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THE LONGITUDINAL MEDIATING EFFECT OF DISTRESS TOLERANCE IN A MINDFULNESS-BASED INTERVENTION: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Objective: The present study aimed to investigate the intermediary role of distress tolerance in Mindfulness-Based Intervention (MBI) with respect to self-perceived stress reduction.

Method: One hundred and twenty-nine adults with a high level of emotional distress were randomized into MBI groups or a waiting-list group. Levels of mindfulness skills, self-perceived stress, and distress tolerance (tolerance, appraisal, absorption, and regulation) were measured four times: pre-test, week 3, week 6, and post-test.

Results: The developmental trajectories modeled by the univariate latent growth curve showed that the factor intervention significantly predicted the slope of observing, non-reactivity, overall mindfulness, and distress appraisal during first six weeks. Bivariate latent growth curve models demonstrated a significant association between increases in the growth rate of distress appraisal and non-reactivity in participants receiving mindfulness training. Such an association was not observed among those who did not receive an MBI. Longitudinal mediation analyses further revealed that the effect of MBI on non-reactivity and self-perceived stress at week 6 was fully mediated by distress appraisal at week 3, respectively.

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Conclusions: Our results indicate that distress appraisal plays an important role during the earlier stage of MBI, which might contribute to a more effective and efficient intervention program in the future.

Keywords: Mindfulness, Stress, Distress Tolerance, Distress Intolerance, Distress Appraisal, Mediation

Previous empirical studies have largely established the effects of mindfulness-based interventions (MBIs) on alleviating suffering (Creswell, 2017). The current major focus of researchers and practitioners in the field of mindfulness is to advance our understanding of the mechanism chain of action underlying MBIs (Hölzel et al., 2011).

A significant challenge to uncovering the mechanism chain across MBIs is the heterogeneity among programs (Chiesa & Malinowski, 2011; Dimidjian & Segal, 2015). In most cases, formal mindfulness practices and psychoeducation are two core components of a standard modern MBI program. Formal mindfulness practices originated from traditional Buddhist meditation, whereas psychoeducational content was designed specifically according to the original target population (Crane et al., 2017). For instance, in addition to formal meditation practices, stress reactions, cognitive patterns, and life-relevant skills were emphasized in Mindfulness-Based Stress Reduction (MBSR), Mindfulness-Based Cognitive Therapy (MBCT), and Dialectical Behavioral Therapy (DBT), respectively (Kabat-Zinn & Hanh, 2009; Linehan, 2014; Teasdale, Williams, & Segal, 2014). The heterogeneity within the meditation instruction and psychoeducation courses indicates that many factors might be involved in the mechanism chain (Creswell, 2017). However, the core etiological processes across emotional disorders, as well as the "one-size-fits-all" intervention effects of MBIs, suggest the existence of transdiagnostic core mechanisms (Wielgosz, Goldberg, Kral, Dunne, & Davidson, 2019). Currently, most evidence demonstrates that mindfulness skills, a set of transdiagnostic protective factors (i.e., observing, describing, acting with awareness, non-judging of experience, and non-reactivity to inner experiences), could be one universal mechanism in MBIs (Gu, Strauss, Bond, & Cavanagh, 2015). Identifying other possible universal influential variables might propel further progress in understanding the mechanism chain, thus accelerating the development in this field.

Distress tolerance, one of the transdiagnostic emotional vulnerability factors, has received attention recently as a core mechanism of action in MBIs for its association with multiple emotional psychopathologies (K. M. Kraemer, Luberto, Hall, Ngo, & Yeh, 2020; Leventhal & Zvolensky, 2015). In broad terms, distress

tolerance (or intolerance) is an umbrella concept depicting one's self-perceived and actual capacity to withstand aversive states, covering multiple constructs such as tolerance of ambiguity, intolerance of uncertainty, discomfort intolerance, tolerance of negative affects, etc. (Leyro, Zvolensky, & Bernstein, 2010). In the narrower sense, distress tolerance refers to individual differences in how one reacts to negative emotions, which could be subsequently divided into four distinct but closely related processes: (1) tolerance (not considering distressing emotions unbearable), (2) appraisal (not showing a lack of acceptance of distress by feeling ashamed or scared when experiencing negative emotions), (3) absorption (full attention is not captured by the distressing emotions), and (4) regulation (not devoting great efforts to avoid or inhibit negative emotions; Gross, 2014; Simons & Gaher, 2005).

Theoretically, it is suggested, from both clinical psychological and Buddhist philosophic perspectives, that how one reacts to suffering plays a central role in the onset, development, maintenance, and recurrence of diverse psychological conditions (Campbell-Sills & Barlow, 2007; Teasdale, Chaskalson, & Kulananda, 2011). Previous studies indicated that individuals who showed high intolerance of negative affect were more likely to use maladaptive emotion regulation strategies to control or inhibit emotions including anxiety and depression. It further leads to a regulatory failure or a negative reinforcement of unhelpful strategies such as avoidance, rumination, substance use and self-injury which, in turn, reduces their quality of life, life satisfaction or lifespan (Barlow & Farchione, 2018; Daros & Williams, 2019; Linehan, 2014). Those who showed a high level of tolerance were found to have fewer problem behaviors aimed at dampening emotional responses (Zvolensky, Bernstein, & Vujanovic, 2011). Accordingly, in the present study, we focused on perceived affective distress tolerance.

One previous meta-analysis synthesized findings from relevant studies showing that distress tolerance of negative affects is significantly positively correlated to problem-solving (r = .08), reappraisal (.11), acceptance (.34), and mindfulness (.38), and negatively correlated to experiential avoidance (-.57), expressive suppression (-.19), rumination (-.29), and worry (-.54; Naragon-Gainey, McMahon, & Chacko, 2017). Furthermore, this construct has been described as a trait-like predictive factor for many emotional problems (Lass & Winer, 2020; Leventhal & Zvolensky, 2015), it has also been repeatedly demonstrated to be malleable in MBI studies, including those conducted on healthy people or patients suffering from eating disorders, obsessive-compulsive disorders, substances use disorders, or borderline personality disorder (Black & Amaro, 2019; Fahmy et al., 2019; Harris, Jennings, Katz, Abenavoli, & Greenberg, 2016; Juarascio et al., 2021; Külz et al., 2019; Lotan, Tanay, & Bernstein, 2013; McMain, Guimond, Barnhart,

Habinski, & Streiner, 2017). Therefore, distress tolerance could be a central mechanism variable in MBIs in both nonclinical and clinical samples and across diagnostic boundaries.

Although distress tolerance might play a major role in the mechanism chain of MBIs, empirical studies mainly address it as an outcome variable. Three studies have examined this chain cross-sectionally. Lotan et al. (2013) found that pre-post changes in trait mindfulness and state mindfulness could predict changes in overall distress tolerance. Two studies investigated whether distress tolerance would mediate the relationship between mindfulness skills and health-relevant outcomes. In Brem et al. (2019), distress tolerance mediated the association from non-judging and non-reactivity to psychological aggression perpetration and physical assault perpetration. de Lisle, Dowling, and Allen (2014) investigated the role of specific facets of distress tolerance in the relationship between mindfulness and psychological distress. Absorption significantly mediated the target relationship in gambling disorders, whereas the mediating effects for tolerance and regulation sub facets were not significant. Although the existing findings are inspiring, the cross-sectional design was limited in making causal inferences because temporal precedence is a premise (Kazdin, 2007, 2009).

