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The Effectiveness of Artificial Intelligence Interventions on Students' Rumination and Emotion Regulation: A Systematic Review

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ABSTRACT

Objective: This systematic review examined the evidence on the effectiveness of artificial intelligence (AI)-based interventions in improving emotion regulation and reducing rumination among students. Given the growing prevalence of emotional difficulties in academic settings, evaluating the role of AI-driven mental health tools is increasingly important.

Methods and Materials: A systematic review was conducted in accordance with PRISMA principles. Electronic databases, including PubMed, Scopus, ScienceDirect, and Google Scholar, were searched for relevant studies published between 2015 and 2024. Eligible studies examined AI-based psychological or digital mental health interventions targeting rumination, emotion regulation, or related mental health outcomes in student populations. After screening and eligibility assessment, 22 studies were included in the final synthesis. Owing to heterogeneity in study designs, interventions, and outcome measures, a narrative synthesis was performed.

Findings: The included studies comprised randomized controlled trials, quasi-experimental studies, mixed-methods research, and observational designs. Most studies reported favorable effects of AI-based tools, including chatbots, mobile applications, and digital platforms, on emotion regulation, stress reduction, and rumination-related outcomes. Improvements were particularly noted in cognitive reappraisal, mindfulness, and self-regulation, along with reductions in repetitive negative thinking. However, the overall strength of evidence was limited by methodological heterogeneity, inconsistent statistical reporting, small sample sizes in some studies, and insufficient long-term follow-up.

Conclusion: AI-based interventions appear promising as accessible and scalable tools to support students' mental health, particularly by enhancing emotion regulation and reducing rumination. Nevertheless, current evidence remains preliminary, and more rigorous longitudinal and controlled studies are needed to establish their sustained effectiveness and clinical utility.

Keywords: Artificial intelligence, emotion regulation, rumination, students, systematic review.

Introduction

Emotion regulation and rumination are two critical psychological processes that significantly influence the mental health and academic functioning of university students (Blanke et al., 2022). Increased levels of rumination and impaired emotion regulation have been strongly associated with psychological disorders, including anxiety and depression, particularly within student populations (Clamor, Lincoln, & Schulze, 2024). Effective regulation of emotions contributes to academic success, stress reduction, and emotional resilience (Enny et al., 2024), while excessive rumination—characterized by repetitive, passive focus on distress—can exacerbate emotional dysregulation and lead to psychological distress (Nolen-Hoeksema, 2008; Smith & Alloy, 2009).

Rumination not only intensifies negative emotions but also impairs problem-solving, reinforcing cycles of psychological discomfort (Alligood et al., 2024). In academic settings, this cognitive process can undermine students' flexibility, resilience, and overall functioning (Mulawarman et al., 2024). Similarly, the inability to manage emotional experiences effectively has been linked to poorer academic performance, reduced psychological well-being, and greater vulnerability to mental health disorders (Berking & Wupperman, 2012; Conley et al., 2014; Marissa et al., 2022).

Emotion regulation, broadly defined, involves modulating emotional intensity, duration, and expression in ways that promote adaptive functioning (Gross, 1998; 2024). This process can be improved through targeted cognitive and behavioral strategies (Boemo et al., 2022) and has become a key focus in both prevention and intervention efforts for student mental health (Shati & Nasser, 2024; Arkan et al., 2024; Vestad & Tharaldsen, 2022). Given the personal, social, and academic pressures students face, scalable, effective interventions that improve emotion regulation and reduce maladaptive cognitive patterns like rumination are urgently needed.

Recent advancements in artificial intelligence (AI)—particularly the use of AI-powered interventions such as chatbots, virtual assistants, and mobile mental health apps—have introduced novel approaches for addressing these psychological concerns. These interventions leverage machine learning and natural language processing to simulate therapeutic dialogue, track mood, provide coping strategies, and offer real-time support (Sanjay et al., 2024; Yuezhong et al., 2024). Specific technologies include large language models (LLMs), such as GPT-based systems, which can generate human-like dialogue, provide empathetic responses, and assist with emotion identification and regulation (Radford et al., 2019; Hadi, 2023).

Preliminary findings indicate that LLM-based interventions may decrease rumination by promoting cognitive restructuring and reflective thinking (Shin & Kim, 2023), and they have been shown to support emotion regulation by delivering consistent, supportive responses in digital therapy contexts (Xu et al., 2024; Liu et al., 2025). These tools also offer potential advantages in terms of accessibility, affordability, and scalability, especially in under-resourced settings where access to trained professionals is limited (Hamiduzzaman et al., 2024).

