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A Randomized Controlled Trial of an Online Self-Help Mindfulness Intervention for Emotional Distress: Serial Mediating Effects of Mindfulness and Experiential Avoidance

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Abstract

Objectives Internet-based self-help Mindfulness Intervention for Emotional Distress (iMIED) program is a newly developed program targeting essential transdiagnostic factors underlying emotional distress, the effects of which have gained initial support in sub-clinical samples. The current study investigated its effects on the underlying mechanisms by examining mindfulness and experiential avoidance as putative mediators.

Method Patients with emotional disorders were recruited online. After interviews, 75 patients were randomly allocated to either iMIED ($n = 37$) including treatment as usual (TAU) or TAU-only control group ($n = 38$). Mindfulness, experiential avoidance, and emotional distress (i.e., anxiety, depression, and general emotional distress) were measured before (T0) and after the intervention (T8). During the intervention period, mindfulness was measured weekly (T1–T7); experiential avoidance was measured at Week 2 (T2) and Week 5 (T5).

Results Intention-to-treat 2×2 repeated-measures ANOVAs showed that, compared with the TAU-only group, mindfulness, experiential avoidance, and emotional distress significantly improved in the iMIED + TAU group (Cohen's $d = 0.53$–0.79). Latent growth curve analyses showed that more than half of the improvement in mindfulness and experiential avoidance occurred at T3 and T5, respectively. Serial mediation analyses found that mindfulness at T3 and experiential avoidance at T5 sequentially mediated the effects of the iMIED program on emotional distress.

Conclusions The current study, using a randomized controlled trial with multiple time-point measurements, demonstrated that the iMIED program offers a scalable approach for the management of emotional distress by increasing mindfulness and decreasing experiential avoidance.

Preregistration The current study was preregistered in the Chinese Clinical Trial Registry (http://www.chictr.org.cn/, Registration number: ChiCTR2100044480).

Keywords Mindfulness-based interventions · Online self-help · Emotional distress · Mindfulness · Experiential avoidance · Mechanisms

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Anxiety disorders and depression are very common mental disorders in China with lifetime prevalence rates of 7.5% and 6.9%, respectively (Huang et al., 2019). However, these disorders are greatly undertreated as shown by a report from the National Health Commission of the People's Republic of China (National Health Commission of PRC, 2019). According to this report, there were only 33,500 psychiatrists and only 6000 psychological therapists in China by the end of 2017. Employed psychological consultants numbered fewer than 30,000, leaving a shortage of almost 1.3 million according to the WHO recommended level of one psychological consultant for every 1000 people (National Health Commission of PRC, 2019). Given the seriousness of the situation, it is of great importance to develop

online self-help psychological intervention programs that are suitable and effective for emotional distress and to examine the underlying mechanisms for optimizing interventions.

Mindfulness-based interventions (MBIs), such as Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1982) and Mindfulness-Based Cognitive Therapy (MBCT; Teasdale et al., 2000), in the form of both group treatment and online self-help, have been demonstrated to be effective in preventing relapse or recurrence in major depression (e.g., Segal et al., 2010, 2020), reducing depression and anxiety symptoms (e.g., Cavanagh et al., 2014; Taylor et al., 2021). Online self-help MBIs, for example, the Mindful Mood Balance program (Segal et al., 2020), an internet-based mindfulness treatment (Boettcher et al., 2014), and mindfulness meditation apps (e.g., Calm, Headspace), can be promising interventions overcoming potential barriers related to cost, reach, and stigma (Taylor et al., 2021). Also, the benefits of online self-help MBIs are likely to bring us closer to improving China's current national conditions which are a high prevalence of emotional disorders but a lack of psychological resources (Huang et al., 2019; National Health Commission of PRC, 2019).

Emerging evidence suggests considerable overlap among emotional disorders (e.g., anxiety disorders, depression), as shown in the high rates of current and lifetime co-occurrence (Kessler et al., 2005), and a common set of underlying psychological vulnerabilities with similar expressions of pathological emotional responding (e.g., Barlow, 2002; Moses & Barlow, 2006). To be more specific, the transdiagnostic model of emotional disorders emphasizes frequent strong emotions, aversive reactions/negative beliefs about emotional experiences, and efforts to avoid or escape uncomfortable emotions (Barlow et al., 2010, 2018; Ellard et al., 2010). Based on this, Barlow et al. (2010) developed the *Unified Protocol for Transdiagnostic Treatment of Emotional Disorders* (UP) to address emotion or emotion-related disorders. The UP emphasizes the adaptive and functional nature of emotions, helps restructure maladaptive cognitive appraisals and facilitate more tolerance of emotions, and seeks to identify and correct maladaptive attempts to regulate emotional experiences (Ellard et al., 2010; Farchione et al., 2012). An abundance of research has demonstrated the efficacy of the UP in treating emotional disorders, with moderate to large effect sizes (for a review, see Carlucci et al., 2021).

However, no well-developed unified protocol of MBIs targeting the commonalities of these disorders exists so far (Maleki et al., 2021). Given the current situation, one of our authors, a qualified teacher of MBSR and certified trainer of the UP, combined the rationales and practices from MBSR and the UP and developed the Mindfulness Intervention for Emotional Distress (MIED) program (Liu, in press). Compared to other MBIs, the MIED program directly addresses the psychopathological mechanisms

underlying emotional disorders (Ju et al., 2022; Liu, in press). It includes four strategies to reduce emotional distress. The first strategy is putting more time and effort into the present moment, resuming a normal life and work, by practicing formal and informal mindfulness practice, and facing difficult situations in life (Dimidjian et al., 2011; Kabat-Zinn, 2003). The second strategy is increasing tolerance of uncomfortable bodily and mental phenomena by not reacting to reduce them when feeling them, such as during interoceptive and emotion exposure tasks (Lynch & Mizon, 2011; Treanor, 2011). The third strategy is recognizing and reducing maladaptive emotion-driven behaviors and avoidance behaviors (Barlow et al., 2010; McCluskey et al., 2020). The fourth strategy is improving cognitive flexibility by treating thoughts as passing psychological events and cognitive reappraisal (Lee & Orsillo, 2014; Morris & Mansell, 2018). All of these strategies are blended into the practices of the MIED program in a stepwise approach (Liu, in press).

