

Original Research

A Scenario-Based Cognitive Behavioral Therapy Mobile App to Reduce Dysfunctional Beliefs in Individuals with Depression: A Randomized Controlled Trial

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Abstract

Introduction: While self-administered mobile app-based cognitive behavioral therapy (CBT) has shown efficiency and effectiveness over the past decade, attempts to address automatic and negative beliefs have been lacking. The purpose of this study was to introduce and verify a mobile app that directly intervenes in dysfunctional thoughts. This app-based treatment includes recognizing automatic and negative thoughts of the protagonist of scenarios, writing advice directly to the main character, and sharing advice provided by other participants.

Materials and Methods: Thirty-four participants diagnosed with Other Specified Depressive Disorder were recruited and randomly allocated to a CBT-based mobile-app program, the *Todac Todac* (TT group), or a daily mood chart app program (control group). Participants were asked to use the software for 3 weeks. Assessments for autonomic thoughts and clinical symptoms were administered at baseline and at a follow-up evaluation.

Results: After completing the 3-week program, Dysfunctional Attitude Scale (DAS) scores in TT group were lower than they were in the control group. In clinical measures, both TT group and control group showed reduced Beck Depression Inventory-II (BDI-II) scores and situation-dependent trait version of State-Trait Anxiety Inventory (STAI-X2) at follow-up. However, TT group showed significantly reduced STAI-X2 scores compared to control group. For all participants, changes in DAS scores were correlated with BDI-II and STAI-X2 scores. **Conclusions:** Our preliminary findings provide promising evidence that scenario-based CBT mobile apps can be used to deliver feasible and efficacious cognitive therapy. Long-term research is needed to determine the impact and effectiveness of this new treatment format.

Introduction

Just a decade ago, the idea of developing a mobile app for intervention in mental illness sounded naive to mental health professionals. Now, it is estimated that more than 30,000 mental health apps are available in the Apple iTunes and Android app stores.¹ Given the accessibility and familiarity of smartphone usage,² both the public and private sectors have shown great interest in developing and distributing mobile apps for people with mental illness. Effectiveness of this new generation of public mental health interventions has also been demonstrated by meta-analyses of web-based mental health services.³⁻⁷

The vast majority of this burgeoning industry pertains to cognitive behavioral therapy (CBT), which is well known as the most effective intervention for depression.⁸ CBT aims to modify an individual's automatic and dysfunctional beliefs, which contribute to depressive episodes. Cognitive restructuring, one of the most representative CBT techniques, helps individuals to recognize and challenge their own logical fallacies, such as black-and-white thinking, catastrophizing, magnification/minimization, mind reading, overgeneralization, and "should" statements.⁹ In this process, therapists usually provide clients with various scenarios, including the cases of the clients, and the clients are asked to explore cognitive distortions that appear in the scenarios.^{10,11} During CBT sessions, therapists typically provide various scenarios, including clients' cases, to the clients, who are then asked to explore cognitive distortions evident in the given scenarios. Correcting such cognitive distortions can help people who are at vulnerable mental state to learn more effective cognitive skills, which in turn can help them return to their daily lives.

Computerized CBT programs borrowing from the existing CBT techniques are expected to help alleviate and contribute to reducing both mood symptoms and improper cognitive schemas; however, evidence for the therapeutic effects of the mobile-based CBT program is scarce on the dysfunctional

beliefs. Several explanations are available. First, treatment courses usually span only 3–4 weeks and may not be enough time to fundamentally restructure schemas. Therefore, mobile-based CBT interventions should take the format tailored to successfully alleviate core cognitive symptoms, namely, the dysfunctional depressive thoughts.¹² Second, given the classification of types of e-commerce, such as e-health services, the majority of available mental health apps take the form of business-to-consumer (B2C, consumers interact with online services) rather than of business-to-business (B2B, institutions sell products to other businesses) or consumer-to-consumer (C2C, interactions between consumers).¹³ In particular, application contents are exceptionally dependent on self-help guide based on psychoeducational materials and instructions.¹⁴ However, some of the more recently developed apps have adopted an anonymous peer-to-peer (C2C) platform, which overcomes the drawbacks of the one-way passive treatment program, receiving high praise from users.¹⁵ In such context, both “choosing and focusing” on direct cognitive intervention and the paradigm shift to C2C services should be considered to increase program compliance and intervention efficiency. Such considerations may lead to cognitive change in mental health app users.

