Evaluating the Efficacy of CBT Based Mental Health Apps in the Treatment of Depression: A systematic literature review

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Abstract

Background: Depression is a common mental health disorder afflicting a significant proportion of the population and has a negative impact on a person's wellbeing. Cognitive Behavioral therapy (CBT) is a current first line treatment for depression and is typically delivered in person by a trained health care provider. There is growing demand for these services and a shortage of health care providers trained in CBT contributes to long wait times for accessing treatment. Other methods to deliver CBT have become of interest, such as self guided CBT based smartphone applications. There has been a rapid expansion in the number of these applications available with few studies conducted to determine their efficacy. Health care providers need to be aware if this intervention is a reliable modality which can be recommend for patients who struggle with depression.

Objective: The purpose of this review was to assess extent research findings with regard to the effectiveness of CBT based smartphone applications in the treatment of depression.

Methods: A literature search was performed using online databases PubMed, Scopus and PsycINFO. Relevant articles were screened and subjected to specific inclusion and exclusion criteria to determine eligibility.

Results: A total of five articles were identified as eligible and reviewed. Four of the five studies reviewed demonstrated a significant reduction in depressive symptoms for their application intervention group. Findings were limited due to inconsistencies between studies which made generalizability of results difficult to interpret.

Conclusions: CBT based smartphone applications for the treatment of depression appear to have some impact in reduction of depressive symptoms. However, due to limitations in study characteristics it is not possible to confidently drawn conclusions about their efficacy. Further research with improved, larger scale trials should be conducted to provide more substantial levels of evidence. Initial findings are

promising that this modality may be used to reduce depressive symptoms in the appropriate subtype of patients who struggle with depression.

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Introduction

Depression is one of the most prevalent mental health disorders afflicting our society today and a leading cause of disability worldwide. The DSM-5 defines depression as the "presence of sad, empty or irritable mood, accompanied by somatic and cognitive changes that significantly impacts an individual's capacity to function". (1) Some of the symptoms of depression include altered sleeping behaviors, increased or decreased appetite, excessive thoughts of guilt, low self esteem, and behavioral changes such as increased agitation or irritability. (1) Patients living with depression suffer from impaired productivity, high absenteeism rates in the workplace, and an overall decreased quality of life which in severe cases can lead to suicide. (2)

The cause of depression is not fully understood, but it is believed to be due to a combination of environmental, genetic and psychological factors. (3) Females are affected at higher rates and are 1.5 to 3 fold more likely to experience depression compared to males. (4) The most common age of onset of depression is in early adulthood or between ages 50 to 60 years, however all age groups are impacted by depression. (5) It has been found that rates of depression are higher in developed countries (15%) compared to the developing world (11%) (6)

According to the World Health Organization in 2015, 4.4% of the world's population was living with a diagnosis of depression. (7) This number is likely underestimated due to the many people who do not seek help for their illness or who are unable to access healthcare services to receive a formal diagnosis of depression. (8) Depression is the largest cause of years lived with disability (YLD), and in 2015, accounted for more than 50 million YLD (7.5% of all YLD) globally. (9) Between 2005 and 2015 it was estimated that the number of people living with depression increased by 18.4% and this number is expected to continue to rise. (10)

In primary care settings in Canada; it is estimated that depression has a prevalence rate of 10%, and contributes to substantial costs on the healthcare system each year (11) Despite the high prevalence of depression it has been estimated that only 56% of patients struggling with this disorder seek treatment. (8) Barriers to seeking treatment include inability to access care from a trained health care provider, restrictions due to geographic location or personal factors such as fears of stigmatization, apathy or reduced mobility due to physical conditions. (8, 12) With rates of depression on the rise it is imperative that other approaches are being sought to improve access to mental health services.