However, challenges remain. Most notably, current research rarely addresses the cultural relevance or potential biases of AI interventions. For example, the effectiveness of AI systems developed in Western contexts may not generalize across different cultures, languages, or value systems (De Choudhury, Pendse, & Kumar, 2023). Furthermore, concerns regarding the ethical use of sensitive data, personalization, and the long-term psychological impacts of AI use remain underexplored (He et al., 2023). These limitations point to the need for a more critical evaluation of the design, deployment, and efficacy of AI-based interventions across diverse student populations.

Although AI applications in education and mental health are rapidly expanding (Priyanka & Subashini, 2024; Radoslav et al., 2024), most existing studies emphasize general benefits—such as increased engagement and personalization—without specifically addressing how these technologies affect foundational psychological constructs such as rumination and emotion regulation. While students express interest in using credible, AI-driven tools (Fadoua et al., 2024), the direct psychological mechanisms through which these tools exert their effects require further investigation.

Despite growing interest, a clear gap remains in the literature regarding the specific impact of AI interventions—especially LLM-driven tools—on students' emotion regulation and rumination. This review seeks to address that gap by synthesizing current

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empirical evidence on AI-based psychological interventions targeted at these two constructs. Understanding how and to what extent these technologies influence emotional and cognitive functioning is essential for developing effective, ethical, and culturally competent digital mental health solutions.

Therefore, this systematic review aims to critically evaluate existing studies on the effectiveness of AI-based interventions, with a particular focus on LLMs, in improving emotion regulation and reducing rumination among students. By identifying strengths, limitations, and gaps in the current literature, this review contributes to ongoing efforts to design evidence-based, scalable mental health technologies tailored to the needs of diverse student populations.

Methods and Materials

Study Design

This systematic review was conducted to evaluate the effectiveness of artificial intelligence (AI)-based interventions—particularly those involving large language models (LLMs)—on emotion regulation and rumination. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor and transparency (Figure 1).

Search Strategy

A comprehensive literature search was conducted in the following electronic databases: PubMed, Scopus, ScienceDirect, Elsevier, and Google Scholar. The search covered peer-reviewed studies published between January 2015 and December 2024, focusing on the growing relevance of AI in digital mental health over the past decade.

A combination of Boolean operators and controlled vocabulary (e.g., MeSH terms in PubMed) was used to build the search queries. The primary keywords and phrases included:

- "Rumination" AND "artificial intelligence."
- "Emotion regulation" AND "large language models (LLMs)."
- "AI-based cognitive behavioral therapy (CBT)."
- "Natural language processing (NLP)" AND "mental health."
- "Intelligent chatbot" OR "digital mental health intervention."
- "Machine learning" AND "emotional support."
- "Therapeutic dialogue" AND "language models."
- "AI-based interventions" AND "stress reduction."

Each keyword set was searched independently, and combinations were refined through database-specific filters where applicable.

Inclusion and Exclusion Criteria

The studies included in this review met the following criteria: Empirical studies published in peer-reviewed journals between 2015 and 2023; focused on AI-based psychological interventions (including LLMs, chatbots, NLP, etc.); addressed outcomes specifically related to emotion regulation and/or rumination; utilized experimental or quasi-experimental designs (e.g., RCTs, pre-post studies, longitudinal designs); reported quantitative outcome measures relevant to psychological functioning and published in English.

Exclusion criteria included: studies without full-text availability, theoretical or conceptual papers without empirical evaluation, reviews, opinion pieces, or editorial letters, and studies not addressing either emotion regulation or rumination as primary outcomes and non-English language publications.

Study Selection Process

A total of 112 articles were retrieved through the database searches. After removing duplicates (n=14), 98 articles remained. Two reviewers independently screened titles and abstracts to assess relevance. Ten articles were excluded for irrelevance, and 24 were removed for lack of full text. This left 64 articles, of which 42 were excluded based on the inclusion criteria. Ultimately, 22 articles were selected for full-text review and inclusion in the synthesis (Figure 1: PRISMA flow diagram).

Quality Assessment and Risk of Bias

To assess the methodological quality and risk of bias of the included studies, the Mixed Methods Appraisal Tool (MMAT, 2018 version) was employed. This tool allows for the evaluation of quantitative, qualitative, and mixed-methods studies using a standardized framework. Two reviewers independently rated each study, and discrepancies were resolved through discussion. Risk of bias was assessed based on factors such as randomization, outcome measurement, reporting completeness, and sample representativeness.

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Data Extraction and Synthesis

Key data extracted from the included studies included: authors, publication year, country, sample characteristics, type of AI intervention, psychological outcome measures (rumination, emotion regulation), study design, and major findings.

Given the heterogeneity in study design, sample populations, and outcome measurement tools, a narrative synthesis was conducted rather than a meta-analysis. This approach enabled thematic grouping of findings based on intervention type (e.g., chatbot-based, LLM-powered, NLP-assisted), targeted outcome (rumination vs. emotion regulation), and study quality. Patterns in effectiveness, limitations, and implementation considerations were analyzed across studies.

