# The effects of mobile apps on stress, anxiety, and depression: overview of systematic reviews

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## Abstract

**Objectives.** Despite a large number of mobile apps in the field of mental health, it is difficult to find a useful and reliable one, mainly due to the fact that the effectiveness of many apps has not been assessed scientifically. The present study aimed to assess the effects of mental health apps on managing the symptoms of stress, anxiety, and depression.

**Methods.** A comprehensive literature search was conducted in PubMed, Scopus, EMBASE, Cochrane, and Web of Science databases for the papers published from 2000 to 2019. Studies were included if they reviewed articles or mobile apps for their effectiveness in stress, anxiety, and depression. The reviews that had considered mobile apps or web-based mobile applications as an intervention or part of intervention were included, as well.

**Results.** A total of 4,999 peer-reviewed articles were identified, out of which nine systematic reviews met the inclusion criteria. Seven systematic reviews measured depression outcomes, three measured stress, and five systematic reviews measured anxiety symptoms. The applications that used behavior change strategies, such as Cognitive Behavioral Therapy, Acceptance and Commitment Therapy, and Behavioral Activation, reported significant effects on depression, anxiety, and stress.

**Conclusion.** It seems that mental health apps can be promising media for reducing depressive symptoms. This field is an emerging area of mobile health, and further research should be done in future in order to reach conclusive evidence.

## Introduction

Mental health problems have a detrimental effect on various aspects of a person's life, including social relationships, physical health, and career and academic success (1). At the moment, stress, anxiety, and depression are the most common psychological problems that cause disability (2;3). Depression has been recognized as one of the most important causes of disability in the world, affecting more than 300 million people (4). The symptoms of depression include loss of enthusiasm, worthlessness, sadness, sleep disorders, anorexia, excessive fatigue, and reduced concentration (5). Depression affects sleep quality, performance, productivity, and routine activities (6). Anxiety is also one of the most common mental illnesses in the world, which has approximately affected 29.8 percent of the people (7). Anxiety has been defined as the body's response to a perceived threat that exacerbates an individual's beliefs, feelings, and thoughts and increases blood pressure, respiration rate, heart rate, sweating, drowsiness, and chest pain (8). Stress is an emotion that begins when an individual realizes that demand is more than the available resources (9). Over the past decade, stress-related illnesses have been thought to be a reason for increased long-term sick leave in many European countries (10). Despite the spread of these diseases, mental health services are limited, and many people do not have access to such services. Approximately 50–78 percent of people with mental health problems are not treated adequately in Europe and the United States (11;12). The situation is worse in middle- and low-income countries, and more people are deprived of treatment (13;14).

The expansion of digital technology has led to an improvement of access to healthcare services (15). Mobile phones with Internet access and the ability to download and launch mobile software applications (apps) offer an affordable and accessible way to provide mental health services, especially in hard-to-reach areas (16). The number of mobile phone users has been expected to reach 1.6 billion worldwide by 2020 (17).

The efficacy of medical intervention can be enhanced by increasing user satisfaction and adherence (18). According to Donkin et al., adherence is defined as "the degree to which the user followed the program as it was designed" (19). Improving adherence to interventions has always been a challenge for researchers, and they always tried to find factors affecting it. In

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this regard, a study found that being female, as well as having higher openness to experience, lower resistance to change, or less depressive symptoms were significant indicators for better intervention adherence (20). Another research has shown that the use of SMS services as a reminder improves adherence to prescription medication (21). Moreover, a study reported that adherence has improved by human support (support of counselors, peers, and phone and e-mail contact) (22). Besides, research suggests that more personalization of digital interventions can enhance adherence (23). In addition, some studies showed a high level of satisfaction among mHealth interventions (18;24;25). In this regard, the details or specificity of the content, data transmission accuracy, mutual feedback systems, as well as configuration of individualized programs are crucial factors for user satisfaction (18). Nevertheless, studies reported that perceived quality and usefulness (26), ease of use, ease of navigation, and interactivity (27), as well as trust (28) and human support (25) had positive effects on user satisfaction.

According to a study, there are more than 15,000 health-related applications, 29 percent of which are related to mental health (29). Mental health applications increase the incentive to use the services among people who do not like face-to-face visits (30). Despite a large number of apps in this domain, it is not easy to find a useful and reliable one, given the fact that the effectiveness of many apps has not been proven scientifically. The research question is: What are the effects of stress, anxiety, and depression-related apps on reduced depression, anxiety, and stress. Therefore, the present study aims to explore the effects of mental health apps on the management of stress, anxiety, and depression symptoms.