The MIED program can be delivered in a group (group-based MIED program) with guidance from a qualified teacher or delivered over the internet in a self-help version (the iMIED program). In the iMIED program, materials are delivered daily, including guided mindfulness meditation, reading or listening materials of knowledge about mindfulness and emotional distress, and other tasks (such as informal mindfulness practice and tasks from UP). The iMIED program lasts for 49 days, and its effects on alleviating anxiety and depression have gained some preliminary support. Until now, it has served more than 10,000 individuals from non-clinical or sub-clinical populations. A preliminary study in subclinical populations found that mindfulness, anxiety, depression, and general emotional distress improved significantly in the iMIED group compared to a waitlist control group (Cohen's $d = 0.47$–0.91; Ju et al., 2022). More studies are needed to investigate its effects on clinical populations and the underlying mechanisms.

Mindfulness is an important mechanism underlying MBIs (e.g., Baer et al., 2012; Gu et al., 2015). Formal mindfulness meditation, such as mindful breathing and body scan, forms the backbone of many mindfulness interventions (for a review, see Creswell, 2017), including the MIED program. Through paying attention to the sensation of breathing or body parts (the target of observation), greater present moment awareness can be achieved by briefly and nonjudgmentally noticing where the mind is wandering, and by repeatedly and gently refocusing one's attention and awareness (Baer, 2003; Kabat-Zinn, 2003). Empirically, several meta-analyses or qualitative reviews showed that MBIs can lead to an increase in trait mindfulness and that this increase is associated with treatment effects on mental health (e.g., Gu et al., 2015; Van der Velden & Roepstorff, 2015).

Another important mechanism underlying MBIs appears to be experiential avoidance (e.g., McCluskey et al., 2020;

Weinrib, 2011), which was defined as an unwillingness to stay in touch with particular private experiences (e.g., sensations, emotions, and thoughts), thereby intentionally engaging in deliberate efforts to control or escape from them (Hayes et al., 1996). Although it may initially lead to a reduction of the avoided discomfort, excessive experiential avoidance is likely to play an important role in the development and maintenance of emotional distress over time (e.g., Hayes et al., 2004; Newman & Llera, 2011). According to the Monitor and Acceptance theory (Lindsay & Creswell, 2017), individuals are more likely to get in touch with their inner experiences (i.e., less experiential avoidance) with the cultivation of awareness and acceptance in MBIs. Therefore, experiential avoidance might be an important mechanism underlying the effects of MBIs on emotional distress.

In MBIs, some studies reported that a significant change in mindfulness occurred during the first few weeks, which could lead to improvements in a variety of mental health outcomes (e.g., Baer et al., 2012). With the development of mindfulness skills, it may become easier for individuals to pay nonjudgmental attention to spontaneously occurring uncomfortable sensations without succumbing to the tendency of avoidance (Antoine et al., 2018; Baer, 2003). For example, Weinstein et al. (2009) found that individuals high in trait mindfulness were less likely to use avoidant coping strategies in response to stress. Over time, individuals learn to observe unwanted private experiences as they arise and pass, with the attitude of openness and acceptance, rather than automatically avoiding these experiences, thereby reducing emotional distress in the end (Antoine et al., 2018; McCluskey et al., 2020; Mutch et al., 2020; Weinrib, 2011). Therefore, increases in mindfulness may precede decreases in experiential avoidances in MBIs (including the iMIED), which functioned as the underlying mechanism, leading to reduced emotional distress.

According to Kazdin (2007), there are several requirements for demonstrating mediators and mechanisms of change, such as (1) the strong association between the intervention, the hypothesized mediators of change, and the outcomes; (2) changes in mediators preceding changes in outcomes; (3) using experimental manipulation; and (4) with plausibility and coherence. A study design that uses a randomized controlled trial with multiple time-point measurements can meet most of the requirements and helps to provide solid evidence for demonstrating mechanisms of change (Kazdin, 2007). However, until now, only a few studies with this study design could meet the above requirements for mechanism, suggesting that variables such as mindfulness, self-compassion, and cognitive reactivity could be the potential mediator (for a review, see Maddock & Blair, 2021). In addition, these studies did not include measurements of mediators during the intervention (e.g., Kuyken et al., 2010). Therefore, more studies are needed to investigate the mechanisms underlying MBIs with an appropriate study design.

Above all, the current study used a randomized control trial with multiple time-point measurements to investigate (1) whether the iMIED program could be an adjuvant treatment for patients with emotional disorders, examining its efficacy in reducing emotional distress, and (2) whether changes of mindfulness and experiential avoidance functioned as the underlying mechanisms. Participants were allocated to the iMIED + TAU (treatment-as-usual) group and the TAU-only group. Emotional distress (i.e., anxiety, depression, and general emotional distress) was measured before and after the iMIED program. The presumed mediator mindfulness was measured weekly consistent with previous studies (e.g., Kiken et al., 2015) and experiential avoidance was measured at Week 2 and Week 5. Given that previous studies have provided strong evidence for the effectiveness of online self-help MBIs (e.g., Segal et al., 2020; Taylor et al., 2021), including the effectiveness of the iMIED program for sub-clinical samples with emotional distress (Ju et al., 2022), the current study hypothesized that iMIED + TAU would be more efficacious than the TAU-only condition, achieving significant reductions in emotional distress and experiential avoidance, and significant improvements in mindfulness. As for the mechanisms underlying the iMIED program, both theoretical and empirical evidence suggests that, with the development of mindfulness skills, individuals are more likely to pay nonjudgmental attention to uncomfortable sensations and feelings without automatically avoiding them, leading to reduced emotional distress (Antoine et al., 2018; Baer, 2003; Mutch et al., 2020). Our second hypothesis was that mindfulness and experiential avoidance would sequentially mediate the effects of the iMIED program on emotional distress. Our exploratory aim was to examine the temporal changes in mindfulness and experiential avoidance during the intervention.

Method

Participants

The sample of the current study was drawn from a larger study in which we aimed to compare the effects and underlying mechanisms of the iMIED program with both group-based MIED program and TAU-only. Participants who received a diagnosis of an emotional disorder were recruited via social networks. Eligibility for the study was determined with an initial screening questionnaire (i.e., physical conditions and the 10-item Kessler Psychological Distress Scale; K10; Kessler et al., 2002) and the *Mini-International Neuropsychiatric Interview* (MINI; Sheehan et al.,

1998; Si et al., 2009). The study enrolled participants who met the following inclusion criteria: (1) age 18–65; (2) at least moderate emotional distress (K10 ≥ 22; Kessler et al., 2002); (3) diagnosis/assessment of emotional disorders or emotion-related disorders, including anxiety disorders (e.g., panic disorder, social anxiety disorder, generalized anxiety disorder) and unipolar depressive disorders, in the past 6 months; and (4) if taking medicine, no change in medicine is expected during the experiment period.

