

Efficacy of Internet-based rumination-focused cognitive behavioral therapy and mindfulness-based intervention with guided support in reducing risks of depression and anxiety: A randomized controlled trial

Winnie W. S. Mak¹  | Alan C. Y. Tong¹  |
 Amanda C. M. Fu¹ | Ivy W. Y. Leung¹ | Olivia H. C. Jung¹ |
 Edward R. Watkins²  | Wacy W. S. Lui³ 

¹Department of Psychology, The Chinese University of Hong Kong, Shatin, Hong Kong

²Department of Psychology, University of Exeter, Exeter, UK

³Center for Personal Growth and Crisis Intervention of the Corporate Clinical Psychology Services, Hospital Authority, Ma Tau Wai, Hong Kong

Correspondence

Winnie W. S. Mak, Department of Psychology, The Chinese University of Hong Kong, Shatin, NT, Hong Kong SAR.
 Email: wwsmak@cuhk.edu.hk

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Abstract

Rumination and worry are common risk factors of depression and anxiety. Internet-based transdiagnostic interventions targeting individuals with these specific risks may be an effective way to prevent depression and anxiety. This three-arm randomized controlled trial compared the efficacy of Internet-based rumination-focused cognitive behavioral therapy (RFCBT), mindfulness-based intervention (MBI), and psychoeducation (EDU) control among 256 at-risk individuals. Participants' levels of rumination, worry, depressive, and anxiety symptoms were assessed at post-intervention (6 weeks), 3-month, and 9-month follow-ups. Linear mixed model analysis results showed similar levels of improvement in all outcomes across the three conditions. Changes in rumination differed comparing RFCBT and MBI, where a significant reduction in rumination was noted at a 3-month follow-up among participants in RFCBT, and no

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significant long-term effect among participants in MBI was noted at a 9-month follow-up. All three conditions showed similar reductions in risks and symptoms, implying that the two active interventions were not superior to EDU control. The high attrition at follow-ups suggested a need to exercise caution when interpreting the findings. Future studies should tease apart placebo effect and identify ways to improve adherence.

KEYWORDS

anxiety, cognitive behavioral therapy, depression, mindfulness, rumination, selective prevention, transdiagnostic risks, worry

INTRODUCTION

Depression and anxiety disorders are the most common mental disorders, affecting around 280 million and 310 million people, respectively (World Health Organization, [n.d.](#)). As of 2020, The global prevalence estimate among the general population across 32 different countries was 28.0% for depression and 26.9% for anxiety (Nochaiwong et al., [2021](#)). Based on the Hong Kong Mental Morbidity Survey, a prevalence of 4.5% for major depressive episode and 4.8% for generalized anxiety disorder were found among community adults in Hong Kong (Lam et al., [2015](#)). Depression and anxiety tend to co-occur and share similar risk factors for onset and common maintenance processes (Topper et al., [2010](#)). In the recent decade, researchers have put much effort into identifying transdiagnostic processes that cut across diagnostic categories and affect the risks of individuals developing anxiety and depression. Among these processes, rumination and worry are found to be predictive of onset, severity, and duration of depression and anxiety (Topper et al., [2010](#); Watkins, [2015](#)). Rumination involves passive thinking about symptoms and associated failures in individuals' past and present; worry refers to uncontrollable thinking on the possibility of adverse outcomes in the future.

A growing body of literature suggests that repetitive thinking patterns, including rumination and worry, are not always unhelpful and may sometimes be functional depending on their style. A maladaptive style is characterized by abstract, overgeneralized, and evaluative processing, whereas an adaptive style is characterized by concrete, specific, and contextualized processing (Watkins, [2008](#)). For instance, individuals who worried about a stressful event were found to be more engaged in problem-solving and information-seeking behaviors (Davey et al., [1992](#)). The extent of rumination after a trauma was also found to be associated with greater posttraumatic growth (Tedeschi & Calhoun, [2004](#)). Therefore, rather than having to eliminate all forms of repetitive thinking, it may be more beneficial to transform maladaptive repetitive thinking styles into adaptive processes.

