i. Title: Self-Directed Digital Interventions for the Improvement of Emotion Regulation – Acceptability and Feasibility for Adolescents: A Systematic Review

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iv. Declaration of Interest

None.

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vii. Author Contributions

A.T., G.H., and B.O. conceived the initial idea for the systematic review. A.T., E.L., and E.S. screened the studies at the title and abstract stage. A.T. and E.S. screened the studies at the full-text stage. A.T. and E.L. extracted data from the included studies and carried out the quality assessment. A.T. drafted the manuscript, and G.H. and B.O. provided critical insight. A.T., G.H., B.O., E.L., E.S., and B.W. contributed to the revision of the manuscript and approved the final version.

viii. Data Availability

Data availability is not applicable to this article as no new data were created or analysed in this study.

Abstract

Background

In-person, therapist-supported interventions targeting emotion regulation (ER) have been shown to improve the mental health of adolescents. Increasingly, self-directed digital interventions (e.g. mobile apps) are being developed as a cost-effective, scalable solution to widen access to support. However, evidence of the acceptability and feasibility of these interventions has yet to be synthesised.

Aims

To identify existing evidence on the benefits, acceptability and feasibility of self-directed digital interventions that target ER in adolescents (aged 11-18 years).

Method

A PRISMA-guided systematic review was conducted to identify studies published from January 2010 to 13th of November 2024 investigating self-directed digital ER interventions for adolescents. A total of 10 electronic databases were searched (e.g. PsycINFO). Data on the effects, and perceived acceptability of the interventions were extracted, with results narratively synthesised. Methodological quality was assessed using the Effective Public Health Practice Project Quality Assessment tool.

Results

Six out of 9049 studies met the eligibility criteria and included preliminary evidence on self-directed digital interventions that target ER, in a pooled sample of 1271 adolescents. All interventions identified were brief (most < 1 month) and included different components to target ER (e.g. Mindfulness, Mood monitoring). Most interventions demonstrated benefits for ER and were acceptable for use by an adolescent population.

Conclusions

Though the evidence base was small, included studies demonstrate preliminary evidence of the benefits and acceptability of self-directed, digital interventions for ER in adolescents. Future research should focus on approaches beyond mindfulness, including targeting the related skills required to access ER strategies and use them flexibly.

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INTRODUCTION

Adolescence is a period of rapid physical, psychological and social development. Approximately 75% of mental illnesses emerge during this period (1) with many persisting into adulthood, producing significant long-term consequences for an individual's social adjustment, physical health, overall functioning (e.g. sleep), and quality of life (2). In the UK, 1 in 6 adolescents (aged 11-16) have been identified as having a probable mental illness – a figure which has steadily increased in the past decade (3). While the exact reasons for this increase are still uncertain, its effects on adolescents and society are a major concern for practitioners, researchers, and policymakers alike (4). Current attempts to support this population are largely designed to target specific conditions (e.g.,

depression (5)). However, 60% of adolescents with one diagnosable mental illness have one or more additional conditions (6). Mental health comorbidity – the presence of two or more mental illnesses in an individual - is the rule rather than the exception and has been associated with greater clinical severity and a poorer overall quality of life (7). Transdiagnostic interventions are designed to be directly effective across several mental illnesses, altering psychopathological processes common to multiple conditions (e.g. emotion regulation) (8). Emerging evidence suggests that this approach is effective in targeting diverse psychopathologies, activating a range of related, beneficial developmental cascades, including improvement in social and academic outcomes (9). A transdiagnostic approach to treatment is also considered to be time- and cost-effective compared to disorder-specific strategies and may offer a more sustainable alternative to treatments currently available to this population (7)

Emotion regulation (ER) has received increased attention in recent years as a transdiagnostic mechanism and clinical target in psychological treatment (10). Though the concept of ER remains unclear by definition, it can be broadly understood as a goal-directed multidimensional process wherein an individual monitors, evaluates and shapes their emotions when they have them, and how they internally experience or outwardly express them (10,11). There have been several different conceptualisations of emotion regulation, but by far the most influential is the 'Process Model of Emotion Regulation' (12). According to this model, an individual recognises an ER goal (e.g. to communicate to others; to modify behaviour), selects, and finally implements specific ER strategies (13). Gross defined a set of five distinct ER processes occurring at different points in an emotional experience (see ***Fig. 1***): situation selection, situation modification, attentional deployment, cognitive change, and response modulation (13). Each can be understood to influence an individual's emotional response in a way that can be interpreted as adaptive (e.g., problem-solving, acceptance) or maladaptive (e.g., withdrawal, suppression (12)), depending on the context.

Maladaptive patterns of emotional experience or expression are typically understood as emotion *dysregulation* and have physiological, cognitive, and social consequences (12,13). Evidence demonstrates emotion dysregulation is present across a range of psychopathologies, including internalising (e.g., generalised anxiety disorder, major depressive disorder, dysthymia) and

externalising disorders (e.g., attention-deficit/hyperactivity disorder [ADHD], conduct disorder, oppositional defiant disorder (14)). Recent findings also indicate a significant shift in ER between ages 13 and 15 (e.g., access to strategies, use of adaptive vs. maladaptive strategies), suggesting that adolescence is a particularly vulnerable period in the development of ER (15). Therefore, interventions targeting ER as a transdiagnostic construct central to the development and maintenance of psychopathology may reduce the risk and severity of adolescent psychopathology.