Exclusion criteria included (1) no access to the internet; (2) inadequate proficiency in Chinese; (3) previous participation in an 8-week mindfulness-based program; (4) a diagnosis of schizophrenia or schizoaffective disorder, current substance abuse disorder, and severe physical condition (e.g., coronary heart disease); and (5) high risk of suicide.

The sample size calculation was based on the estimated between-groups difference effect size of 0.70, which is considered medium to large. Based on a two-sided test with an alpha of 0.05 and a power of 80%, with an estimated effect size of 0.70, we needed at least 34 patients in each group. The above power analysis was conducted using G-Power 3.1.9.4.

In total, 238 participants completed the sign-up questionnaires, of whom 42 were excluded for severe mental or physical disorders or low scores of psychological distress (Fig. 1). After the research interview, 97 participants were excluded for meeting the exclusion criteria or not participating in the interview, and three did not sign the informed consent, leaving 105 participants included in the randomization. The current study only included participants randomized to the iMIED + TAU group and the TAU-only group, leaving a final sample size of 75.

Procedure

The current study was a prospective, repeated measure, randomized controlled trial of iMIED + TAU versus TAU-only. Data were collected between April and June of 2021. As shown in Fig. 1, participants who received the diagnosis of an emotional disorder or self-identified as patients with an emotional disorder were invited to complete a sign-up questionnaire attached to the advertisement. Among them, those who seemed eligible to participate were invited for an online research interview after verbal consent was obtained. During the interview, participants were thoroughly screened for inclusion and exclusion criteria with the use of the MINI, screening questions, and presentation of diagnosis documents. In addition, the study information and procedure were explained in detail. The interviews were conducted by eight master's or doctoral students majoring in clinical psychology, all of whom have received the MINI training. After the eligibility assessment, 108 participants were contacted to provide digitally signed informed consent and to complete a

baseline assessment (measures of mindfulness, depression, anxiety, general emotional distress, and experiential avoidance). Then, eligible participants were randomly allocated to three groups.

The intervention started on a Monday and lasted for 7 weeks. At the end of certain weeks, participants needed to complete measures of mindfulness weekly (T1–T7) and experience avoidance at Week 2 (T2) and Week 5 (T5) based on that week's experience. One week after the end of the iMIED program, participants were invited to complete post-intervention assessments (T8). After finishing post-tests, participants in the TAU-only group received the iMIED program.
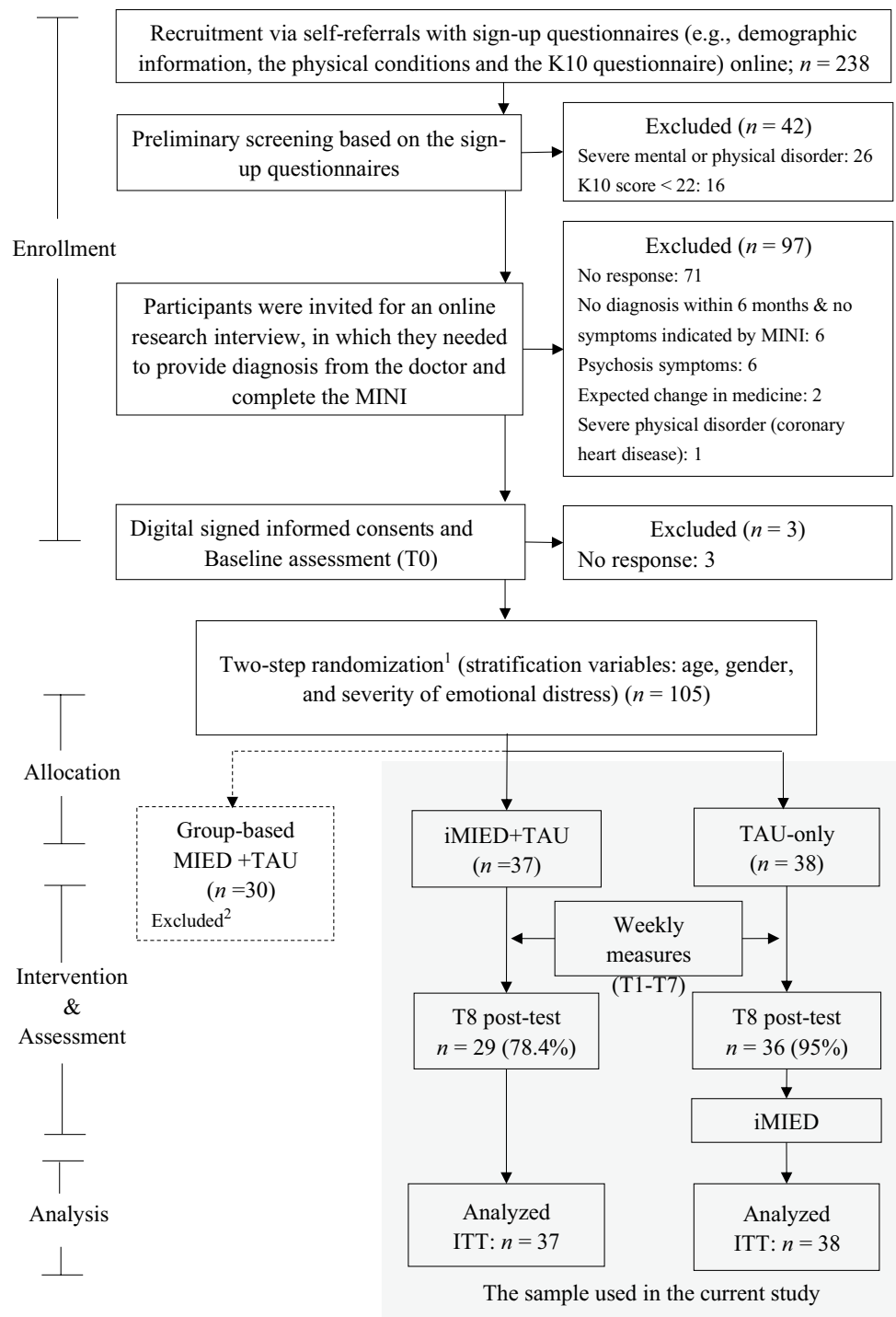
Randomization and Masking