The present study aimed to introduce and verify a novel scenario-based CBT mobile app, mind-growth program Todac Todac (TT; in Korean, tap tap). The app was developed with focus on targeting dysfunctional beliefs in individuals at high risk of psychiatric illness or with psychiatric disorders. This novel app includes three steps as follows: (1) Step I: identifying cognitive distortions using a scenario-based quiz; (2) Step II: “Decatastrophizing” questions aimed to correct unrealistic concerns; and (3) Step III: “Distancing” questions using open-ended questions, which encourage the users to gain distance from the dysfunctional thought by giving advice to others in a situation similar to the scenario. After each step, users can assess others’ responses and advice. The design of TT app, thus, utilizes the advantages of both B2C and C2C that facilitate cognitive reconstruction and self-growth.

Conventional face-to-face CBT shows a robust medium effect on maladaptive beliefs of depressed individuals.¹⁶ Similarly, this smartphone app delivery of scenario-based CBT was assumed to have a significant effect on automated and dysfunctional thoughts. The goal of this randomized controlled trial (RCT) was twofold: First, to examine the hypothesis that this app-based CBT program will reduce clinical symptoms compared to a mood diary group. Second, to assess whether this scenario-based platform results in modifying the users’ dysfunctional beliefs through reappraisal and reconstructing.

Materials and Methods

TRIAL DESIGN

This study is a RCT with two groups: a scenario-based CBT mobile app group (TT group) and an app-based mood charting group (control group). Randomization, based on a computerized random number generator, occurred immediately after obtaining informed consent, but before screening clinical symptoms. Following randomization, participants were asked to spend 10–15 min a day for 3 weeks on the TT or mood chart app. Push alarms within the app were used to prevent the absence of app usage for two or more consecutive days. Participants were compensated for their participation (valued at USD 30). Furthermore, after completing participation, those assigned to the control group were informed that they could use the TT app without any restriction.

PARTICIPANTS

Figure 1 shows the flow of participants through the trial. Participants were initially recruited through web-based advertisements, posters, and outpatient psychiatric clinics. For study inclusion, participants had to meet following criteria: the DSM-5 diagnosis for Other Specified Depressive Disorder,¹⁷ fluent in Korean, 12 or more years of formal education, and familiar with Internet and smartphone app use familiarity. Exclusion criteria were as follows: high risk of suicide attempt, diagnosis of psychosis or major depressive disorder based on the Structured Clinical Interview for the DSM-IV, Non-Patient Edition,¹⁸ current psychiatric drug use during at least 4-week period before participating in the program, and/or family history of psychiatric disorder. Of 91 eligible volunteers, 29 did not meet inclusion criteria, and 14 refused participation in these follow-up studies. The remaining 48 participants were randomly assigned to two groups. Seven participants in each group did not participate in enough training and were excluded from the final analysis. Thus, final participants who enrolled in the study were 34 patients who met the DSM-5 criteria for Other Specified Depressive Disorder (30 females; aged 18 to 35 years, mean = 23.71, standard deviation [SD] = 3.26) with significant symptoms of depression (indicated by a Beck Depression Inventory-II [BDI-II] score of 10 or higher; mean = 24.12, SD = 7.96, min = 10, max = 44).¹⁹

INTERVENTIONS

The intervention protocol for the mind growth program TT app was developed based on the conventional CBT manual.⁹ One trial consists of one scenario and a related three-step quiz (Fig. 2). Participants were asked to perform three trials per day.