Rumination-focused cognitive behavioral therapy (RFCBT) was developed to alter the process of ruminative thinking (Watkins, [2009](#); Watkins et al., [2007](#)). RFCBT uses the functional-analytic and contextual approach in behavioral activation treatment to reduce unhelpful

ruminations. Conceptualizing rumination as avoidance thinking habits, RFCBT applies functional analysis to reduce avoidance and replace it with adaptive approach behaviors. It coaches individuals to counter their maladaptive rumination with meaningful behavioral engagement and contingency if-then plans. It also uses experiential and imagery exercises and behavioral experiments to promote concrete processing, absorbing flow experiences, and self-compassion. A case series (Watkins et al., 2007) and a randomized controlled trial (RCT; Watkins et al., 2011) have demonstrated RFCBT to be efficacious in reducing ruminations, improving depressive symptoms and co-morbidity disorders among individuals with residual depression. Further study comparing RFCBT and traditional CBT both delivered in a group format found that RFCBT outperformed traditional CBT on participants' level of depressive symptoms at post-intervention among adults with depression (Hvenegaard et al., 2020). Topper et al. (2017) found that both group-based and Internet-based RFCBT outperformed waitlist control in terms of reducing rumination and worry (Cohen's $d = .53$ to $.89$), as well as symptoms of depression and anxiety (Cohen's $d = .36$ to $.72$) at post-program, and the effects were maintained at follow-ups for 12 months.

One feature of preoccupying and repetitive thought is its tendency to shift attention away from the present moment to attending events that have already happened, that is rumination, or to events that may or may not happen in the future, that is worry. This ongoing state of attentional distraction can interfere with individuals' concentration and is associated with increased distress and functional impairment (Hallion et al., 2018). As such, interventions that emphasize present-moment attention and nonattachment, such as mindfulness-based interventions (MBIs), can potentially reduce preoccupying and repetitive thoughts and their associated symptoms. The mindfulness-based approach emphasizes on self-regulation of attention and orientation toward the present moment with curiosity, openness, and compassion (Kabat-Zinn, 2013). Emotional balance is attained through enhanced awareness of individuals' sensory perceptions, feelings, thoughts, and their relations with the surroundings. This sensing and re-perceiving mode allows space for individuals to decide on the most appropriate course of action rather than jumping prematurely and automatically into a reactive mode (Shapiro et al., 2006). During mindfulness meditation practices, shifting individuals' attention to the present moment experience may help them to disengage from ruminative or worrisome thought processes (Evans & Segerstrom, 2011; Fisak & von Lehe, 2012; Gu et al., 2015).

MBIs were found to be efficacious in ameliorating an array of common mental disorders, with most research studies focusing on depression and anxiety. A review of 44 meta-analyses of RCTs on MBIs found MBIs to have small to large effects across populations and mental health conditions (Goldberg et al., 2022). Specifically, a meta-analysis found face-to-face MBI to effectively reduce rumination and worry with a large effect size (Hedges $g = 1.13$) among non-clinical samples of individuals (Querstret et al., 2020). MBI was also found to be effective in reducing rumination among people with lifetime mood disorders, after controlling for reduction in affective symptoms and dysfunctional beliefs (Ramel et al., 2004).

Like many other places, most people in Hong Kong do not seek professional mental health services when in need. Among young adults aged 25–35 years old, less than 25% of them who met the criteria for a common mental disorder ever sought services (Lam et al., 2015). Barriers to mental health help-seeking included low mental health literacy, stigma toward help-seeking, and preference for self-reliance (Andrade et al., 2014). Among Hong Kong Chinese, in which both attitudinal (e.g. subjective norms) and practical barriers (e.g. costs and waiting time) contributed to mental health help-seeking (Mo & Mak, 2009), stigma and face concern were particularly salient factors in deterring help-seeking (Chen et al., 2020). To address this unmet

treatment need, prevention and delivering interventions using novel approaches are warranted (Kazdin, 2019).

The explosion of Internet access and mobile technology enables the delivery of mental health interventions to those who would not otherwise seek help previously because of stigma and practical barriers (Hollis et al., 2015). Specifically, Internet-based intervention is a convenient and anonymous approach that makes prevention more accessible by reducing time and costs (Griffiths & Christensen, 2007), mitigating stigma with anonymity and privacy (Gega et al., 2013), and was found to be comparable with face-to-face interventions (Andersson et al., 2014; Carlbring et al., 2018). Increasing evidence has shown Internet-based interventions to be effective in reducing symptoms among adults with depression and/or anxiety disorders (Andersson & Cuijpers, 2009; Mewton et al., 2014; Moshe et al., 2021; Richards & Richardson, 2012). Topper et al. (2017) demonstrated that therapist-guided web-based RFCBT was as effective as group-delivered RFCBT in reducing depressive and anxiety symptoms and preventing depression incidence up to 12 months. A meta-analysis of 15 Internet-based MBI RCTs found a small between-group effect size for depression ($g = .29$) and anxiety ($g = .22$) as compared with a control (Spijkerman et al., 2016). In Hong Kong, Internet-based mindfulness-based training was also found to produce a small to medium effect size in improving mental well-being and psychological distress (Mak et al., 2017, 2015, 2018).