In the current study, we only aimed at investigating the effects and mechanisms of the iMIED + TAU compared to the TAU-only. In the larger study, some participants could not be allocated to the group-based MIED + TAU group due to scheduling conflicts. To guarantee the randomization of the current study and to make sure partial data of the large study meet the requirement of randomization, the randomization was conducted in two steps: (1) participants who were not able to be allocated in the group-based MIED group (n = 36) were first randomly allocated to the iMIED + TAU group and TAU-only group on a 1:1 ratio; (2) the rest of the participants (n = 69) were randomly allocated to the three groups (group-based iMIED + TAU, iMIED + TAU, TAU-only) on a 3:2:2 ratio. Therefore, in the current study, participants of the iMIED + TAU group and TAU-only group were randomly allocated. The final sample size of each group is shown in Fig. 1. The randomization was conducted by an independent researcher, who was not part of the research team, using a stratified random method. Randomization was stratified for (1) gender, (2) age, and (3) severity of general emotional distress (K10 score ≤ 24 versus K10 score ≥ 25). Participants were informed about the condition they had been assigned to by the first author. Two research assistants conducted all the assessments separately following the same procedure.

Interventions

1. **iMIED program:** The iMIED program integrates the rationales and practices from the UP and MBIs. Formal mindfulness exercises (e.g., body scan, mindful breathing, and mindful stretching) and informal mindfulness practices (e.g., mindful tooth brushing) were adapted from MBIs. In addition, the iMIED program selected several important tasks from the UP, like practicing tolerating uncomfortable feelings by interoceptive exposure practices (e.g., rapid breathing), identifying avoidant

Fig. 1 RCT CONSORT diagram: Flow of participants from screening to analysis. ITT, intent-to-treat. [1]Two-step randomization: details can be found in Randomization and Masking. [2]The group-based MIED program was not the one of interest

Enrollment

Recruitment via self-referrals with sign-up questionnaires (e.g., demographic information, the physical conditions and the K10 questionnaire) online; *n* = 238

Preliminary screening based on the sign-up questionnaires

Excluded (*n* = 42)
Severe mental or physical disorder: 26
K10 score < 22: 16

Participants were invited for an online research interview, in which they needed to provide diagnosis from the doctor and complete the MINI

Excluded (*n* = 97)
No response: 71
No diagnosis within 6 months & no symptoms indicated by MINI: 6
Psychosis symptoms: 6
Expected change in medicine: 2
Severe physical disorder (coronary heart disease): 1

Digital signed informed consents and Baseline assessment (T0)

Excluded (*n* = 3)
No response: 3

Two-step randomization[1] (stratification variables: age, gender, and severity of emotional distress) (*n* = 105)

Allocation

Group-based MIED +TAU (*n* =30)
Excluded[2]

iMIED+TAU (*n* =37)

TAU-only (*n* = 38)

Weekly measures (T1-T7)

Intervention & Assessment

T8 post-test *n* = 29 (78.4%)

T8 post-test *n* = 36 (95%)

iMIED

Analysis

Analyzed ITT: *n* = 37

Analyzed ITT: *n* = 38

The sample used in the current study

behaviors and emotion-driven behaviors and reducing them step by step, identifying common maladaptive automatic thoughts (e.g., overestimating probability and catastrophizing), and using the above strategies in daily life by completing challenging tasks. The iMIED program was delivered by a WeChat Mini Program and lasted for 49 days. Each day, participants received different materials including (a) an audio recording of mind-

fulness meditation guidance; (b) learning materials in text or audio; and (c) assignments (for example, informal mindfulness practice, emotion journal, and challenging tasks). In total, it took about 30 min per day to finish all the tasks.

2. **TAU:** In the current study, TAU consisted of all medicinal and psychological treatments received between baseline and post-treatment (about 2 months). Medicinal

treatments included receiving lorazepam, olanzapine, paroxetine hydrochloride, sertraline, etc. Psychological treatments included receiving cognitive behavioral therapy or psychodynamic therapy.

Outcome Measures

Mindfulness

The Chinese version of the 20-item Five Facet Mindfulness Questionnaire-Short Form (FFMQ-SF; Hou et al., 2014) was used to assess mindfulness. It was composed of the following 5 facets: Observing (4 items; e.g., "I can feel pure sensations like the wind or the sunlight touching my skin."), Describing (4 items; e.g., "I'm good at finding words to describe my feelings."), Acting with awareness (4 items; e.g., "When I do things, my mind wanders off and I'm easily distracted."), Non-judging of inner experience (4 items; e.g., "I judge my thoughts as good or bad."), and Non-reactivity to inner experience (4 items; e.g., "I think before reacting under stressful situations."). Items were scored on a 5-point Likert scale ranging from 1 (*never or very rarely true*) to 5 (*often or always true*). Items 2, 4, 5, 6, 8, 13, 16, and 20 were reverse-coded. Scores were summed up, and higher scores indicated greater levels of mindfulness. Both correlated and hierarchical 5-factor models demonstrated good model fits (Hou et al., 2014). In the current study, the Cronbach's α of the FFMQ-SF was 0.77.

General Emotional Distress

The Chinese version of the 10-item Kessler Psychological Distress Scale (K10; Kessler et al., 2002; Zhou et al., 2008) was used to assess general emotional distress. The questions in the K10 focus on anxiety and depression experienced in the past 4 weeks. Items were scored on a 5-point Likert scale ranging from 1 (*none of the time*) to 5 (*all of the time*). The higher the score, the worse the mental state. According to Andrews and Slade's (2001) study, there is a strong association between a high score on the K10 and a current diagnosis of an anxiety or an affective disorder. Therefore, apart from being used as a tool to measure general emotional distress, K10 was also used as an initial screening tool for identifying participants who may have emotional disorders. An example item is "In the past four weeks, how often did you feel nervous?" In the current study, the Cronbach's α of the K10 was 0.87.

Anxiety

To assess anxiety levels, we used the Chinese version of the 21-item Beck Anxious Inventory (BAI; Beck et al., 1988; Zheng et al., 2002). Participants needed to choose how much

each symptom had affected them in the last 2 weeks based on a 4-point Likert-type scale ranging from 0 (*not at all*) to 3 (*severely—it bothered me a lot*). The items reflect symptoms of anxiety, including numbness or tingling, feeling hot, fear of the worst happening, and so on. The higher the score, the more severe the anxiety symptoms. In the current study, the Cronbach's α of the BAI was 0.93.