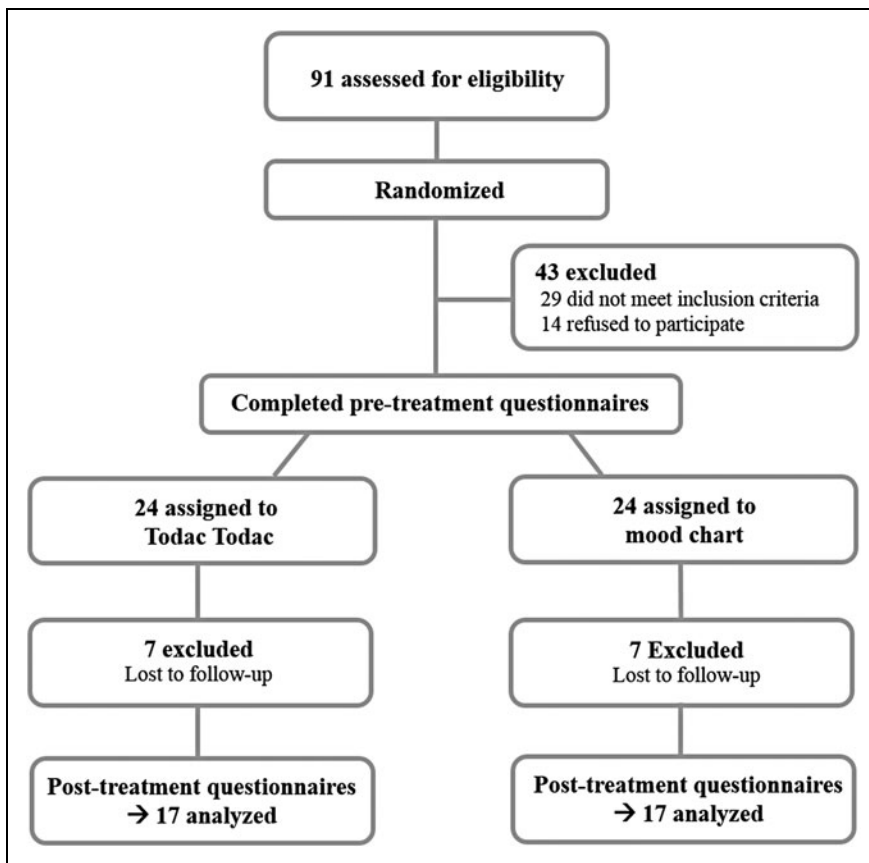


Fig. 1. Flow of participants through the trial.

Step I: identifying cognitive distortions. After reading a short story describing vague or frustrating situation (e.g., a story of an employee who joined a new company but is sensitive to the evaluation of others; a story of a young man who failed to get a

job and is worried about ruining everything after that), users are asked to find the protagonist's automatic and systematic negative beliefs in each vignette ("What is the dysfunctional belief of the main character in the story?"). The multiple-choice question describes typical cognitive distortions common in psychiatric patients, such as black-and-white thinking, catastrophizing, magnification/minimization, mind reading, overgeneralization, "should" and "must" statements, and tunnel vision. Immediately after each response, a bar graph of the response rate of others is displayed, allowing the participant to see the answers most people chose (i.e., the correct answers).

Step II: the "Decatastrophizing" questions. Individuals with mental illnesses tend to predict either an unrealistic worst-case scenario or hold an unrealistically optimistic view. In either case, the question of "guessing what is really going to happen" is very helpful for these patients with an impaired grasp of reality and tunnel vision. In this step, users are asked to choose among three alternatives the most realistic outcomes for each scenario: most unrealistic pessimistic, most realistic, and

most unrealistic optimistic ones ("What would be the most realistic outcome that could happen in this situation?"). This step provides the participant opportunity to confront and correct the level of anxiety that causes his or her maladjustment.



Fig. 2. Screenshot of the Todac Todac app, including scenario-based three-step quiz.

Immediately after each response, the most realistic expectation is displayed, allowing the participant to correct their unrealistic concerns or wishes.

Step III: the “Distancing” questions. Users are asked to imagine what to advise a close friend or family member in a similar situation. This training may encourage users to distance themselves from distorted thoughts (“If your friends and family members were in same situation, and you were a counselor, what would you tell them?”). At this stage, individuals will experience growing as counselors for themselves. After completing each step, individuals can post and share their advice on the timeline, as well as read advice from others.

Control group. In comparison, participants in the mood chart control group were asked to complete a daily mood diary, recording their mood state (e.g., depressed, manic) and sleep quality/quantity. Completing the mood chart takes 10–15 min.

OUTCOME MEASURES

Every participant completed all assessments listed below both at baseline and 3 weeks after the start of the program. The main outcome measure was the Dysfunctional Attitude Scale (DAS),²⁰ which indicates the extent to which an individual agrees or disagrees with a set of functional and dysfunctional attitude statements. The level of negative beliefs of depressed individuals was estimated based on the total score. Psychiatric symptoms of depression and anxiety were assessed by the BDI-II¹⁹ and the trait version of the State-Trait Anxiety Inventory (STAI-X2).²¹ Higher scores on each scale indicate greater levels of clinical symptoms. The most widely used self-esteem measure, the Rosenberg Self-Esteem Scale (RSES),²² was used to assess participants’ psychological resources essential for mental health. To rule out the impact of changes in environmental factors, quality of life (QoL) was also explored for each group.²³

PROCEDURE

The two-arm trials examining the effects of a scenario-based CBT app on dysfunctional cognition used a 3-week prospective longitudinal design. At baseline, participants completed clinical screening (Structured Clinical Interview for DSM-IV, Non-Patient edition [SCID-NP], DAS, BDI-II, STAI-X2, RSES, and QoL) and measures of self-report questionnaires and received information about how to use the mobile intervention app. After 3 weeks of app use, participants were associated with the same measures as they did at baseline. All participants provided written informed consent. This study was conducted in accordance with the guidelines provided by the Institutional Review Board at Chung-Ang University.

