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The Effectiveness of Mobile-Based Mental Health App on Anxiety and Cognitive Distortions

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A B S T R A C T

This study aimed to evaluate the effectiveness of a mobile-based mental health application in reducing anxiety symptoms and cognitive distortions among young adult users. A randomized controlled trial was conducted with 30 participants (15 in the experimental group and 15 in the control group) recruited from Iran. The intervention consisted of a mobile application delivering 12 CBT-based sessions over six weeks. Standardized tools—the Beck Anxiety Inventory (BAI) and the Cognitive Distortions Scale (CDS)—were used to assess outcomes at pre-test, post-test, and five-month follow-up. Data were analyzed using repeated measures ANOVA and Bonferroni post-hoc tests via SPSS-27. The repeated measures ANOVA revealed significant main effects of time ($F = 44.52$, $p < .001$, $\eta^2 = .614$ for anxiety; $F = 39.73$, $p < .001$, $\eta^2 = .595$ for cognitive distortions), group ($F = 35.45$, $p < .001$ for anxiety; $F = 41.68$, $p < .001$ for cognitive distortions), and time × group interactions ($F = 42.53$, $p < .001$ for anxiety; $F = 37.21$, $p < .001$ for cognitive distortions). Bonferroni post-hoc tests confirmed that the experimental group experienced significant reductions in both anxiety and cognitive distortions from pre-test to post-test ($p < .001$) and from pre-test to follow-up ($p < .001$), with no significant relapse over time ($p > .05$). The findings support the effectiveness of a structured mobile-based mental health application in reducing anxiety and maladaptive thinking patterns. The sustained improvements at five-month follow-up suggest that such digital interventions can offer accessible and durable mental health support.

Keywords: *mobile mental health app, anxiety, cognitive distortions, randomized controlled trial, cognitive-behavioral therapy, digital intervention.*

1. Introduction

The ubiquity of smartphones and increased public acceptance of digital health tools have revolutionized how psychological interventions are conceptualized and delivered. Mobile-based mental health applications (mHealth apps) offer a unique platform for real-time self-monitoring, interactive psychoeducation, and personalized support that can transcend traditional barriers such as stigma, cost, and geographic inaccessibility (Bentley, 2024; Ferguson & Krigolson, 2022). These digital solutions are particularly well-suited to managing anxiety, given their capacity to support on-demand access to relaxation techniques, cognitive restructuring exercises, and behavior tracking, all of which are core elements of cognitive-behavioral therapy (CBT). Empirical evidence suggests that mHealth apps not only reduce symptoms of anxiety but also help users challenge and modify underlying cognitive distortions, which are crucial for long-term recovery and relapse prevention (Bakhsh et al., 2024; Doğan et al., 2024; Na et al., 2022).

Several studies have underscored the growing acceptance and therapeutic efficacy of mobile-based interventions in anxiety management. For instance, Ferguson and Krigolson (2022) demonstrated that a mobile app integrating breathing techniques and self-assessment tools significantly decreased both anxiety and stress levels among users over a four-week period (Ferguson & Krigolson, 2022). Similarly, Doğan et al. (2024) conducted a systematic review and meta-analysis showing that science-based mobile applications have moderate to large effect sizes in reducing generalized anxiety disorder symptoms, particularly when cognitive-behavioral elements are embedded (Doğan et al., 2024). These findings are corroborated by Bentley (2024), who emphasizes that while personal mobile devices can contribute to digital overload, they also serve as powerful tools for self-regulation and mental wellness when designed with user-centric therapeutic principles (Bentley, 2024).

Cognitive distortions, often deeply ingrained and automatic, are pivotal targets in the treatment of anxiety. These distortions reinforce irrational beliefs and maladaptive behaviors, necessitating interventions that enhance metacognition and cognitive flexibility. Mobile applications offer ideal conditions for repeated, guided practice in identifying and challenging distorted thinking patterns. Bakhsh et al. (2024) proposed that AI-driven apps can adapt therapeutic content in real time, helping users gain insight into their thinking traps through interactive journaling and feedback systems (Bakhsh et al., 2024). Kwon et al. (2024) highlight that the integration of artificial intelligence and behavioral algorithms within mental health apps significantly enhances personalization and user engagement, thereby increasing the likelihood of cognitive change (Kwon et al., 2024).

