for depression produced large positive associations with increased engagement ER skills. Nevertheless, positive treatment outcomes were also positively associated with reduced disengagement ER skills and general emotion dysregulation. Given pretreatment relationships between intrapersonal skills and symptoms of depression and anxiety^{18,21–25}, young people with depression appear to endorse rumination (or repetitive thinking) more strongly along with avoidance and suppression of their negative emotions. Coupled with lower use of problem solving and other engagement ER skills^{34,56,57}, rumination can increase the risk of suicidal thoughts and behaviours⁵⁸ and so youth with depression may simply have more skills to gain from treatment to avoid negative mental-health outcomes. Regardless of how one defines ER skills, it appears that helping to correct a bias in using disengagement over engagement ER skills is common to interventions for depression in youth and young adults. As a result, overall reductions in emotion dysregulation were also associated with large effect-size reductions in depression symptoms during treatment in a similar manner. Collectively, our multidimensional investigation permitted a nuanced investigation of these three different ER skills constructs with treatment outcomes and explains the multiple possible pathways to recovery for youth with anxiety. As a result, interventions that focus on improving engagement ER skills, and decreasing disengagement ER skills and emotion dysregulation, may all be particularly affecting for anxiety and depression symptom reduction.

There were some unexpected findings; youth aged 18–21.9 exhibited positive, but smaller in magnitude, correlations between symptom reduction and improved ER skills versus two other age groups. There is considerable moderator (that is, outcome) heterogeneity for studies in this age group, which may have suppressed enhanced positive relationships (Supplementary Table 3). Moreover, shorter treatments, blended or online formats and cognitive training and acceptance- or ER-based interventions exhibited some negative correlations (opposite direction than expected) for both anxiety and depression compared to previous research^{42–46}. It is possible that longer treatments are necessary for youth anxiety and depression to build engagement ER skills (perhaps related to exposure protocols) whereas positive associations in disengagement ER and emotion dysregulation were found regardless of treatment length. Our findings related to blended or online and acceptance- or ER-based interventions should be interpreted with caution due

to the lower number of studies contributing to these analyses. In addition, studies incorporating acceptance- or ER-based interventions appeared to be smaller in sample size and had more ROB concerns on average, which may have led to these unexpected findings. Finally, cognitive training interventions are usually delivered as brief treatments (that is, single-session) and observed changes to ER skills pre- to posttreatment may not be immediately observable.

Reductions in anxiety and depression symptoms during treatment were not universally associated with reduced disengagement ER skills on an individual basis. In fact, reduced suppression was in the direction opposite to expectations for changes in anxiety and depression, while avoidance was in the direction opposite to expectations for changes in the latter only. Improvements in all three engagement ER skills considered here were positively associated with anxiety and/or depression symptom reduction, although problem solving had the largest observed association. Alternatively, reductions in suppression and avoidance were not consistently associated with reductions in depression and or anxiety symptoms. Previous reviews^{39,35} found decreases in all disengagement ER skills (rumination, avoidance and suppression) following psychological treatment, a potential reflection of the shared repetitive thinking construct that underlies psychopathology⁵⁹. However, the present study quantitatively assessed specific ER skills and focused on depression and anxiety symptoms in youth and young adults, which could potentially explain the difference in findings. While replication and more stringent mediation methods are necessary to understand these relationships, results indicate that it may not be necessary to completely reduce disengagement ER skills for positive anxiety and depression treatment outcomes. We also note that the labels ‘disengagement’ and ‘engagement’ are used to indicate habitual use of these skills over relatively long periods of time, which over the long-term are respectively associated with higher and lower levels of psychopathology^{24,25,34}, and research about their relationship with emotional experiences^{36,60}. Nevertheless, our two-factor grouping of ER skills fails to consider the context in which those skills are used, a factor found to be increasingly important to determine effectiveness and mental-health outcomes^{37,38}, although less research has been conducted on posttreatment individuals.

Substantial differences between RCTs and non-RCTs that met criteria for inclusion suggested that our RCTs may be different from the broader sample of treatment studies at large. Although we largely confirmed our meta-analytic findings in non-RCTs, the associations were more limited in some cases (that is, emotion

dysregulation) by the smaller number of studies included overall. Our ROB assessment for RCTs found less than 20% were at high risk for bias, even after we used a conservative approach that automatically elevated some studies to high risk. No study had two or more domains where high risk was identified. Results from funnel plot examination and the trim-and-fill procedure indicated that findings with respect to interventions were underestimated due to our selection of a large range of studies that were variable in their reduction of depression and anxiety symptoms. This is also indicated by the small-to-medium effect-size reduction in symptoms for RCTs compared to the large effect sizes seen in the relatively more uncontrolled nature of non-RCTs. Thus, we argue that our findings remain unchanged even after considering potential study selection and publication bias.