In the current study, we would like to advance this investigation by exploring the potential mechanism role of distress tolerance in a randomized controlled trial on individuals suffering from high emotional distress (i.e., people who did not attain the diagnostic criteria but are at high risk of developing multiple emotional disorders; Barlow et al., 2010). Accordingly, a series of exploratory analyses are conducted with respect to intervention effects on self-perceived stress, underlying mechanism of action (i.e., mindfulness skills and affective distress tolerance), and potential moderator (sex).

Method

Procedure

The sample size was determined based on the predetermined schedule. Five hundred and thirty-two Chinese individuals completed our online questionnaires of recruitment. Three hundred and forty-four adults who met the inclusion criteria were invited to attend the subsequent screening process. Two hundred and fifty-four individuals received an online structured interview, i.e., the MINI-International Neuropsychiatric Interview, given by psychology graduate students and a research

assistant. Inclusion criteria were (1) an overall score of the 10-item Kessler Psychological Distress Scale no less than 22 (Taylor, Agho, Stevens, & Raphael, 2008), (2) no prior 8-week MBI training experience, (3) less than 20 mins/week of meditation practice, (4) no serious physical illness, (5) aged equal to or greater than 18, and (6) availability for the whole program. Participants were excluded if they met the criteria for a current or previous diagnosis of psychotic disorders, bipolar disorders, substance abuse or dependence, antisocial or borderline personality disorder, reported low emotional distress, suicide ideation or intention, or refusal to cooperate during the interview. Finally, one hundred and twenty-nine individuals were randomly assigned, independently by the third author, to either an online guided 8-week MBI group, an online self-help MBI group, or a waiting-list control group using a stratified random method. The strata were calculated based on the age range, and the final strata were determined when the sex ratio approached 1:1 within each stratum. All data were analyzed following the intention-to-treat (ITT) principle. The CONSORT flowchart of participants is illustrated in Figure 1. The whole intervention was conducted during the COVID-19 pandemic. All groups received the same online assessments at pre-test (2020/03/20–03/23), week 3 (2020/04/06–04/14), week 6 (2020/04/27–05/06), and post-intervention (2020/05/15–05/24), which also included questionnaires and behavioral tasks unrelated to the current study. Demographic information is presented in Table 1. All participants signed informed consent via an online document. A certificate was delivered to each participant of the intervention groups as a reward. For those in the control group, the online self-help course was provided after post-assessment as remuneration. The study was approved by the Association for Ethics and Human and Animal Protection in the School of Psychological and Cognitive Sciences, Peking University. No intervention-related unexpected adverse events were observed.

Table 1. Demographic statistics

Characteristic	Online MBI (n = 43)	Self-help MBI (n = 43)	Control (n = 43)	Condition difference	Total Sample (N = 129)
Age in years (M±SD)	32.16±9.10	32.23±9.72	32.35±8.90	$F_{(2, 126)}$ = .00	32.25±9.17
Sex				$\chi^2_{(2)}$ =.10	
Female	35	35	34		104
Male	8	8	9		25
Education in years (M±SD)	17.19±2.63	17.45±2.10	17.41±3.00	$F_{(2, 126)}$ = .13	17.35±2.58

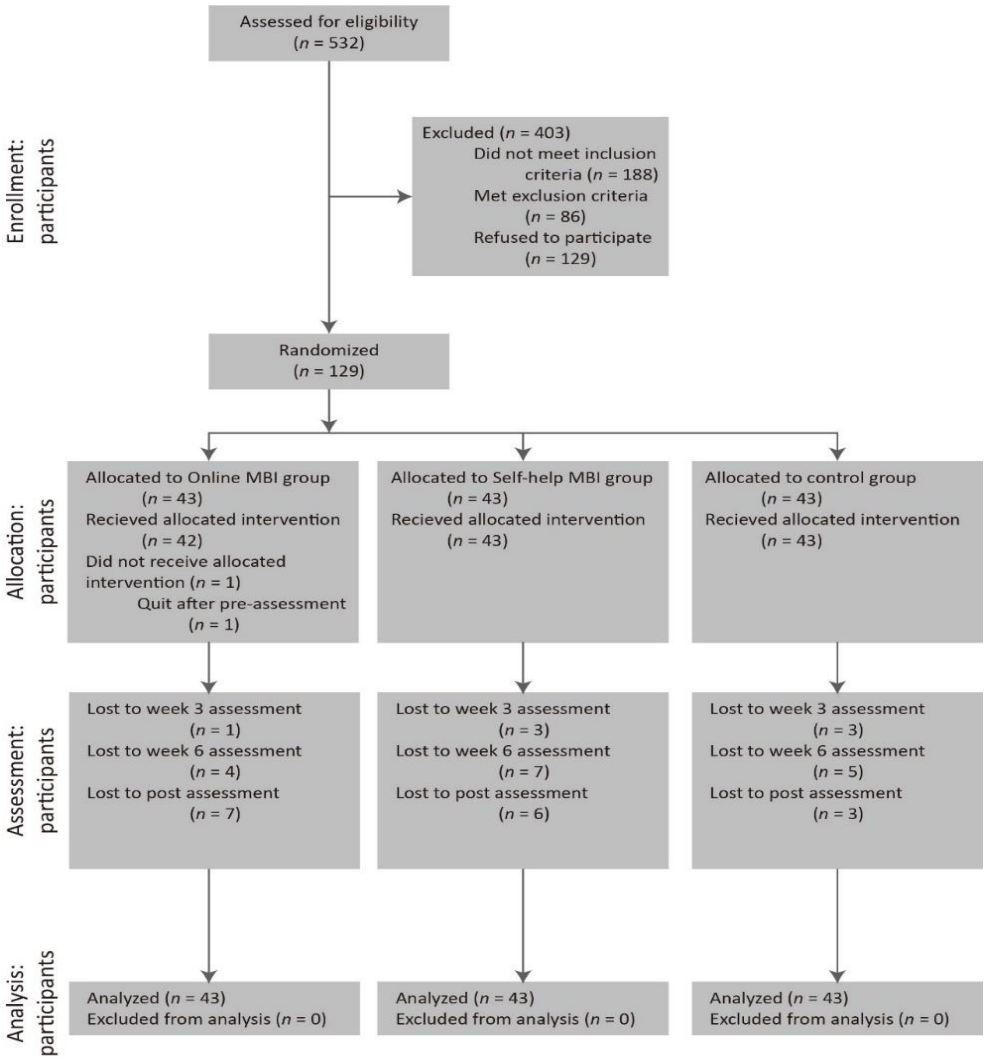

Figure 1. CONSORT Flowchart of Participants

Measures

We employed the 10-item Chinese version of the Kessler Psychological Distress Scale to evaluate the level of emotional distress (K10; Kessler et al., 2002) during the pre-screening. A higher overall score indicates a higher level of emotional distress (i.e., symptoms caused by emotions such as anxiety and depression). The cut-off value was set to 22, which corresponds to a "high" and a "very high" level of distress.

The 14-item Chinese version of the Perceived Stress Scale (CPSS) measures one's self-perceived stress (Cohen, Kamarck, & Mermelstein, 1983). Items are rated on a 5-point Likert scale from 0 to 4, with a higher overall score indicating a higher level of perceived stress. The CPSS showed a good internal consistency ($\alpha = .900$) in Yang, Huang, Wu, and Li (2007). In the current study, Cronbach's alpha was .910.

The Chinese version of the Five Facets of Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006) and its 20-item version (Hou, Wong, Lo, Mak, & Ma, 2014) were adopted to assess an overall mindfulness level as well as five distinct facets of mindfulness (i.e., observing, describing, acting with awareness, non-judging of experience, and non-reactivity to inner experience). Items are rated on a 5-point Likert scale from 1 to 5, with a higher overall score representing a higher mindfulness level. Cronbach's alpha was .439 to .843 in the previous literature (Deng, Liu, Rodriguez, Xia, 2011) and .814 to .889 in the present study.