Current first line treatments of depression

Current guidelines recommend antidepressant medication and/or evidence based psychotherapy as first line treatments for depression, (13) and both have proven to be equivalent in terms of efficacy for reducing depressive symptoms. (14) Pharmacologic therapy is commonly associated with adverse side effects such as insomnia, weight gain and sexual dysfunction; which makes this form of treatment less desirable for some patients and increases risk of non adherence to treatment. (15) A form of psychotherapy known as Cognitive Behavioral Therapy (CBT), is another first line treatment for depression and is becoming a more popular approach for patients with depression who wish to avoid pharmacologic therapy and their associated side effects. (16)

Cognitive Behavioral Therapy

CBT was developed by Aaron Beck and is based on the premise that our thoughts influence our emotions which in turn influence behavior. (17) The goal of CBT is to enable the patient to identify their distorted negative thought processes and through use of skills learned through CBT, allows one to make changes to thought patterns, emotions and behavior. (16,17,18) This enables the patient to develop the skills to cope with their depressive symptoms and CBT has been shown to reduce rates of relapse for depression. (16,18) Typically, CBT is delivered in a clinical setting by a therapist or health care provider

trained in CBT. Patients need to attend multiple sessions with the need for additional exercises and practice outside of sessions to gain the most benefit. (19) Barriers to accessing CBT are commonly encountered. Few health care providers are trained in delivering CBT, leading to impaired access and prolonged wait lists for these services. (20) Cost is another issue preventing patients from accessing CBT, and patients who do not have extended insurance may not be able to afford sessions. Geographic location, time constraints and transportation to get to the facilities to partake in CBT sessions are other common barriers. (20, 21)

Alternative methods used to deliver Cognitive Behavioral Therapy

With the demand for mental health services on the rise and the insufficient number of health care providers and resources; new treatment modalities which are evidence based and easily accessible are being sought as a solution to caring for the growing number of patients struggling with depression. Methods used to deliver CBT which are more accessible to the general population have been investigated such as telephone CBT (22), text message delivered CBT (23), and internet delivered CBT (24). Internet delivered CBT (iCBT) has been found to be non-inferior when compared to face to face CBT in the treatment of depressive disorders with the potential to be more cost effective. (24) Given the promising results from the previous studies (22, 23, 24) interest has begun to turn to self guided CBT which may serve to improve access to this form of treatment, while reducing wait times and strain on the health care system.

Of these modalities, the use of smartphone applications or “apps” as a method of delivering CBT has become a rapidly growing area of interest. It is estimated over 8 billion people worldwide have access to a mobile phone (25), signifying there is the potential to reach a large proportion of the population who struggle with depression through this method. Generally, these apps can be downloaded onto a smartphone at no to little cost, and allow the patient to access treatment at their

convenience in a discreet manner without the need to take time out of their day to attend in person CBT sessions.

However, there is concern regarding the increasing number of mental health apps available to the public, with few having been evaluated through research trials to support their efficacy. Health care providers need to be aware which of these apps exist and have proven to be beneficial in the treatment of depression so they can make informed decisions and provide accurate information to their patients. This paper will review the current body of randomized controlled trials which have been conducted using CBT based smartphone apps as an intervention for depression and evaluate their findings.

Objective

The objective of this paper is to answer the clinical question: "In adults with depression, what is the efficacy of CBT based smartphone applications in relieving depressive symptoms from baseline; compared to those who do not use these applications for their depression?"

Methods

A literature search was performed using the online databases PubMed, PsycINFO and Scopus using search terms "cognitive behavior therapy", "CBT", "depression", "major depressive disorder", "mobile applications", "smartphone applications". PubMed yielded 57 articles, PsycINFO yielded 579 articles, and 544 articles were retrieved from Scopus providing a total of 1,180 articles. Studies included were required to have the following criteria: a) randomized controlled trials b) published in English c) primary outcome was assessment of depressive symptoms d) contained a smartphone application which demonstrated CBT principles e) published between 2009-2019 in a peer reviewed journal. (Table 1) Studies were excluded if they did not include an app that was downloaded onto a smartphone device as their intervention. Study protocols, case studies or other reviews and meta-analysis were excluded as well. The titles of the articles were screened for duplicates and for significance to the study and were

removed if they did not meet inclusion criteria. After the initial screening 24 articles met the inclusion criteria and their abstracts were reviewed to further determine eligibility. A further 19 studies were deemed ineligible and excluded leaving five studies suitable for review. (Figure 1.)