## Methods

A systematic literature review was conducted in PubMed, Scopus, Web of Science, Cochrane library, and Embase databases for the relevant articles published from 2000 to 2019. The search included a combination of MeSH terms and keywords related to mobile applications, stress, anxiety, depression, and effectiveness. The search was structured according to the PICO framework: P (problem) was depression, anxiety, or stress, I (intervention) was mobile app and web application, C (comparison) was other mHealth initiatives, and O (outcome) was reduced levels of depression, anxiety, or stress. The details of the search strategy have been presented as Supplementary File 1.

The studies were screened in several phases using inclusion and exclusion criteria. At first, all titles and abstracts were screened to remove irrelevant and duplicate studies. Then, full-text copies of all potentially related articles were obtained. The full texts of the papers were also obtained in case their abstracts were insufficient to determine their eligibility. Reference lists of the included articles were also screened, and a search was done in Google Scholar using similar keywords to identify further eligible articles. Next, the full-text articles were screened and were excluded if they did not meet the inclusion criteria. It should be noted that the selection of the eligible articles and completion of the data extraction table were carried out by two authors (FKh and AA) independently, and any disagreement was resolved through discussion.

## Eligibility Criteria

All systematic review and meta-analysis studies that assessed the effects of mental health apps on the symptoms of stress, anxiety,

and depression were included. The included studies were published in English-language peer-reviewed journals, systematically reviewed mobile apps intervention for their effectiveness in stress, anxiety, and depression, evaluated physical or emotional symptoms of stress, anxiety, and/or depression as one of their primary or secondary outcome measures, and used mobile apps (Android or IOS) or web-based mobile applications as an intervention or as a part of an intervention. There was no limitation regarding the participants' age or gender.

The studies were excluded if they (i) involved only a computer-based, Internet-based, or text messaging intervention without a mobile app component, (ii) included only a description of the mobile app without the outcome data, (iii) reviewed other mental health symptoms (e.g., schizophrenia, bipolar affective disorder, paranoia, post-traumatic stress disorder, and psychosis), (iv) did not provide outcome measurement scale, and (v) included protocols and conference abstracts.

## Methodological Quality of the Reviewed Studies

The methodological quality of the included articles was assessed independently using the Assessment of Multiple Systematic Reviews (AMSTAR) instrument. This validated tool evaluated the degree to which the review methods avoided bias by assessing the methods against eleven distinct criteria (see Table 1). Each item was rated as "yes" (one score) or "no," "cannot answer," and "not applicable" (zero scores). The scores could range from 0 to 11. Accordingly, the scores were classified into three categories of low quality (0–3), moderate quality (4–7), and high quality (8–11) (39). Each included article was independently assessed by two authors (FKh and AA) in terms of methodological quality, and any disagreement was discussed in order to reach consensus. The included studies were of various qualities, but they were mostly of moderate quality according to the AMSTAR tool. In addition, most reviews ($n = 8$) were of moderate quality, and one was of low quality.

## Outcome Measures

The primary outcome measures were changes in stress, anxiety, and depression symptoms, and the secondary outcome measures were effects on satisfaction and adherence rate.

## Results

### Selection and Inclusion of Studies/Search Results

A total of 4,992 peer-reviewed articles were identified in PubMed ($n = 1,220$), Scopus ($n = 3,352$), EMBASE ($n = 321$), Cochrane ($n = 92$), and Web of Science ($n = 7$) databases. After searching the reference lists of the included articles and Google Scholar using similar keywords, seven other articles were added, as well. After removing the duplicates, 4,999 articles were reduced to 4,353. Furthermore, 4,314 articles were excluded after reviewing the titles and abstracts, and full texts of 39 articles were reviewed. After reviewing the full texts, 28 articles were removed because they did not follow the systematic review design ($n = 8$), did not use application interventions ($n = 3$), reviewed other mental health symptoms ($n = 1$), were a conference abstract ($n = 1$), did not measure stress, anxiety, and depression symptoms ($n = 2$), were duplicate ($n = 2$), did not evaluate the effectiveness or efficacy of the apps ($n = 3$), reviewed the same articles ($n = 6$), did

**Table 1.** Methodological quality of the systematic reviews based on the AMSTAR instrument scores

| Author | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ariane Kerst (31) | No | CA | CA | No | No | Yes | CA | Yes | CA | No | NO | 2 |
| Uthara Nair (32) | Yes | Yes | No | No | CA | Yes | Yes | Yes | Yes | Yes | No | 7 |
| Joseph Firth (33) | No | Yes | Yes | No | No | Yes | Yes | CA | Yes | Yes | No | 6 |
| Amy Leigh Rathbone (20) | No | Yes | Yes | No | No | Yes | Yes | CA | Yes | CA | No | 5 |
| Elizabeth Stratton (34) | No | Yes | Yes | No | No | Yes | Yes | Yes | Yes | Yes | No | 7 |
| Vikas Menon (35) | No | Yes | Yes | Yes | No | Yes | No | No | No | No | No | 4 |
| Lyzwinski (36) | No | Yes | No | No | No | Yes | Yes | CA | CA | Yes | No | 4 |
| Tara Donker (37) | No | Yes | Yes | No | No | Yes | Yes | Yes | CA | Yes | No | 6 |
| Kathleen M. Griffiths (38) | No | CA | Yes | No | No | Yes | Yes | CA | Yes | NO | No | 4 |