[Insert Fig.1 here]

Existing psychological interventions adopt different approaches to improving emotion regulation. Some focus on reducing the use of ER strategies which may be understood as maladaptive, such as rumination (e.g., Rumination-focused cognitive behavioural therapy, RF-CBT (16)), while others focus on increasing the use of strategies which may be understood as adaptive, such as acceptance (e.g., Acceptance and Commitment Therapy, ACT (17)). Others move beyond modifying the use of specific strategies and instead focus on developing wider ER skills (e.g. identifying and labelling emotions, understanding the context in which emotions occur, applying distress tolerance techniques) (e.g., Dialectical Behaviour Therapy, DBT; (18)). Much of the research to date has focused on the effectiveness of *in person* ER interventions, despite a growing number of *self-directed digital* solutions (e.g. mobile apps) for adolescent ER and psychopathology (19). Such interventions are led by the service user, with little to no support from anyone else (e.g., therapist, parent/carer), and aim to widen access to support for adolescents. Some attempts have been made to examine the effectiveness of digital interventions targeting ER in adolescents and emerging findings demonstrate that, in general, such interventions (e.g., digital games, virtual reality therapies) are effective in improving ER (20). However, the effectiveness of interventions delivered in this self-directed format is, as yet, unclear. It is thought that this approach has a greater capacity for innovation and engagement with adolescents (21) and the potential to extend effective care cost-effectively and sustainably (22), but more research is needed to determine how such interventions can be applied at scale to support this population.

Review Objectives

This systematic review investigates evidence on current self-directed digital interventions developed for adolescents (aged 11-18 years), and their effects on emotion (dys-)regulation, psychopathology, and functioning (e.g., academic achievement). This review provides an important extension to existing work which has thus far demonstrated the effectiveness of in-person or therapist-supported interventions available for young people (aged 6 – 24 years (14,19)), as well as the utility of a broad spectrum of digital emotion regulation interventions for adolescents (20). This review takes a more specific focus to develop evidence on a burgeoning number of *self-directed*, scalable, digital mental health interventions available to adolescents with or without diagnosed psychopathology. This is a timely contribution, employing a systematic review approach to provide a robust insight into the existing evidence base that underpins the growing number of publicly available emotion regulation mobile apps developed to provide mental health support at scale to young people (23).

Specifically, we sought to answer the following research questions:

1. Are current self-directed digital interventions that target ER acceptable and feasible for use within an adolescent population?
2. Do self-directed digital interventions that target ER in adolescents have benefits for psychopathology and overall functioning (e.g. academic achievement)?
3. How do the components of current self-directed digital interventions map onto existing theory and models of ER?

METHODS

This systematic review was registered in PROSPERO, the International Prospective Register of Systematic Reviews (CRD42022385547). The primary amendment to this protocol (24) is the decision not to undertake a meta-analysis due to the methodological and clinical heterogeneity of the included studies. We also decided to include a new database (ACM Digital Library) after the review was registered. No further amendments were made. The review was conducted according to the

procedure and requirements described in the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines (25). The completed PRISMA checklist is provided in ***Supplementary File 1.***

Search Strategy

The search strategy (provided in full in ***Supplementary File 1***) was designed to identify all studies examining one or more self-directed digital mental health interventions for adolescents, which include at least one component to target emotion (dys-)regulation (i.e. strategy or skill). It searched for synonyms for the following three concepts: *adolescents, emotion (dys-) regulation, and self-directed digital interventions*. The strings were combined based on the population (i.e. adolescents aged 11-18), intervention format (i.e. self-directed digital interventions) and intervention target (i.e. emotion regulation) of interest. Limitations were placed on the publication date (i.e. from 2010) and language (i.e. English). A body of research addressing this topic was identified before the search through word of mouth, key reference lists and simple searches to check iterations of the strategy. The search was revised until it was sensitive enough to capture the pre-identified studies.

Information Sources

Ten electronic databases were searched for studies published from January 1, 2010, to 13th November 2024: MEDLINE, PsycINFO; Global Health: Scopus; Web of Science Core Collection; EBSCO CINAHL; EBSCO ERIC; OVID Embase; The Cochrane Central Register of Controlled Trials (CENTRAL); and ACM Digital Library. Grey literature such as preprints and theses were also included in this review (databases: HMIC, EThOS, PsyArXiv, Trip, ClinicalTrials.gov). This search was updated periodically to identify any new relevant research from the selected databases (most recent search, 13th November 2024. No further studies identified for inclusion).

Eligibility Criteria

Studies were screened according to set eligibility criteria ***(Table 1***). Studies were eligible for inclusion if the intervention included at least one component to target emotion regulation (i.e. an

emotion regulation strategy or skill) **and** the study included a valid measure of emotion regulation. Studies that do not measure emotion regulation using a validated measure were excluded from this review, to protect against the inclusion of evidence that is not robust, or studies that target emotion regulation but measure a related but distinct construct (e.g. self-regulation, coping), or do not provide any evidence on the effects of the intervention on emotion regulation. Studies must report primary research with direct contact or observation of individuals, but there were no further restrictions on study design, setting, or geographical location.