Depression

The Chinese version of the 21-item Beck Depression Inventory-II was used to assess depression (BDI-II; Beck et al., 1996; Wang et al., 2011). Participants needed to rate each item based on four response choices according to the severity of the symptoms during the past 2 weeks, ranging from 0 (*the absence of a symptom*) to 3 (*an intense level*). The items reflect a variety of depressive symptoms, such as self-dislike, social withdrawal, and sleep disturbance. The higher the score, the more severe the depression symptoms. In the current study, the Cronbach's α of the BDI-II was 0.92.

Experiential Avoidance

The Chinese version of the Acceptance and Action Questionnaire-II was used to assess participants' levels of experiential avoidance (AAQ-II; Bond et al., 2011; Cao et al., 2013). It consisted of 7 items, scored on a 7-point Likert scale ranging from 1 (*never*) to 7 (*always*). An example item is "I'm afraid of my feelings." Higher scores suggest greater experiential avoidance. In the current study, the Cronbach's α of the AAQ-II was 0.87.

Data Analyses

All the data were analyzed and reported following the CONSORT guidelines (Schulz et al., 2010). For all analyses, we conducted intention-to-treat (ITT) analyses (Tripepi et al., 2020), with missing data imputed with the expectation–maximization method recommended by Newgard and Lewis (2015).

Mixed-model repeated-measure ANOVAs in IBM SPSS Statistics (version 24.0) were used to analyze the effects of time, the effects of group, and the interaction between Time and Group (intervention effects) across measurement points. For all measures, 2 (Time: T0, T8)×2 (Group: iMIED+TAU vs. TAU-only) ANOVAs were conducted. For significant interaction effects, post hoc analyses were conducted. Because of the disadvantages and difficulty of interpreting partial η^2 (Levine & Hullett, 2002), the between-groups differences at post-treatment were also assessed using Cohen's *d* statistics as estimates of effect size (Morris, 2008). Effect sizes are usually defined as small when $d \leq 0.20$; medium when $d \geq 0.50$; and large when $d \geq 0.80$ (Cohen, 1988).

Since mindfulness and experiential avoidance were measured multiple times, we employed latent growth curve models (LGCMs) to explore their longitudinal trajectories. In the current study, LGCMs consisted of an intercept factor and a slope factor. The intercept factor loading was specified as 1, representing the value of the initial time point. The slope factor loadings followed an unspecified shape model (i.e., 0, *, 1), such that factor loadings of T2 and T5 (for experiential avoidance; λ_{T2}, λ_{T5}) and T1–T7 (for mindfulness; $\lambda_{T1} \sim \lambda_{T7}$) were freely estimated. In this way, we did not impose a priori assumption about the trajectory and facilitated flexible modeling of non-linear growth trajectories. The freely estimated factor loadings for T1–T7 indicate the proportion of overall change that occurred between T0 and the corresponding time point relative to the total change across 9 time points. In the current model, the means of the intercept factors (α_{Int}) represent baseline scores, and the means of the slope factors (α_{Slp}) represent the extent of change from the pre- to post-intervention. LGCMs were conducted separately first. Then, Group (0 = TAU-only; 1 = iMIED + TAU) as a factor was added as a covariate to investigate the treatment effects on changing trajectories of mindfulness and experiential avoidance. If the estimate of α_{Slp} on Group (β_1) is significant, then the extent of change is significant between the two groups. LGCMs were conducted using the R package lavaan (Rosseel, 2012).

To examine whether mindfulness and experiential avoidance were the potential mediators underlying the effects of the iMIED program on emotional distress, several serial mediation models were tested using PROCESS 3.3 (MODEL 6; Hayes, 2018) in SPSS. In each model, group (0 = TAU-only; 1 = iMIED + TAU) was entered as the predictor, and mindfulness and experiential avoidance were entered separately or sequentially as the serial mediators (measurement time point depended on the LGCMs results), while anxiety, depression, and general emotional distress were entered as the outcomes. Bootstrapping was implemented in these analyses to obtain 95% bias-corrected confidence intervals for the indirect effect estimates. If the

values between the upper and lower confidence limits do not include 0, this indicates a statistically significant indirect effect (Preacher & Hayes, 2008).

Results

Participant Flow and Characteristics

A total of 75 patients from the iMIED + TAU (n = 37) and TAU-only group (n = 38) were included in the study (see Fig. 1 for a detailed description of the participant flow). The sample consisted of mostly women 53 (70.67%), with an average age of 31.53 years old (SD = 10.26). The average length of education was 15.71 (SD = 2.55) and the average per capita monthly income was 13,144.00 RMB (SD = 46,024.77). Among them, 32.0% were full-time students, 68.0% were employees or others; 24.00% with anxiety disorders, 25.30% with depression disorders, 44.00% with both anxiety and depression disorders, and 6.70% with other emotion-related disorders (e.g., bipolar disorder, but without psychotic symptoms); 58.67% were receiving medicinal treatment while 26.67% were receiving psychotherapy. No significant differences in baseline characteristics were observed between groups (all p-values > 0.05). Thus, they were not included as controlled variables in the following analyses. Concerning outcome variables at baseline, no statistically significant differences were found between groups (all p-values > 0.05).

Intervention Effects of the iMIED Program

The average time for completing the tasks of the iMIED + TAU group was 28.08 days (out of 49 days) (SD = 16.42). As shown in Table 1, for mindfulness, general emotional distress, depression, and experiential avoidance, the Time × Group interactions were significant (all p-values < 0.05), while for anxiety, the Time × Group interactions

Table 1 Intent-to-treat analyses (ITT) of intervention effects

Scale	iMIED + TAU		TAU-only		Group		Time		Group × Time interaction		
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	F	p	F	p	F	p	Partial η^2
FFMQ-SF score	56.63 (9.22)	62.59 (7.88)	54.11 (9.21)	55.42 (10.13)	6.31	0.014	17.80	< 0.001	7.26	0.009	0.09
K10 score	33.77 (5.40)	27.76 (8.11)	33.42 (5.88)	33.95 (7.55)	4.71	0.033	11.08	0.001	15.77	< 0.001	0.18
BDI-II score	22.51 (10.76)	13.84 (11.21)	24.05 (12.23)	20.49 (13.73)	2.79	0.099	21.77	< 0.001	3.80	0.055	0.05
BAI score	18.91 (11.31)	13.27 (9.44)	21.79 (12.55)	19.92 (12.67)	3.59	0.062	16.95	< 0.001	4.27	0.042	0.06
AAQ-II score	35.36 (7.33)	28.86 (8.68)	37.32 (6.69)	34.04 (7.32)	5.34	0.024	37.29	< 0.001	4.08	0.047	0.05