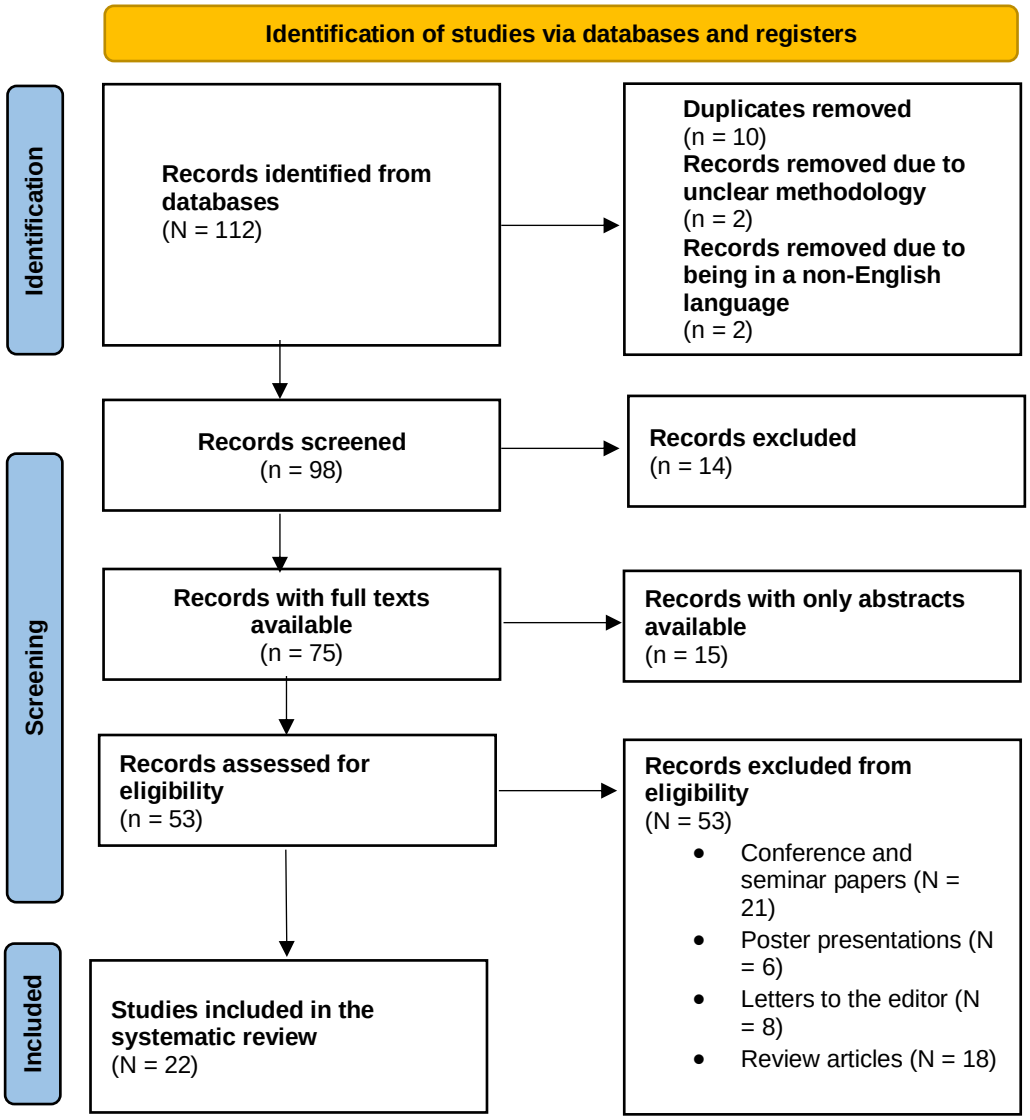

Figure 1

Article selection process

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Findings and Results

Demographic Characteristics

Table 1 summarizes the reviewed studies. The analysis of the reviewed studies showed that the number of participants ranged from 20 to 287. Additionally, in studies that employed single-subject designs, the number of participants ranged from 1 to 2.

In terms of gender, 30% of the studies included only female participants, 55% assessed both genders, and 10% evaluated only male participants. In 5% of the studies, no information was provided on the participants' gender.

Regarding age, 75% of the studies reported that participants were aged 18 to 50 years. Only one study (5%) reported an average age above 40 years. In addition, in the single-subject studies, the participants' ages were reported separately as 22, 30.64, and 49 years. The findings indicated that most studies focused on adolescents and young adults.