Evidence showed that both RFCBT and MBI are efficacious in reducing anxiety and depressive symptoms and that they take into effect via different pathways. Specifically, RFCBT works by changing repetitive negative thinking habits with techniques of behavioral activation, functional analysis, and scheduling of contingency plans, whereas MBI disengages individuals from repetitive thinking by cultivating one's present-moment awareness to bodily sensations, thoughts, and feelings and nonattachment to the ever-changing nature of all matters (Ho et al., 2022). Although Internet-based RFCBT and MBI had gained support respectively, they were not compared against each other in a selective prevention trial targeting people at risk. The present study attempts to test the efficacy of Internet-based RFCBT and MBI in reducing transdiagnostic risks, namely, rumination and worry and ameliorating depressive and anxiety symptoms, relative to psychoeducation (EDU) control. We targeted individuals with elevated levels of rumination and worry as early intervention targeting people at risk is expected to block the chain of actions right from the beginning and prevent them from developing depressive and/or anxiety disorders later. We hypothesised that RFCBT and MBI will demonstrate superior efficacy in reducing rumination, worry, depressive, and anxiety symptoms as compared with EDU at the post-intervention, 3-month, and 9-month follow-up (H1). Furthermore, we hypothesised that RFCBT and MBI will show comparable efficacy in reducing risks, that is a test of noninferiority (H2).

METHODS

Trial design

The present study is a researcher-blind, three-arm RCT comparing RFCBT and MBI with an EDU control group. Clinical ethics approval was obtained from the Joint Chinese University of Hong Kong, New Territories East Cluster Clinical Research Ethics Committee (Reference No.: CRE- 2014.063), and the Kowloon Central/Kowloon East Cluster Research Ethics Committee of the Hospital Authority (Reference No.: KC/KE-16-0213/ER-3). The trial was registered under

institutional registry (RCT Trial no: CUHK_CCT00453) and Chinese Clinical Trial Registry (Trial no: ChiCTR-IOR-15006470).

Participants

Participants were individuals who were at risk for depression and anxiety in the general population and fulfilled the following inclusion criteria: scored above 75th percentile on either measure of worry (≥ 50 on the Penn State Worry Questionnaire [PSWQ]; Meyer et al., 1990) or rumination (≥ 40 on the Rumination Response Scale [RRS]; Nolen-Hoeksema & Morrow, 1991) based on previous prevention trials (Cook et al., 2019; Topper et al., 2017); are at least 18 of age; comprehend Chinese and spoken Cantonese; are computer literate; and have access to the Internet throughout the entire study period on any chosen device including a computer, a tablet, or a mobile phone. Exclusion criteria were having a DSM-5 diagnosis of current or past major depressive episodes, generalized anxiety disorder, manic episodes, and psychotic disorders, and being actively suicidal, as assessed by the Mini-International Neuropsychiatric Interview (M.I.N.I.; Sheehan et al., 1998). We purposefully excluded those who have been previously diagnosed because this selective prevention study attempts to test the prevention potential of RFCBT and MBI that target the transdiagnostic risk factors associated with depression and anxiety. Participants were recruited through the following channels: mass mailing and emails to non-governmental organisations and tertiary institutions; distribution of posters and leaflets to local clinics and social service centers; and posting advertisements at popular online networking platforms (e.g. Facebook and Instagram), newspapers, and magazines. Individuals who were interested in the study could register on the trial website where informed consent was sought through a built-in consent form. Apart from inclusion and exclusion criteria, details on study aims, length of the program, involvement of the participants, and randomization of participants to interventions were also described. Individuals who agreed to participate proceeded to registration by clicking the “*I agree*” button.

Screening

Upon registration, participants completed a screening questionnaire on worry and rumination. Participants who scored above 75th percentile on either measure of worry or rumination were invited to the laboratory, where research staff conducted M.I.N.I. to assess eligibility. Those who scored below this percentile were thanked for their interest to participate, and they were provided a printed leaflet listing the contact information of community-based mental health services in Hong Kong.