FFMQ-SF, Five Facet Mindfulness Questionnaire-Short Form (mindfulness); *K10*, 10-item Kessler Psychological Distress Scale (general emotional distress); *BDI-II*, Beck Depression Inventory-II (depression); *BAI*, Beck Anxious Inventory (anxiety); *AAQ-II*, Acceptance and Action Questionnaire-II (experiential avoidance)

were marginally nonsignificant ($p = 0.055$). Results of post hoc analyses showed that mindfulness, general emotional distress, depression, and anxiety significantly improved from pre- to post-treatment in the iMIED + TAU group (all p-values < 0.05), but not in the TAU-only group. In addition, post-test mindfulness of the iMIED + TAU group was significantly higher than that of the TAU-only group (Cohens' $d = 0.79$), while post-test general emotional distress, depression, and anxiety of the iMIED + TAU group were significantly lower than those of the TAU-only group (Cohens' $d = 0.53–0.79$). Although experiential avoidance reduced from pre- to post-treatment in both groups (all p-values < 0.01), post-test experiential avoidance of the iMIED + TAU group was significantly lower than the TAU-only group (Cohen's $d = 0.65$). Detailed results of post hoc analyses were presented in Table S1 and S2 in the Supplementary Information.

Changing Trajectories of Mindfulness and Experiential Avoidance

As shown in Table 2, mindfulness increased significantly with time in the iMIED + TAU group ($\alpha_{Slp} = 5.13$, $p < 0.001$), but not in the TAU-only group ($\alpha_{Slp} = 0.58$, $p = 0.232$). In addition, the mean slope differed significantly between groups ($\beta_1 = 3.88$, $p = 0.006$). Inspection of the freely estimated factor loadings indicated that the majority of the growth of mindfulness occurred after T3 ($\lambda_{T3} = 0.49$, $p < 0.001$), with the Group effect being controlled.

As for experiential avoidance, which was measured at T0, T2, T5, and T8, it decreased significantly with time in

the iMIED + TAU group ($\alpha_{Slp} = -6.47$, $p < 0.001$), and in the TAU-only group ($\alpha_{Slp} = -3.30$, $p = 0.002$). However, the mean slope of the iMIED + TAU group was larger than that of the TAU-only group ($\beta_1 = -4.16$, $p = 0.005$). Inspection of the freely estimated factor loadings indicated that the majority of the decrease in experiential avoidance occurred between T0 and T5 ($\lambda_{T5} = 0.60$, $p < 0.001$), with the Group effect being controlled. Changing trajectories of mindfulness and experiential avoidance are presented in Fig. 2.

Mechanisms of the iMIED Program on Emotional Distress

Since a large proportion of the growth of mindfulness occurred after T3 and a majority of the decrease of experiential avoidance occurred at T5, we examined a series of serial mediation models, in which mindfulness at T3 and experiential avoidance at T5 were entered sequentially as mediators, and anxiety, depression, and general emotional distress at T8 (post-test) entered as the outcome variable separately.

As shown in Fig. 3, the Group, with iMIED + TAU coded as 1 and TAU-only coded as 0, could significantly and positively predict mindfulness at T3 ($a_1 = -0.51$, $p = 0.027$). Mindfulness at T3 could negatively predict experiential avoidance at T5 ($a_3 = -0.48$, $p < 0.001$), which could positively predict emotional distress at T8 (anxiety: $b_2 = 0.35$, $p = 0.006$; depression: $b_2 = 0.51$, $p < 0.001$; general emotional distress: $b_2 = 0.48$, $p < 0.001$).

As shown in Table 3, the indirect effect through mindfulness at T3 only and experiential avoidance at T5 only were

Table 2 Latent growth curve parameter estimates

	FFMQ-SF score			AAQ-II score		
	iMIED + TAU	TAU-only	Full sample	iMIED + TAU	TAU-only	Full sample
α_{Slp}	5.13***	0.58	−2.61	−6.47***	−3.30**	1.55
α_{Int}	57.55***	55.49***	52.30***	35.37***	37.54***	37.77***
$\phi_{Slp,Int}$	−18.14	8.61*	−1.73	−4.99	−1.65	−1.90
λ_{T1}	0.01	−.18	0.03	/	/	/
λ_{T2}	0.17	−1.16	0.08	−0.06	0.52**	0.04
λ_{T3}	0.53***	−0.43	0.49***	/	/	/
λ_{T4}	0.63***	0.72**	0.69***	/	/	/
λ_{T5}	0.84***	0.93**	0.83***	0.57***	0.85***	0.60***
λ_{T6}	0.86***	0.95***	0.87***	/	/	/
λ_{T7}	1.06***	0.99***	1.02***	/	/	/
β_1	/	/	3.88**	/	/	−4.16**
β_2	/	/	2.63	/	/	−1.08

FFMQ-SF, Five-Facet Mindfulness Questionnaire-Short Form (mindfulness); *AAQ-II*, Acceptance and Action Questionnaire-II (experiential avoidance); α_{Slp}, mean of slope factor; α_{Int}, mean of intercept factor; $\phi_{Slp,Int}$, covariance between slope and intercept factor; λ_{Tx}, freely estimated factor loading at Tx ($x = 1–7$); β_1, α_{Slp} on Group; β_2, α_{Int} on Group