[Insert Table 1 here]

Study Selection

All identified studies were exported to Endnote 20, and any duplicates were removed following a specified method (26) before being imported into Rayyan (27) for further deduplication and screening. Abstracts and titles of identified studies were screened by A.T. as a primary screener based on the eligibility criteria**.** A total of 50% of articles were jointly assigned for second screening at the title and abstract stage (E.L. screened 10%; E.S. screened 15%; J.L. screened 25%). There was strong agreement between the screener pairs (E.L + A.T $\kappa = .99$; E.S. + A.T $\kappa = .99$; J.L. + A.T $\kappa = .98$). Disagreements (n = 35) regarding the inclusion of a study were discussed, and research articles reviewed, until a consensus was reached. Those studies that met the eligibility criteria entered the full-text screening stage for further checks against the eligibility criteria. The full-text screening allowed for the identification of those interventions that did not measure emotion (dys-)regulation directly. All articles were independently screened by A.T and E.S at the full-text stage. There was strong agreement between the screener pairs ($\kappa = .86$). Disagreements (n = 1) regarding the inclusion of a study were discussed, and research articles reviewed, until a consensus was reached.

Data Extraction and Management

Data was extracted and collated from eligible studies by two independent reviewers (A.T. and E.L.) and tracked in Microsoft Excel using a structured coding form and associated coding manual. Information relating to study characteristics (e.g. author(s), publication date), participant

characteristics (e.g. age, gender), digital intervention characteristics (e.g. name, focus), and relevant clinical and emotion dysregulation outcomes were extracted from each study. Data was first extracted on 16th August 2023. Study investigators were contacted for missing/unreported data or additional details, as required.

Outcomes

The primary outcome of this review is the change in emotion (dys-)regulation, occurring as a result of participation in a self-directed digital intervention that addresses emotion (dys-) regulation. Emotion (dys-)regulation must be assessed, and where possible, using a valid and appropriate item, scale, or measure (e.g., Child Social Behaviour Questionnaire (28)), including through clinical interviews or self-reported measures. An existing review of emotion (dys-)regulation assessment (29) and similar reviews (30,31) were used as guidance to decide on a measure's eligibility. The measure must have been cited as valid by at least one of these reviews to be judged as eligible. Effect sizes were extracted for measures of emotion regulation (or calculated when data were available) and interpreted according to Cohen's conventions (32). Other outcomes of interest in this review were the change in psychopathology and functioning (e.g. academic achievement). Symptoms of psychopathology were assessed by any available valid and appropriate measure, including through clinical interview or self-reported measures. Where data was available, information about the acceptability and feasibility of the interventions was also collated.

Quality and Risk of Bias Assessment

Information to determine any study bias was also collated. Two researchers (A.T. and E.L.) independently assessed the methodological quality of the included studies using the Effective Public Health Practice Project Quality Assessment tool (EPHPP). The EPHPP is applicable to a range of quantitative study designs (e.g. case-control studies) and has been judged to be particularly suitable for systematic reviews on the effects of interventions/treatments (33). Evidence has shown the EPHPP has good content and construct validity (33,34).

Data Synthesis

Meta-analyses could not be undertaken due to the heterogeneity of interventions, study designs and outcome measures. There were also too few studies to synthesise into comparable groups. As such, a narrative synthesis of the results was conducted, guided by recommendations from Popay and colleagues (35). The effects of identified interventions are summarised based on the specific components employed to target ER, drawing attention to the notable differences in the conceptualisations of ER as a clinical target (i.e. ER strategies, ER skills and deficits). Specific attention is also given to the acceptability and feasibility of the self-directed digital intervention format. Data from these studies, including significance and direction of effects, is presented in summary tables. Given the range of outcome measures and statistical approaches applied across studies, results should not be compared across interventions.

RESULTS

A total of 9094 records were retrieved from the database searches (see ***Fig. 2*** for the study selection process). After 3113 duplicate records were removed, the abstracts and titles of the remaining records were screened according to the eligibility criteria. At the abstract and title screening stage, 5907 records were excluded. In total, 74 papers entered the full-text screening stage, of which six met the eligibility criteria and provided sufficient data (36–41)

[Insert Fig.2 here]

Characteristics of Included Studies

The characteristics of the included studies are summarised in ***Table 2***. Most (k = 5) were conducted in the United States of America (USA) and employed a sample of between 80 – 618 adolescents aged 12-20 years. Studies were a mixture of brief cohort (one group pre + post-test) studies (k = 3; (36,39,40)) and randomised controlled studies (k = 3; (37,38,41)) comparing the intervention to either an active or wait-list control. Two studies tested the same intervention – the first was a cohort study to test preliminary feasibility and acceptability (36) and the second was a pilot randomised

controlled trial (RCT) to confirm the intervention's effects (37). Across most studies (k = 5), investigating the effects of a self-directed digital intervention in improving ER was the focus. However, for one study, the primary focus was on mental health symptoms (depression and anxiety), however ER was captured as a secondary outcome (41). A range of measures were used to capture change in ER as a result of using the intervention (***Table 2***). Only half of the studies (36,37,41) investigated the impact of the intervention on improving psychopathology, but most measured at least one related functional outcome (i.e. stress, worry, life satisfaction, self-control), though the types of outcomes measured differed across studies (36,38–41). Results from the assessment of risk of bias are shown in ***Table 2***. The quality of most of the included studies was weak or moderate. The uncontrolled study design was one of the primary reasons for the lower quality ratings, as well as the lack of blinding and missing information about confounders in some studies. Full ratings for each included study are included in ***Supplementary File 2***