Randomization

Randomization took place after eligible participants completed the pre-program assessment at the laboratory. A simple randomization was performed based on a computer-generated sequence with a fixed ratio of 1:1:1. The assignment algorithm was constructed independently by the computer engineer who built the infrastructure of the TourHeart website. Researchers did not have access to the randomization process. Participants were blinded by telling them the

three programs were related to their mental health during the recruitment process. Although the consent form stated clearly that the study involved random assignment, participants did not have information regarding the other two programs until all follow-up assessments were completed. Participants received a brief introduction to the website and the conditions to which they were assigned after randomization by an external student helper hired for the purpose of blinding. They were informed that the next session will be unlocked only when they have completed the previous session. They were encouraged to log in at least three times a week and spend about 15 min to complete one session. Participants in RFCBT and MBI conditions were additionally informed about the coach's feedback based on their responses to the exercises.

Intervention

A website named "TourHeart" was developed to deliver the interventions under one platform. It was available from July 2016 until September 2018 and can be accessed through different browsers including Internet Explorer, Safari, and Chrome. It was also compatible with smartphones. For all conditions, the website includes the following common features: (1) About Us where users can know more about this project and the research team; (2) Social Resources where users can find information on mental health-related social resources including telephone hotlines and community mental health centers; (3) Resources Download where users can download audio exercises for the condition to which they were assigned (except for EDU); (4) Setting where users can change the password of their accounts; and (5) TourHeart Quotes where users can view and share quotes related to users' assigned condition. Multimedia Appendix 1 of the [Supporting Information](#) shows the screenshots of the TourHeart website.

Besides these common features, the two interventions (RFCBT and MBI) and the control condition (EDU) each consisted of a six-module online program, which was further subdivided into three to five sessions per module. Each session would be unlocked to the participants upon their completion of the previous session. Participants were expected to log in at least three times a week and spend about 15 min to complete one session. Guided support was given to the participants in RFCBT and MBI by trained undergraduate-level helpers (coaches) under the supervision of two registered clinical psychologists. They gave feedback on the participants' responses to the built-in exercises and homework using templates. Reminder emails were sent each week in efforts to engage participants and increase the completion of assessments following the program. Although most of the contents in RFCBT were directly translated from the original English version used in previous studies (Cook et al., 2019; Topper et al., 2017), cultural adaptation was made to fit with the local context, for example, the name of RFCBT in English was "MindReSolve" and it was translated into a meaningful Chinese phrase that connotated "the tour of our minds"; contents were translated into Traditional Chinese, the official language used in Hong Kong; local idioms and examples were used to engage participants and facilitate their understanding; and the virtual training buddies (fictional characters) had local names and backgrounds. MBI and EDU were constructed based on previous studies and awareness campaigns conducted by the research team (Mak et al., 2018, 2017, 2015), in which many of the concepts and practices are similar to those found in MBSR and MBCT. We also have included Buddhist psychological constructs such as interconnectedness, nonattachment, loving kindness, and compassion into this MBI, which is consistent with the development of second-generation MBI (Van Gordon & Shonin, 2020). Tones and wordings were calibrated among the three conditions. There were program-specific gadgets to facilitate participants' learning; these included

the “If-Then plans” in RFCBT, “Practice logbook” in MBI, and “Mental-health quizzes” in EDU. Because of length constraints, details of each condition conforming to the template for intervention description and replication checklist (TIDieR; Hoffmann et al., 2014) were presented in Appendix 1 of the [Supporting Information](#).

Measurement

The Chinese version of the following validated instruments was administered to participants at baseline, end of program, 3-month follow-up, and 9-month follow-up. All assessments were administered online.

Rumination

The 22-item RRS (Nolen-Hoeksema & Morrow, 1991) was used to assess the frequency of ruminative responses to depressed mood, with items relating to the self (e.g. “Think about all your shortcomings, failings, faults and mistakes”), one’s symptoms (e.g. “Think about how sad you feel”), and reflections on one’s mood (e.g. “Analyze recent events to try to understand why you are depressed”). Participants rated on a 4-point Likert-type scale from 1 (almost never) to 4 (almost always). Higher total scores (ranging from 22 to 88) indicate a greater tendency to ruminate. In the present study at pre-screening, RRS has a Cronbach α of .85.

Worry

The 16-item PSWQ (Meyer et al., 1990) measures participants’ generalized, excessive, and uncontrollable pathological worry. Its items assess frequency (e.g. “I am always worrying about something”), intensity (e.g. “My worries overwhelm me”), and automaticity (e.g. “I know I shouldn’t worry about things, but I just can’t help it”) of worry. Participants rated on a 5-point Likert-type scale from 1 (not at all typical of me) to 5 (very typical of me) and yielded a total score ranging from 16 to 80. In the present study at pre-screening, PSWQ has a Cronbach α of .69.