CA, cannot answer; NA, not applicable.

not provide outcome measurement scale ($n = 2$), and other reasons ($n = 2$). Finally, nine systematic reviews were included. The results of the included studies were extracted, reviewed, and reported in a systematic format. The screening process was detailed in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram (Figure 1).

The characteristics of the included systematic reviews are presented in Table 2. A total of nine articles were included in this review, consisting of six systematic reviews and three systematic reviews with meta-analysis. The publication dates of the systematic reviews ranged from 2010 to 2018, with a remarkable increase in the number of publications from 2017; seven systematic reviews were published from 2017 to 2018 (31–36). According to Supplementary File 2, the maximum number of systematic reviews was found for depression disorders ($n = 7$). In addition, systematic reviews examined depression, anxiety, and stress ($n = 2$), depression and anxiety ($n = 2$), as well as depression and stress ($n = 1$) simultaneously.

Totally, seventy-six articles in the nine systematic reviews met the inclusion criteria of the study. These studies were conducted on a total of 3,581 participants (ranging from 8 to 855). However, thirty-two out of the seventy-six articles were repeated. On average, each systematic review contained four articles that met the aim of the current study. Most systematic reviews included young adult to adult populations (18–55 years old) (32;33;36;38). In addition, in one systematic review, the participants aged 18–65 years (34).

In three systematic reviews, other disorders were studied in addition to depression, anxiety, and stress. Other disorders included psychotic disorders, sleep disorder, substance abuse (37), suicidal behavior (35;37), schizophrenia (20;35), bipolar disorders, eating disorders, gambling (37), smoking cessation, medication adherence, and mood depressive disorders (20). Furthermore, other interventions were used in addition to mobile applications in six systematic reviews. These interventions included electronic-based (36) and Internet-based interventions (38), SMS (20), eHealth interventions (34), mobile phone-based technologies (35), and telemedicine (32). The duration of interventions varied from 1 week (37) to 1 year (38). Besides, the duration of interventions was more than 6 weeks in eight studies (20;31;32;34–38).

We assessed systematic reviews in line with outcome variables. Our findings related to the comparison between outcome variables among included systematic reviews are summarized in Table 3. We tried to find a common measurement scale among included studies. The effect sizes were comparable finding between systematic reviews, although it was not reported in one study. In this regard, the largest effect size was found in Menon et al. (35) and Kerst et al. (31) studies. In both systematic reviews, all reviewed mobile apps interventions were effective in reducing intended symptoms. Moreover, the acceptability of these studies was good, which is an important factor for the successful implementation of an intervention in practice (40). Hence, the smallest effect size was from Nair et al. study (32). This can be related to high attrition rates as well as a lack of participant blinding that were reported as common limitations.

### Effects on Depression, Stress, and Anxiety

Five systematic reviews that measured depression outcomes using the Patient Health Questionnaire (PHQ-9) showed a reduction in the depression score (20;31;32;34;37). Three systematic reviews that used Beck Depression Inventory (BDI) also revealed a reduction in the depression score (20;31;37). However, one study that used the "Center for Epidemiologic Studies Depression Scale" (CES-D) did not show any significant reduction in the depression score (38). Furthermore, three systematic reviews measured stress outcomes using the Perceived Stress Scale (PSS) and showed a significant reduction in the stress scores (20;34;36). However, stress was measured by the Mesure de Stress Psychologique (MSP) scale in one study, which revealed no significant reduction (36). In addition, three systematic reviews measured anxiety outcomes using Generalized Anxiety Disorder 7-item (GAD-7) (20;33;37). In one study, no significant reduction was found in the anxiety scores (20). Furthermore, State and Trait Anxiety Inventory (STAI) was used in one systematic review, which indicated a significant reduction in the anxiety scores (37). Besides, two systematic reviews used the Depression Anxiety Stress Scale (DASS) to measure depression, anxiety, and stress (20;37). One study showed no significant reduction in the scores of depression, anxiety, and stress (37). However, two systematic reviews used the General Health Questionnaire (GHQ) and obtained significant results (20;36).