Results

A pilot RCT performed by Watts et al. (26) attempted to determine if their mobile app based on CBT principles called "The Get Happy Program", would provide the same effectiveness in reduction of depression symptoms compared to a second group who accessed the program through a computer. Participants were recruited by direct application through the study's website. To be included participants needed to demonstrate self reported mild-moderate depression as deemed consistent with their PHQ-9 score. 22 participants were randomly assigned to the mobile app intervention and 30 participants were allocated to the computer intervention. Due to limited sample size they elected to not include a control group. For both mobile app and computer modalities participants had to complete 6 lessons over an 8 week period. The program required both groups to apply CBT principles to help an animated character overcome depression, and subsequently were taught to apply these lessons to their own life. Primary outcomes in this study were for depressive symptoms as recorded by PHQ-9, BDI-II and measures of psychological distress through K-10 scale. Analyses were conduced using linear mixed model repeated measures (ANOVA). The study concluded that in both mobile app and computer intervention groups there were improvements in PHQ-9, BDI-II and K-10 scores, with the mobile app group showing a slightly improved rate of reduction in PHQ-9 and BDI-II scores deemed clinically significant. ($p=<0.001$). (26) 68.6% of total participants completed all lessons.

Another RCT which was performed by Arean et al. (27), compared two intervention smartphone apps versus a control app for the treatment of depression. Participants were recruited through online advertising and various social media outlets. The treatment period was 4 weeks with follow up

conducted at 8 and 12 weeks. Participants were paid $15.00 to complete the initial inclusion assessment survey and were reimbursed $20.00 for completing assessments at the 4, 8 and 12 week intervals. Participants were included if they had a PHQ-9 score greater than 5 on the 9 item scale or greater than 2 on item 10 of the PHQ-9. They were also required to have access to a smartphone and iPad 2.0 or newer. 209 participants were randomly assigned to Project: EVO, a smartphone app that utilizes CBT theory to alter depressive symptoms. 211 participants were allocated to iPST; an app designed based on CBT problem solving theory, and 206 participants were assigned to use the Health Tips app which served as a control group and relayed health advice. The study found that during the initial 4 weeks PHQ-9 scores for depression decreased 0.73 points per week, with no significant differences between the intervention groups compared to control. There was no significant change in PHQ-9 scores between groups at the 8 and 12 weeks follow up assessments. Treatment remission, classified as reduction of pre-treatment PHQ-9 scores of 50% or more, was found in 45% of Project: EVO participants, 46% of iPST participants and 34% of control Health Tips group. ($\chi^2 = 3.36$, p= .19) (27)

Arean et al. (27) compared patients based on depression severity and found that for patients classified with baseline mild depression there was no significant difference in PHQ-9 score or rates of remission between the intervention apps (Project:EVO, iPST) compared to the control app(Health Tips). (45% Project:EVO, 46% iPST and 34% of Health Tips attained treatment remission, χ^2=3.36, P =.19) For patients who were classified as having higher baseline depression it was found that their PHQ-9 scores were significantly lower at week 12 in the iPST intervention group (difference = 1.79, SE 0.76, t_{201} = -2.36, p =0.02) but not in the Project: EVO group. (p = .15) (27) Adherence was a limitation of this study as 57.9% of participants in both Project: EVO and iPST intervention groups did not download their assigned app.

Mantani et al. (28) conducted a randomized controlled trial using the Japanese created app called “Kokoro-app”. The study aimed to determine the effectiveness of Kokoro app as an adjunctive

therapy for patients diagnosed with major depressive disorder and who were deemed anti-depressant resistant after taking one or more antidepressants (other than escitalopram or sertraline), for four or more weeks at a therapeutic dose with no previous exposure to CBT therapy. The Kokoro app consists of eight sessions focused on training the participant in the methods of CBT including two sessions on self-monitoring of symptoms, two sessions on behavioral activation and two sessions of cognitive restructuring, with the final session focused on relapse prevention.