STATISTICAL ANALYSES

Mann–Whitney or chi-square tests were performed as non-parametric tests between groups, while the Wilcoxon signed-rank test was used as a nonparametric paired test for cognitive and psychiatric symptom changes after the intervention and the Spearman test for correlation analysis.

Results

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Before the intervention, dysfunctional attitude, clinical symptoms, including depression, and resilience in participants of the TT group did not show any significant difference compared to those of the control group (*Table 1*; all $ps > 0.05$).

EFFECTS OF THE MOBILE APP INTERVENTIONS

At follow-up, the DAS mean scores improved significantly in the TT group after using app-based intervention for 3 weeks (Wilcoxon’s test, $Z = -2.533$, $p = 0.011$), while the control group did not show changes in negative beliefs ($p > 0.05$). DAS scores in the TT group were lower than they were in the control group ($Z = -2.26$, $p = 0.024$).

The Wilcoxon test for clinical symptoms showed reduced BDI-II (TT group: $Z = -3.386$, $p = 0.001$; control group’s $Z = -3.011$, $p = 0.003$) and situation-dependent STAI-X2 (TT group’s $Z = -2.913$, $p = 0.004$ vs. control group’s $Z = -2.511$, $p = 0.012$) scores for both groups after completing the 3 week course. However, despite the improvement of anxiety evident in both groups, a group difference was found in BDI-II score at trend level ($Z = -1.90$, $p = 0.058$, TT group < control group) and in the STAI-X2 ($Z = -2.10$, $p = 0.035$, TT group < control group) at follow-up.

In the case of self-esteem, which showed no significant problems at baseline, there was no change after 3 weeks of intervention for either group (all $ps > 0.05$). No group difference was found in QoL at follow-up ($p > 0.05$; *Table 1*).

CORRELATION ANALYSIS

The changes in DAS scores showed moderate or greater correlations with both the scores of BDI-II (Spearman’s $\rho = 0.38$, $p = 0.027$) and of STAI-X2 (Spearman’s $\rho = 0.73$, $p < 0.001$).

Discussion

Mobile mental health apps with sophisticated and rigorous design and methodology are becoming increasingly popular.²⁴ It is clear that a variety of innovative app-based therapies will meet the needs of many patients and change the landscape of mental healthcare. In this RCT study, a scenario-based mental health app, TT, demonstrated superior cognitive and clinical outcomes for patients with other specified depressive disorder compared to those in the control condition, who

Table 1. Demographic and Clinical Characteristics at Baseline and at Follow-Up

	TT GROUP (<i>n</i> = 17)	CG (<i>n</i> = 17)	GROUP COMPARISON	
			Z OR FISHER'S EXACT TEST ^a	<i>p</i>
Male/female	2/15	2/15	N/A	1.000
Age (years)	24.76 ± 3.70	22.65 ± 2.42	−1.56	0.119
QoL	96.82 ± 16.73	90.00 ± 18.02	−1.19	0.234
DAS				
DAS at baseline	148.76 ± 33.12	165.82 ± 26.35	−1.52	0.130
DAS at follow-up	127.65 ± 29.13	154.06 ± 30.88	−2.26	0.024
Paired test ^b	<i>Z</i> = −2.53, <i>p</i> = 0.011	<i>Z</i> = −1.61, <i>p</i> = 0.107		
BDI-II				
BDI-II at baseline	22.65 ± 7.94	25.59 ± 7.93	−0.88	0.379
BDI-II at follow-up	10.00 ± 7.09	16.00 ± 10.32	−1.90	0.058
Paired test ^b	<i>Z</i> = −3.39, <i>p</i> = 0.001	<i>Z</i> = −3.01, <i>p</i> = 0.003		
STAI-X2				
STAI-X2 at baseline	57.00 ± 9.27	60.82 ± 7.31	−0.95	0.342
STAI-X2 at follow-up	46.00 ± 10.62	53.88 ± 10.28	−2.10	0.035
Paired test ^b	<i>Z</i> = −2.91, <i>p</i> = 0.004	<i>Z</i> = −2.51, <i>p</i> = 0.012		
RSES				
RSES at baseline	27.65 ± 2.34	27.59 ± 1.91	−0.19	0.847
RSES at follow-up	27.88 ± 1.90	27.59 ± 2.29	−0.75	0.452
Paired test ^b	<i>Z</i> = −0.44, <i>p</i> = 0.658	<i>Z</i> = 0.00, <i>p</i> = 1.00		

^aNonparametric *Z*-values from nonparametric Wilcoxon rank-sum test and Fisher's exact test for continuous and categorical variables, respectively.