In the Distress Tolerance Scale, items were rated on a 5-point Likert scale (1 = *strongly agree* to 5 = *strongly disagree*), so that the total average score represents one's ability to withstand aversive emotional states (Simons & Gaher, 2005). The average score of each subdimension indicates one's tolerance level in each process: distress tolerance (e.g., with the item "I can't handle feeling distressed or upset"), distress appraisal (e.g., with the item "My feelings of distress or being upset are not acceptable"), distress absorption (e.g., with the item "When I feel distressed or upset, I cannot help but concentrate on how bad the distress actually feels"), and distress regulation (e.g., with the item "I'll do anything to stop feeling distressed or upset"). We adopted the Chinese version scale and did reverse coding to all items except item 6 to assure that current findings could be compared to previous studies employing the original version scale. Cronbach's alpha was .750 to .910 in the previous literature (You & Leung, 2012) and .720 to .820 in this study.

Instructed items were inserted for quality control in all assessments (9 at pre- and post-test, 5 at week 3 and week 6; e.g., with the item "Please select the number indicating *Not at all* for the current item"). Considering that participants might be less focused when completing online measurements without monitoring (i.e., outside the laboratory), a less strict standard was adopted in the current study by allowing participants to have one false answer out of all instructed items. Kam and Chan (2018) suggested that it showed a similar screening effect with the strictest cut-off value (i.e., all-or-none). The ratio of participants with >1 incorrect instructed item was 7.75% at the pre-test, 7.75% at week 3, 8.53% at week 6, and 8.53% at the post-test. These data were treated as missing values in data analysis.

Intervention

The intervention program (Figure 2), Mindfulness Intervention for Emotional Distress (MIED), was developed and provided by the corresponding author, a mental health supervisor with 20 years of clinical experience, 15 years of

mindfulness meditation practices, and 14 years of mindfulness education experience. The program was adapted, based on the MBSR, and the Unified Protocol for Transdiagnostic Treatment of Emotional Disorders, for individuals who were patients with anxiety and/or depression disorders or sub-healthy individuals (Cassiello-Robbins, Rosenthal, & Ammirati, 2021; Farchione et al., 2012). The guided intervention group completed an 8-week (50 days) training through Zoom meetings (Zoom, Zoom Video Communications, Inc., San Jose): A 2.5-hour session was held once per week. A silent day of 8 hours was inserted between week 6 and 7 as in the MBSR. Participants were instructed to practice MBSR-originated formal meditation (e.g., the body-scanning, mindful hatha yoga, sitting meditation, and walking meditation) for at least 15 minutes per day following given recordings in addition to their in-session practices. Participants were also encouraged to integrate mindfulness skills into their daily life activities. The online self-help courses (49 days) were delivered via the WeChat App (WeChat, Tencent Inc., Shenzhen). All course materials were recorded, written, edited, or proofread by the corresponding author. Participants were required to spend around 30 minutes every day reading psychoeducation materials and practicing formal and informal mindfulness activities following the given instructions.

Week	Themes	Examples
1	Mindfulness Practices: Bring your attention back to the present moment	**Q:** How should I accomplish a successful mindfulness practice? **A:** We have nowhere to go or no state to maintain. The operational core of the mindfulness meditation practice is to be aware of the object we're experiencing and accept any feelings or thoughts that occurred during the process. Any time you notice your mind wandering, just bring it back to the present moment. You don't need to blame yourself for that's how our brain works.
2	The Functions and Values of Emotions	**Q:** I don't want to feel any anxiety. How can I get rid of it? **A:** All we do is to help you restore your emotions, life, and work, rather than eliminate any emotion. In reality, all healthy people have emotions. No one can get rid of them. Emotions play vital roles for the human being, especially from an evolutionary perspective. Each emotion, whether we consider it a negative or a positive one, has its adaptive functions for us. For instance, anxiety helps us prepare for the future.
3	Emotional Distress: Origins and Coping	**Q:** Why do I feel like my life has been kind of ruined by anxiety? How to fight it? **A:** I agree. An inappropriate way to cope can indeed lead to more suffering caused by emotions like anxiety. In fact, the actions or reactions of fighting against those emotions would become the origins of your suffering. So the strategy we're using to help you restore your anxiety is to increase your capability of tolerance it. When you can participate in activities with the presence of anxiety, you may find that the detrimental effects of anxiety on you will be smaller and smaller.
4	Willingly "expose" yourself to Uncomfortable Feelings	
5	Reduce Maladaptive Avoidance and Emotion-Driven Behaviors	
6	Thoughts are just thoughts	
7	Facing the Feared Situations in Your Life	
8	Summary and Future Goals	

Figure 2. The weekly themes and examples of client-therapist dialogues for the MIED program.

Data Analysis

All data were analyzed using SPSS (20.0; SPSS, Inc, Chicago) or R statistical software environment (packages "lavaan," "tidyverse," "bruceR," "mediation," "semPower," and "bmem") with a significance level set at .05. Little's Missing Completely at Random (MCAR) test showed that the MCAR assumption could not be rejected for all measures (*ps* > .05). Missing data were handled using multiple imputation (Bell, Fiero, Horton, & Hsu, 2014). A set of one-way analysis of variance (ANOVA) was performed for baseline measures to assess whether all groups were comparable at the beginning of the intervention. Pearson *r* effect sizes are small (.10), moderate (0.30), or large (0.50). The intervention effects were analyzed with two-factor mixed-design ANOVAs (2 times: Pre-, Post) X (3 groups: Online guided intervention, Online self-help intervention, Waitlist control). The Partial eta-squared (η_p^2) was reported as an indicator of effect size in ANOVA tests. The Huynh-Feldt correction was used to compensate for sphericity violations. For modeling, data of two online intervention groups were pooled to obtain one single comparison with the blank control group. Development trajectories were independently modeled with linear univariate and bivariate latent growth curve models (LGCM). The latent factors, intercept (baseline level) and slope (rate of change across assessment periods) were estimated independently for each or each pair of outcomes. The factor loadings for the latent factor slope were fixed (0, 2, 5, 8). Model fit measures included Chi-Square/df ratio, root-mean-square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). Chi-Square/df ratio lower than 3 and values below .08 for RMSEA indicated a good fit (MacCallum et al., 1996). Values above .90 for CFI and TLI were considered acceptable. The number of bootstrap samples for mediation models was 5000. Mediated effects and the corresponding 95% confidence intervals (CIs) were calculated. Continuous variables were mean-centered before performing the moderated mediation model. Post hoc power analyses were conducted based on the difference between slopes for linear bivariate regressions (Erdfelder, Faul, & Buchner, 1996), on the misfit indices RMSEA for the LGCMs (Jobst, Bader, & Moshagen, 2021), and on bootstrap confidence intervals for mediation analyses (Zhang, 2014).

Results

Treatment Adherence

The average class attendance ratio was 79.07% in the Online MBI group and 80.68% in the Self-help MBI group (p = .764). The numbers of participants completing all sessions were Online MBI (n = 16) and Self-help MBI (n = 10). The

overall loss to assessments was at 30.23% and more specifically, Online MBI at 27.91%, Self-help MBI at 37.21%, and Control group at 25.58%. One participant declined to participate in the assigned intervention due to a schedule conflict. Thirty-seven participants were unable to be contacted. One participant did not assess within the required time. Table 1 provides descriptive characteristics by group and for the total sample.