### Characteristics of Depression, Stress, and Anxiety Apps

In total, twenty-two apps with specific names were reported in the nine systematic reviews. The most commonly reviewed apps were
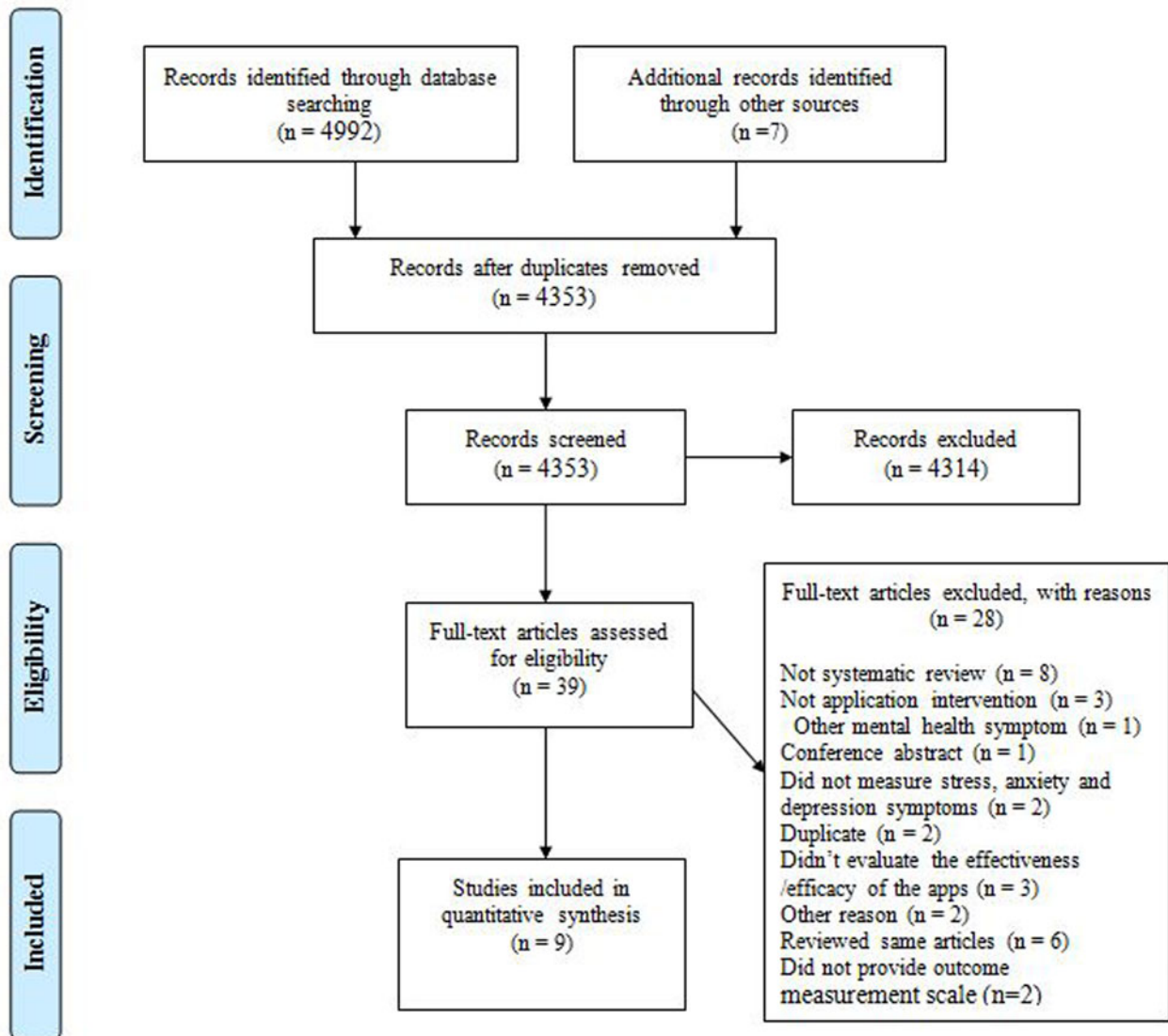
**Figure 1.** PRISMA flow diagram.

Flowy, Get happy, myCompass, and Mood Gym. The applications that used behavior change strategies, such as Cognitive Behavioral Therapy (CBT), Acceptance and Commitment Therapy (ACT), Behavioral Activation (BA), mindfulness-based therapy, and stress inoculation therapy, reported significant effects on depression, anxiety, and stress (33–38). However, no significant reduction was found in one study using CBT (38). myCompass was a self-monitoring app that used CBT, positive psychology, and problem-solving training strategies. Furthermore, it provided feedback and tips via SMS (33). Another effective app was Get happy, which was based on the principles of ACT and provided personalized strategies relating to relationships, personal growth, leisure, and work education (20). Mood Gym was yet another app that was proved to be effective in preventing and reducing depression and anxiety. It was a web-based app based on cognitive, behavioral, and interpersonal therapy, problem-solving, and coping strategies. Mood Gym provided weekly phone calls to users. It also provided quizzes, exercises with visual aids, and detailed feedback. The content of the Mood Gym included thoughts, moods, and ways to change them (38).