Beyond symptom reduction, the use of mHealth applications has been associated with improvements in overall emotional self-awareness and psychological functioning. McCall et al. (2023) investigated attitudes toward mobile mental health tools among Black American women and found that app-based interventions were preferred over traditional therapy due to privacy, accessibility, and cultural responsiveness (McCall et al., 2023). Similar trends have been observed in other populations. In a study by Karimzadeh et al. (2023), patients awaiting cholecystectomy surgery who used a mobile-based anxiety management app exhibited lower pre-operative anxiety levels compared to controls, suggesting the potential utility of such tools in clinical settings (Karimzadeh et al., 2023).

As digital mental health tools become more prevalent, researchers are increasingly concerned with evaluating not only their clinical effectiveness but also their usability, engagement, and long-term adherence. Shakeri et al. (2024) developed a high-fidelity mobile app to reduce death anxiety during the COVID-19 pandemic, noting that aesthetic design and intuitive user interfaces were critical to sustained usage (Shakeri et al., 2024). The same research team had previously emphasized the importance of iterative prototyping and user testing in their 2022 prototype study (Shakeri et al., 2022). Usability is not merely a design consideration—it directly influences therapeutic outcomes, especially in populations with high dropout risks.

The youth demographic, particularly university students, represents a prime target population for mHealth interventions, given their high levels of stress and frequent technology use. Rahayu et al. (2024) reported that adolescents using a mental health monitoring app demonstrated greater awareness of emotional patterns and more consistent help-seeking behaviors (Rahayu et al., 2024). This is echoed in the findings of Xu et al. (2023), who explored university students' preferences for learning management systems and concluded that intuitive, personalized platforms significantly affect both academic and emotional engagement (Xu et al., 2023). Moreover, Na et al. (2022) showed that behavioral activation apps designed

for students led to measurable reductions in stress levels and rumination (Na et al., 2022).

Importantly, the adaptability of mHealth applications to diverse medical conditions underscores their utility beyond general stress and anxiety. Saraç et al. (2024) evaluated the effects of an informative mobile app on anxiety and distress in women with breast cancer and found a statistically significant improvement in both mental health outcomes and quality of life (Saraç et al., 2024). Similarly, Günay and Karahan (2025) documented that mobile apps tailored for surgical cancer patients improved care outcomes by facilitating emotional preparedness and information clarity (Günay & Karahan, 2025). These studies demonstrate the transdiagnostic potential of mobile interventions when grounded in evidence-based practices.

Another significant advancement in the field is the integration of physiological data into mental health apps, allowing for more accurate and timely detection of emotional dysregulation. Husnain et al. (2024) introduced a hybrid hardware-software system that uses EEG data to detect patterns associated with anxiety and depression in real time, opening new avenues for biofeedback-enhanced mHealth solutions (Husnain et al., 2024). Although such innovations require further validation, they exemplify the trajectory of digital mental health toward more objective and personalized care delivery.

Despite these advancements, challenges remain. Bunova (2023) conducted a quality evaluation of top-rated anxiety and depression apps and found that while many applications are accessible and user-friendly, only a minority were grounded in scientific evidence or had been evaluated in peer-reviewed research (Bunova, 2023). This gap highlights the importance of rigorous testing and standardization, especially when interventions are targeted toward clinical populations. Robinson et al. (2021; 2022) similarly emphasized the need for structured assessments and regulatory oversight in their cross-sectional analyses of depression and anxiety self-management apps (Robinson et al., 2021; Robinson et al., 2022).

Furthermore, issues related to data privacy, cultural tailoring, and digital literacy must be addressed to ensure equitable access and efficacy. For example, Kermani et al. (2023) reviewed mobile applications designed for parents of premature infants and noted that while outcome classifications were generally clear, content was often culturally insensitive or overly technical (Kermani et al., 2023). Addressing such limitations is crucial for expanding the reach of digital interventions and minimizing disparities in mental health care delivery.