Depressive and anxiety symptoms

The Chinese version of the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001) and the Generalized Anxiety Disorder Assessment (GAD-7; Spitzer et al., 2006) were used to assess depressive and anxiety symptoms, respectively. PHQ-9 assesses the frequency and severity of symptoms such as depressed mood, loss of interest, appetite, and sleep disturbances. Scores range from 0 to 27, with higher scores indicating more severe depressive symptoms. The GAD-7 consists of seven items that ask about the frequency and severity of symptoms of generalized anxiety disorder, such as worry, restlessness, and difficulty concentrating. Scores range from 0 to 21, with higher scores indicating more severe anxiety symptoms. In the present study, the Cronbach α of PHQ-9 and GAD-7 were .82 and .88 at baseline, respectively.

Sample size estimation

The sample size was calculated based on estimated minimum clinically important differences (MCIDs) for the outcomes on risks using RRS and PSWQ. Because there were no established MCIDs of RRS and PSWQ, we adopted the universally applicable rule of thumb that the MCID is equal to half the standard deviation of the measurement (Norman et al., 2003). Based on prior studies, the standard deviation of RRS for a normative population of young adults is 7.58 (Topper et al., 2017) and 13.4 for PSWQ (Davey & Wells, 2006). The proposed MCIDs are thus a reduction of 3.79 points on the RRS and 6.7 points on the PSWQ. According to an online power calculator (Sealed Envelope, n.d.), 63 participants per condition (189 in total) are required to have an 80% chance of detecting significant difference at the 5% level. With an estimated 20% follow-up attrition rate, the estimated total sample size required was 79 participants per condition (237 in total).

Statistical analysis

All analyses were conducted using IBM SPSS version 26.0 (IBM, 2022). Descriptive statistics of participants' demographics, risk variables (RRS, PSWQ), and symptom variables (PHQ-9, GAD-7) at baseline were obtained. An intention-to-treat (ITT) approach was adopted to evaluate the efficacy of the interventions. A series of linear mixed model (LMM) analyses were conducted where each risk and symptom variable were modeled with time, condition, and their interaction as fixed effects. Unstructured covariance and intercepts were included as random effects. Missingness was handled by restricted maximum likelihood estimation. Mixed models were a well-established method for imputation of missing values using restricted maximum likelihood (Jacobson et al., 1984). Post hoc pairwise comparisons with Bonferroni's adjustment at each level of time and at each level of condition were performed whenever a time \times condition interaction effect was significant.

Pre-post- and pre-follow-up effect sizes (Cohen's d) were calculated by subtracting the pre-post/pre-follow-up (3- and 9-month) change score for each risk and outcome measure from the pre-post/pre-follow-up change score of the condition on that measure and dividing it by the overall estimated pooled standard deviation at baseline for the respective measure (Goulet-Pelletier & Cousineau, 2018). Between-group effect sizes were calculated by subtracting the within-group effect sizes (Cohen's d_{rm}) from each other (Morris & DeShon, 2002).

Karin et al. (2018) recommended that any differences in treatment adherence should be accounted for in a sensitivity test. Because in the attrition analysis, we found that participants' progress significantly differed at various time points, a sensitivity test was conducted following the procedure of Rickardsson et al. (2021), using LMM analysis with progress controlled for as a covariate and accounted for its random effect. Furthermore, given the high attrition, we have also conducted a per-protocol analysis on participants who have finished all course contents, that is completers. Because the results of the sensitivity test and per-protocol analysis did not differ from the main analysis (ITT results), the details were presented in Appendix 2 of the [Supporting Information](#).

RESULTS

Participants characteristics

Participants were recruited between July 2016 and February 2018. A total of 1019 individuals registered, and 256 of them met the inclusion criteria and were randomized to one of the three conditions: RFCBT, MBI, and EDU. See Figure 1 for the CONSORT flow chart.