## Satisfaction, Adherence, and Acceptability

Two systematic reviews revealed the users' high satisfaction with smartphone apps (31;37). Additionally, three systematic reviews showed high adherence to the intervention (Smartphone application intervention) (20;31;37). However, one study showed low adherence to the intervention (mobile and web-based apps interventions) (36). Furthermore, five systematic reviews reported the high acceptability of smartphone applications among users (31;33;35;37). The users were more satisfied with the apps that used behavior change strategies (31;37).

## The Methodological Shortcomings of the Included Studies

We categorized the main methodological shortcomings of the included studies in Supplementary File 3. Accordingly, the main limitation was heterogeneity in the aims, methodology, or outcome measures of the studies that made it hard to draw a clear conclusion (20;31–33;35;37). Also, another limitation was missing studies because of including just English-language, peer-reviewed

**Table 2.** Characteristics of the included systematic reviews

| id | Author/ year of publication | *Population (age range)/ type of population | *No. and type of eligible articles (eligible for this study) | *Type of intervention (length of follow-up) | *Outcome variable | *Result | Methodological shortcomings | Assessed quality (tools) | Strategies | *Questionnaire | *App name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Ariane Kerst, 2018 (31) | 24–626 (NA) People with clinical and subclinical levels of depression | 12 (12) 3 RCTs, 2 pilot-RCTs, 2 single-arm pilot trials, 1 prospective cohort study, 3 review articles, 1 meta-analysis | Treatment apps (3–12 weeks) | 1. Symptoms of depression 2. Effectiveness of apps in depression | 1. Decline in the BDI score 2. Reduction of depression 3. High participant satisfaction and acceptability of mobile interventions 4. Adherence rates from 70% up to 94% | 1. The apps were varied and it was not clear which components of the interventions were effective and which mode or frequency of use was most beneficial for adherence and outcomes. 2. The review focused especially on treatment apps for depression, which might have excluded other good internet interventions studied. | Yes using quality checklists | 1. CBT, 2. ACT, 3. BA, 4. Behavioral strategies like targeting emotional regulation or cognitive reframing. 5. Clinician support | 1. PHQ 2. BDI | NR |
| 2. | Uthara Nair, 2018 (32) | 71–300 (26.3–32.6) Pregnant women and mothers for up to 12 months postpartum | 10 (2) 2 RCT | Mobile app (4–8 weeks) | Maternal depression | A study showed an improved service delivery and patient engagement. In another study, postnatal depression scores did not show any significant improvement, but improvements were observed in parental self-efficacy, social support, and parenting satisfaction. | 1. Small number of trials, variation in measurement scales and time points, and lack of consistent outcome reporting affected the ability to quantify the results. 2. Self-referral recruitment introduced sampling and reporting bias. | Yes (JBI) | CBT, BA, unspecified psychoeducation, mood tracking, and communication with therapists via face-to-face contact, telephone call, or e-mail | 1. EPDS 2. PHQ | Home but not alone |
| 3. | Joseph Firth, 2017 (33) | 30–302 (18–43) General and clinical population | 9 (9) 9 RCTs | Smartphone app (4 weeks–1 month) | Reduced symptoms of anxiety | Three apps significantly reduced the symptoms of anxiety. | 1. Significant heterogeneity 2. Different interventions and control conditions used | Cochrane Collaboration's risk of bias tool | 1. Game-like interface to train users in diaphragmatic breathing 2. M-SIT 3. CBM 4. ACT 5. Behavioral exercises and mood tracking 6. Personalized guidance messages from a therapist twice per week | 1. (GAD-7), 2. (DASS), 3. (HADS), 4. (STAI), 5. (BAI), 6. (SIAS), 7. (LSAS) | "Flowy" "myCompass" "SuperBetter" "LivingSMART" |
| 4. | Amy Leigh Rathbone, 2017 (20) | 9–855 (NR) General and clinical population | 27 (10) 7 RCTs 3 within groups | App (1–6 months) | Improvement in depression, anxiety, and stress | All studies showed significant reductions of anxiety, stress, and depression High satisfaction High adherence Mindful Moods was an effective tool for assessing the symptoms of depression. Catch It had small to moderate effects on positive moods but had a moderate to large effect on negative moods. My compass had a significant, small effect on anxiety and a significant moderate effect on stress. | 1. Cannot be generalized to a larger sample size because of the small number of the included reviews. 2. Cross-cultural variations cannot be reported because just English-language articles were included. 3. Risk of bias assessment was carried only out by one author. 4. The outcomes of the review as a whole were incommensurable due to the heterogeneous nature. | Yes Cochrane Risk of Bias Assessment Tool | 1. CC and problem-solving therapy 2. CBT 3. ACT | 1.GAD-7 2. DASS 3. PSS 4. BDI 5. GHQ | 1. Mindful Moods 2. Catch It 3. my Compass 4. MEMO 5. Get Happy 6. Health Tips 7. Smart CAT 8. FOCUS 9. Flowy |