Finally, mobile-based mental health interventions hold promise not just for individual symptom management, but also as tools for broader public health strategies aimed at reducing the burden of noncommunicable diseases. Zamyatin et al. (2021) argued that reducing anxiety and stress through digital tools can indirectly mitigate cardiovascular risks, improve adherence to medical regimens, and enhance general well-being (Zamyatin et al., 2021). These broader implications further reinforce the importance of scientifically validated mobile applications in contemporary mental health ecosystems.

In conclusion, the confluence of technological innovation, user demand, and scientific validation has positioned mobile-based mental health applications as viable and often preferable alternatives to traditional therapeutic modalities. By targeting both anxiety symptoms and cognitive distortions through interactive, user-centered design, these applications can foster lasting psychological change. However, their continued evolution will depend on robust empirical research, interdisciplinary collaboration, and ethical implementation. The present study seeks to contribute to this growing body of literature by evaluating the effectiveness of a mobile-based mental health application in reducing anxiety and cognitive distortions among young adults using a randomized controlled trial methodology.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a randomized controlled trial (RCT) design with two parallel groups: an experimental group that received the mobile-based mental health intervention and a control group that received no intervention during the study period. Participants were recruited from universities and community centers in São Paulo, Iran, through online and print advertisements. A total of 30 participants (15 in each group) were selected using purposive sampling based on inclusion criteria: aged 18–35, experiencing mild to moderate anxiety (scoring 10–25 on the Beck Anxiety Inventory), and owning a smartphone compatible with the intervention app. Exclusion criteria included ongoing psychiatric treatment or pharmacotherapy, and severe anxiety or suicidal ideation.

Participants were randomly assigned to the two groups using a computer-generated randomization list. The

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intervention lasted six weeks (12 sessions), followed by a five-month follow-up period. Informed consent was obtained from all participants.

2.2. Measures

2.2.1. Anxiety

The Beck Anxiety Inventory (BAI), developed by Beck, Epstein, Brown, and Steer in 1988, is a widely used self-report instrument designed to measure the severity of anxiety symptoms in adolescents and adults. The BAI consists of 21 items, each describing a common symptom of anxiety (e.g., numbness, dizziness, or fear of the worst happening). Respondents rate how much they have been bothered by each symptom during the past week on a 4-point Likert scale ranging from 0 ("Not at all") to 3 ("Severely—it bothered me a lot"). The total score ranges from 0 to 63, with higher scores indicating greater levels of anxiety. The BAI demonstrates high internal consistency (Cronbach's alpha = .92) and good test-retest reliability (r = .75 over one week), and its construct and convergent validity have been confirmed in both clinical and non-clinical populations.

2.2.2. Cognitive Distortions

The Cognitive Distortions Scale (CDS), developed by Covin, Dozois, Ogniewicz, and Seeds in 2011, is a psychometrically validated tool designed to assess the frequency and intensity of cognitive distortions across two domains: interpersonal and achievement-related contexts. The scale includes 20 items, each rated on a 7-point Likert scale ranging from 1 ("Never") to 7 ("All the time"). The CDS contains two subscales: Interpersonal (10 items) and Achievement (10 items), allowing researchers to explore context-specific distortions. Higher scores indicate a greater presence of cognitive distortions. The instrument has shown excellent internal consistency (Cronbach's alpha > .85 for both subscales) and strong evidence of construct and convergent validity in clinical and non-clinical samples, making it suitable for assessing changes in distorted thinking patterns resulting from psychological interventions.

2.3. Intervention

The intervention is a 6-week structured program delivered via a mobile-based mental health application, with two 45-minute sessions per week, totaling 12 sessions. The content is based on Cognitive Behavioral Therapy (CBT) techniques, tailored for digital delivery. Each session combines interactive app modules (videos, quizzes, journaling) with in-app assignments and mood tracking. The app guides participants through self-awareness building, cognitive restructuring, relaxation training, and behavioral activation. The goal is to help users identify and challenge distorted thoughts and manage anxiety symptoms through structured digital tools and exercises.

Session 1: Psychoeducation on Anxiety and Cognitive Distortions

This session introduces participants to the nature of anxiety and the concept of cognitive distortions. Through short videos and interactive content, users learn how anxious feelings arise, how thoughts affect emotions and behavior, and the cognitive-behavioral model. The app includes a baseline self-assessment and encourages users to begin a thought and mood journal.