[Insert Table 2 here]

Intervention Characteristics

The characteristics of the included interventions are summarised in ***Table 3.*** All interventions were brief and were in the early stages of development and testing. The active intervention period in all studies lasted between 14 to 49 days, though some studies allowed participants to engage with the intervention beyond this point (36,37,41). Some interventions offered shorter daily activities (1-15 minutes; (36,37,40)), while others comprised longer modules (20-45 minutes each) that participants completed once a week (38,39,41).

[Insert Table 3 here]

All interventions were self-directed and delivered digitally, although the format varied between studies. Half of the interventions included (k = 3) were app-based and could be accessed via smartphones whenever and wherever the participant chose (36,37,40). The remaining interventions, whilst self-directed, were delivered during a dedicated intervention session via tablet or computer in a classroom at school (38,39,41).

Effects of the Interventions

Full details of the interventions and study findings are included in the ***Supplementary File 2.*** The type of intervention, intervention components, outcomes reported, effect sizes, and any significant results are summarised in ***Table 4***.

[Insert Table 4 here]

Interventions targeting antecedent-focused ER strategies: Mindfulness and Mood Monitoring

The most common component across most identified interventions was mindfulness - an approach which focuses on observing, describing, acting with awareness, non-judging, and non-reactivity to emotional experiences (42). A total of four out of the five interventions included a mindfulness component (i.e. breathwork, meditation) to support young people in regulating their emotions (36,37,39–41). Significant improvements to ER were observed in three of these interventions (36,37,39,41), whilst the fourth observed no significant improvements in ER over time (40). Despite the significant improvements observed, effect sizes were small to moderate overall (see ***Table 4***). Notably, some adverse effects were observed. In the study by Hilt and colleagues (37), a mindfulness-based intervention with a mood-monitoring component was compared to a mood-monitoring-only control. Whilst significant reductions in rumination were observed overall ($t(69.86) = 3.53$, $p < .001$), a quarter of adolescents in the mindfulness condition experienced clinically significant worsening of rumination at the end of the intervention period (37).

Psychopathology was included as an outcome of just two of the interventions across three studies. The first intervention was tested across a cohort study (36) and pilot randomised controlled trial (RCT; (37)). It included mindfulness and mood-monitoring components. Overall, the intervention reduced anxiety symptoms in both studies; however, this reduction was non-significant in the pilot RCT (37). In contrast, whilst the authors observed a significant reduction in depressive symptoms in the pilot RCT (37), there was no significant impact of the intervention on depressive symptoms in the cohort study (36).

Interventions targeting antecedent-focused ER strategies: Problem Solving and Behavioural Avoidance

In addition to mindfulness activities, the intervention by Mrazek and colleagues (39) included exercises to target other antecedent-focused ER strategies, such as problem-solving or behavioural avoidance. In this cohort study, the intervention was found to significantly improve ER in adolescents, but the effect size was small overall (d = 0.29). After participating in the intervention, adolescents also showed significant changes in perceived stress management. Despite this, there were non-significant changes in actual stress and overall life satisfaction among adolescents (39). Psychopathology was not included as an outcome in this study.

Interventions targeting multiple ER strategies and related skills (e.g. emotional awareness)

Two interventions identified (38,41) had a wider focus, targeting several different antecedent- and response-focused ER strategies (e.g. acceptance, expressive suppression). The first (38) included activities to develop the skills related to ER, such as emotional awareness and emotion controllability beliefs. This intervention was tested in a pilot RCT with a wait-list control and was found to be beneficial in improving the ER overall. Participants who completed this intervention perceived themselves as having better emotional competence and endorsed greater use of the ER strategies targeted by the intervention. Participants reported greater belief that emotions can be changed, greater awareness of their emotions, self-efficacy for managing emotions, and perceived access to ER strategies. There were unexpected effects for behavioural measures of distress tolerance; participants who completed the intervention persisted for less time on tasks and showed reduced distress tolerance compared to wait-list controls. Psychopathology was not included as an outcome in this study.

The second intervention (41) targeted a broad spectrum of emotion regulation strategies and abilities through a cognitive behavioural therapy (CBT) and behavioural activation (BA) approach. Though one module was dedicated to emotion regulation, different strategies and abilities relevant to ER were included throughout (i.e. problem-solving, cognitive reappraisal, emotional awareness). The intervention was tested in a cluster RCT and demonstrated mixed effects for improving ER among participants. It was shown to be significant in improving expressive suppression when compared to a

wait-list control. However, a non-significant decrease in cognitive reappraisal was observed. There were no significant intervention effects observed for either depressive or anxiety symptoms.