Baseline Conditions

There were no significant (*ps* > .05) differences in baseline age, sex, or education year by groups. Outcomes did not significantly differ by group (*ps* > .05) except for the observing facet ($p = .046$). The above findings demonstrated that all groups were similar at baseline. Table 2 provides correlations between baseline variables. As expected, self-perceived stress was significantly negatively correlated with all facets of distress tolerance as well as the overall distress tolerance (*ps* < .010).

Table 2. Pearson *r* correlations for Baseline Outcome Measures (*N = 129*)

Variable	1	2	3	4	5	6	7	8	9	10	11
1. CPSS Perceived Stress	—										
2. Distress Tolerance	–.506**	—									
3. Distress Appraisal	–.528**	.695**	—								
4. Distress Absorption	–.571**	.713**	.688**	—							
5. Distress Regulation	–.299**	.469**	.620**	.533**	—						
6. Overall Distress Tolerance	–.569**	.862**	.887**	.875**	.755**	—					
7. FFMQSF Observing	–.011	.125	.061	.067	–.008	.076	—				
8. FFMQSF Describing	–.246**	.231**	.296**	.219*	.044	.239**	.396**	—			
9. FFMQSF Acting with awareness	–.508**	.327**	.381**	.475**	.245**	.426**	–.014	.130	—		
10. FFMQSF Non-Judging	–.280**	.346**	.406**	.371**	.320**	.426**	–.191*	–.005	.336**	—	
11. FFMQSF Non-reactivity	–.421**	.315**	.222*	.382**	.142	.320**	.442**	.365**	.056	–.072	—
12. FFMQSF Total	–.527**	.485**	.484**	.526**	.251**	.523**	.571**	.670**	.564**	.358**	.600**

* $p < .05$. ** $p < .01$. *** $p < .001$.

Intervention Effects

Two (Time: Pre-/Post-) x three (Group: Online MBI/Online Self-help MBI/Control) mixed-design ANOVAs were conducted separately for overall mindfulness, observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience, self-perceived stress, distress tolerance, distress appraisal, distress absorption, distress regulation, and overall distress tolerance. It was shown that the time by group interaction was found to be significant for overall mindfulness ($p < .001$), observing ($p = .001$), describing ($p = .037$), acting with awareness ($p = .028$), non-reactivity ($p = .001$), and self-perceived stress ($p = .021$). The interaction was marginally significant for distress appraisal ($p = .056$; Figure 3, both intervention groups showed an improvement trend, whereas the waitlist control group did not exhibit a positive change), but not for other outcomes ($ps > .05$). Further analysis showed that both intervention groups showed similar effects for all variables at post-test ($ps > .05$). Compared to pre-test, two intervention groups showed significant improvement at post-test in observing, describing, non-reactivity, and overall mindfulness. For acting with awareness and distress appraisal, the online intervention group showed significant increases whereas other groups did not. All three groups showed significant decreases in self-perceived stress and increases in non-judging from pre- to post-assessment (see Table 3 for details).

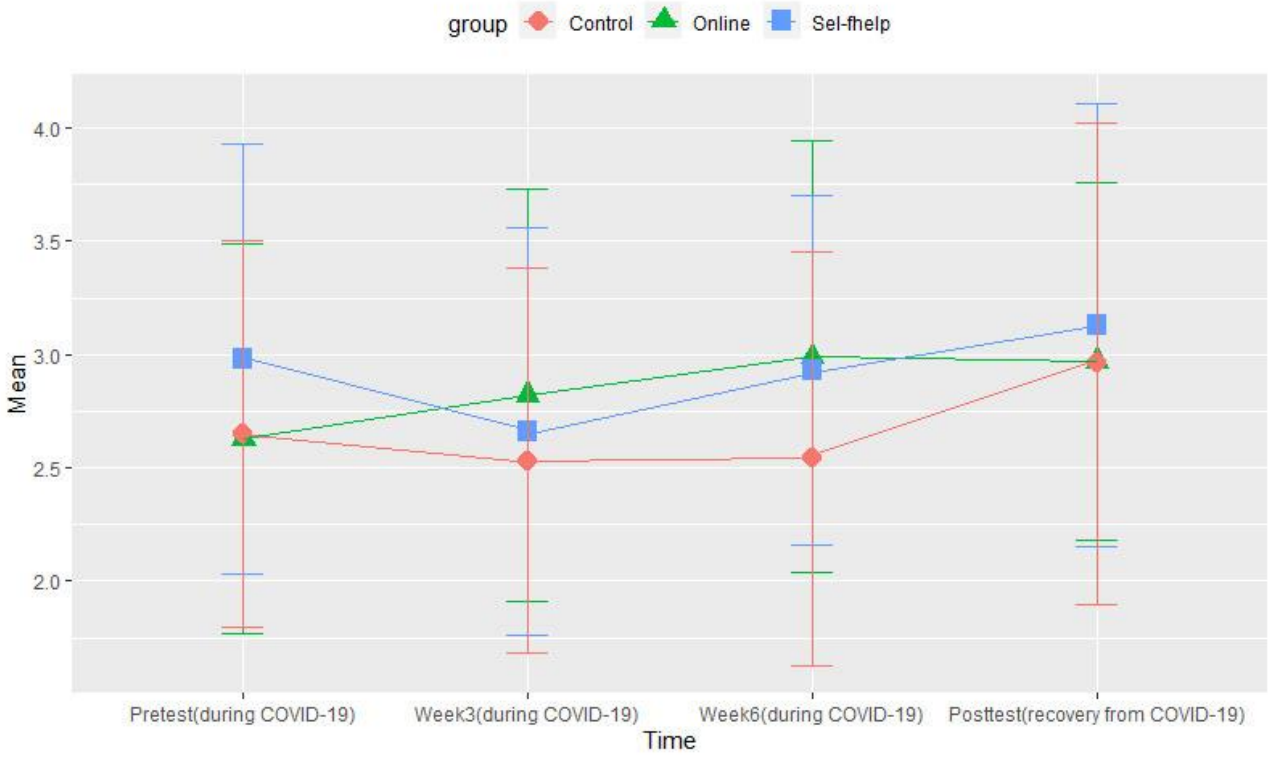

Figure 3. The Developmental trend of Distress Appraisal

Table 3. Baseline, week3, week6, post-intervention estimated means, standard deviations, ANOVA and effect sizes for outcome measures