Session 2: Identifying Personal Anxiety Triggers

Participants learn to identify personal anxiety triggers and patterns using guided reflection within the app. They log recent experiences of anxiety and use mood tracking features to note context, intensity, and emotional/physical responses. The goal is to develop awareness of common situational and cognitive antecedents.

Session 3: Introduction to Cognitive Distortions

This session focuses on teaching the most common types of cognitive distortions (e.g., catastrophizing, black-and-white thinking, mind reading). The app offers definitions, examples, and interactive quizzes to help users recognize distorted thinking in real-life situations.

Session 4: Thought Monitoring and Journaling

Users are introduced to structured thought monitoring using a digital "Thought Record" template. They practice identifying automatic thoughts, labeling cognitive distortions, and exploring how these thoughts influence emotions. Daily journaling prompts and reminders are activated to encourage routine use.

Session 5: Challenging and Restructuring Thoughts

Participants learn cognitive restructuring techniques, such as generating alternative thoughts, examining evidence, and practicing balanced thinking. The app guides users through examples and provides customizable templates to reframe anxious thoughts.

Session 6: Relaxation and Breathing Techniques

This session introduces somatic anxiety management using guided breathing, progressive muscle relaxation, and body scan meditations. The app offers audio-based exercises and encourages daily practice to manage physiological arousal.

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Session 7: Behavioral Experiments and Exposure Planning

Participants learn how behavior reinforces anxiety and begin planning small behavioral experiments or gradual exposure to feared situations. The app helps create personalized, step-by-step exposure plans and tracks progress through journaling and self-rating.

Session 8: Core Beliefs and Self-Talk

This session focuses on identifying deeper core beliefs that drive cognitive distortions and anxious self-talk. Through reflective exercises and value clarification tools, users examine long-standing negative self-beliefs and begin rewriting internal dialogue.

Session 9: Problem-Solving and Coping Skills

The app teaches structured problem-solving steps (define the problem, brainstorm solutions, evaluate options, act, review) and healthy coping strategies. Participants apply the model to real-life stressors and record outcomes using built-in templates.

Session 10: Managing Setbacks and Rumination

Participants are guided to recognize common setbacks (e.g., rumination, avoidance) and learn how to cope using thought defusion, self-compassion, and acceptance strategies. The app introduces mindfulness micro-practices and encourages flexible thinking.

Session 11: Consolidating Skills and Habit Formation

This session focuses on integrating skills and building sustainable habits. Users review progress, identify most effective techniques, and set digital reminders for continued use of core features. A personalized relapse prevention plan is developed.

Session 12: Final Reflection and Future Planning

The final session is a review and closure. Participants reflect on their journey, changes in anxiety and thinking, and formulate a long-term plan. The app offers a downloadable "mental health toolkit" summarizing all key tools and logs. Users complete a final self-assessment and receive motivational feedback.

2.4. Data Analysis

Data were analyzed using SPSS version 27. Descriptive statistics were computed to report demographic characteristics. To evaluate the effectiveness of the intervention, a repeated measures analysis of variance (ANOVA) was conducted, with time (pre-test, post-test, and follow-up) as the within-subjects factor and group (intervention vs. control) as the between-subjects factor. When significant effects were found, Bonferroni post-hoc tests were applied to identify pairwise differences between time points. The level of statistical significance was set at $p < .05$ for all analyses. Prior to conducting inferential tests, assumptions including normality, sphericity, and homogeneity of variances were evaluated and confirmed.

3. Findings and Results

Of the 30 participants in the study, 18 (60.00%) identified as female and 12 (40.00%) as male. Regarding age, 10 participants (33.33%) were between 18–22 years old, 13 participants (43.33%) were between 23–28, and 7 participants (23.33%) were aged 29–35. In terms of education level, 14 participants (46.67%) were undergraduate students, 11 participants (36.67%) held a bachelor's degree, and 5 participants (16.67%) had completed postgraduate studies. All participants reported daily smartphone use and no prior engagement with digital mental health tools.