Feasibility and Acceptability of the Interventions

The acceptability and feasibility of these interventions are described in ***Table 5***. As most interventions were in the earlier stages of their development, for many studies, understanding the acceptability and feasibility of the intervention was very much the focus.

[Insert Table 5 here]

Most studies (k = 4) measured the intervention acceptability among adolescents; to do so, various quantitative and qualitative methods were employed. Overall, the authors commented that their interventions were acceptable for use among adolescents, in keeping with previous evidence (22,43). Many adolescents felt that the interventions were easy to use, and the exercises were clear, helpful, and easy to understand. One study also measured parents' perceptions and found that they similarly reported the beneficial impact of the intervention on their children (36).

Differences were observed in terms of the extent to which different intervention components were perceived as helpful, in one of the studies (41) Participants reported that the intervention was most helpful in confronting problems and recognising negative thoughts, but least helpful in changing behaviour. In this particular intervention, the least utilised activities were relaxation and mindfulness techniques.

Importantly, some participants had negative experiences with some of the interventions, finding them not helpful at all or reporting that they negatively impacted their mental health or ability to regulate their emotions. One study reported four adverse events among their participants (37). All four events involved increased awareness of negative thoughts and feelings during the intervention period. Two participants reported this in each condition (mindfulness+mood-monitoring vs. mood-monitoring alone); thus, it may be related to monitoring negative emotions.

DISCUSSION

The aim of this systematic review was to synthesise evidence on current self-directed, digital interventions that target ER, and to explore their benefits and acceptability among adolescents (aged 11-18 years). Overall, the evidence base was small. Just six papers were identified, which measured the effects of a total of five brief interventions for ER. There was large clinical and methodological diversity across interventions and studies; each of the interventions included different components to target ER. These components have been mapped onto the Process Model of ER (12)to better illustrate the diversity in approaches to targeting ER in adolescence (***Fig. 3***). Although Gross's process model of ER (12) suggests dynamic variability in the consequences of each of the proposed ER strategies (e.g. cognitive reappraisal), in practice, researchers and clinicians alike have tended to interpret them as adaptive (e.g., mindfulness, acceptance) or maladaptive (e.g., withdrawal, suppression; (44)). This has similarly directed intervention efforts, with the focus often being on developing interventions aimed at increasing the use of "adaptive" strategies and/or decreasing the use of "maladaptive" strategies.

[Insert Fig.3 here]

This was reflected in the interventions identified in this review. The majority focused on increasing the use of the 'adaptive' strategy mindfulness to improve ER. Mindfulness-based interventions have gathered increasing attention within the field (45) and are increasingly employed in schools to support adolescents with their emotional well-being and mental health (46). Though mindfulness was offered as a component across four out of five identified digital interventions, findings on its benefits were mixed. Though some significant improvements to ER were observed, effect sizes were small overall. One study also reported that participants engaged with mindfulness techniques the least, when compared to other intervention activities (41). Of particular note in one study (37) was the finding that a quarter of adolescents who completed the mindfulness-based intervention experienced clinically significant worsening of rumination. This would align with existing evidence that mindfulness is not always a helpful strategy, particularly when applied universally to the adolescent population (47).

This study also reported four adverse events among their participants; all four events involved increased awareness of negative feelings during the intervention period, supporting previous findings in adults that mood monitoring, in the absence of adequate strategies to process the emotions identified, can sometimes be harmful rather than helpful (48,49). Indeed, there is a growing consensus that the adaptiveness of any given ER strategy is context-dependent rather than universal and depends on the appropriateness of the strategy to the specific situation in which it is used (44). There has been increased evidence that the use and functional benefits of any specific type of ER strategy will tend to vary across people and situations, and by extension, the most effective use of ER strategies is likely to be one that is most flexible (44,50). As such, interventions such as the one proposed by Houck and colleagues (38) and Kuosmanen and colleagues (42), which included activities to develop the related skills required to access certain strategies and use them flexibly, may be the most appropriate approach to supporting adolescents with ER and their mental health.

Few studies measured the impact of targeting ER on mental health outcomes. The impact of these interventions on adolescent psychopathology was measured in just three studies, two of which investigated the same intervention (36,37). Overall findings were mixed; whilst reductions in symptoms of anxiety and depression were observed, these were non-significant across studies. Given growing evidence on the importance of ER for psychopathology in adolescence (19), its omission as an outcome in most studies was surprising and limits current attempts to better understand its role in supporting adolescents. However, this may reflect the fact that most interventions were in the earlier stages of their development and, therefore, understanding the feasibility of the intervention in targeting ER was the primary focus for most studies (51). Greater research is needed to understand the effects of targeting ER through self-directed digital interventions on adolescent psychopathology.

Clinical Implications

This review identified a total of six studies which investigated the effects of five self-directed, digital interventions available to adolescents (aged 11-18 years). Despite large methodological and clinical heterogeneity, preliminary evidence from these studies suggests that these interventions showed benefits for ER. The self-directed and digital format was also highly feasible and acceptable to

adolescents, a finding that is in keeping with previous research on digital interventions for young people (43). Though the evidence base was small, this review highlights some important considerations for researchers and practitioners working to support adolescents with their mental health.