Participants were recruited by the study psychiatrists and invited to participate on a voluntary basis. 164 participants were enrolled in the study with 81 participants allocated to the intervention group (smartphone CBT app and medication change), and 83 participants enrolled in the control group (medication change only). At the beginning of the study all participants changed their previous antidepressant medication to escitalopram (5-10 mg) or sertraline (25-100 mg). Their prior antidepressant was completely tapered by week 5 of the study. In person CBT was prohibited in both groups for the duration of the study. Symptoms were assessed by masked assessors through telephone interviews and PHQ-9 scores recorded at weeks 0, 1, 5, 9 and 17; with the primary outcome of the study being the PHQ-9 score at 9 weeks. The results were generated based on an intention to treat analysis and found that participants in the intervention group scored 2.48 points lower on the PHQ-9 at week 9 (95% CI 1.23-3.72, $p<.001$). (28)

A randomized controlled trial conducted by Lüdtke et al. (29) tested the effects of their CBT based smartphone app called “Be Good To Yourself” on depressive symptoms. The app was created for iOS smartphones and therefore limited to participants who owned an iPhone. The app was designed with CBT principles based on cognition, mindfulness, social competence and activation exercises, with a total of 40 exercises available. The study included a sample of 90 participants recruited from online depression forums or an outpatient clinic. A formal diagnosis of depression was not mandatory to be included in the study, however participants needed to report a subjective need for intervention of their

depressive symptoms to be deemed eligible. Baseline assessment surveys were conducted for all participants prior to the start of the study and depressive symptom severity was assessed through the PHQ-9. Participants were randomly allocated to the intervention group or a waitlist control group. The intervention group was granted access to the app 24 hours after completion of the initial baseline survey, and were granted access for 4 weeks. The waitlist control received an email notification that the app would become available to them in 4 weeks time after the post assessment surveys were completed. An incentive to complete the post assessment survey was provided in the form of a PDF document containing additional CBT exercises.

The Lüdtke et al. (29) trial's primary outcome was assessing reduction of depressive symptoms as recorded by survey assessment through completion of PHQ- 9 scores. Results were calculated by ANCOVA on an intention to treat between group difference. The study concluded a small effect size in reduction of depressive symptoms in the treatment group compared to the waitlist control group however results were not deemed clinically significant.($F(1;71) = 0.173$ $p = 0.678$, $\eta^2_p = 0.002$, $p = 0.952$) (29) 84% of participants completed the study, however frequency of app use was an issue as only 39% of applicants used their app frequently. 45.5% of the participants in the intervention group and 50% of participants in the wait list group were taking a pharmacologic medication for their depression prior to and throughout the study. 59.1% of the intervention group and 38.6% of the wait list group had received in person CBT with a therapist previously.

Bakker et al. (30) conducted a randomized control trial of three CBT based smartphone apps; MoodKit, MoodMission and MoodPrism compared to a control group. These intervention apps are found on the app store and available for download at no charge, except for the MoodKit app (available for download for a fee of $6.99). For the sake of their study, the Moodkit app was provided to participants allocated to that group at no charge. Participants were recruited through online social media outlets Twitter, Facebook and websites of other mental health organizations. A total of 78

participants were randomly allocated to the MoodKit app intervention group. The MoodKit app design incorporates four tools consisting of self guided CBT based activities, thought checking, mood tracking and a journal entry component. 78 participants were allocated to the MoodMission app intervention. Users would input their self reported symptoms and based on the level of current emotional distress the MoodMission app would provide the participants with CBT activities called “Missions” they could choose from to complete. Another 78 participants were assigned to the MoodPrism app intervention. MoodPrism is designed as a mood tracking app, and based on participants self reports provides relevant links to information and CBT exercises to cope with their symptoms. The primary outcome measures of this study included effects on depressive symptoms through use of PHQ-9 scale and effects on symptoms of anxiety (GAD-7) and well being (WEMWBS). Participants were excluded if they did not own an iPhone or were taking psychotropic medications at the time of the study. The intervention lasted 30 days, and concluded that participants in the MoodKit ($F= 4.24$, $p <.05$) and MoodMission ($F= 4.39$, $p = <.05$) intervention groups achieved significant reductions in their depressive symptoms. (30)