Research Design

A total of 22 studies on AI-based interventions in mental health were reviewed. The designs of these studies included 10 randomized controlled trials (RCTs) accounting for 45.5%, of which 2 were double-masked RCTs (9.1%), 1 was a non-blinded RCT (4.5%), 1 was an open-label RCT (4.5%), 1 was a fully remote RCT (4.5%), 1 was a Phase III RCT (4.5%), and 1 was a multi-center RCT (4.5%). Furthermore, 2 pre-test-post-test studies (9.1%), 1 pilot study (4.5%), 2 one-week and four-week comparative studies (9.1%), 1 observational study with mixed methods (4.5%), 1 cross-sectional online study (4.5%), 1 system design and evaluation study (4.5%), 2 single-group studies (9.1%), and 1 experimental study (4.5%) were reviewed. These studies focused on the development and evaluation of rule-based chatbots for mindfulness-based stress reduction (MBSR) interventions, the use of transformer models for emotion simulation in internet-based cognitive behavioral therapy (iCBT), and the application of explainable AI (XAI) methods such as SHAP (SHapley Additive exPlanations) for data analysis and interpretation. In addition, some studies focused on the design and evaluation of AI-based systems like EMMA. Several studies also employed mixed methods and observational designs to explore user interactions with large language model (LLM)- based technologies. Specifically, some studies assessed real-world data, designed and evaluated AI systems, and analyzed writing styles using machine learning techniques.

Overall, the findings indicated that most studies employed quantitative and experimental methods to assess the effectiveness of digital interventions on emotion regulation and rumination reduction. At the same time, some studies also shifted toward mixed-methods and natural data analysis approaches.

Psychological Indicators Addressed in the Reviewed Studies

Analysis of the 22 reviewed studies revealed that the psychological indicators assessed spanned a broad range of mental health dimensions, emotion regulation, and coping strategies. The most important variables examined were emotion regulation, rumination, stress, anxiety, depression, and psychological well-being (Table 1).

The majority of the studies (about 65%) focused on the effectiveness of digital interventions (such as chatbots and mental health apps) on emotion regulation, stress reduction, and depression. Accordingly, the impact of large language models (LLMs) and internet-based cognitive behavioral therapy (iCBT) on treatment personalization and improvements in cognitive performance was emphasized in some studies.

Moreover, 40% of the studies focused on reducing rumination and improving coping styles, demonstrating that digital interventions and AI-based chatbots can influence cognitive regulation strategies such as acceptance, reappraisal, and the reduction of automatic negative thoughts.

Approximately 35% of the studies also explored the effect of interacting with mental health apps on motivation, quality of life, and reduction of depression and anxiety symptoms. Specifically, some studies have shown that using LLM-based chatbots can facilitate mindfulness-to-meaning, thereby contributing to positive well-being.

Several studies also examined user acceptance and interaction with mental health technologies. These studies (about 30%) focused on the extent of user interaction with chatbots and apps and their impact on treatment adherence and improvements in psychological symptoms.

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Overall, the findings suggested that digital interventions, particularly AI-based ones, play a significant role in improving emotion regulation, reducing rumination, and enhancing mental health, making them viable approaches to psychological treatment.

Interventions

In the reviewed studies, technology-based psychological interventions, including chatbots, mobile applications, and AI platforms, have been utilized to improve mental health, manage stress, regulate emotions, and reduce rumination. These interventions have been designed in various ways, with differing durations and intervals. A summary of these interventions is provided below:

App-Based Interventions

Seven-week, passive psychoeducational programs designed for stress management have been introduced as one of the common methods in these studies. These programs typically include sessions on stress management techniques and mindfulness practices, which users follow independently.

Applications such as Headspace and Wysa have been used to support mental health and manage anxiety and depression. These apps are particularly designed for longer durations (e.g., 2 months) to provide users with sustained interactions and continuous practice.

Chatbot-Based Interventions

Many studies have utilized chatbots for psychological education and interventions. Interventions such as the ELME chatbot, which includes daily sessions (10-20 minutes) on stress and mindfulness, or chatbots like "Worry Less, Remember More", designed to reduce worry and improve cognitive performance, are among those used.

CBT-based chatbots have also been employed to reduce rumination and manage emotions. These chatbots specifically focus on improving automatic negative thoughts and teaching users how to apply cognitive-behavioral therapy (CBT) techniques.

AI-Based Interventions and AI-Powered Platforms

AI platforms, such as Eleos Health, have been used alongside CBT to summarize therapy sessions and provide therapists with feedback. These platforms assist therapists in managing therapy sessions more effectively and receiving real-time feedback. Moreover, emotionally intelligent chatbots like EMMA have been used to deliver mental health interventions and help users manage their emotions and negative feelings.

Simulation Models and Virtual Reality

The use of emotion simulation models with transformer technology in iCBT aims to create personalized treatment and enhance its effectiveness. These models are designed to assist users in simulating and managing emotions in various situations.

Self-Help Interventions and Online Therapy

Chatbot-based self-help interventions, which have been evaluated less than other methods such as bibliotherapy, demonstrate that chatbots can be effective tools for reducing rumination and depression.