*(Continued)*

**Table 2.** (*Continued.*)

| id | Author/ year of publication | *Population (age range)/ type of population | *No. and type of eligible articles (eligible for this study) | *Type of intervention (length of follow-up) | *Outcome variable | *Result | Methodological shortcomings | Assessed quality (tools) | Strategies | *Questionnaire | *App name |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5. | Elizabeth Stratton, 2017 (34) | 2,922 (18–65 years old) Current paid employment and working-age adults | 23 (2) 2 RCTs | App (6–10 weeks) | Stress, depression | Significant effects were found on depression, BA, negative thoughts, knowledge, work productivity, work absence, and workplace distress. Unselected and unguided mindfulness had a small to moderate effect on reducing depression and a large effect on reducing stress. Mindfulness had a small to moderate effect on the overall symptoms at follow-up, with a large effect on stress. Stress management in selected formats had large and moderate effects when guided on reducing the overall symptoms and a large effect on reducing depression, anxiety, and stress. These results continued at postintervention, but the effect on stress management was no longer significant. | 1. Small number of studies 2. Not clearly defining the intervention type 3. Self-reported reduction of symptoms rather than a clinical diagnosis 4. Initial screening of some titles by one author | Yes Downs and Black Checklist | 1.CBT 2. Mindfulness-based approaches 3. Stress Management 4. Cognitive Training 5. ACT | 1. PSS 2. PHQ | MoodHacke Oiva |
| 6. | Vikas Menon, 2017 (35) | 30–720 (not reported) Psychiatric populations | 24 (8) Not reported | Mobile phone apps (6 weeks) | Depression, anxiety | All mobile phone-based apps were effective in reducing stress, anxiety, and depression symptoms and reduced the burden of depressive symptoms. Behavioral activation app and mindfulness app were feasible and effective. Mobile-based CBT app was efficacious as was the computer-based CBT program in reducing depressive symptoms over 6 weeks. "Kokoro" app was feasible and acceptable. Active intervention significantly reduced social anxiety. Inoculation training significantly reduced anxiety and enhanced coping skills. | 1. Drawing clear conclusions is onerous because of heterogeneity in the aims, methodology, and outcome measures of the studies. 2. Unpublished or ongoing studies or those not available in academic databases might have been excluded from this review. 3. Generalization of results to the real-world settings is hard because of short duration, small samples, and possibility of participants in controlled settings showing greater adherence to interventions. 4. Some trials might have been missed as they did not fit into the definition of psychotherapy used for the purpose of this review. | No | Emotional self-awareness, BA, mindfulness app, mobile-based CBT | | Kokoro SmartCAT myCompass |
| 7. | Lyzwinski, 2017 (36) | 43–73 (20–56) Healthy adults >18 years | 21 (3) 2 RCTs 1 pre/post design | Mobile and web-based app (6 weeks–4 months) | Effectiveness of app in stress | Two apps caused significant improvements in stress. One app did not significantly reduce stress. Low adherence | Some studies might have been missed in spite of the systematic search. | Yes Cochrane risk of bias grading tool | 1. Mindfulness meditation and instructions 2. MBSR techniques (yoga, body scans, breathing exercises, and sitting, walking, and meditation demonstrations) 3. ACT | 1. PSS 2. GHQ | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8. | Tara Donker, 2013 (37) | 8–117 People with mental health symptoms or disorders | 8 (7) 6 RCTs 1 Pre-post pilot | Mental health apps (6 days–8 weeks) | depression, anxiety, stress | Five studies showed significant reductions in depression, stress, and anxiety. In two studies, no significant differences were found in depression, anxiety, and stress outcomes at post-test and follow-up. Moderate to high satisfaction High adherence Acceptability of technology | 1. Restricted interpretations because of the small number of included studies 2. Underpowered to detect the subtler effects of the interventions because of the small number of participants 3. Low quality of the included studies 4. Inability to examine whether significant differences existed between higher- and lower-quality studies due to the small number of studies 5. Long-term effects remained as yet unknown because there were no studies that examined the long-term efficacy of mental health apps. 6. Only studies from peer-reviewed, English-language journals were included. 7. Small sample sizes hampered the precision and accuracy of the statistical results and, therefore, limited the interpretations. | Yes Cochrane Risk of Bias Assessment Tool | | 1. DASS 2. PHQ-9 3. STAI 4. BDI-II 5. GAD-7 | 1. Mobilyze! 2. Mobile Stress Management 3. Get Happy |
| 9. | Kathleen M Griffiths, 2010 (38) | 48–525 (18–50) Participants with a formal diagnosis of a depressive or anxiety disorder and those who were self-selected as requiring self-help | 26 (6) 6 RCTs | Web site application (5 weeks–12 months) | Depression, anxiety | All six studies were effective in the symptoms of depression and anxiety | NR | Yes Cochrane Collaboration's Tool | CBT | CES-D | 1. ODIN, 2. MoodGYM 3. BluePages 4. Sadness |