	Pre			Week 3			Week 6			Post			Statistics	
Variable	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Pre to Post within group (effect of time)	Pre to post between group (time by group interaction)
FFMQSF_Total	56.01± 6.92	58.84± 8.55	58.32± 9.08	59.68± 8.74	59.90± 7.73	58.68± 7.74	63.13± 7.97	63.38± 7.60	59.09±8 .41	65.09± 6.97	66.31± 7.13	59.02±7 .38	$F_{(1, 126)}$ = 82.83***, η_p^2 = .40	$F_{(2, 126)}$ = 16.53***, η_p^2 = .21
FFMQSF_Observing	11.01± 2.64	12.12± 3.05	12.58± 3.21	12.25± 2.59	12.34± 2.74	12.24± 3.31	13.00± 2.55	13.45± 2.99	12.39±2 .93	12.93± 2.63	13.88± 3.21	12.56±3 .01	$F_{(1, 126)}$ = 28.23***, η_p^2 = .18	$F_{(2, 126)}$ = 7.36***, η_p^2 = .11
FFMQSF_Describing	11.76± 2.80	12.04± 3.06	12.28± 3.17	11.95± 2.94	12.51± 2.43	12.38± 2.73	12.45± 2.59	13.02± 2.39	12.36±2 .62	12.79± 2.70	13.16± 2.39	12.00±2 .86	$F_{(1, 126)}$ = 6.39*, η_p^2 = .05	$F_{(2, 126)}$ = 3.40*, η_p^2 = .05
FFMQSF_Acting with awareness	11.30± 3.06	11.97± 2.97	11.20± 3.89	11.96± 2.71	11.74± 3.20	11.14± 3.24	12.67± 2.70	11.35± 3.04	11.02±3 .45	13.09± 2.72	12.72± 2.48	11.05±3 .49	$F_{(1, 126)}$ = 7.47**, η_p^2 = .06	$F_{(2, 126)}$ = 3.69*, η_p^2 = .06
FFMQSF_Non-Judging	12.12± 2.22	12.90± 2.64	11.74± 3.02	13.16± 2.51	12.65± 3.14	12.18± 2.60	13.10± 2.93	13.24± 2.98	12.12±2 .83	14.14± 2.23	14.33± 2.60	12.71±2 .51	$F_{(1, 126)}$ = 36.82***, η_p^2 = .23	$F_{(2, 126)}$ = 1.57, η_p^2 = .02
FFMQSF_Non-reactivity	9.97± 2.35	9.90± 2.57	10.40± 3.13	10.60± 2.29	10.88± 2.24	11.07± 2.35	11.79± 2.10	12.32± 2.09	11.22±2 .60	11.93± 2.18	12.29± 2.00	10.54±2 .22	$F_{(1, 126)}$ = 33.80***, η_p^2 = .21	$F_{(2, 126)}$ = 7.12**, η_p^2 = .10
CPSS Perceived Stress	33.00± 7.27	33.28± 8.19	32.77± 7.44	29.59± 7.64	30.58± 8.29	32.12± 6.82	29.20± 8.17	27.93± 7.55	31.25±6 .95	26.61± 6.14	27.54± 7.27	30.29±7 .03	$F_{(1, 126)}$ = 64.26***, η_p^2 = .34	$F_{(2, 126)}$ = 3.96*, η_p^2 = .06
Distress Tolerance	2.76± 0.88	2.91± 0.89	2.63± 0.95	2.90± 0.91	2.85± 0.9	2.77± 0.85	3.15± 0.88	3.17± 0.93	2.75± 1.06	3.24± 0.88	3.32± 0.89	3.03± 1.1	$F_{(1, 126)}$ = 21.85***, η_p^2 = .15	$F_{(2, 126)}$ = .07, η_p^2 = .00
Distress Absorption	2.93± 0.88	3.04± 0.79	2.94± 0.9	3.04± 0.8	3.09± 0.7	2.80± 0.73	3.16± 0.75	3.22± 0.7	2.81± 0.92	3.51± 0.71	3.25± 0.72	3.10± 0.89	$F_{(1, 126)}$ = 10.32**, η_p^2 = .08	$F_{(2, 126)}$ = .51, η_p^2 = .01

	Pre			Week 3			Week 6			Post			Statistics	
Variable	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Online MBI (*M*±*SD*)	Self-help MBI (*M*±*SD*)	Control (*M*±*SD*)	Pre to Post within group (effect of time)	Pre to post between group (time by group interaction)
Distress Appraisal	2.63± 0.86	2.98± 0.95	2.65± 0.85	2.82± 0.91	2.66± 0.9	2.53± 0.85	2.99± 0.95	2.93± 0.77	2.54± 0.91	2.97± 0.79	3.13± 0.98	2.96± 1.06	$F_{(1, 126)} = 16.63$***, $\eta_p^2 = .12$	$F_{(2, 126)} =$ .2.95, $\eta_p^2 =$ .05
Distress Regulation	2.91± 0.73	3.09± 0.81	2.99± 0.72	3.01± 0.58	2.94± 0.78	2.80± 0.67	3.07± 0.65	2.91± 0.69	2.89± 0.69	3.15± 0.64	3.04± 0.72	3.14± 0.77	$F_{(1, 126)} = 2.32$*, $\eta_p^2 = .02$	$F_{(2, 126)} = 1.17$, $\eta_p^2 = .02$
Overall Distress Tolerance	2.81± 0.71	3.00± 0.74	2.80± 0.71	2.94± 0.69	2.88± 0.67	2.72± 0.58	3.09± 0.62	3.06± 0.61	2.75± 0.75	3.18± 0.66	3.13± 0.72	3.16± 0.72	$F_{(1, 126)} = 9.53$**, $\eta_p^2 = .07$	$F_{(2, 126)} = .74$, $\eta_p^2 = .01$

* $p < .05$. ** $p < .01$. *** $p < .001$.

Changes Throughout the Intervention

Growth over pre-week 3, growth over pre-week 6, and growth over pre-post were examined for investigating changes induced by mindfulness training. For pre-week 3, we regressed changes between week 3 and the pre-test on the factor intervention (dummy codes representing conditions: 1 = with mindfulness, 0 = without mindfulness). For pre-week 6 and pre-post, we regressed the latent variable slope from the LGCM on the factor intervention.

For pre-week 3, general linear models showed that the factor intervention significantly predicted the changes in observing and self-perceived stress (Table 4). For pre-week 6, the linear univariate LGCM fits the data well for all outcomes except self-perceived stress (Table 5). The factor intervention significantly predicted the rates of changes over time for observing, non-reactivity to inner experiences, overall mindfulness, self-perceived stress, and distress appraisal, but not for other outcomes (Table 4). For pre-post, fits measures indicated that the linear LGCM fits the data well for observing, describing, acting with awareness, distress tolerance, distress appraisal, and distress regulation (Table 5). The factor intervention significantly predicted the rates of change over time for observing, describing, acting with awareness, non-reactivity, overall mindfulness, and self-perceived stress, but not for other outcomes (Table 4).

Mechanism Exploration via Bivariate LGCMs

To further address the potential mechanism underlying MBI, we investigated the relationship between the rates of change in distress appraisal and mindfulness skills. Since univariate LGCMs showed that the factor intervention could predict the slopes of distress appraisal during the first six weeks, we separately conducted bivariate LGCMs for each pair on two subgroups: participants who did and did not receive the mindfulness intervention.

For those who have received the intervention, results of model fit measures indicated that only models for the observing – distress appraisal pair and non-reactivity – distress appraisal pair fit the data well (Table 5). There were significant correlations between the slope of non-reactivity and the slope of distress appraisal (r = .828, p = .012, power = .050), the slope of non-reactivity and self-perceived stress (r = –.588, p = .001, power = .678), the slope of overall mindfulness and distress appraisal (r = 1.260, p = .001, power = .769), the slope of overall mindfulness and self-perceived stress (r = –.762, p < .001, power = .898), and the slope of distress appraisal and self-perceived stress (r = –.607, p = .001, power = .802), whereas the correlation for observing – distress appraisal, observing – self-perceived stress was not significant (ps > .05, power = .222 and .796, respectively).

For those who did not receive the training, fit indices suggested a good or acceptable fit of all models except for the overall mindfulness – self-perceived stress pair (Table 5). Unlike participants who have been provided with MBI, the correlation between the slope of non-reactivity and distress appraisal (r = –.141, p = .526, power = .050) and that between the slope of non-reactivity and self-perceived stress (r = –.361, p = .213, power = .050) were not significant among those without MBI. Like participants who received MBI, there were significant correlations between the slope of overall mindfulness and distress appraisal (r = .729, p = .023, power = .059), the slope of overall mindfulness and self-perceived stress (r = –1.010, p = .002, power = .167), and the slope of distress appraisal and self-perceived stress (r = –.490, p = .031, power = .133), whereas the correlation for observing – distress appraisal, and observing – self-perceived stress was not significant (ps > .05, power = .106 and .050, respectively) among those who did not receive a mindfulness training.