Discussion

Of the five studies reviewed, four (26, 27, 28, 30) demonstrated statistically significant reduction of depressive symptoms based on their chosen methods of analyses. All studies (26, 27, 28, 29, 30) were randomized controlled trials with one study being a pilot RCT. (26) The number of participants included in the studies ranged from 52 to 626 participants, and the largest intervention group contained 211 participants (27). Duration of the intervention ranged from 4 to 9 weeks. The studies were conducted in various countries including United States (27), Japan (28), Australia (26, 30) and Germany (29). Four of the five studies included a waitlist control group (27, 28, 29, 30). Three of the studies (26, 27, 28) had follow up assessments performed after the initial outcome assessments were completed. All studies

focused on impact of their app intervention for depressive symptoms as one of their primary measure outcomes. (26, 27, 28, 29, 30)

There are challenges regarding control group design when conducting research involving a form of psychotherapy such as CBT. The studies that included a waitlist control group (27, 28, 29, 30) had the potential to be affected by bias due to a sense of expectancy. (33) This could have led to the disappointment of participants assigned to the waitlist control group, and potentially affected the results when participants were granted access to the app intervention. All studies that included waitlist controls were mindful of providing their app intervention to the control groups after initial assessments were completed so as to avoid ethical compromise by withholding treatment for depression from participants in the control groups. (34) All studies were aware of participants who scored high on the suicidality scales and excluded those participants due to their high risk; but provided assistance to those individuals in the form of sources of support and crisis resources.

Three studies did not require participants to have a formal diagnosis of depression to be included in the study; but did require participants to report a self identified need to reduce depressive symptoms. (26, 29, 30) One study's inclusion criteria was specific to participants that had received a formal diagnosis of major depression and were classified as antidepressant resistant. (28) All studies performed initial baseline depression severity assessments prior the start of the trials (26, 27, 28, 29, 30) Including participants with varying severities of depression may have provided a more accurate representation of the general population, which would provide evidence of how a CBT app intervention may work for patients who do not suffer from DSM diagnosis of depression. However, there is some concern this may compromise validity of results. For example, it is known mild depression tends to remit on its own (31) and therefore it would be difficult to conclude the reduction in depressive symptoms was solely due to the app intervention as compared to natural regression. None the less, having

accessible treatment options for all members of the population who struggle with variable severities of depression is important, and CBT based smartphone apps may serve to fill that role.

The participants from the Mantani et al. study (28) diagnosed with antidepressant refractory major depressive disorder were subject to a medication change and the Kokoro app intervention. It is possible that some of the positive results in reduction of PHQ-9 scores could have been attributed to the change in pharmacologic therapy and not solely due to the app itself. The study did prohibit patients from receiving in person CBT therapy while they were enrolled in the study, however the concurrent medication changes makes determining the efficacy of their app problematic. Two studies (27, 29) reported the proportion of their participants that were receiving other psychiatric therapy at the time of the study; however it is possible that the results generated in those studies were skewed due to this secondary effect. Bakker and colleagues (2018) excluded participants who were taking psychotropic medication at the time of the study to avoid this possible confounding variable. The Watts et al. (26) study did not disclose information regarding pharmacologic or other psychiatric therapy use in their participants.