* According to our objectives; ACT, acceptance and commitment therapy; BA, behavioral activation; BDI, Beck depression inventory; CBT, cognitive behavioral therapy; CBM, cognitive bias modification; CC, cognitive control; DASS, depression anxiety stress scales; EPDS, Edinburgh postnatal depression scale; JBI, Joanna Briggs institute critical appraisal checklist for RCTs; M-SIT, multimedia videos for mobile stress inoculation training; MBSR, mindfulness-based stress reduction; NR, no report; NA, no answer; PHQ, patient health questionnaire; PSS, perceived stress scale; CES-D, Center for Epidemiologic Studies Depression Scale; MSP, Mesure de Stress Psychologique; GHQ, General Health Questionnaire; STAI, State and Trait Anxiety Inventory.

**Table 3.** The comparison between outcome variables among included systematic reviews

| Author/year of publication | Outcome variables |
|---|---|
| Ariane Kerst, 2018 (31) | Depression: $d = 1.25$, $f = 16.34$, $p < .05$ |
| Uthara Nair, 2018 (32) | Depression: $d = -2.7$, Mean difference $= -.69$ |
| Joseph Firth, 2017 (33) | Anxiety: $d = .325$, $p < .01$ |
| Amy Leigh Rathbone, 2017 (20) | Depression: $d = .54$<br>Anxiety: $d = .38$<br>Stress: $d = .5$, $P < .05$ |
| Elizabeth Stratton, 2017 (34) | Depression: $d = $ N/R, Mean difference $= 11$, SD $= 4.7$<br>Stress: $d = $ N/R, Mean difference $= 2.8$, SD $= .15$, $P < .05$ |
| Vikas Menon, 2017 (35) | Depression: $d = 1.26$<br>Anxiety: $d = .9$, $P < .05$ |
| Lyzwinski, 2017 (36) | Stress: $d = .55$, $p < .01$ |
| Tara Donker, 2013 (37) | Depression: $d = .46$<br>Anxiety: $d = .87$<br>Stress: $d = .33$ |
| Kathleen M Griffiths, 2010 (38) | Depression: $d = .51$<br>Anxiety: $d = .65$ |

*d*, effect size; *P*, *p*-value; NR, not reported.

articles, or searching in specific (narrow) databases (20;31;35–37). Moreover, subjective assessment, which means self-reported measurement instead of a clinical diagnosis, was also reported (32;34).

## Discussion

App-based interventions caused a reduction in depression, anxiety, and stress symptoms in almost all reviewed studies. These results were promising and in line with those of the previous studies (41–43). The results suggested that mobile apps had the potential to be effective in improving the symptoms of depression, anxiety, and stress. Given the increasing popularity of smartphones, mHealth has the potential to be effective in mental healthcare delivery, especially in low- and middle-income countries and hard-to-reach populations (44).

The present study findings showed that the duration of interventions was more than 6 weeks in eight systematic reviews. So, it can be noted that for behavior change to happen, the duration of mobile app interventions should be more than a month. This result was in agreement with those of other studies, indicating that longer durations of interventions or follow-ups were necessary to evaluate the effectiveness of mobile apps (45–47). Additionally, our overview showed that the use of reminders was an important factor to increase the acceptability of a mobile app intervention. Several studies have proved the effectiveness of electronic reminders in improving adherence to treatment and medication (48–50).

The results of this systematic review recommended the interventions, such as CBT, ACT, BA, mindfulness-based therapy, and stress inoculation therapy, which were based on behavior change strategies for the reduction of depression, anxiety, and stress. Some studies also reported the effectiveness of behavior change strategies in the field of mental health (51–54).

The findings of the present systematic review indicated that the target groups of most apps were young adults and adults, which might be due to the prevalence of psychiatric disorders among these age groups (55). Teenagers had received the least attention and were studied in just one systematic review. Because teenage is a transitional period, more attention should be given to this age group. During this period, teenagers experience a variety of biological, cognitive, and social changes and encounter a great amount of emotional distress, which can lead to complications (56). Another age group that has been ignored is the senior citizen group. According to the World Health Organization (WHO), the world population is aging quickly. Between 2015 and 2050, the percentage of the world's population aged over 60 years has been estimated to almost double from 12 to 22 percent. Approximately 15% of adults aged 60 years and over suffer from a mental disorder. Mental health and well-being are as important in older age as at any other time during life (57). Hence, future research is recommended to focus more on these two age groups.