Table 4. Changes in mindfulness skills, self-perceived stress, and distress tolerance throughout the MBI

Variable	Pre–Week 3			Pre–Week 3–Week 6			Pre–Week 3–Week 6–Post		
	β [95% CI]	*p*	Statistical power (by Δ slope)	β [95% CI]	*p*	Statistical power (by RMSEA)	β [95% CI]	*p*	Statistical power (by RMSEA)
Observing	0.193 [0.020, 0.365]	0.038	0.416	0.359 [0.159, 5.48]	<.001	0.050	0.694 [0.325, 5.651]	<.001	0.220
Describing	0.042 [–0.134, 0.217]	0.677	0.065	0.248 [–0.029, 3.714]	0.079	0.050	0.72 [0.3, 5.317]	0.001	0.050
Acting with awareness	0.05 [–0.126, 0.225]	0.567	0.077	0.112 [–0.115, 2.926]	0.334	0.050	0.291 [0.056, 4.39]	0.015	0.187
Non-Judging	-0.008 [–0.184, 0.167]	0.929	0.051	0.066 [–0.161, 2.53]	0.569	0.050	0.215 [–0.031, 3.671]	0.087	0.296
Non-reactivity	0.026 [–0.149, 0.202]	0.785	0.054	0.357 [0.134, 5.091]	0.002	0.050	0.591 [0.346, 6.682]	<.001	0.638
Overall mindfulness	0.135 [–0.039, 0.309]	0.111	0.914	0.443 [0.222, 5.88]	<.001	0.050	0.595 [0.396, 7.829]	<.001	0.412
CPSS Perceived Stress	–0.208 [–0.380, –0.036]	0.012	0.997	–0.197 [–0.016, –4.099]	0.032	0.765	–0.227 [–0.026, –4.178]	0.027	0.433
Distress Tolerance	–0.056 [–0.232, 0.119]	0.521	0.053	0.17 [–0.145, 3.018]	0.29	0.068	0.084 [–0.17, 2.608]	0.517	0.050
Distress Appraisal	0.136 [–0.038, 0.310]	0.142	0.063	1.024 [0.026, 3.971]	0.044	0.050	0.217 [–0.107, 3.274]	0.189	0.066

Variable	Pre–Week 3			Pre–Week 3–Week 6			Pre–Week 3–Week 6–Post		
	β [95% CI]	*p*	Statistical power (by Δ slope)	β [95% CI]	*p*	Statistical power (by RMSEA)	β [95% CI]	*p*	Statistical power (by RMSEA)
Distress Absorption	0.036 [–0.140, 0.211]	0.687	0.051	0.237 [–0.061, 3.519]	0.119	0.218	0.027 [–0.53, 2.055]	0.924	0.245
Distress Regulation	0.108 [–0.066, 0.283]	0.235	0.056	0.098 [–0.31, 2.431]	0.637	0.161	–0.1 [0.195, –2.624]	0.507	0.174
Overall Distress Tolerance	0.078 [–0.097, 0.253]	0.358	0.053	0.222 [–0.033, 3.669]	0.087	0.100	0.025 [-0.244, 2.142]	0.856	0.692

Note. RMSEA = root-mean-square error of approximation; CI = confidence interval.

Table 5. Model Fit Measures for Linear Latent Growth Curve Models.

Variable	Time points	χ^2	df	χ^2/df	RMSEA	CFI	TLI
FFMQSF Observing	Pre–Week3–Week6	.853	2	.427	<.001	1.000	1.021
FFMQSF Observing	Pre–Week3–Week6–Post	12.564	7	1.795	.078	.981	.973
FFMQSF Describing	Pre–Week3–Week6	.044	2	.022	<.001	1.000	1.043
FFMQSF Describing	Pre–Week3–Week6–Post	4.270	7	.610	<.001	1.000	1.015
FFMQSF Acting with awareness	Pre–Week3–Week6	.099	2	.050	<.001	1.000	1.033
FFMQSF Acting with awareness	Pre–Week3–Week6–Post	11.543	7	1.649	.071	.983	.976
FFMQSF Non-Judging	Pre–Week3–Week6	1.091	2	.546	<.001	1.000	1.028
FFMQSF Non-Judging	Pre–Week3–Week6–Post	14.677	7	2.097	.092	.956	.937
FFMQSF Non-reactivity	Pre–Week3–Week6	1.606	2	.803	<.001	1.000	1.011
FFMQSF Non-reactivity	Pre–Week3–Week6–Post	25.261	7	3.609	.142	.888	.840
FFMQSF Total	Pre–Week3–Week6	.007	2	.004	<.001	1.000	1.034
FFMQSF Total	Pre–Week3–Week6–Post	17.872	7	2.553	.110	.967	.953
CPSS Perceived Stress	Pre–Week3–Week6	7.548	2	3.774	.147	.975	.924·
CPSS Perceived Stress	Pre–Week3–Week6–Post	18.632	7	2.662	.113	.968	.954
Distress Tolerance	Pre–Week3–Week6	2.172	2	1.086	.026	.998	.995
Distress Tolerance	Pre–Week3–Week6–Post	5.326	7	.761	<.001	1.000	1.016
Distress Appraisal	Pre–Week3–Week6	.827	2	.414	<.001	1.000	1.041
Distress Appraisal	Pre–Week3–Week6–Post	7.594	7	1.085	.026	.996	.994
Distress Absorption	Pre–Week3–Week6	3.354	2	1.677	.072	.986	.958
Distress Absorption	Pre–Week3–Week6–Post	13.220	7	1.889	.083	.957	.939
Distress Regulation	Pre–Week3–Week6	2.915	2	1.458	.060	.985	.954
Distress Regulation	Pre–Week3–Week6–Post	11.154	7	1.593	.068	.953	.933
Overall Distress Tolerance	Pre–Week3–Week6	2.450	2	1.225	.042	.997	.991
Overall Distress Tolerance	Pre–Week3–Week6–Post	27.413	7	3.916	.150	.857	.796

	Subgroups	χ^2	df	χ^2/df	RMSEA	CFI	TLI
FFMQSF Observing - Distress Appraisal	With mindfulness	10.319	7	1.474	.074	.980	.957
FFMQSF Observing - Distress Appraisal	Without mindfulness	8.316	7	1.188	.066	.985	.968
FFMQSF Non-reactivity - Distress Appraisal	With mindfulness	2.913	7	.416	<.001	1.000	1.061
FFMQSF Non-reactivity - Distress Appraisal	Without mindfulness	3.976	7	.568	<.001	1.000	1.102
FFMQSF Total - Distress Appraisal	With mindfulness	19.440	7	2.777	.144	.937	.866

	Subgroups	χ^2	df	χ^2/df	RMSEA	CFI	TLI
FFMQSF Total - Distress Appraisal	Without mindfulness	7.251	7	1.036	.029	.998	.996
FFMQSF Observing - CPSS Perceived Stress	With mindfulness	20.123	7	2.875	.148	.951	.894
FFMQSF Observing - CPSS Perceived Stress	Without mindfulness	4.451	7	.636	<.001	1.000	1.044
FFMQSF Non-reactivity - CPSS Perceived Stress	With mindfulness	17.481	7	2.497	.132	.960	.915
FFMQSF Non-reactivity - CPSS Perceived Stress	Without mindfulness	2.309	7	.330	<.001	1.000	1.087
FFMQSF Total - CPSS Perceived Stress	With mindfulness	23.764	7	3.395	.167	.941	.874
FFMQSF Total - CPSS Perceived Stress	Without mindfulness	9.414	7	1.345	.090	.988	.973
Distress Appraisal - CPSS Perceived Stress	With mindfulness	20.409	7	2.916	.149	.943	.877
Distress Appraisal - CPSS Perceived Stress	Without mindfulness	8.812	7	1.259	.078	.987	.972

Note. RMSEA = root-mean-square error of approximation; CFI = comparative fit index; TLI = Tucker-Lewis index.