All 256 participants were retained for analysis. Table 1 shows their demographic characteristics. Although most attributes were comparable, the overall completion rate differed

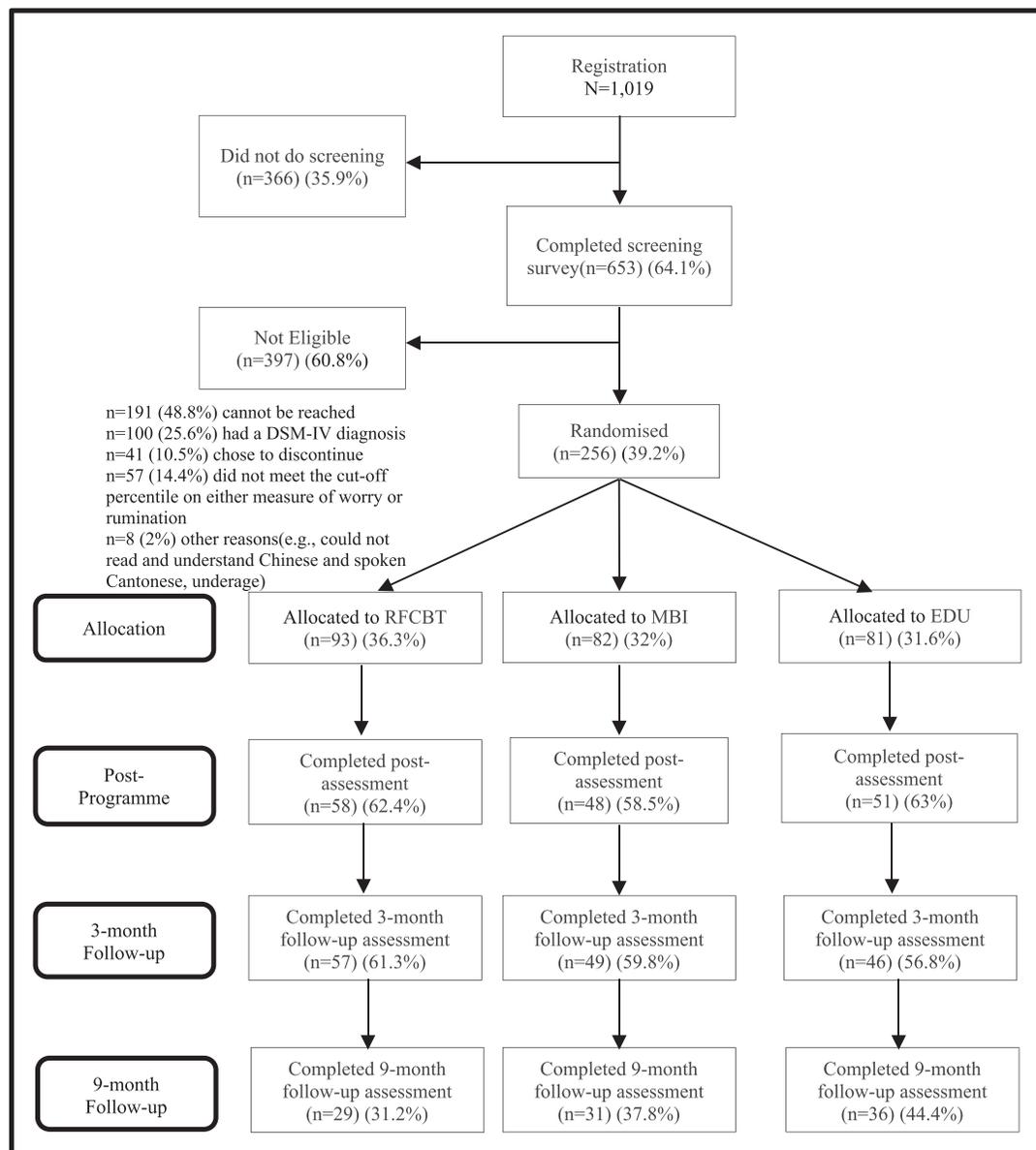


FIGURE 1 CONSORT flowchart of the study.

TABLE 1 Baseline characteristics across conditions.