Our sensitivity analyses were attempts to understand which features of interventions were linked to larger associations between symptom reduction and improvement in ER skills, as well as who might benefit the most. Overall, studies that produced larger positive associations tended to have interventions that were longer (>6 sessions), delivered in group format and were CBT based. There were relatively consistent effects regardless of sample type and age, suggesting that most youth with depression and anxiety symptoms can benefit from interventions that yield ER skill improvements and especially those under 18. There were some differences depending on whether depression versus anxiety symptoms were targeted. In addition to the above findings, shorter interventions and individual formats were also effective approaches at times for depression symptoms and produced positive associations with improvements in ER skills. Overall, there were mixed findings with respect to which interventions enhanced treatment outcomes for depression versus anxiety, and this was probably related to a difficulty in dividing the studies into distinct categories on the basis of therapeutic orientation. Nevertheless, CBT-based interventions more consistently improved engagement (and reduced disengagement) ER skills, while acceptance- or ER-based interventions were successful in reducing emotion dysregulation. Mindfulness-based interventions were also particularly effective in reducing disengagement ER skills. As treatments become more transdiagnostic, these findings could help clinicians design and evaluate new formats of intervention delivery for the population they serve.

Broader clinical implications may include facilitating the design and implementation of briefer, more efficacious treatments for depression and anxiety that specifically target improvements to ER skills. Discussions with youth indicated a need for greater awareness around the relationship between ER skills and mental health, and a greater understanding of how improvements in ER skills contribute to more positive treatment outcomes. Our youth advisory also commented on a need to increase the agency and autonomy of young people by developing self-assessment tools to understand which skills they already have, and which could use improvement. In addition, helping youth to understand the types of ER skill they might gain from certain interventions may help them make better, informed decisions about treatment. At a higher level, the advisory recommended reforms to school curriculums to incorporate ER skills training at all levels of education as a preventative strategy to mitigate mental-health concerns in young people. This approach would have the benefit of removing barriers typically associated with treatment in young adults (for example, cost of services, finding a therapist, stigma) and could incorporate peer-led delivery of skills coaching.

Results also serve to support affective science perspectives on mental disorders and theoretical models of emotion dysregulation^{7,28–30}. Reductions in symptoms during treatment were generally associated with improvements in ER skills, translating into the reduction of emotion dysregulation. Moreover, the results of our

synthesis support continued distinction between the two groupings of skills used in this study, as findings for engagement and disengagement ER skills were generally in the expected direction, supporting their earlier putative associations with psychopathology and models of their common structure^{34,36}. However, subtle differences between the two skills groupings also remained and played an important role in identifying key factors involved in the treatment of depression versus anxiety. Overall, we demonstrated more specificity of the ER constructs compared to past reviews^{39,35} by conducting separate analyses for more generalized measures of emotion dysregulation and specific ER skills.

Additional limitations of the present meta-analysis include limiting the selection of studies to only those written in English and relying almost entirely on data from self-report measures, which can be susceptible to recall bias⁶¹. Future treatment trials should also consider more ecologically valid tools such as experience sampling assessments to evaluate treatment success⁶². Further, adults with higher levels of emotion dysregulation have more difficulty reporting on their emotional experiences^{63,64}, which suggests that youth may introduce substantial variability in subjective responses as well. There were slight biases in how studies contributed to the meta-analysis; for example, RCTs with mindfulness-based interventions more often assessed engagement ER skills (for example, acceptance), whereas trials of acceptance/ER-based and cognitive training interventions more often assessed disengagement ER skills (for example, rumination). There was some indication of publication bias and significant heterogeneity between individual RCTs treating depression and anxiety symptoms; however, we attempted to mitigate concerns by conducting sensitivity analyses and considering other non-RCTs that met the criteria for inclusion, which tended to align with the overall findings. It is worth restating that we were unable to examine more causal relationships, such as whether improvements in ER skills in the middle of treatment acted as a mediator for positive treatment outcomes at the end of treatment or at follow-up, something we hope future research can address.