Several studies have demonstrated that physician support through phone calls, SMS, or e-mails could improve the outcomes (31;32). This result was consistent with those obtained by Mohr et al. (58) and Cuijpers et al. (59), which indicated that clinician support was an influential factor in improving the patients' adherence to interventions. Therefore, physician support has been recommended to be included as a part of the interventions to achieve higher efficiency.

The findings of the current overview confirmed those of the previous studies, which showed that the effect of interventions might be lower in active controls (receiving an intervention) compared with those in the waiting list (receiving no interventions) (60). The use of an active control group could improve the outcome for controlling the condition. This finding could be explained by the Hawthorne effect; the subjects of a study changed their behavior due to their awareness of being observed (61). Accordingly, using the app itself improved the outcome for users. Hence, using an active control group is recommended in order to determine whether the improvement is due to the use of the app alone or due to the app content.

The included systematic reviews were conducted on different populations. In addition, some reviews had focused on specific populations, such as pregnant women and mothers up to 12 months postpartum (32), current paid employment and

working-age adults (34), healthy adults (36), and people with mental health symptoms or disorders (31;35;37;38). On the other hand, some other studies were not focused on a specific population and reviewed general and clinical populations (20;33). In this regard, the results of a study showed that designing interventions for healthcare students or providers reduced stress and depression (62). Besides, mobile phone-based apps designed for psychotic populations were effective in reducing the symptoms of stress, anxiety, or depression (35). Nonetheless, other studies with wider populations showed different results. Some of them showed effective results (20;31;38), whereas some others revealed both effective and ineffective findings (36;37). Thus, it could be concluded that the interventions that were designed for specific populations were more effective. However, in the case of large populations, it might be difficult to meet the needs of different users, and it might impact on effectiveness. The results also indicated that the two systematic reviews that showed more positive results had longer follow-up periods (20;38). Therefore, longer interventions are likely to have more effective results. It can also be concluded that applications are more effective in long-term use.

Mental health apps can provide remote therapy sessions for those people who do not obtain treatment due to geographic, social, or health (physical disability and stigmatization concerns) barriers. This gives them a chance to being treated in geographically desired places, as well as saving their time and monetary cost of traveling (63). In addition, the mental health app can provide portable and flexible professional help for people in need of treatment in a timely and anonymous manner. Moreover, it can be effective for people who are not seeking treatment (64), whereas nonvalidated apps can have negative impacts on patients (65). Unfortunately, only a few research studies have systematically evaluated the efficacy of mental health app. A systematic review study in 2016 found only five mental health-related apps, out of which only three were examined in an RCT (37). In addition, a study that searched app markets for mental health-related application found 208 apps, but the effectiveness of the majority of them was not validated by scientific research (66). Moreover, another study conducted in 2019 revealed that although there are hundreds of mental health apps in the app markets, just nineteen eligible studies were found that evaluated the efficacy of apps in an RCT research (65).

Although app markets have surged enormously, selecting a reliable and effective app is another issue (31). A study showed that only 14 out of 100 mental health applications benefitted from clinically validated evidence (44). Nonvalidated mental health mobile apps could be harmful to users (67). Keeping this in mind, a validated mobile phone-based application should become available to assist the community. Moreover, according to a study, the eHealth literacy of most young people in Iran was reported to be at a low level. Therefore, necessary measures should be taken to improve people's eHealth literacy when using health app (68). In conclusion, the present study findings revealed that mobile apps had the potential to be effective in improving the symptoms of depression, anxiety, and stress. Therefore, the results supported the development of mental health apps as a valuable intervention.

## Limitation

The current study had several limitations. First, the included studies were of varied qualities. Second, in spite of a systematic search of five databases, the possibility of missing some articles cannot be ignored. Third, despite the promising findings, it should be noted that the evidence is still limited, and the results should be interpreted with due caution. Overall, this is an emerging area of research, and further exploration should be done in future in order to reach conclusive evidence.

## Conclusion

The current systematic review aimed to summarize the evidence on the effectiveness of mobile-based applications in monitoring stress, anxiety, and depression symptoms. To the best of our knowledge, this is the first overview of the systematic reviews examining the effects of mobile app interventions on stress, anxiety, and depression symptoms. The study findings might be of use for mental health app users, researchers, and healthcare providers. They can also be helpful for the future development of new mobile apps targeting mental health. It seems that mental health apps can be promising media to reduce depressive symptoms.

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