Demographic/ outcome	Category	Entire sample (<i>n</i> = 256)	RFCBT (<i>n</i> = 93)	MBI (<i>n</i> = 82)	EDU (<i>n</i> = 81)
		<i>M</i> (<i>SD</i>)/ <i>n</i> (%)			
Age (years old)	-	27.64 (9.55)	28.33 (10.62)	26.28 (7.64)	28.21 (9.95)
Gender	Men	70 (27.3%)	26 (28%)	22 (26.8%)	22 (27.2%)
	Women	186 (72.7%)	67 (72%)	60 (73.2%)	59 (72.8%)
Education	Primary or below	3 (1.2%)	3 (3.2%)	0 (0%)	0 (0%)
	Secondary	25 (9.8%)	13 (14%)	7 (8.5%)	5 (6.2%)
	Bachelor/ diploma/ associate degree	178 (69.5%)	60 (64.5%)	57 (69.5%)	61 (75.3%)
	Master or above	50 (19.5%)	17 (18.3%)	18 (22%)	15 (18.5%)
Employment	Student	114 (44.5%)	42 (45.2%)	39 (47.6%)	33 (41.3%)
	Full-time	114 (44.5%)	40 (43%)	37 (45.1%)	37 (46.3%)
	Part-time	12 (4.7%)	6 (6.4%)	3 (3.7%)	3 (3.8%)
	Casual	2 (.8%)	1 (1.1%)	1 (1.2%)	0 (0%)
	Housekeeper	3 (1.2%)	2 (2.2%)	0 (0%)	1 (1.3%)
	Unemployed	7 (2.7%)	1 (1.1%)	1 (1.2%)	5 (6.3%)
	Retired	3 (1.2%)	1 (1.1%)	1 (1.2%)	1 (1.3%)
Monthly income (HKD)	<\$10,000	9 (3.5%)	3 (3.2%)	3 (3.7%)	3 (3.7%)
	\$10,000– \$29,999	86 (33.6%)	31 (33.3%)	28 (34.1%)	27 (33.3%)
	\$30,000– \$59,999	25 (9.8%)	10 (10.8%)	6 (7.3%)	9 (11.1%)
	≥\$60,000	6 (2.3%)	2 (2.2%)	2 (2.4%)	2 (2.5%)
	Did not disclose	127 (49.6%)	46 (49.5%)	41 (50%)	40 (49.4%)
Religion	No religion	158 (61.7%)	60 (64.5%)	57 (69.5%)	41 (51.2%)
	Christians	72 (28.1%)	26 (28%)	17 (20.7%)	29 (36.3%)
	Catholics	13 (5.1%)	4 (4.3%)	4 (4.9%)	5 (6.3%)
	Buddhists	10 (3.9%)	3 (3.2%)	3 (3.7%)	4 (5%)
	Others	2 (.8%)	0 (0%)	1 (1.2%)	1 (1.3%)
Mindfulness experience	Yes	75 (29.3%)	19 (20.4%)	29 (35.4%)	27 (33.3%)
	No	181 (70.7%)	74 (79.6%)	53 (64.6%)	54 (66.7%)
CBT experience	Yes	3 (1.2%)	1 (1.1%)	2 (2.4%)	0 (0%)
	No	253 (98.8%)	92 (98.9%)	80 (97.6%)	81 (100%)

TABLE 1 (Continued)

Demographic/ outcome	Category	Entire sample (<i>n</i> = 256)	RFCBT (<i>n</i> = 93)	MBI (<i>n</i> = 82)	EDU (<i>n</i> = 81)
		<i>M</i> (<i>SD</i>)/ <i>n</i> (%)			
Received psychological treatment in the past 6 months	Yes	16 (6.3%)	6 (6.5%)	7 (8.5%)	3 (3.7%)
	No	240 (93.8%)	87 (93.5%)	75 (91.5%)	78 (96.3%)

Abbreviations: EDU, psychoeducation; MBI, mindfulness-based intervention; N/A, not applicable; RFCBT, rumination-focused cognitive behavioral therapy.