PRIME, a digital intervention aimed at increasing motivation and improving quality of life compared with standard treatments or waiting lists, is another innovation identified in these studies.

Digital Interventions and Web-Based Platforms

Internet-based rumination-focused cognitive behavioral therapy (i-RFCBT), implemented in both guided and unguided formats, has been evaluated as an effective intervention for reducing depression and rumination when compared to standard care.

These interventions have been conducted over timeframes ranging from three weeks to two months. Some studies included active or no-treatment control groups, and follow-up assessments were also considered in certain cases.

Overall, these interventions—utilizing modern technologies such as chatbots, AI platforms, and mobile applications—have been designed and evaluated to enhance mental health, reduce stress and anxiety, and improve quality of life. Many of these approaches have been specifically applied to targeted populations, such as university students, individuals with depression and anxiety, or those with cognitive difficulties, and their effectiveness in these contexts has been systematically assessed.

Scope and Focus of the Reviewed Studies

The reviewed studies have primarily focused on the acceptability, feasibility, and effectiveness of artificial intelligence (AI)-based interventions—particularly chatbots and mental health applications—in enhancing emotion regulation, reducing rumination, anxiety, and depression, and improving psychological well-being. Numerous studies have shown that these tools are generally well accepted by users and perceived as cost-

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effective and accessible alternatives for delivering mental health support. The findings indicated that such technologies play a significant role in supporting emotion regulation and stress reduction by providing cognitive-behavioral strategies and mindfulness training. Several studies have also compared AI-driven interventions with traditional therapeutic methods, demonstrating that chatbots and digital tools powered by large language models (LLMs) can yield outcomes comparable to—or even more effective than—conventional approaches such as internet-based cognitive behavioral therapy (iCBT) or bibliotherapy. Accordingly, efforts have also been made to automate therapeutic processes and enhance personalization by developing emotional simulation models and automatically detecting negative thought patterns. Another key focus has been user engagement with mental health apps, with findings suggesting that the degree of interaction with these tools may be a crucial factor in the success of digital interventions. Finally, some studies have evaluated the effectiveness of AI-based interventions in specific populations, such as veterans with cognitive impairments and individuals with severe psychotic disorders.

Discussion and Conclusion

This systematic review examined the effectiveness of AI- and mindfulness-based interventions in improving emotion regulation and reducing rumination. While several included studies demonstrated promising outcomes—particularly in cognitive reappraisal, emotional monitoring, and reduced rumination—the overall evidence base remains limited in scope, statistical power, and methodological consistency.

Several studies (e.g., Weiss et al., 2024; Schillings et al., 2024) reported increased cognitive reappraisal and reduced rumination following digital psychological interventions. Similarly, Li and Chung (2024) observed reduced stress and rumination through a mindfulness-based chatbot. However, the impact of AI-based interventions on more complex outcomes like depression and anxiety was inconsistent. For example, Sadeh-Sharvit et al. (2024) reported significant reductions in symptoms compared with treatment as usual. In contrast, Weiss et al. and Schillings et al. found no significant direct effects on anxiety or stress. These discrepancies may be attributed to differences in study design, sample size, intervention duration, and demographic characteristics.

Notably, AI-driven systems such as transformer-based models (Liu et al., 2024; Striegl et al., 2024) were shown to simulate emotions effectively and enhance intervention delivery, suggesting that AI's capacity for personalization and real-time feedback may play a central role in their psychological utility. According to Sadeh-Sharvit et al. (2024), AI also facilitated more frequent engagement during sessions, whereas passive programs (e.g., psychoeducational apps) yielded preventive effects rather than therapeutic change (Weiss et al., 2024).

These outcomes align with theoretical models of emotion regulation, such as Gross's Process Model, which emphasizes the importance of reappraisal and emotional awareness—functions that AI systems can support through personalized interactions and consistent monitoring. For rumination, which involves repetitive negative thinking, AI's ability to disrupt maladaptive patterns via adaptive feedback may be particularly valuable (Nolen-Hoeksema, 1991).

Nevertheless, the methodological limitations of many included studies must be considered. Several relied on small, non-representative samples, short intervention periods, and lacked long-term follow-up (e.g., Mehta et al., 2021). Several studies (e.g., Li & Chung, 2022; Tara Austin et al., 2024) reported benefits that appeared to diminish over time, underscoring the importance of evaluating the sustainability of digital intervention effects. Additionally, the lack of rigorous randomization procedures and potential biases in self-reported outcomes limit generalizability.

Despite these limitations, some findings support the feasibility and acceptability of digital mental health tools. Studies by Wang and Miller (2023) and Conley et al. (2024) demonstrated meaningful reductions in rumination and enhanced self-regulation using just-in-time adaptive interventions (JITAI). However, Tara Austin et al. (2024) and Lewis et al. (2022) also noted logistical barriers, including technical glitches, challenges with electronic consent, and inconsistent user engagement.