Similarly, a separate but ongoing debate centres on whether depressive or anxious symptoms cause difficulties in ER or vice versa. One possibility not examined here is that these constructs exhibit reciprocal relationships that change dynamically over time with other additional variables, such as the person's environment and conditioning playing a role in how one learns to regulate their emotions^{29,30,65}. This may be particularly relevant for adolescents and young adults who rely on family members, caregivers and interpersonal relationships for emotional support. More broadly, there is important discussion regarding the overlapping nature of depression and anxiety with certain ER skills (for example, rumination and depression^{56,66}, avoidance and anxiety⁵⁷); this conceptual issue has been noted previously^{34–36,39,56,57} and may contribute to artificially inflated effects in the current synthesis. Moreover, there are critical discussions revolving around what constitutes an ER skill and whether definitions have become too broad³⁶. These issues can make it difficult to understand whether changes in depression and anxiety are caused by changes in ER skills or the opposite, or whether they simply represent overlapping constructs. Despite an attempt, this synthesis was not able to examine or incorporate analyses related to whether interpersonal ER skills improve in relation to depression and anxiety symptom reduction over treatment in youth. We do not diminish the potential importance that psychological treatments have on improving interpersonal ER in comparison to intrapersonal ER skills. Given the recent development of appropriate interpersonal ER skills measures^{19,27,68}, we are hopeful that future research will address this, and the other issues noted above, in an appropriate and quantitative manner.

Drawing inferences from the large body of evidence incorporated into the current study, we found that improvements in intrapersonal ER skills defined in three different ways (for example,

emotion dysregulation, disengagement ER and engagement ER) were associated with significant treatment gains for depression and anxiety in youth and young adults. Interventions with six or more sessions, cognitive-behavioural interventions and a group format of delivery produced larger associations between improvements in ER and symptom reduction. These findings are consistent with the improvement of ER skills as a transdiagnostic active ingredient in the treatment of depression and anxiety in young people. Dissemination of these findings to youth and healthcare providers will aid in increased awareness and more informed decisions regarding treatment.

Methods

Protocol. We used established PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines and the AMSTAR recommendations to conduct this review⁶⁹. We also followed procedures outlined by the Cochrane Handbook for Systematic Reviews⁷⁰.

Inclusion (and exclusion) criteria. Studies were identified according to the following criteria for inclusion (in bold), with notes relevant for exclusion described:

- (1) **Written in English.**
- (2) **Primary cohort data in peer-reviewed source.** Secondary sources, case studies, dissertations and published abstracts were excluded.
- (3) **Young people with a mean age between 14.0 and 24.9 received an intervention.** This age range was chosen on the basis of epidemiological studies regarding the age of-onset for depression and anxiety¹². Studies that reported only age range were retained if the median value fell in the above age range, unless the authors used a sample of considerable interest (for example, college or high school students; $n = 3$ in the current synthesis).
- (4) **Contains a psychological intervention.** We defined a psychological intervention as any evidence-based intervention that was grounded in psychological principles to reduce symptoms of anxiety and/or depression. This definition was designed to include protocols derived from established and more novel psychological treatments across a range of modalities (for example, CBT and CBM). We excluded interventions that were psychoeducational only (for example, provided pamphlet, online resource), pharmacological or neurostimulation-based. We used lists of treatments endorsed by Division 12 (Society of Clinical Psychology) of the American Psychological Association as a guide to evidence-based psychological interventions⁷¹.
- (5) **Outcome measure assessing depression and/or anxiety symptoms.** Studies could vary in diagnostic focus (for example, although most targeted depression or anxiety, some studies did recruit young persons with eating or substance use disorders) but were required to include a dimensional outcome measure of depression, social anxiety and/or generalized anxiety (for example, Multidimensional Anxiety Scale for Children Revised Child Anxiety and Depression Scale; Reynolds Adolescent Depression Scale; Screen for Child Anxiety Related Disorders). No cutoff on these measures was applied. We excluded studies with more general measures of psychopathology (for example, internalizing symptoms) and well-being (for example, quality of life) as they do not assess depression or anxiety precisely and affect the capacity to pool and interpret results. We did not explicitly exclude studies with a focus on panic disorder, agoraphobia or specific phobia. We excluded studies with primary diagnoses of obsessive-compulsive disorder and posttraumatic stress disorder because the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders now places them in a separate classification section from the depressive and anxiety disorders described above⁷².
- (6) **Outcome measure assessing ER skills or lack thereof.** We included studies that incorporated a general measure of emotion dysregulation (for example, ER skills deficits) and/or a specific measure of ER skills, on the basis of previous expert reviews (for example, rumination, suppression, avoidance, cognitive reappraisal, acceptance or problem solving)^{34–36,39,56,57}. We excluded studies with more general measures of coping, unless the study used a subscale that overlapped substantially with one of the above specific ER skills. We considered several assessment measures related to expert reviews of interpersonal ER^{19,20,27,68}, however, we were unable to locate any intervention trials that used these measures. For more details on our operational definitions as well as examples of scales and items used, see the Supplementary Information. There, we also include findings pertaining to interpersonal ER summarized in a qualitative format.