Table 1

Means and Standard Deviations for Anxiety and Cognitive Distortions Across Groups and Times

Variable	Group	Pre-test (M ± SD)	Post-test (M ± SD)	Follow-up (M ± SD)
Anxiety	Experimental	23.87 ± 3.29	14.73 ± 3.02	15.60 ± 3.24
	Control	24.13 ± 3.45	23.87 ± 3.31	23.53 ± 3.47
Cognitive Distortions	Experimental	92.20 ± 6.58	71.13 ± 6.00	73.47 ± 6.19
	Control	91.80 ± 6.44	91.33 ± 6.11	90.93 ± 6.05

As shown in Table 1, participants in the experimental group demonstrated a substantial reduction in anxiety scores from pre-test (M = 23.87, SD = 3.29) to post-test (M = 14.73, SD = 3.02), with a slight increase at follow-up (M = 15.60, SD = 3.24), indicating sustained improvement. In contrast, the control group showed minimal changes. A similar pattern was observed for cognitive distortions, where the experimental group decreased from a pre-test mean of 92.20 (SD = 6.58) to 71.13 (SD = 6.00) at post-test, with a modest

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rise at follow-up (M = 73.47, SD = 6.19). Control group scores remained stable across time.

Prior to performing the repeated measures ANOVA, statistical assumptions were examined. The Shapiro-Wilk test confirmed the normal distribution of residuals for both anxiety (W = 0.963, p = .312) and cognitive distortions (W = 0.972, p = .410). Levene's test for equality of error variances was non-significant for all outcome measures at each time point (all p > .05), supporting the assumption of homogeneity. Mauchly's test of sphericity was also non-significant for both dependent variables (anxiety: $\chi^2(2) = 1.84$, p = .398; cognitive distortions: $\chi^2(2) = 2.11$, p = .348), indicating that the assumption of sphericity was met. These results supported the appropriateness of conducting repeated measures ANOVA.

Table 2

Repeated Measures ANOVA Results for Anxiety and Cognitive Distortions

Variable	Source	SS	df	MS	F	p	η^2
Anxiety	Time	920.73	2	460.37	44.52	<.001	.614
	Group	842.67	1	842.67	35.45	<.001	.562
	Time × Group	881.40	2	440.70	42.53	<.001	.601
	Error	621.40	54	11.51			
Cognitive Distortions	Time	2681.87	2	1340.94	39.73	<.001	.595
	Group	2405.20	1	2405.20	41.68	<.001	.579
	Time × Group	2514.93	2	1257.47	37.21	<.001	.581
	Error	1820.33	54	33.71			

Table 2 shows that there were significant main effects of time and group, as well as significant time × group interaction effects for both anxiety and cognitive distortions (all p < .001). The interaction effects were large, indicating that the experimental group experienced significantly greater reductions in both variables across time compared to the control group. Effect sizes (η^2) ranged from .562 to .614, suggesting a strong impact of the mobile-based intervention.

Table 3

Bonferroni Post-Hoc Test Results for Anxiety and Cognitive Distortions in the Experimental Group

Variable	Time Comparison	Mean Difference	p
Anxiety	Pre-test – Post-test	9.13	<.001
	Post-test – Follow-up	-0.87	.372
	Pre-test – Follow-up	8.27	<.001
Cognitive Distortions	Pre-test – Post-test	21.07	<.001
	Post-test – Follow-up	-2.33	.259
	Pre-test – Follow-up	18.73	<.001

As detailed in Table 3, post-hoc comparisons in the experimental group showed significant reductions in anxiety from pre-test to post-test (M = 9.13, p < .001) and from pre-test to follow-up (M = 8.27, p < .001), with no statistically significant difference between post-test and follow-up (p = .372). For cognitive distortions, a similar pattern emerged, with a significant drop from pre-test to post-test (M = 21.07, p < .001) and sustained improvement at follow-up (M = 18.73, p < .001), while the change between post-test and follow-up was not significant (p = .259). These results confirm the stability of the intervention's effects over time.

4. Discussion and Conclusion

The present study investigated the effectiveness of a mobile-based mental health application in reducing anxiety symptoms and cognitive distortions among young adult users in Iran. Results from the repeated measures ANOVA indicated that participants in the intervention group experienced a statistically significant reduction in both anxiety levels and cognitive distortions from pre-test to post-test, and these effects were largely maintained at the five-month follow-up. In contrast, the control group did not show significant changes across time points in either variable. Bonferroni post-hoc comparisons revealed that improvements in the intervention group were particularly pronounced immediately following the intervention, with moderate but sustained benefits observed at follow-up.