Several studies also highlighted variability in response based on clinical status or user characteristics. For example, Lewis et al. (2020) found greater benefits

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in early-stage psychosis patients, while chronic populations responded less favorably. This emphasizes the need to consider individual differences in designing AI-driven mental health tools.

Finally, studies such as those by Ghandeharioun et al. (2019) and Cook et al. (2019) suggest the potential for AI and mobile technologies to personalize interventions using real-time sensor data or guided app protocols. However, ethical considerations (e.g., privacy, over-reliance, digital fatigue) must be addressed, as excessive dependence on digital tools may inadvertently hinder social connection or emotional self-reliance (Hoffner & Lee, 2015).

While AI- and mindfulness-based digital interventions show promise in enhancing emotion regulation and reducing rumination, the current body of evidence does not warrant definitive conclusions regarding their effectiveness in treating broader psychological conditions such as anxiety and depression. The findings of this review should be interpreted with caution due to variability in study quality and intervention types, as well as limited long-term data.

To ensure responsible and effective implementation, future research should prioritize: large-scale randomized controlled trials (RCTs) to validate outcomes; longitudinal studies to assess the durability of effects; subgroup analyses to understand for whom and under what conditions AI tools are most effective; ethical frameworks addressing privacy, consent, and digital dependency; and integration strategies to combine digital tools with traditional face-to-face care.

For practitioners, AI-based tools may serve as adjuncts to traditional therapy—supporting self-monitoring, emotion regulation, and early symptom detection, particularly in educational or low-resource contexts. However, implementation must be accompanied by training, monitoring, and user feedback mechanisms to ensure safety and efficacy.

In summary, digital mental health interventions, especially those leveraging AI and LLMs, offer a valuable new frontier in mental health care. Their future role will depend on evidence-based design, personalized delivery, and a careful balance between technological innovation and human-centered care.

A review of previous studies confirmed the significant and positive effects of technology-based psychological interventions on improving psychological symptoms such as anxiety, depression, stress, and rumination. These interventions—particularly those utilizing chatbots and AI-based applications to support cognitive-emotional processes—demonstrated effectiveness in reducing rumination, enhancing mindfulness, and increasing the use of emotion regulation strategies. However, the authors emphasize that, despite these promising outcomes, some interventions yielded mixed results across groups, depending on symptom severity. This issue highlights the need for further research, particularly longitudinal follow-ups, to assess the long-term sustainability of these effects across diverse and specific populations. Moreover, the reviewed studies highlighted the importance of designing personalized interventions tailored to users' needs to optimize the effectiveness of these tools across varied contexts and demographic groups.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Declaration of Helsinki, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

All authors equally contribute to this study.

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Table 1. A systematic review of the studies on the effectiveness of AI-based interventions in students' rumination and emotion regulation