Primarily, though most of the interventions employed mindfulness as a strategy to improve ER, this was not a universally acceptable or beneficial approach. Given the deluge of literature on mindfulness-based interventions, such a finding suggests that there is a need to look elsewhere for additional solutions to support young people with their ER and mental health. One such recommendation would be to focus on developing research into other ER strategies that receive arguably less attention (e.g. cognitive reappraisal) and the related skills required to access these strategies and use them flexibly. Individual, social, cultural, and environmental factors are known to be highly influential in the success of different ER strategies (44). As such, the focus of interventions should move beyond teaching adolescents different strategies but also equipping them with the skills they need to apply them confidently (e.g. emotional awareness, self-efficacy). A further key finding of note from this review was the strong feasibility and acceptability of the self-directed digital format for delivering this type of intervention to adolescents. Digital health is a growing field and provides opportunities to broaden access to care in a cost-effective and sustainable manner. Particularly among adolescents, this is known to be a highly acceptable format for the delivery of mental health interventions (43).

Limitations of this Review

The findings of this review should be interpreted with caution due to several limitations. Primarily, the lack of studies identified limits conclusions that could be drawn. Despite the planned focus of this review on psychopathology, as it transpired, just three studies measured this as an outcome, and findings were mixed. Moreover, only symptoms of anxiety and depression were measured, making it difficult to draw conclusions about the effects of ER as a transdiagnostic mechanism. There was also significant clinical and methodological heterogeneity among identified studies, meaning it was not possible to directly compare interventions and make conclusions about those most effective in improving ER and psychopathology. However, we argue that insight can be gleaned from understanding

the different approaches currently taken to improve ER in adolescents and their effects within individual studies, but acknowledge that, with the lack of available evidence, no definitive conclusions should be drawn about the effectiveness of any individual approach in comparison to another.

Only 50% of studies were dually screened at title and abstract stage. Though rater pairs showed strong agreement on those articles that were screened, the lack of 100% dual screening may contribute to the decreased number of identified studies.

There was considerable variation across the measures used to capture change in ER, as expected given the large variation in the different conceptualisations of ER and its subsequent measurement (52). Though some validated measures exist, these are not employed consistently across studies of ER, meaning it is difficult to compare the effects of different interventions. Similarly, functional outcomes such as academic achievement or life satisfaction were different across all of the included studies and thus could not be compared.

There were further limitations within the studies included in this review. The quality of the studies was limited, and many of the interventions were at the early stages of testing. Most studies were pre-post cohort studies and did not include a comparison group, which contributed to the increased risk of bias. Similarly, many of the included studies had short follow-up time periods, meaning any change in effects observed over time was not captured here. Further, though the participants included in these studies were ethnically diverse, most were conducted in the USA, limiting conclusions that can be drawn about the benefits of these interventions globally. As such, many findings that were reported in this review should be interpreted in light of these shortcomings.

Suggestions for Future Research

As the prevalence of mental health problems among adolescents increases, more research must be done to determine the impact of self-directed digital interventions targeting transdiagnostic mechanisms like ER, particularly when applied at scale to support adolescents with their mental health. Recommendations from this research echo a common suggestion within the ER literature – to better refine and clarify the concept of ER as it applies to research and practice. In this review, several different measures of ER were employed, dependent on the authors' understanding of ER as a concept to be

targeted in an intervention. The lack of conceptual clarity surrounding ER and the way its change can be interpreted or measured means it is difficult to compare and synergise ER interventions and illuminate components that are most beneficial in improving ER and mental health. Clarifying the definition of ER is an essential step to a more synchronous approach in the field and ultimately to better understanding how this mechanism can be targeted to support adolescents with their mental health.

Conclusions

This is the first systematic review to synthesise evidence on the effects of highly scalable and cost-effective self-directed digital interventions that target ER in adolescents. Though the evidence base was small, included studies demonstrate preliminary evidence of the benefits and acceptability of self-directed, digital interventions for ER in adolescents. Most of the interventions targeted mindfulness as a strategy to improve ER, yet this was not a universally acceptable approach. Large-scale empirical research focused on comprehensive ER interventions for adolescents across the world is needed, especially those which investigate the intervention effects on psychopathology. Practitioners should focus on approaches beyond mindfulness, including targeting other ER strategies that receive arguably less attention in the digital intervention field and the related skills required to access these strategies and use them flexibly.