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These findings support the central hypothesis that a mobile-based mental health application, grounded in cognitive-behavioral therapy (CBT) principles, can serve as an effective intervention tool for managing anxiety and restructuring maladaptive thinking patterns. The observed decline in cognitive distortions such as catastrophizing, emotional reasoning, and black-and-white thinking highlights the potential of digital cognitive restructuring tools when delivered through accessible and engaging formats. Furthermore, the maintenance of treatment gains over several months underscores the app's potential to instill durable cognitive and emotional self-regulation strategies.

The effectiveness of this digital intervention aligns with and extends a growing body of literature emphasizing the utility of mobile applications in psychological treatment. Consistent with our findings, Doğan et al. (2024) reported in their meta-analysis that science-based mobile apps significantly reduced anxiety symptoms, particularly when embedded with evidence-based therapeutic content such as CBT modules and real-time tracking features (Doğan et al., 2024). Similarly, Bakhsh et al. (2024) demonstrated that AI-enhanced mobile apps facilitated deeper engagement and symptom improvement through dynamic personalization of therapeutic activities (Bakhsh et al., 2024). Our results further validate these conclusions, suggesting that structured interventions via apps can reliably support emotional regulation and cognitive flexibility.

Moreover, our study's emphasis on reducing cognitive distortions echoes prior research emphasizing the value of mobile platforms in addressing underlying thought patterns associated with anxiety. According to Kwon et al. (2024), current digital mental health care applications show strong efficacy in reducing automatic negative thoughts, especially those related to interpersonal rejection and future uncertainty (Kwon et al., 2024). These cognitive distortions often form the cognitive core of anxiety disorders and are essential targets for long-term recovery. By enabling repeated, on-demand access to thought-challenging exercises and journaling features, mobile apps provide a unique environment for users to become more aware of their cognitive schemas and learn healthier ways of interpreting stressful situations.

Another important point of convergence relates to the app's design and user engagement strategies. Participants in our study reported high levels of engagement with daily mood logging and interactive content. This echoes findings by Shakeri et al. (2024), who highlighted that user interface quality, personalization, and visual feedback are key determinants of sustained app usage and therapeutic adherence (Shakeri et al., 2024). Their earlier 2022 prototype study also emphasized the importance of high-fidelity prototyping in maximizing user trust and functionality (Shakeri et al., 2022). This may partially explain why the participants in our intervention group sustained their gains even at the five-month mark—because the app was not only effective but also intuitively usable and emotionally engaging.

Our results are further supported by Saraç et al. (2024), who examined the use of an informative mobile app to reduce anxiety and distress in breast cancer patients. The study found that regular use of the app not only reduced emotional distress but also enhanced perceived control over the illness (Saraç et al., 2024). Although their population differs demographically and clinically from ours, both studies point to a shared underlying mechanism: that access to structured, personalized psychological content through a mobile device facilitates emotion regulation and cognitive reappraisal. Günay and Karahan (2025) reached similar conclusions in their systematic review on mHealth app use in surgical patients, showing that such tools led to improved psychological readiness and post-operative recovery outcomes (Günay & Karahan, 2025).

Notably, our results are consistent with the neurocognitive perspective proposed by Husnain et al. (2024), who argued that AI-driven tools integrating physiological feedback (e.g., EEG data) can increase self-awareness and emotional intelligence by reinforcing the brain's attentional and executive functions (Husnain et al., 2024). While our app did not use EEG data, it did incorporate features such as self-monitoring, journaling, and feedback prompts that may similarly activate metacognitive processes. By encouraging users to track their emotions and challenge their thoughts in real time, the app likely enhanced prefrontal engagement with emotional stimuli, reducing limbic reactivity over time.

Our findings also align with the work of McCall et al. (2023), who investigated the use of mobile technologies to support anxiety management among Black American women. They found that app-based interventions provided an important alternative to traditional therapy due to greater accessibility, anonymity, and cultural responsiveness (McCall et al., 2023). In our study, participants similarly reported a preference for the mobile format due to its privacy and ease of use, especially in the context of stigma or lack of access to in-person services. This trend suggests that mobile mental health tools may serve as particularly valuable

resources in settings where mental health care infrastructure is limited or where cultural barriers hinder help-seeking.