In the Mantani et al (28) study, the study psychiatrists approached their own patients and invited them to participate voluntarily in the study. The study states full disclosure of the trial was provided to the patients and informed consent was obtained, however since the patients knew the study psychiatrists prior to partaking in the trial they may have felt obligated to join the study and this could have been a confounding factor. Another factor to consider is that the study psychiatrists would likely have developed therapeutic relationships with participants prior to the start of the study; further influencing their willingness to partake in the trial which could be considered a conflict of interest. Other studies (27, 29, 30) advertised for study participants on online discussion forums for patients struggling with depression or used internet advertisements on Craigslist, Twitter, Facebook or advertised on their study website (26), which may have helped to minimize bias.

Adherence to the app intervention was a common problem among many of the studies and this has been cited as one of the major concerns with using a self guided app intervention as a treatment modality for depression. (32) The study conducted by Mantani and colleagues (2017) had the highest rate of adherence with a 90% completion rate of participants. The high rates of adherence in this study may have been due to how participants were recruited by their own psychiatrists, which has the potential to act as a confounding variable. Determining ways to increase frequency of app use and improve adherence need to be better evaluated to fully determine the efficacy of app interventions in the treatment of depression.

Some studies provided monetary or other forms of incentives for completion of assessments, and this may have contributed to falsified results. For each assessment completed, Bakker et al. (30) provided participants with a ballot to enter in a draw for an iPad. Arean et al. (27) provided participants with monetary honorariums in the sum of $15-20 for each assessment completed. One study (29) provided PDF documents containing additional CBT exercises as incentive for completing surveys. Incentives provided to participants for completion of the study were not mentioned in two studies (26, 28). Incentives are a way to increase adherence of study participants, however they increase risk of participants involving themselves in a study for ulterior motives and may affect validity of results obtained.

The individual apps which demonstrated statistically significant reductions in depressive symptoms included the Get Happy App (26), iPST app (27), the Kokoro-app (28) and MoodMission and Mood Kit apps (30) These results should be interpreted with caution, as comparison of the studies was made difficult due to the varying sample sizes, different outcome measures (Table 3), variability in study length, app interventions and potential confounding variables as mentioned previously. No study evaluated the long term benefits of their app intervention past 17 weeks (28) and this is another

limitation which makes it difficult to drawn conclusions in regards to long term effects of CBT based smartphone app interventions.

Another consideration regarding the benefits to a CBT app intervention in the treatment of depression is for patients who are afraid to seek care due to stigma. (8, 35) Having an intervention on one's personal phone allows the patient to interact with the intervention in a discreet manner in an environment of their choice. It is known that a significant proportion of people who struggle with depression do not seek help for their symptoms, (8) with fear of stigma being one of those reasons. Smartphone app interventions could serve as a possible solution to reduce the number of patients who do not seek treatment due to stigma surrounding their depression.

CBT is effective for preventing new onset depression. (37, 38) There is the potential that CBT based smartphone apps could be recommended for patients at high risk of developing depression to prevent their symptoms from progressing. If used regularly there may be the potential to decrease incidence of new cases of depression and reduce costs to the health care system and society, while allowing patients to experience an improved quality of life and retain productivity.

Patients who are waiting for a referral to a mental health clinician could use a CBT app in the interim prior to their initial visit. Having background knowledge of CBT prior to an initial assessment may serve to expedite the treatment process and accelerate recovery times. CBT app interventions could serve as a type of blended therapy to compliment in person sessions. Ly and colleagues (2015), (36) compared blended therapy consisting of face to face sessions supplemented with a behavioral activation smartphone application against full face to face behavioral activation therapy. The authors concluded that the blended treatment was non-inferior to the standard in person treatment group. A blended treatment group has the potential to reduce individual time required with a clinician and could serve to

increase the number of patients able to be seen; contributing to a reduction in wait times for accessing CBT.

CBT is a proven effective therapy in the treatment of depression (16), however it is not a therapy that is suitable for everyone. CBT requires commitment, engagement and cooperation. Some patients may find CBT time consuming due to the additional exercises that must be completed outside of sessions. The self guided nature of using a CBT based smartphone app for the treatment of depression is suitable for individuals that are highly motivated and willing to continue using the app to receive the most benefit. For these reasons some patients would not be appropriate candidates for a CBT based smartphone app intervention for treatment of their depression.