Involvement of youth with lived experience. A youth advisory was recruited from members of the National Youth Action Council at the Centre for Addiction and Mental Health were involved in all stages of the current research. The council was developed to engage young persons in clinical, educational and research programming. Two youth facilitators and three members of the council with lived

experience about psychological treatments for depressive and/or anxiety symptoms advised the design and implementation of the current review, and associated knowledge dissemination activities. Advisory meetings provided input on the study questions and design, results interpretation and recommendations for knowledge dissemination materials and knowledge mobilization from a youth perspective.

Search strategy and study selection. Articles were identified through searches using database-specific subject headings and keywords in natural language in the following databases: Medline (including epub ahead of print, in-process and other non-indexed citations), Embase, APA PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and The Cochrane Library. A medical librarian (T.R.) developed the search strategies with input from the team and conducted all searches on 26 June 2020. We used terms to capture psychopathology (for example, depression or anxiety) and youth and young adult populations (for example, young adult or transitional age). These concepts were then combined with two separate strands. The first strand listed specific therapeutic modalities (for example, CBT), while the second strand combined terms related to mental-health services (for example, psychotherapy) with ER terms (for example, mood regulation). This approach allowed us to capture studies that may not include ER skills as a primary outcome. Conference abstracts, dissertations, case reports, commentaries, editorials and letters to the editor were excluded when possible. Year limits applied were from 1994 to the present, coinciding with the development and publication of diagnostic and ER conceptual definitions⁷³. No language limits were applied. The full Medline and PsycInfo search strategies can be found in our Supplementary Information. Results of the literature search were imported into online software (Covidence), where duplicates were removed.

At the first stage, all titles and abstracts were screened for inclusion by two independent team members and conflicts were resolved by team consensus (81% average agreement, $\kappa = 0.51$). Although this indicated moderate interrater agreement for this stage (rather than substantial, $\kappa = 0.61$ – 0.80 , or almost perfect agreement, $\kappa = 0.81$ – 1.00), this was most probably due to the use of maybe ratings (that is, three response alternatives) in Covidence at this stage, which were later resolved through consensus meetings. The second screening stage used two response alternatives. Here, each full-text article was similarly reviewed by two team members with conflicts resolved by team consensus (96% average agreement, $\kappa = 0.82$). At each stage, the team carefully excluded studies that focused on severe medical issues (for example, cancer, HIV, heart/liver diseases), brain or notable body trauma (for example, traumatic brain/spinal cord injuries, stroke), neurodevelopmental disorders (for example, foetal alcohol spectrum and autism spectrum disorders), intellectual disabilities or impairments and psychiatric conditions that would supersede a diagnosis of a depressive or anxiety disorder in terms of severity (for example, psychotic spectrum disorders). Reference lists of chosen articles were also hand searched to identify any relevant resources not captured by the systematic searches.

Data extraction. We extracted data from all studies selected for inclusion; however, primary analyses were conducted on data from RCTs due to their rigorous study design. We then compared the study characteristics of RCTs to non-RCTs (that is, single intervention arm or non-random allocation to treatment arms) to examine differences as well as potential publication bias. The study characteristics of included RCTs and non-RCTs and are presented in Supplementary Tables 1 and 2 (respectively), including the mean age and range, sex, sample type (for example, college, outpatient, high school), sample size, intervention setting (for example, hospital, university), intervention arm comparisons, mode of delivery (for example, group, individual, blended), intervention length and session frequency and outcome measures.