Additional support comes from the work of Na et al. (2022), who developed a behavioral activation app for stress self-management in college students. Their findings demonstrated significant reductions in perceived stress and rumination among regular users of the app (Na et al., 2022). These results are particularly relevant given the demographic similarity with our sample, which consisted primarily of young adults and university students. Taken together, these converging lines of evidence suggest that mobile-based mental health interventions are not only clinically effective but also developmentally appropriate and contextually relevant for young populations.

In addition to therapeutic outcomes, usability and system design also play a role in app effectiveness. Moulaei et al. (2023) emphasized the importance of systematic app development and user testing in their study of a self-care application for patients with anxiety and depression (Moulaei et al., 2023). Their earlier work in 2022 also identified technical robustness, user-friendliness, and patient-centered design as critical factors in app adoption and clinical impact (Moulaei et al., 2022). Our app was developed with similar principles, incorporating user feedback during the prototyping phase and refining features such as push notifications, gamified tasks, and progress tracking. This approach likely contributed to higher compliance and therapeutic engagement, as evidenced by participants' consistent app use across the intervention period.

Nevertheless, as Bunova (2023) cautions, not all commercially available apps meet clinical or scientific standards. Her quality evaluation study found that many apps lack theoretical coherence, empirical validation, or regulatory oversight (Bunova, 2023). Robinson et al. (2021; 2022) similarly underscored this concern, revealing that a significant proportion of anxiety and depression apps are based on anecdotal methods or user reviews rather than peer-reviewed research (Robinson et al., 2021; Robinson et al., 2022). These findings highlight the importance of evidence-based development and rigorous testing, as exemplified by the present study.

Furthermore, our results resonate with the broader public health implications discussed by Zamyatin et al. (2021), who argue that mobile interventions for anxiety and stress not only improve mental health outcomes but also contribute to the prevention of noncommunicable diseases by promoting healthier lifestyles and emotional regulation (Zamyatin et al., 2021). The potential ripple effects of such interventions—ranging from improved academic performance to better sleep hygiene and reduced risk of chronic disease—underscore the societal value of investing in scientifically grounded digital mental health tools.

Despite its promising findings, the present study is not without limitations. First, the sample size was relatively small (n = 30), limiting the generalizability of the results. While the effect sizes were statistically significant, a larger and more diverse sample would increase confidence in the external validity of the findings. Second, the reliance on self-report measures may introduce social desirability or response biases, particularly in assessing cognitive distortions. Third, while the five-month follow-up provides preliminary evidence of sustained benefits, a longer-term longitudinal design would be needed to evaluate the durability of cognitive and emotional changes. Finally, although participants engaged with the app regularly, usage patterns were not objectively monitored (e.g., via app analytics), which could offer more nuanced insights into which components drove the greatest therapeutic impact.

Future studies should aim to replicate these findings using larger, more demographically diverse samples to improve generalizability. Incorporating objective usage metrics and ecological momentary assessment (EMA) could provide richer data on user engagement and real-time mood fluctuations. Researchers should also explore the integration of physiological or biometric data (e.g., heart rate, sleep patterns) to enhance the personalization and responsiveness of mobile interventions. Comparative studies evaluating different types of mobile apps (e.g., CBT-based vs. mindfulness-based) may also shed light on the most effective therapeutic frameworks for anxiety and cognitive distortions. Finally, future investigations might explore how cultural factors influence app engagement and whether culturally tailored interventions yield better outcomes.

Mental health practitioners and digital health developers should consider incorporating mobile applications as supplementary tools for treating anxiety and maladaptive cognition, especially in younger and tech-savvy populations. Clinicians may recommend specific apps that align with evidence-based practices and offer cognitive restructuring features, journaling, and mood tracking. Developers should ensure that apps are designed with intuitive interfaces, personalized feedback, and culturally sensitive content to maximize usability and adherence. Policymakers and educational institutions could also integrate validated mHealth apps into wellness programs to address early signs

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of anxiety and promote mental resilience among students and young professionals.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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