REFERENCES

1. Kim-Cohen J, Caspi A, Moffitt TE, Harrington H, Milne BJ, Poulton R. Prior Juvenile Diagnoses in Adults With Mental Disorder Developmental Follow-Back of a Prospective-Longitudinal Cohort. 2003.
2. Clarke A, Inês Pote, Miriam Sorgenfrei. Adolescent mental health evidence brief 1: Prevalence of disorders. Early Intervention Foundation. 2020;
3. Newlove-Delgado T, Williams T, Robertson K, McManus S, Sadler K, Vizard T, et al. Mental Health of Children and Young People in England 2021-wave 2 follow up to the 2017 survey. 2021;
4. Gunnell D, Kidger J, Elvidge H. Adolescent mental health in crisis. Vol. 361, BMJ (Online). BMJ Publishing Group; 2018.
5. Knapp M, Wong G. Economics and mental health: the current scenario. World Psychiatry. 2020;19(1):3–14.
6. Organization WH. Mental Health of Adolescents [Internet]. Vol. 2021. 2021. Available from: https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health
7. Dalgleish T, Black M, Johnston D, Bevan A. Transdiagnostic approaches to mental health problems: Current status and future directions. J Consult Clin Psychol. 2020;88(3):179.
8. Roefs A, Fried EI, Kindt M, Martijn C, Elzinga B, Evers AWM, et al. A new science of mental disorders: Using personalised, transdiagnostic, dynamical systems to understand, model, diagnose and treat psychopathology. Behaviour Research and Therapy. 2022;153:104096.
9. Forbes MK, Rapee RM, Krueger RF. Opportunities for the prevention of mental disorders by reducing general psychopathology in early childhood. Behaviour Research and Therapy. 2019;119:103411.

10. Aldao A, Gee DG, De Los Reyes A, Seager I. Emotion regulation as a transdiagnostic factor in the development of internalizing and externalizing psychopathology: Current and future directions. Dev Psychopathol. 2016;28(4pt1):927–46.
11. D'Agostino A, Covanti S, Rossi Monti M, Starcevic V. Reconsidering emotion dysregulation. Psychiatric Quarterly. 2017;88:807–25.
12. Gross JJ. Antecedent-and response-focused emotion regulation: divergent consequences for experience, expression, and physiology. J Pers Soc Psychol. 1998;74(1):224.
13. Gross JJ. Emotion regulation in adulthood: Timing is everything. Curr Dir Psychol Sci. 2001;10(6):214–9.
14. Helland SS, Mellblom A V, Kjøbli J, Wentzel-Larsen T, Espenes K, Engell T, et al. Elements in mental health interventions associated with effects on emotion regulation in adolescents: a meta-analysis. Administration and Policy in Mental Health and Mental Health Services Research. 2022;49(6):1004–18.
15. Zimmermann P, Iwanski A. Emotion regulation from early adolescence to emerging adulthood and middle adulthood: Age differences, gender differences, and emotion-specific developmental variations. Int J Behav Dev. 2014;38(2):182–94.
16. Watkins E, Scott J, Wingrove J, Rimes K, Bathurst N, Steiner H, et al. Rumination-focused cognitive behaviour therapy for residual depression: A case series. Behaviour research and therapy. 2007;45(9):2144–54.
17. Hayes SC, Strosahl KD, Wilson KG. Acceptance and commitment therapy. Vol. 6. Guilford press New York; 1999.
18. Linehan M. Skills training manual for treating borderline personality disorder. Guildford Press; 1993.
19. Moltrecht B, Deighton J, Patalay P, Edbrooke-Childs J. Effectiveness of current psychological interventions to improve emotion regulation in youth: a meta-analysis. Eur Child Adolesc Psychiatry. 2021;30(6):829–48.
20. Reynard S, Dias J, Mitic M, Schrank B, Woodcock KA. Digital interventions for emotion regulation in children and early adolescents: systematic review and meta-analysis. JMIR Serious Games. 2022;10(3):e31456.
21. Moltrecht B, Patalay P, Bear HA, Deighton J, Edbrooke-Childs J. Interdisciplinary development of a transdiagnostic mobile app to enhance children's emotion regulation: sharing insights and lessons learned. JMIR Form Res. 2021;
22. Moltrecht B, Patalay P, Deighton J, Edbrooke-Childs J. A school-based mobile app intervention for enhancing emotion regulation in children: exploratory trial. JMIR Mhealth Uhealth. 2021;9(7):e21837.
23. Eisenstadt M, Liverpool S, Infanti E, Ciuvat RM, Carlsson C. Mobile Apps That Promote Emotion Regulation, Positive Mental Health, and Well-being in the General Population: Systematic Review and Meta-analysis. JMIR Ment Health [Internet]. 2021 Nov 8 [cited 2025 Sep 15];8(11):e31170. Available from: http://www.ncbi.nlm.nih.gov/pubmed/34747713
24. Thomson A, Lawrence EG, Oliver BR, Wright B, Hosang GM. Self-directed digital interventions for the improvement of emotion regulation—effectiveness for mental health and functioning in adolescents: protocol for a systematic review. BMJ Open. 2024;14(4):e081556.