ROB in individual studies. Quality and ROB was assessed using the Cochrane Collaboration Risk of Bias tool (v.2.0)⁷⁴. This tool allows sources of bias to be assessed in five domains: generation of randomized allocation sequence, concealment of randomization, reporting of incomplete outcome data, selective reporting of data and protection against contamination. We followed the provided algorithm to assess individual domains, with two minor modifications to improve the consistency of the overall bias rating. First, any study with least one high risk rating or ≥ 4 some concerns ratings automatically received a high overall rating to improve the conservative nature of ROB ratings and distribute them more evenly for later sensitivity analyses. Second, low-risk studies had either all low-risk ratings across the five domains or only one some concerns rating. Quality ratings were completed by S.A.H. and S.A. and all ratings were discussed through consultation meetings with A.R.D. for final consensus. A full breakdown for each domain and their overall score provided in Supplementary Table 4. Because the design of non-RCTs would automatically introduce multiple concerns with respect to randomization and participant allocation, we did not complete ROB ratings for these studies.

Calculation of effect sizes. Quantitative data from RCTs were imported directly into comprehensive meta-analysis (CMA) v.3.3.070 (Biostat) and converted to a standardized score (Hedges' g). Hedges' g was used because it can correct for small sample sizes and because the magnitudes for effect sizes are similar to

Cohen's d (≥ 0.20 for small, ≥ 0.50 for medium and ≥ 0.80 for large)⁷⁵. Effect sizes were calculated only from reliable and validated self-report and observer-rated questionnaires (that is, no single item assessments). We extracted data from as many studies as possible using the means, standard deviations, change scores, effect sizes and/or t - or F -tests reported in each article. Positive effects were coded when change in that variable were in the expected direction over treatment (as hypothesized above). We prioritized intent-to-treat sample size and treatment data (71%); otherwise, completer data was used (29%). When more than one measure was used for a single outcome (for example, for depression, anxiety, ER skills), or more than two interventions were compared (for example, three-arm studies), we computed all effect sizes and standard errors and grouped them under each study using additional variables for treatment arm and specific measure. Later, in the meta-analysis we used outcome as the inner factor and study as the outer factor to account for nesting of effect sizes in each study.

Meta-analysis. Given the stochastically dependent nature of our five outcome variables^{6,77}, we ran a multivariate meta-analysis using the metafor package in R (v.4.0.2)⁷⁸. This method allowed us to conduct one large meta-analysis followed by sensitivity analyses, simplifying the output. Random-effects models were used, which assume that included studies are from populations of studies that differ from each other systematically. The effect sizes calculated in CMA were exported and loaded into R. As we lacked previous knowledge of the covariance structure between the dependent effect sizes, we followed established methods⁷⁶ and estimated our meta-analytic outcomes while 'using robust computations of the variances that consider the dependence of the effect-size estimates within studies'. Thus, a working covariance matrix was created across each of the outcome variables in each study based on an estimate of the population-level correlations. We chose a conservative ρ (Rho) value of 0.70 to estimate this population-level correlation, given that depression and anxiety symptoms are strongly correlated but not completely overlapping (that is, between 0.60 and 0.80)⁷⁹. While previous meta-analyses found medium effect-size correlations between anxiety/depression symptoms and disengagement ER strategies (for example, ≤ 0.56), with smaller effect-size correlations for engagement ER strategies³⁴, 0.70 was used to more conservatively control for shared variance among all outcome variables. In preliminary analyses, we tested several assumptions for our proposed ρ value (0, which would indicate no population-level correlation; 0.50, 0.70 and 0.90). As the assumed correlation between our dependent variables increased, the estimates for each outcome decreased (in line with theoretical assumptions). However, results were relatively insensitive to small differences when $\rho > 0$, with all estimates remaining significant, therefore we continued using 0.70.

To examine the associations between changes in depression or anxiety symptoms and change in ER skills in three overarching categories associated with their operational definition (for example, disengagement ER, engagement ER, emotion dysregulation), we used the correlation matrix that was produced by the metafor package. These computed correlations represent the estimated restricted maximum likelihood relationship between two random effects, which are assumed to follow a multivariate normal distribution. This differs from product-moment correlations between two observed variables and therefore cannot be tested using standard methods for traditional correlation coefficients (that is, Pearson, Spearman). To test the sensitivity of the overall correlations, we compared them against restricted models where each of the six correlations were set to zero (using the rho argument), reducing each by one parameter. The analysis of variance function in R was used to produce a likelihood ratio test, which follows (asymptotically) a chi-square distribution where degrees of freedom is equal to the difference in the number of parameters in the full and the reduced model. In addition, we report the correlation estimates from our sensitivity analyses to examine the relative magnitude of association between changes in each ER skills construct with changes in depression and anxiety while also controlling for shared associations. A caveat is that we do not present tests to support significant differences between the correlations themselves. All meta-analysis statistics, in addition to other statistics computed in this paper use two-sided probability.