Mechanism Exploration via Mediation Models

Mediation models were initially planned to be performed by separately regressing post-test measures on the factor intervention (1/0) and entering week 3 and week 6 measures as potential mediators (Table 5). Variables that were demonstrated to be significantly predicted by the intervention in the univariate LGCMs would have been considered potential mediators. Accordingly, we could not conduct serial mediation analyses because none of the latent variable slopes for distress tolerance-relevant outcomes could be predicted by the factor intervention in the four-time-points univariate LGCMs.

We explored the relationship between mindfulness skills and distress tolerance by performing another set of simple mediation analyses based on the pre-test, week 3, and week 6 measures, consistent with the time points involved in the bivariate LGCMs. In total, fourteen mediation models were constructed for exploring all possible paths during the first six weeks of the intervention (Table 6). Results showed that the mediating effect of distress appraisal on the relationship between receiving or not mindfulness intervention and non-reactivity to inner experiences was significant (effect = .269, 95%CI [.024, .702]) and that on the relationship between receiving or not receiving mindfulness intervention and self-perceived stress was significant (effect = –.871, 95% CI [–1.701, –.197]). The ratio of indirect to total effect was 32.22% and 32.42%, respectively. Results of other mediation models showed that the indirect effects of corresponding potential mediators were not significant. Thus, the impact of MBI on non-reactivity to inner

experiences and self-perceived stress could be explained through distress appraisal (Figure 4).

We also explored whether sex could moderate the uncovered mediation effects. For the mediator variable model, the outcome variable was distress appraisal at week 3, the predictive variable was the factor intervention (1/0), and the moderator variable was sex (1/0, 1 = female, 0 = male). The effect of sex on distress appraisal was not significant (effect = .241, p = .391), neither was the interaction term (effect = –.404, p = .391). For the dependent variable models, the outcome variable was self-perceived stress at week 6 or non-reactivity at week 6; the mediator variable was distress appraisal at week 3; the predictive variable was the factor intervention (1/0), and the moderator variable was sex (1/0). Results indicated that the effect of sex on self-perceived stress at week 6 (effect = 3.639, p = .588) or non-reactivity at week 6 (effect = 1.069, p = .607) was not significant. Sex did not significantly moderate the mediation effects of distress appraisal on self-perceived stress at week 6 (intervention x sex: effect = 3.261, p = .355; sex x distress appraisal: effect = –3.208, p = .170) or non-reactivity at week 6 (intervention x sex: effect = .576, p = .597; sex x distress appraisal: effect = –.416, p = .564).

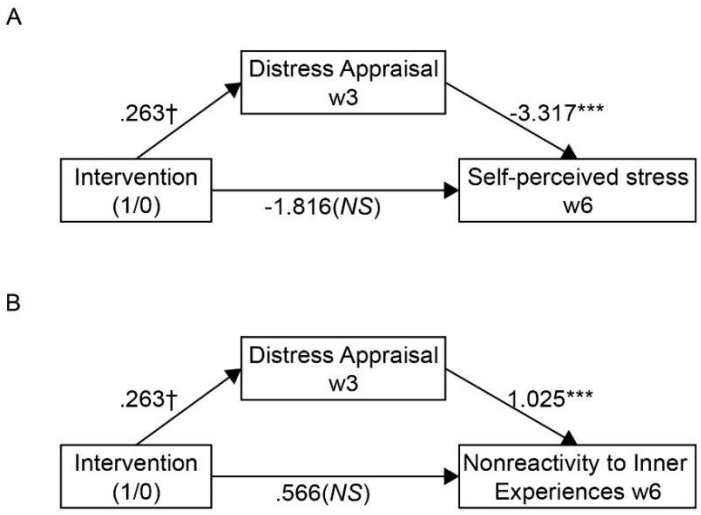

Figure 4. Mechanisms unveiled through mediation analyses. *Note.* Panel A, week 3 distress appraisal mediated the effect of the mindfulness intervention on week 6 self-perceived stress. Panel B, week 3 distress appraisal mediated the effect of the mindfulness intervention on week 6 non-reactivity to inner experiences**.**

†p < .10, * p < .05. ** p < .01. *** p < .001.

Table 6. Results of mediation analyses.

Model	Path	Indirect effect	Direct effect	Proportion of mediation (%)	Statistical power (by Indirect Effect)
Model 1	group-w3DTappraisal-w6OBS	.153 [–.045, .463]	.683 [–.340, 1.895]	18.30	0.856
Model 2	group-w3DTappraisal-w6NR	.269 [.024, .702]	.566 [–.227, 1.604]	32.22	0.842
Model 3	group-w3DTappraisal-w6TOTAL	1.207 [–.019, 3.149]	2.955 [.132, 5.725]	29.00	0.852
Model 4	group -w3OBS-w6DTappraisal	.002 [–.069, .068]	.373 [.073, .614]	.53	0.016
Model 5	group -w3NR -w6DTappraisal	–.031 [–.115, .030]	.406 [.077, .737]	-8.27	0.198
Model 6	group -w3TOTAL-w6DTappraisal	.044 [-.061, .160]	.331 [.061, .551]	11.73	0.092
Model 7	group -w3OBS-w6CPSS	–.025 [–.704, .491]	–2.662 [–5.108, –.368]	.93	0.086
Model 8	group -w3NR - w6CPSS	.375 [–.349, 1.173]	–3.062 [–5.800, –.711]	-13.96	0.952
Model 9	group -w3TOTAL-w6CPSS	–.495 [–1.543, .782]	–2.193 [–4.157, .318]	18.42	1.000
Model 10	group- w3CPSS -w6OBS	.205 [–.017, .549]	.631 [–.259, 1.601]	24.52	0.242
Model 11	group- w3CPSS -w6NR	.253 [–.003, .591]	.583 [–.118, 1.248]	3.30	0.294
Model 12	group- w3CPSS -w6TOTAL	1.108 [–.400, 2.421]	3.054 [.936, 5.101]	26.62	1.000
Model 13	group-w3DTappraisal-w6CPSS	–.871 [–1.701, –.197]	–1.816 [–4.049, .266]	32.42	0.852
Model 14	group -w3CPSS-w6DTappraisal	.098 [–.028, .214]	.277 [.032, .557]	26.13	0.078

Post hoc Power Analysis

For all growth curve models, power analyses were performed to compare each of the hypothesized models against the corresponding saturated model. The probability to identify the actual effect with our present sample size was illustrated in Table 4. For all simple mediation models, the statistical powers were displayed in Table 6.