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Fig. 2 Changing trajectories of mindfulness (**a**) and experiential avoidance (**b**) from pre-intervention (T0) to post-intervention (T8). Error bars represent the standard error of the mean
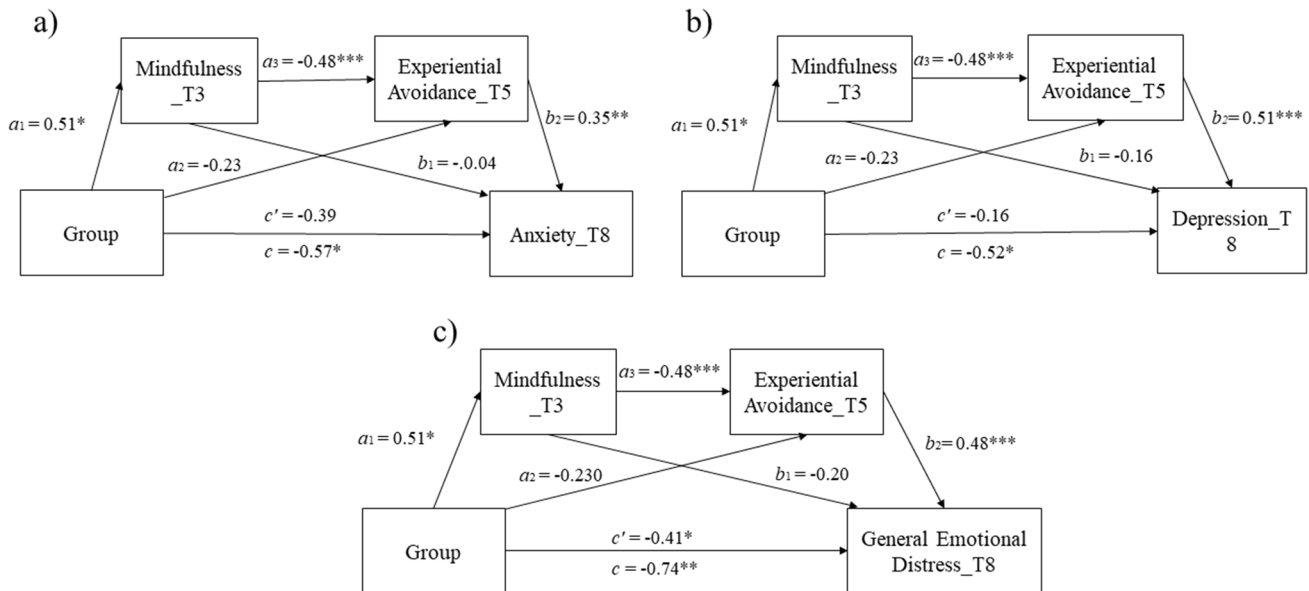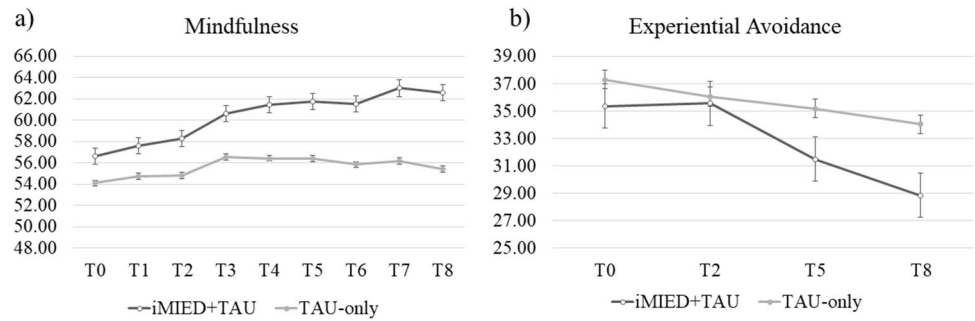
a)
Mindfulness

b)
Experiential Avoidance

—◇—iMIED+TAU —▲—TAU-only

a)

Mindfulness_T3 $a_3 = -0.48^{***}$ Experiential Avoidance_T5

$a_1 = 0.51^*$

$a_2 = -0.23$ $b_1 = -.0.04$ $b_2 = 0.35^{**}$

Group $c' = -0.39$ Anxiety_T8

$c = -0.57^*$

b)

Mindfulness_T3 $a_3 = -0.48^{***}$ Experiential Avoidance_T5

$a_1 = 0.51^*$

$a_2 = -0.23$ $b_1 = -0.16$ $b_2 = 0.51^{***}$

Group $c' = -0.16$ Depression_T8

$c = -0.52^*$

c)

Mindfulness_T3 $a_3 = -0.48^{***}$ Experiential Avoidance_T5

$a_1 = 0.51^*$

$a_2 = -0.230$ $b_1 = -0.20$ $b_2 = 0.48^{***}$

Group $c' = -0.41^*$ General Emotional Distress_T8

$c = -0.74^{**}$

Fig. 3 Path analysis illustrating the serial indirect effect of mindfulness at Week 3 and experiential avoidance at Week 5 on the relationship of the iMIED program and emotional distress. Group (1 = iMIED + TAU; 0 = TAU-only); c', direct effect; c, total effect; $^{***}p < 0.001$, $^{**}p < 0.01$, $^*p < 0.05$

Table 3 Indirect effects of the serial mediation model (partially standardized)

Scale	Parameters	Estimates	Standard error	95% confidence interval
BAI score	$a_1{*}b_1$	−0.02	0.07	[−0.18, 0.11]
	$a_2{*}b_2$	−0.08	0.08	[−0.26, 0.06]
	$\mathbf{a_1{*}a_3{*}b_2}$	**−0.09**	**0.05**	**[−0.20, −0.01]**
BDI-II score	$a_1{*}b_1$	−0.08	0.08	[−0.27, 0.03]
	$a_2{*}b_2$	−0.12	0.11	[−0.34, 0.08]
	$\mathbf{a_1{*}a_3{*}b_2}$	**−0.13**	**0.06**	**[−0.25, −0.02]**
K10 score	$a_1{*}b_1$	−0.10	0.07	[−0.27, 0]
	$a_2{*}b_2$	−0.11	0.10	[−0.31, 0.09]
	$\mathbf{a_1{*}a_3{*}b_2}$	**−0.12**	**0.06**	**[−0.23, −0.02]**

K10, 10-item Kessler Psychological Distress Scale (general emotional distress); *BDI-II*, Beck Depression Inventory-II (depression); *BAI*, Beck Anxious Inventory (anxiety). Significant mediation effects are presented in bold

non-significant. However, when testing the serial mediation model, mindfulness at T3 and experiential avoidance at T5 sequentially and fully mediated the effects of the iMIED program (Group) on both anxiety and depression at T8, while sequentially and partially mediated the effects of the iMIED program on general emotional distress at T8.

Adverse Events

Adverse events were assessed post-intervention by asking participants to report whether or not they experienced any unpleasant event related to mindfulness meditation during the intervention period. If so, participants were asked to further describe the event. Of the 28 participants in the iMIED + TAU group who provided valid questionnaires, 9 (32.14%) of them reported at least one unpleasant event that happened to them. Those unpleasant events were mainly about difficulty with sticking to the practice, feeling restless and bored while doing mindfulness meditation, and feeling upset when losing focus often, which are common experiences during mindfulness meditation as found in other studies (e.g., Solhaug et al., 2016).

We used independent t-tests to compare whether changes in mindfulness, emotional distress (e.g., anxiety, depression), and experiential avoidance from pre- to post-test differed between those who reported unpleasant events and those who did not. Results found that only the reduction of experiential avoidance of the former group ($\Delta = 3.33$) was significantly smaller than that of the latter group ($\Delta = 9.32$; $t(28) = 2.08$, $p = 0.048$).