Assessing homogeneity and sensitivity analyses. The metafor package provided Cochran's Q values to test the significance of heterogeneity in both the moderators and the residual model (after accounting for heterogeneity of the moderators). In addition to the Q statistic, I^2 is an intuitive and simple expression of the inconsistency of studies' results and indicates the percentage (0% indicating none, 25% low, 50% moderate and 75% substantial heterogeneity) of variation across studies that is due to heterogeneity rather than chance⁸⁰. The I^2 value does not depend on the number of studies for its calculation and was estimated using the formula: $I^2 = 100\% \times ((Q - \text{degrees of freedom})/Q)$. As an additional method to probe heterogeneity, sensitivity analyses were planned to probe the overall effects of RCTs. We conducted analyses based on sample type (for example, college, outpatient, high school), sample size, mode of delivery (for example, group, individual, blended), intervention length, analytic approach and overall ROB rating.

In addition to study selection bias, publication bias for the treatment of depression and anxiety symptoms was assessed by funnel plot inspection, Egger's test for asymmetry and Duval and Tweedie's trim-and-fill procedure⁸¹; the last yields an estimate of the effect size after publication bias has been considered

with an imputation of missing studies. These analyses were completed in CMA. In addition to this standard procedure, we ran exploratory analyses using data extracted from non-RCTs as a comparative analysis on examining the differences in RCT versus non-RCT study characteristics. Effect sizes were first calculated in CMA as above, and then exported and run in R using the same multivariate approach.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The data that support the findings of this study are available through an OSF repository (<https://osf.io/56fvu>). Additional details are available from the corresponding author on request.

Code availability

The R script used to produce the statistics in this review can be provided on request from the corresponding author.

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depression and anxiety aged 14–24. More information about the initiative and the other teams funded can be found here (<https://wellcome.org/what-we-do/our-work/mental-health-transforming-research-and-treatments>).

Author contributions

A.R.D., S.A.H. and L.C.Q. conceived, designed and obtained funding for the study. T.R. designed and executed the search strategy in consultation with A.R.D., S.A.H. and L.C.Q. T.R. managed the database of search results. A.R.D. and S.A. performed data analysis. A.R.D., S.A.H. and L.C.Q. organized and met with the youth advisory board. All authors (A.R.D., S.A.H., S.A., S.K., T.R. and L.C.Q.) contributed to study selection and screening procedures, as well as writing of the paper and additional supplementary materials.

Competing interests

None of the authors have financial conflicts of interest to disclose or have a relationship that may pose a conflict of interest in relation to the content presented in the paper. The authors independently chose the active ingredient based on their expertise and the funding source did not play a role in the design of this review, data collection and analyses, or the decision to publish this paper. None of the authors have previously received funding from the funding source.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1038/s41562-021-01191-9>.

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Software and code

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Data collection No software was used.

Data analysis We used Comprehensive Meta-Analysis 3.0 to calculate effect sizes (Hedges' g) and run additional supplementary tests of study selection bias. We used the program R (version 4.0.2) to run the multivariate multilevel meta-analysis using the package "metafor".

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Behavioural & social sciences study design

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Study description	We completed a multivariate meta-analysis on 88 studies (with 90 randomized controlled trials) to examine the association between changes in depression and/or anxiety symptoms during psychological treatments and changes in emotion regulation skills. We completed secondary analyses on 55 studies with non-RCTs.
Research sample	The 90 RCTs cover data from (N=11,652) participants. The 55 non-RCTs were based on information from (N=3,117) participants.
Sampling strategy	Articles were identified through searches using database-specific subject headings and keywords in natural language in the following databases: Medline (including Epub ahead of print, in-process, and other non-indexed citations), Embase, APA PsycInfo, Cumulative Index to Nursing & Allied Health Literature (CINAHL), and The Cochrane Library. A medical librarian developed the search strategy. 17848 studies were identified before duplicates were removed.
Data collection	We conducted a systematic review and multivariate meta-analysis according to the standard PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and the AMSTAR recommendations to conduct this review. We also followed the procedures outlined by the Cochrane Handbook for Systematic Reviews.
Timing	The search for the systematic review was conducted in June 2020.
Data exclusions	All of the available data was utilized to run the multivariate meta-analysis.
Non-participation	Since this is a review, we only report this information on the primary studies that were included in our analyses.
Randomization	Since this is a review, we only report this information on the primary studies that were included in our analyses.

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