Limitations

This review was selective in the type of articles selected, with the requirement being studies that were randomized controlled trials. Another limitation was that few studies were identified that met criteria for inclusion. Given that this area of research is a relatively new domain there will likely be more trials conducted in the near future, but at present this hinders the conclusions drawn from this study. Databases used to retrieve articles in this study were PubMed, Scopus and PsycINFO. This too may have led to limitations in this study as there are other databases that could have yielded additional articles which supported CBT based apps in the treatment of depression. If this study were to be replicated broadening databases may serve to further improve validity of results. Another limitation is the small sample sizes of the studies, and how intervention characteristics varied which makes generalizability of results problematic and inhibits the initial positive results. There is a restriction for this type of intervention for patients who do not own a smartphone. Not all patients could benefit from this type of intervention which limits its clinical utility in certain populations.

Future Research

Additional research is needed to determine what specific components of CBT based smartphone apps prove to be the most effective at reducing depressive symptoms. CBT is an umbrella term and there are a variety of characteristics that make CBT exercises effective and by identifying these specific aspects one can improve delivery of the intervention and treatment outcomes. Other research is needed to determine what factors contribute to adherence and frequency of app use which would be valuable in determining how to motivate patients to use smartphone app interventions. Another worthwhile aspect to elucidate is if there are long term benefits which exist after using a CBT based smartphone app. At present no studies have been conducted to determine the long term effects of CBT apps for depression past 17 week follow up. (28) Additionally, future development of CBT based smartphone apps should include consultation from CBT therapists and clinicians as they are able to detail what methods of intervention may work best and can provide their clinical expertise. Larger scale studies will need to be conducted before more definitive conclusions can be drawn about the effects of CBT based smartphone apps in the treatment of depression.

Future research comparing CBT delivered through a smartphone app intervention versus in person standard CBT delivery could be conducted to determine if CBT app interventions have the potential to act as a substitute for traditional face to face therapy. As the current literature stands there have been no studies performed to assess this. It would be of interest to determine if a CBT based smartphone intervention could serve as a substitute for in person CBT instead of an adjunct. However, it should be noted that not all patients with depression would be suitable candidates for a full self guided intervention and in depth studies would need to be performed to determine the appropriate subset of patients who may benefit from a full self guided intervention in the treatment of their depression.

Conclusion

This review focused on studies that were randomized controlled trials and delivered CBT through a smartphone app as an intervention for the treatment of depression. The apps included in the trials varied in their methods of CBT delivery, however all used CBT principles and were found to reduce depressive symptoms at varying levels of significance. Despite the methodological limitations of each study, the results from this review indicate there is potential for the use of CBT based smartphone apps in the treatment of depression. Further research is needed to identify ways to improve adherence to app use and to determine what specific components of a CBT app intervention are the most effective.

The clinical implications for the use of this technology could in theory improve access to treatment for patients with depression who are unable or wary of seeking mental health services; with the potential to decrease wait times for CBT and reduce costs to the health care system. The field of CBT based smartphone apps is still in it's infancy, however given the preliminary positive results from the studies reviewed it is reasonable to say there is a place for CBT based smartphone apps in the treatment of depression, however further studies need to be conducted to fully determine where that role stands. The hope is that with future research this modality will be utilized in the appropriate population to reduce depressive symptoms in patients who struggle with this disorder.