Discussion

Our findings support the efficacy of the iMIED program in improving patients' mindfulness, reducing their anxiety, depression, general emotional distress, and experiential avoidance, with medium effect sizes (Coden's $d = 0.53$–0.79) compared to TAU-only. Beyond that, results from LGCMs indicated that during the iMIED program, more than half of the increase in mindfulness occurred by the third week, while more than half of the decrease in experiential avoidance occurred by the fifth week. Moreover, higher levels of mindfulness in the third week resulting from the iMIED program predicted lower levels of experiential avoidance in the fifth week, which in turn predicted lower levels of depression, anxiety, and general emotional distress after the intervention.

The affective benefits of the iMIED program indicated that it is a promising online self-help mindfulness program for helping patients with various emotional disorders. Previous meta-analyses focusing on the effects of self-help mindfulness or mindfulness-related interventions consistently found small-to-medium effect sizes for anxiety and depression in comparison to controlled conditions (e.g., Taylor et al., 2021; Victorson et al., 2020). The current study found a medium effect size for the iMIED program in reducing emotional distress, which is quite high among online self-help programs. However, the effect sizes of the current study were smaller compared to another internet-based mindfulness treatment for patients with

anxiety disorders ($d = 0.81$ for depression; $d = 1.00$ for anxiety; calculated based on Table 2 in the manuscript; Boettcher et al., 2014). Participants' characteristics (participants with anxiety disorders versus participants with various emotional disorders) and intervention doses (doing mindfulness meditation twice per day versus once per day) could be the reasons leading to the differences, which are worth further investigation in future studies.

Despite this, the effect size of the iMIED program for anxiety ($d = 0.59$) was a bit higher than the one found in the online Mindful Mood Balance Program for patients with residual depressive symptoms ($d = 0.40$; Segal et al., 2020), while the effect size for depression was similar, supporting the affective benefits of the iMIED program. More importantly, compared to previous online self-help MBIs, the iMIED program could be used as an adjuvant treatment for patients with various emotional disorders (e.g., anxiety disorders, depression), rather than just targeting specific disorders. Given the enormous public health need due to the high prevalence of emotional disorders combined with insufficient resources to provide adequate care (Huang et al., 2019; National Health Commission of PRC, 2019), online services can provide much needed help. The iMIED program is an effective online self-help program that can be easily accessed to overcome potential barriers related to cost, reach, and stigma. As a scalable intervention, it has the potential to significantly improve mental health care in China (Taylor et al., 2021).

As for the changing trajectories and changing times of mindfulness and experiential avoidance, we found that more than half of the increase in mindfulness occurred by the third week, which is similar but 1 week later than the time of change of mindfulness found in Baer et al. (2012). However, our study used an online self-help MBI and compared it with a TAU-only control group while Baer et al.'s study used the traditional group-based MBSR without comparison with a control group, which might explain the different times of change in mindfulness. Nevertheless, both the current study and Baer et al.'s study support that a significant increase in mindfulness occurred during the first half of the course, in which participants were already asked to practice mindfulness meditation daily. As for experiential avoidance, to our knowledge, most studies only examine it before and after MBI (e.g., Antoine et al., 2018). Therefore, it remains unknown whether experiential avoidance changed during the intervention. In the current study, experiential avoidance was also measured at Week 2 and Week 5 to examine this question exploratively. Results supported that more than half of the change occurred at Week 5. It is reasonable since mindfulness increased before Week 5, which could also lead to decreased experiential avoidance, which is in line with previous findings and the Monitor and Acceptance theory (Lindsay & Creswell, 2017) that with the cultivation of awareness and acceptance, individuals will have less experiential avoidance (Antoine et al., 2018).

Most importantly, the current study is the first randomized controlled trial using multiple-time measurements finding that the temporal precedence of mindfulness and experiential avoidance as the mechanisms underlying the affective benefits of the mindfulness-based intervention in patients with emotional disorders. This is in line with what was found in Mutch et al. (2020) but gives more profound evidence since their studies only used a within-participant design with pre-posttests. The current findings support the idea that the effect of mindfulness on emotional distress is mediated through decreasing the tendency to avoid uncomfortable private experiences. This is achieved by consistently focusing attention on the present moment while not avoiding or diminishing uncomfortable feelings. These and other strategies aiming at increasing mindfulness (both formal and informal practices) and decreasing experiential avoidance (e.g., mindfulness stretching, hyperventilation, challenging tasks) should be emphasized and strengthened to optimize the intervention effects.

The current study also examined the potential adverse effects of the iMIED program. Although about 31% of participants reported at least one unpleasant event, all of them were common experiences during mindfulness meditation according to previous research (e.g., Solhaug et al., 2016). In addition, individuals who reported experiencing unpleasant events did not benefit less than those not reporting so in reducing emotional distress and improving mindfulness, which appears to be generally overlooked by studies focusing on the adverse effects of MBIs (e.g., Britton et al., 2021). However, interestingly, individuals who reported experiencing unpleasant events tended to have less reduction of experiential avoidance after the intervention. This should be further verified in future studies.

Limitations and Future Research

Several limitations deserve mention. First, the sample contained 70% female participants, limiting the generalizability of the current findings. Future studies still need to increase the sample size and the percentage of male participants, for example, by cooperating with clinical centers to conduct multicenter RCTs (Kraemer & Robinson, 2005). Second, the control group used in the current study was a variable TAU group. Unlike other studies (e.g., Segal et al., 2020), in the current study, 58.67% of patients were receiving medicinal treatment, 26.67% were receiving psychotherapy as TAU, and the rest of the participants did not report any of these treatments. Although this reflects the reality of patients getting treatments nowadays, and no difference was found in the percentage of patients getting treatments between the two groups, future studies still need to use a more rigid TAU-only group as the controlled group. Thirdly, the current study did not use extended follow-up measures to explore the maintenance effects of the iMIED program for patients with emotional disorders. Future studies need to include follow-up

assessments. Last but not least, since the current study only measured mindfulness and experiential avoidance during the intervention, and because the measurement time points of experiential avoidance were less than that of mindfulness, we still cannot conclude that mindfulness improved before experiential avoidance, which decreases before emotional distress improves. Future studies need to measure both mechanism variables and outcome variables before, during, and after the intervention to examine the underlying mechanisms, according to the temporal precedence rule proposed by Kazdin (2007).

Declarations

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