25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372.
26. Falconer J. Removing duplicates from an endnote library. [Internet]. Vol. 2022. 2018. Available from: https://blogs.lshtm.ac.uk/library/2018/12/07/removing-duplicates-from-an-endnote-library/
27. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev. 2016;5:1–10.
28. Luteijn EEF, Jackson SAE, Volkmar FR, Minderaa RB. The development of the Children's Social Behavior Questionnaire: Preliminary data. J Autism Dev Disord. 1998;
29. Adrian M, Zeman J, Erdley C, Lisa L, Sim L. Emotional dysregulation and interpersonal difficulties as risk factors for nonsuicidal self-injury in adolescent girls. J Abnorm Child Psychol. 2011;39:389–400.
30. Aldao A, Nolen-Hoeksema S, Schweizer S. Emotion-regulation strategies across psychopathology: A meta-analytic review. Clin Psychol Rev. 2010;30(2):217–37.
31. Sloan E, Hall K, Moulding R, Bryce S, Mildred H, Staiger PK. Emotion regulation as a transdiagnostic treatment construct across anxiety, depression, substance, eating and borderline personality disorders: A systematic review. Clin Psychol Rev. 2017;57:141–63.
32. Cohen J. Statistical Power Analysis for the Behavioral Sciences. Statistical Power Analysis for the Behavioral Sciences [Internet]. 2013 May 13 [cited 2025 Jul 28]; Available from: https://www.taylorfrancis.com/books/mono/10.4324/9780203771587/statistical-power-analysis-behavioral-sciences-jacob-cohen
33. Deeks JJ, Dinnes J, D'Amico R, Sowden AJ, Sakarovitch C, Song F, et al. Evaluating non-randomised intervention studies. Health Technol Assess. 2003;7(27):iii–173.
34. Thomas BH, Ciliska D, Dobbins M, Micucci S. A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions. Worldviews Evid Based Nurs. 2004;1(3):176–84.
35. Popay J, Roberts H, Sowden A, Petticrew M, Arai L, Rodgers M, et al. Guidance on the conduct of narrative synthesis in systematic reviews. A product from the ESRC methods programme Version. 2006;1(1):b92.
36. Hilt LM, Swords CM. Acceptability and preliminary effects of a mindfulness mobile application for ruminative adolescents. Behav Ther. 2021;52(6):1339–50.
37. Hilt LM, Swords CM, Webb CA. Randomized controlled trial of a mindfulness mobile application for ruminative adolescents. Journal of Clinical Child & Adolescent Psychology. 2023;1–14.
38. Houck C, Modrowski CA, Hadley W, Barker D, Myers V, Bala K, et al. A pilot study of a tablet-based emotion regulation intervention for early adolescents. Journal of Developmental & Behavioral Pediatrics. 2022;43(8):e505–14.
39. Mrazek AJ, Mrazek MD, Reese J V, Kirk AC, Gougis LJ, Delegard AM, et al. Mindfulness-based attention training: Feasibility and preliminary outcomes of a digital course for high school students. Educ Sci (Basel). 2019;9(3):230.
40. Schnitker SA, Shubert J, Ratchford JL, Lumpkin M, Houltberg BJ. Mixed results on the efficacy of the CharacterMe smartphone app to improve self-control,

patience, and emotional regulation competencies in adolescents. Front Psychol. 2021;12:586713.
41. Kuosmanen T, Fleming TM, Newell J, Barry MM. A pilot evaluation of the SPARX-R gaming intervention for preventing depression and improving wellbeing among adolescents in alternative education. Internet Interv. 2017 Jun 1;8:40–7.
42. Baer RA, Smith GT, Hopkins J, Krietemeyer J, Toney L. Using self-report assessment methods to explore facets of mindfulness. Assessment. 2006;13(1):27–45.
43. Liverpool S, Mota CP, Sales CMD, Čuš A, Carletto S, Hancheva C, et al. Engaging children and young people in digital mental health interventions: systematic review of modes of delivery, facilitators, and barriers. J Med Internet Res. 2020;22(6):e16317.
44. Bonanno GA, Burton CL. Regulatory flexibility: An individual differences perspective on coping and emotion regulation. Perspectives on psychological science. 2013;8(6):591–612.
45. Goldin P, Gross J. Effect of mindfulness meditation training on the neural bases of emotion regulation in social anxiety disorder. Emotion. 2010;10(1):83–4.
46. Emerson LM, De Diaz NN, Sherwood A, Waters A, Farrell L. Mindfulness interventions in schools: Integrity and feasibility of implementation. Int J Behav Dev. 2020;44(1):62–75.
47. Kuyken W, Ball S, Crane C, Ganguli P, Jones B, Montero-Marin J, et al. Effectiveness and cost-effectiveness of universal school-based mindfulness training compared with normal school provision in reducing risk of mental health problems and promoting well-being in adolescence: the MYRIAD cluster randomised controlled trial. BMJ Ment Health. 2022;25(3):99–109.
48. Palmier-Claus J, Shryane N, Taylor P, Lewis S, Drake R. Mood variability predicts the course of suicidal ideation in individuals with first and second episode psychosis. Psychiatry Res. 2013;206(2–3):240–5.
49. Faurholt-Jepsen M, Frost M, Ritz C, Christensen EM, Jacoby AS, Mikkelsen RL, et al. Daily electronic self-monitoring in bipolar disorder using smartphones–the MONARCA I trial: a randomized, placebo-controlled, single-blind, parallel group trial. Psychol Med. 2015;45(13):2691–704.
50. Aldao A, Nolen-Hoeksema S. The influence of context on the implementation of adaptive emotion regulation strategies. Behaviour Research and Therapy. 2012 Aug;50(7–8):493–501.
51. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. BMJ [Internet]. 2021 Sep 30;374:n2061. Available from: http://www.bmj.com/content/374/bmj.n2061.abstract
52. Gross JJ. Emotion regulation: Current status and future prospects. Psychol Inq. 2015;26(1):1–26.