Discussion

The current study explored the role of distress tolerance in an 8-week MBI among individuals with high emotional distress. Firstly, cross-sectional correlations showed that all facets of distress tolerance are negatively correlated to self-perceived stress and positively correlated to most facets of mindfulness skills. Secondly, our findings showed that the MBI program significantly reduced participants' self-perceived stress, and meanwhile, improved their mindfulness skills. The MBI also

showed a beneficial effect on cultivating one's ability to accept distress, i.e., distress appraisal. Thirdly, results of growth trajectories indicated that whether participants received or not mindfulness training did not predict the growth rate of distress tolerance throughout the whole intervention. However, univariate LGCMs showed that during the first six weeks of the intervention, being involved or not in an MBI significantly predicted the growth rate on distress appraisal, as well as observing, non-reactivity to inner experiences, overall mindfulness, and self-perceived stress. More specifically, for those who received MBI, an increase in distress appraisal is significantly positively associated with an increase in non-reactivity. This association was not observed among those who did not receive an MBI. Among these individuals, the growth rate of distress appraisal was found to be positively related to that of overall mindfulness and negatively associated with a decrease in self-perceived stress during the epidemic. Fourthly, mediation analyses further proved that, during the first six weeks of the intervention, the effect of MBI on self-perceived stress was fully mediated via distress appraisal. Distress appraisal significantly fully mediated MBI's effect on non-reactivity as well. Finally, these mediating effects did not differ by sex.

Cross-sectionally, bivariate correlations revealed that describing, acting with awareness, non-judging to the inner experiences, and non-reactivity were positively correlated to the overall distress tolerance. The observing skill was found to be not significantly correlated with any of the facets of distress tolerance. Our results and findings are consistent with previous literature, where distress tolerance and mindfulness skills (except for the observing) were found to be interrelated with each other among healthy individuals, people with behaviors of problematic smoking, alcohol and other drug use, smartphone use, or gambling, clinically elevated levels of health anxiety, and symptoms of substance use disorder or obsessive-compulsive disorder (Arnaudova & Amaro, 2020; Bravo, Boothe, & Pearson, 2016; Brem et al., 2019; Cano et al., 2020; de Lisle et al., 2014; Elhai, Levine, O'Brien, & Armour, 2018; Hsu, Collins, & Marlatt, 2013; Kim, Li, Broyles, Musoka, & Correa-Fernandez, 2021; Leeuwerik, Cavanagh, & Strauss, 2020; Luberto et al., 2014; Luberto & McLeish, 2018; Nila, Holt, Ditzen, & Aguilar-Raab, 2016; O'Bryan, Luberto, Kraemer, & McLeish, 2018; Pearson, Lawless, Brown, & Bravo, 2015; Vujanovic, Bonn-Miller, Bernstein, McKee, & Zvolensky, 2010).

Throughout the first six weeks of the intervention, our results showed that, compared to participants who did not receive any intervention, those who had received mindfulness training experienced significantly greater increases in observing, non-reactivity, overall mindfulness, and distress appraisal, as well as a larger reduction in self-perceived stress than those who did not. However, across the whole intervention, the growth rate of distress tolerance could not be predicted by the factor intervention as we expected. We considered two possible leading causes. Firstly, a national epidemic-relevant policy was published at post-test (i.e., people were able to return to work instead of being isolated at home), so the environmental

factors might have had a larger effect on post-test measures than the intervention per se (Wang et al., 2022). Secondly, the level of a certain mechanism variable might show a fluctuation during the intervention. For instance, negative cognitive bias has long been associated with the maintenance of depressive symptoms (Drozd, Rychlik, Fijalkowska, & Rygula, 2018). Interventions targeting reducing negative bias might evoke changes in the cognitive processing system, manifesting as a change in negatively biased processing as well as an elevated flexibility of cognitive processing (Steinman et al., 2020). A higher level of flexibility might, however, retrospectively promote the negatively biased processing because it is appropriate to certain situations (Parsons, Kruijt, & Fox, 2016). No previous study has investigated the developmental trajectories of distress tolerance during the MBI. Further studies were warranted to investigate the role of distress tolerance displayed throughout different periods across the MBI.

Furthermore, results of bivariate LGCMs found a significant correlation between the increase in non-reactivity and the increase in distress appraisal only in individuals receiving mindfulness training. It suggested that MBI has a specific impact on the relation between non-reactivity and distress appraisal throughout the first six weeks of the intervention. It is plausible that, during the intervention, individuals with high emotional distress gradually learned to feel less ashamed or unaccepting of their own aversive emotional experiences. At the same time, they learned to not have to react immediately to unwanted experiences and became capable of not using their habitual maladaptive emotion regulation strategies (Barlow et al., 2010). The strong associations also suggested the potential existence of a causal relationship between these two learning processes throughout the intervention.

Simple mediation analyses further examined the potential causal relationships throughout the first six weeks of the MBI. Our findings revealed two paths: Distress appraisal explained how and why MBI works to (a) reduce one's level of self-perceived stress and (b) enhance one's ability of non-reactivity to inner experiences. In addition, moderated mediation analyses indicated that sex did not significantly moderate these two paths. The current findings provided empirical evidence for supporting the transdiagnostic pathology theories where cognitive reappraisal and maladaptive emotion-driven/avoidance behaviors were considered as three core elements for multiple emotional disorders (Campbell-Sills & Barlow, 2007). The first path we found indicated that participants learned to reappraise the aversive emotions as acceptable, which directly led to relief from stress in the first 6 weeks of the intervention. The second path indicated that individuals with high emotional distress first gradually learned to change their appraisal of unwanted emotional experiences and refrain from the secondary emotions triggered by the primary emotions (Linehan, 2014). As a result, they developed the ability to pause between the perception of an emotional reaction and the subsequent regulatory tendencies or overt behaviors. We might infer that this elevated ability to let go could

further contribute to stress reduction in a longer term (Creswell & Lindsay, 2014). Future studies were warranted to investigate whether the present causal chains could be established in different clinical conditions.

Several limitations need to be considered when interpreting the current findings. Participants were recruited from the WeChat public page of the mindfulness lab. They showed more interest in participating in MBI, which might impact the generalizability of our findings. The sample size was relatively small, which led to limited statistical power in certain models. A further examination of a larger population is needed. Secondly, an epidemic-relevant covariate might contribute to interpreting some unexpected results of the current study. For instance, the control group showed a significant reduction in self-perceived stress and increases in non-judging, distress tolerance, and distress absorption from baseline to post-test. Similarly, bivariate latent growth curve models conducted on people who did not receive the mindfulness intervention revealed a temporal synergistic relationship between distress appraisal and overall mindfulness, as well as an antagonistic relationship between distress appraisal and self-perceived stress. Although we were unable to pre-include epidemic-relevant factors, further investigations might consider adding environmental factors as covariates for causal interference in an intervention setting (Allen, Evans, & Wyka, 2021). Thirdly, in the current study, we found significant mediating effects of distress appraisal. The measure items were suggested by some researchers to reflect a more general self-criticism (Leeuwerik et al., 2020). Objective measures or disaggregation of this construct would be desired in future studies to clarify the mechanism of change underlying MBI (H. C. Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001).

Conclusions

The current study revealed the role of distress appraisal (i.e., one facet of an individual's ability to withstand negative emotions) as a core mechanism variable in an 8-week MBI among individuals at high risk of developing multiple emotional disorders. Our findings provide empirical evidence for two paths: Distress appraisal cultivated in MBI could (a) directly lead to a reduction in self-perceived stress in the first six weeks of the intervention, or (b) result in elevation of non-reactivity to inner experiences, which might contribute to more beneficial interventional effects in the long term. Future clinical practitioners could emphasize the content relevant to the attitude people hold towards unwanted experiences or encourage individuals to face unpleasant feelings to improve the effectiveness and efficiency of MBI in today's fast-paced modern society.

Authors' note

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