Author/Country	Research Design	Sample	Intervention	Follow-up	Tools	Data Analysis	Results
Weiss et al. (2024)/Austria	Randomized Controlled Trial (RCT) with a control group without intervention	253 university students (80% psychology students)	7-week app-based passive psychoeducational stress management program	Before and after intervention	DASS-21 (Depression, Anxiety, Stress), RSQ (Response Styles), ERQ (Emotion Regulation)	ANCOVA and statistical significance tests	Significant improvement in emotion regulation strategy "reappraisal" (p=0.004) and reduction in symptom-related rumination (p=0.01), but no significant reduction in depression, anxiety, and stress scores. Preventive effect in individuals with mild symptoms.
Schillings et al. (2024)/Germany	Two-center double-masked randomized controlled trial (RCT)	118 participants (59 intervention group, 59 control group) with moderate to high stress	3-week chatbot-based intervention ELME, daily sessions (10-20 min) focused on stress, mindfulness, and interoception	After 3 weeks (T2) and after 6 weeks (T3)	Perceived Stress Scale (PSS), mindfulness, interpersonal sensitivity, mental well-being, emotion regulation (reappraisal and suppression)	Multivariate regression, statistical tests for longitudinal changes	No significant decrease in stress (P=.96). Significant increase in mindfulness and reappraisal in the intervention group. Mental well-being improvement in both groups. Longer-term intervention and subgroup analysis were recommended.
Sadeh-Sharvit et al. (2024)/USA	Randomized Controlled Trial (RCT)	47 adults (34 women, 13 men) with an average age of 30.64 years	Comparison of Cognitive Behavioral Therapy (CBT) with Eleos Health AI platform vs. standard treatment	2 months	PHQ-9 (Depression), GAD-7 (Anxiety), standardized questionnaires	Intention-to-treat analysis, independent t-tests, and effect size analysis	Significant improvement in depression (34%) and anxiety (29%) in the AI group compared to standard treatment (20% depression, 8% anxiety). 67% increase in therapy session attendance in the AI group—no significant difference in treatment satisfaction.
Frischholz et al. (2024)/Japan	One-group pretest-posttest design with 2 testing sessions	35 participants (19 men, 16 women, aged 18-50 years)	CBT intervention using a virtual agent, conversation scenario on automatic negative thoughts	Follow-up 1 week after the first session	Depression symptom questionnaires and cognitive variables	Wilcoxon and t-test for analyzing changes in stress and anxiety. Linear regression for cognitive predictors	Significant reduction in stress (P<.001) and anxiety (P<.003). Increased recognition of negative thoughts and motivation to change them. No significant correlation between motivation and anxiety or stress changes (P>.04).
Li & Chung (2024) (2024)/Hong Kong	Pre-test–Post-test one-group study	30 university students with depression symptoms	8-week MBSR-based chatbot program	None	Redesigned questionnaire: PSS-14, GAD-7, FFMQ-39	Results were statistically significant, confirmed by a t-test for rumination and a Wilcoxon for PHQ-4, with $p<0.05$	Significant improvement in reducing depression, anxiety, stress, and improvement in quality of life in the chatbot intervention group.
Liu et al. (2024)/China	Use of explainable AI (XAI) techniques, such as SHAP, for interpreting and analyzing results from machine learning models	User interactions	Use of ChatGPT as a tool to assist counselors in interacting with patients	None	BERT for classifying ChatGPT-generated content, SHAP for analysis	Deep learning models analyzed HGC and AIGC content to distinguish between human and AI-generated content	93.76% accuracy in classification. Results showed that AIGC models, especially ChatGPT, have effective support for psychological counselors and enhance psychological interventions.
Striegl et al. (2024)/Germany	Transformer-based model for simulating emotions in iCBT	20 participants	Emotion simulation model using transformer technology in iCBT	None	Transformer model, new emotion simulation dataset (75,503 samples), emotional evaluation (valence, arousal, dominance)	Pearson correlation coefficient: r=0.90 for valence, r=0.77 for arousal, r=0.64 for dominance, technical effectiveness, and acceptability of the model in iCBT, better emotion simulation for a personalized and more effective therapy experience.	The proposed system for dimensional text-based emotion recognition using deep learning outperformed the rule-based approach in technical evaluation and demonstrated feasibility for use in CBT-based conversational agents.
Tara-Austin et al. (2024)/USA	A pilot randomized controlled trial	15 veterans (average age 49.5 years)	"Worry Less, Remember More" is an emotion-regulation intervention designed to reduce worry and improve cognitive performance.	Follow up with semi-structured interviews and self-assessment before and after the intervention.	Self-assessment questionnaire for evaluating cognitive issues, intrusive thoughts, and intervention effectiveness	Descriptive analysis and comparative analysis pre- and post-intervention using self-assessments and interviews	92% of veterans reported benefiting from the intervention and would recommend it to others. The intervention improved cognitive issues but did not affect intrusive thoughts. Challenges in the electronic consent process and session reminders.
Wang et al. (2024)/Canada	Two comparative study designs (one-week and four-week)	An unknown number of university students	Two types of chatbot interventions: one focusing on mindfulness, and the other on values, compared to the active control group (simple check-in)	Four weeks (second study)	Self-report questionnaires including stress reduction, cognitive decentering, and positive reappraisal scales	Statistical tests comparing intervention and control groups	Both chatbot interventions improved well-being via the MM pathway compared with the control group. Increased cognitive decentering and positive reappraisal in the long-term intervention.
Conley et al. (2024)/USA	Randomized controlled trial (RCT)	145 university students with depression symptoms	Headspace app for 2 months	3 months after intervention	Self-report questionnaires including depression, anxiety, stress, positive and	Intent-to-treat analysis and statistical tests to compare groups over time	Significant reduction in depression, anxiety, and stress, with a significant increase in happiness, self-regulation, and trait mindfulness, with results sustained at 3-month follow-up.