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Tables

Inclusion Criteria	Exclusion Criteria
English language	Studies that did not involve an application for download onto a smartphone (ex: mobile web apps)
Randomized Controlled Trials	No mention of depression, CBT, or smartphone application in the title or abstract
Depression symptoms as primary outcome	Case studies
Smartphone application with Cognitive Behavioral Therapy principles as primary intervention	Reviews or metanalyses
Peer reviewed Journals published between 2009-2019	Study protocols or proposals

Table 1. Criteria used for inclusion and exclusion of identified articles

Author, country, year, number of participants	Type of Study	Sample type	Smartphone Application name(s)	Intervention/Control/ Follow up	Primary Outcomes	Results
Watts et al. Australia, 2013 (26) n = 52	Pilot RCT	Self identified mild-moderate depression consistent with PHQ-9 scores	Get Happy App	8 weeks of app use vs 8 weeks accessing program through computer No control 3 month follow up	PHQ-9 BDI-II K-10	Significant reduction in depressive symptoms and psychological distress for both groups PHQ-9 (p = <0.001) BDI-II (p = <0.001) K-10 (p=<0.001)
Arean et al. USA, 2016 (27) n = 626	RCT	PHQ-9 score > 5 or >2 on item 10 of PHQ-9	Project:EVO app vs iPST app	4 weeks Health Tips app (control) Follow up assessments at 8,12 weeks	PHQ-9 SDS	PHQ-9 scores decreased by an average of 0.73 points/week, no significant difference between groups Participants with higher baseline depression had significant reduction at week 12 in the iPST group (difference 1.79, SE 0.76, t_{201} = -2.36, p =0.02) but not Project:EVO (p= .15) SDS disability scores decreased by an average 0.67 points/week, no significant difference between groups
Mantani et al. Japan, 2017 (28) n = 164	RCT	Anti depressant refractory major depressive disorder	Kokoro-app	9 weeks Waitlist control Follow up assessment at 17 weeks	PHQ-9	PHQ-9 scores significantly decreased by 2.48 points in the app group (95% CI 1.23-3.72, p < .001) Results were maintained at follow up

Lüdtke et al. Germany, 2018 (29) n = 90	RCT	Self identified need for help with depression symptoms	Be Good To Yourself app	4 weeks Waitlist control No follow up	PHQ-9	No significant difference was found between the intervention compared to waitlist group.
Bakker et al. Australia, 2018 (30) n = 312	RCT	Self reported depressive symptoms	MoodMission MoodKit MoodPrism	30 days Waitlist control No follow up	PHQ-9 GAD-7 WEMWBS	MoodKit and MoodMission demonstrated significant reductions in depression (p = <.001) No significant reduction in PHQ-9 scores was found in the MoodPrism intervention or waitlist groups None of the apps had significant effects on anxiety compared to waitlist All app interventions were significant for improved wellbeing (p = <.001)

PHQ-9 = Patient Health Questionnaire 9- item, BDI-II = Beck Depression Inventory II, K-10 = Kessler 10 item Psychological Distress Scale, SDS = Sheehan Disability Scale, GAD-7 = Generalized Anxiety Disorder Scale 7-item, WEMWBS = Warwick-Edinburgh Mental Well-Being Scale

Table 2. Overview of studies included for review

Primary Outcome Measure Scales	Abbreviation	Description
Patient Health Questionnaire-9	PHQ-9	Scores each DSM-IV criteria for depression, scores range from 0-27. Higher scores correlate for greater severity of depression
Beck's Depression Inventory Second Edition (38)	BDI-II	Measures severity of depressive symptoms based on DSM-V criteria. Scores range from 0-63, higher scores indicate greater severity of depression
Kessler 10-item Psychological Distress Scale (39)	K-10	Measures psychological distress over two week period. Scores range from 10-50, higher scores indicate higher amounts of distress
Sheehan Disability Scale (40)	SDS	Measurement of functional disability due to psychiatric symptoms, assesses absenteeism and presenteeism. Higher scores indicate greater functional disability
Generalized Anxiety Disorder Scale 7-item (41)	GAD-7	Screens and assesses severity of Generalized Anxiety Disorder. Higher scores indicate more severe anxiety
Warwick-Edinburgh Mental Well-being Scale (42)	WEMWBS	Assesses life satisfaction and well being based on 14 item questionnaire. Lower scores correlate with poorer wellbeing

Table 3. Summary of methods used to assess and score primary outcome measures of studies reviewed

Figures

Figure 1. Flow diagram of articles included