^bWilcoxon test for paired samples (follow-up, baseline)

BDI-II, Beck Depression Inventory-II; CG, control group; DAS, Dysfunctional Attitude Scale; N/A, not applicable; QoL, quality of life; RSES, Rosenberg Self-Esteem Scale; STAI-X2, trait version of the State-Trait Anxiety Inventory; TT, Todac Todac.

kept a mood diary. To our knowledge, this is the first study to verify the direct effects of a CBT mobile app on dysfunctional beliefs and clinical symptoms in depressed patients.

Over the past decade or so, considerable research has demonstrated the efficiency and effectiveness of app-based treatment.^{25,26} However, determining the therapeutic mechanisms of mobile-based therapy remains a challenging task.²⁷ Moreover, general mental health apps typically focus on (1) exercise and mood, (2) behavioral activation, and (3) coping strategies,²⁴ while rarely addressing the core cognitive symptoms of mood disorder, namely, dysfunctional beliefs. In the TT app, users are given opportunities to look for negative cognitive distortions evident in the main characters in frustrating sce-

narios and provide advice to those who have experienced this situation. Through this process, a depressed individual can break his or her negative perspective with repeating the exercise of stepping back and examining the situation objectively. In the present preliminary study, only 3 weeks of app use led to remarkable decreases in depression, anxiety, and negative thoughts in individuals diagnosed with other specified depressive disorder.

Academic interest in the impact of psychotherapy on dysfunctional beliefs arose relatively recently. A recent meta-analysis demonstrated that psychotherapy, including CBT, has a robust and stable impact on dysfunctional cognitions in depressed individuals.¹⁶ In the present study, similar to the results of previous meta-analytic research, the index of negative thoughts, DAS scores, was reduced in the TT group compared to control group, and the changes in DAS scores revealed remarkable correlations with the BDI-II scores. Thus, the scenario-based CBT program TT using traditional CBT proved to be an effective application for modifying dysfunctional beliefs with a more appropriate schemata.⁹

Interestingly, DAS changes showed stronger links with STAI-X2 changes than they did with those of the BDI-II. Indeed, it has been reported that anxiety is related to various cognitive distortions, such as dysfunctional attitudes and negative automatic thoughts.²⁸ Given that the specific therapeutic mechanisms underlying the modification of dysfunctional beliefs in

depression remain unclear,²⁹ future studies should investigate exactly how psychotherapy affects depression. However, the present result builds for the case that interventions on negative thinking augment the alleviation of anxiety, which could indirectly improve depressive symptoms.

In contrast, it should be noted that the mood diary program, too, demonstrated therapeutic effects on depression and anxiety. A mood chart aims to increase awareness of the appearance or fluctuation of mood symptoms and is widely used in the management of mood disorders.^{30,31} Therefore, mood chart may help individuals to acquire meta-awareness of internal experiences, as well as moods, to help

reduce depression onset.³² In this line, the recovery of clinical symptoms in the control group is a plausible result. Research on the utility of mobile-based mood charts is also under way.³⁰

The generalizability of our observations may be limited by the study's small sample size and gender bias. Further study should recruit a large sample, as well as consider the even distribution of gender, to provide results representative of the effectiveness in male users. The current findings are also limited by the absence of information on the physiological changes accompanying the recovery of clinical symptoms. The effects of mental health apps focusing on dysfunctional beliefs should be further substantiated in a greater number of patients, assessing both physiological and psychological variables. We are planning a follow-up study in light of the above limitations. Despite the limitations, our findings suggest several directions to be considered for mobile app design. The World Health Organization suggests that untreated mental disorders account for 13% of the total global burden of disease.³³ Moreover, human resources for mental healthcare are not sufficient in low- and middle-income countries. Along this line, newly developed apps should take a "choice and focus" strategy, consider both B2C and C2C formats, and provide specific and tailored ways to intervene in the pathogenesis of various symptoms of mental illness. Efforts to clarify the goals and targets can enhance the effectiveness of app-based therapies. App-based psychotherapy should also grow within the framework of evidence-based therapy. In other words, through research validation, the dynamics and limitations of the effects of app-based therapies should be investigated.

In the present study, we demonstrate that the scenario-based CBT mobile app functions as an effective platform that contributes to the correction of cognitive distortions, as well as the alleviation of depression and anxiety. Although preliminary, the direct intervention to automatic and dysfunctional beliefs delivered a number of potential benefits that warrant further investigation. Through this novel platform, we hope to assist individuals in their paths as mental healthcare practitioners who care for themselves.

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Disclosure Statement

No competing financial interests exist.

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