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					negative affect, self-regulation, and mindfulness		
Wang & Miller (2023)/USA	Randomized controlled trial (RCT), double-masked	20 patients with clinical depression (after initial screening of 59 patients)	Just-in-time adaptive intervention mindfulness and resilience-focused cognitive behavioral therapy (JITAI-MRFCBT) vs. no treatment control	35 days (7-day baseline, 21-day intervention, 7-day post-test)	Daily reports of rumination-related symptoms via text (5 times a day)	Two-tailed independent t-test with bootstrapping	Significant reduction in the number of rumination episodes (P<.001) and time spent ruminating (P=.04) in the JITAI-MRFCBT group compared to the control. Decrease in the carryover of rumination from one episode to the next—recommendation for larger-scale trials.
Shidara et al. (2022)/Japan	Experimental study	Users interacting with a virtual agent	Use of a virtual agent for cognitive restructuring and its impact on mood improvement	No long-term follow-up reported	User-agent interaction analysis, facial expression analysis, and changes in automatic thoughts	Human-agent interaction analysis, the relationship between facial expressions and mood improvement, qualitative and quantitative analysis	The data support the potential of virtual agents in cognitive restructuring and mood improvement, providing a technical framework for automating interaction based on verbal and nonverbal behaviors.
Li & Chung (2022)/China	Randomized controlled trial (RCT), no blinding	83 university students (41 chatbot group, 42 bibliotherapy group)	Self-help chatbot vs. minimal bibliotherapy	16 weeks, assessments every 4 weeks	Questionnaires: PHQ-9, GAD-7, PANAS, CSQ-8, & WAI-SR	Intention-to-treat (ITT) and completers' analysis, comparative statistics (ANOVA, t-test)	Significant reductions in depression (PHQ-9) and anxiety (GAD-7) in the chatbot group; anxiety reduction was only significant in the first 4 weeks; stronger therapeutic alliance in the chatbot group; process factors influenced user experience more than content
Lene et al. (2021)/USA	One-Group Pretest-Posttest Design	105 students with high rumination, randomly selected	Chatbot delivering CBT with a focus on rumination	None	Rumination and anxiety scales	Statistical analysis of chatbot impact on rumination and anxiety symptoms	Reduction in rumination and anxiety in the chatbot group
Lewis et al. (2020)/UK	Open RCT	81 patients out of 181 eligible candidates	Active symptom monitoring app vs. routine care	6 and 12 weeks	PANSS, empowerment scale, qualitative analysis	Statistical group comparison, qualitative analysis for system acceptance	Active monitoring improved psychosis symptoms in the early intervention center; no impact in chronic patients; 90% continued app use for 12 weeks; 100% of staff accepted the alert system
Ghandeharioun et al. (2019)/Global	Design and evaluation of the EMMA system	39 participants	Emotionally intelligent chatbot "EMMA" for mental health interventions	2 weeks	Smartphone sensor data, user-reported feelings	Personalized machine learning model for mood recognition; user evaluation on pleasantness and responsiveness	Users found the system pleasant; the chatbot recognized moods from phone sensor data.
Cook et al. (2019)/UK	Phase III RCT	235 university students with high worry/rumination	Internet-based rumination-focused CBT (i-RFCBT), guided and unguided, vs. routine care	15 months (follow-up at 3, 6, and 15 months)	Structured diagnostic phone interviews (for depression) + self-report questionnaires (depression, anxiety, rumination, and worry)	Survival analysis (Hazard Ratio), comparative statistics	34% reduced depression risk in the guided group (HR=0.66, P=.20), best for high-stress individuals (HR=0.43, P=.02), significant short- to mid-term reductions in rumination, worry, and depression; similar completion rates; suggested larger-scale unguided model trials
Inkster et al. (2018)/USA	Mixed-methods observational study	129 users (108 high-use, 21 low-use)	Wysa mental health support app	Two assessment points	PHQ-9, in-app feedback	Comparative analysis of depression score changes, Mann-Whitney test, and effect size	Significant depression improvement in high-use group (mean=5.84, SD=6.66) vs. low-use (mean=3.52, SD=6.15), effect size 0.63, 67.7% positive feedback
Daniel A. Schlosser (2018)/USA	Fully remote RCT	43 participants (22 PRIME, 21 control); 38 completed PRIME	PRIME digital intervention vs. routine care/waitlist	12 weeks, 3-month follow-up for PRIME	Self-report questionnaires (depression, defeatist beliefs, self-efficacy, social motivation, negative symptoms)	ANCOVA, comparative tests, follow-up analysis	PRIME significantly improved depression, defeatist beliefs, self-efficacy, and social motivation, effects sustained at 3 months
Fitzpatrick et al. (2017)/USA	Randomized Clinical Trial	70 participants (mean age 22.2)	Automated conversational agent "Woebot" for CBT	2–3 weeks post-intervention	PHQ-9, GAD-7, PANAS	One-way ANCOVA	The Woebot group had a significant reduction in depression (PHQ-9); the control group had no significant change; both groups showed anxiety reduction among completers.
Hoffner & Lee (2015)/USA	Online cross-sectional study	287 young smartphone users	Responding to mobile phone loss scenarios, evaluating the impact on emotional regulation	No follow-up	Online questionnaire on phone use for emotional regulation	Correlation between emotion regulation strategies and phone use, regression analysis	Reappraisal linked to loss of interpersonal contact/social support; suppression linked to loss of entertainment/information; emotional regulation via phone tied to mental health

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