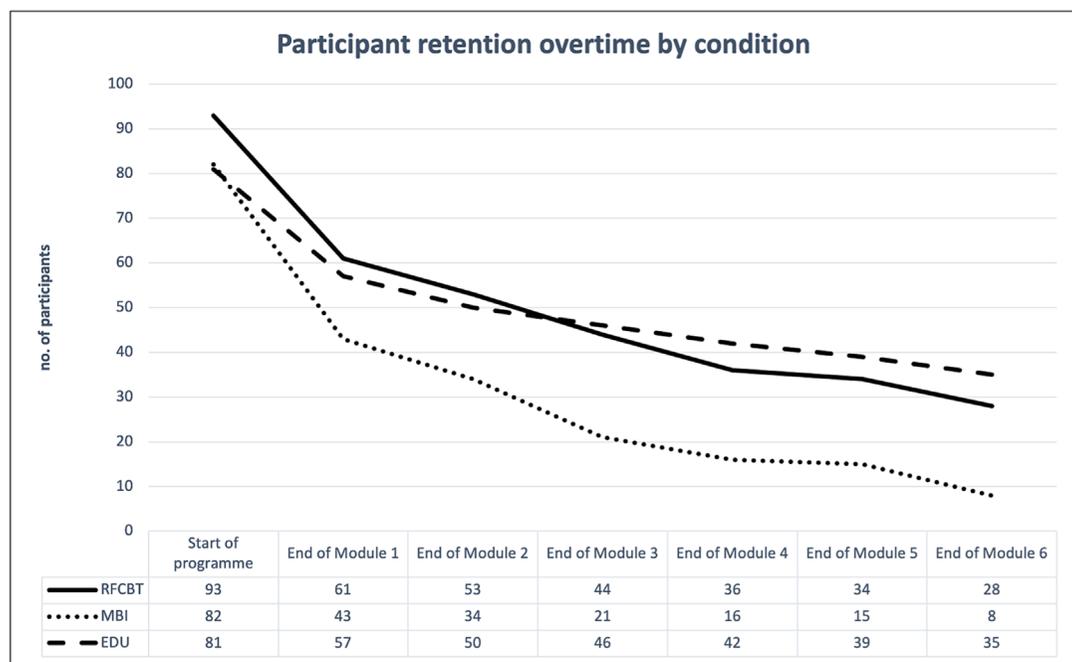


FIGURE 2 Module-by-module retention.

across the conditions, $F(2,253) = 7.7, p < .001$. Post hoc analysis showed that the intervention completion rate, in terms of the percentage of course contents unlocked, of the MBI participants was significantly lower than that of the RFCBT ($p = .011$) and the EDU ($p < .001$) participants. The average completion rate of MBI was 35.8%, which was about two modules and two sessions completed, whereas the average completion rate of RFCBT was 52.7%, which was about three modules and one session completed, and 58.2% for EDU, which is about three modules and two sessions completed. The module-by-module retention rate is illustrated in Figure 2.

Attrition analysis

No significant difference was found in the retention rates at post-program (RFCBT = 62.4%, MBI = 58.5%, EDU = 63%, $\chi[22] = .4$, $p = .818$), 3-month (RFCBT = 61.3%, MBI = 59.8%, EDU = 56.8%, $\chi[22] = .4$, $p = .831$), and at 9-month follow-up (RFCBT = 31.2%, MBI = 37.8%, EDU = 44.4%, $\chi[22] = 3.3$, $p = .197$). Comparing the participants who were retained and dropped out at various time points, they had comparable demographics and similar levels of baseline scores on the risk and outcome variables except for those at post-program. At post-program, people who dropped out had significantly higher baseline levels of worry, $t(254) = 2.47$, $p = .014$, and anxiety symptoms, $t(177.6) = 2.87$, $p = .005$. Table 2 shows the detailed statistics of the attrition analysis.

Main results

Table 3 shows the estimated marginal means and observed means and standard deviations of the risk and outcome variables. Table 4 shows the detailed statistics of within- and between-group effects in each condition.

Efficacy on rumination and worry

With all conditions as a whole, the time effects on rumination and worry were significant (RRS: $F(3,352.3) = 49.9$, $p < .001$; PSWQ: $F(3,372.69) = 33.3$, $p < .001$), indicating an overall reduction in rumination and worry overtime for all participants who used the TourHeart website. The time \times condition interaction was only significant for rumination, $F(6,352) = 2.4$, $p = .025$, but not for worry, $F(6,372.3) = 1.1$, $p = .375$, meaning that the change pattern of rumination varied across the three conditions.

The significant interaction on rumination was followed up by post hoc pairwise comparisons on condition level, that is (1) EDU versus RFCBT, (2) EDU versus MBI, and (3) RFCBT versus MBI. A significant interaction was found when pairing RFCBT and MBI, $F(3,233.59) = 4.7$, $p = .003$. Specifically for participants in RFCBT, rumination dropped from baseline to post-programs as with the two other conditions. However, a significant increase ($p = .041$) in RRS, that is rebound, was noted at 3-month follow-up. Later at 9-month follow-up, rumination scores went down again.

For participants in MBI, RRS scores returned to baseline level in the long term as indicated by the nonsignificant difference comparing the baseline and 9-month follow-up ($p = .177$). In other words, the improvement on rumination did not maintain among MBI participants. Figures 3 and 4 show the illustrations of the change in risks across time in each condition.

Efficacy on depressive and anxiety symptoms

The time effects on depressive and anxiety symptoms were both significant (PHQ-9: $F(3,375.62) = 52.7$, $p < .001$; GAD-7: $F(3,357.31) = 57.6$, $p < .001$). All participants experienced a reduction in their symptoms after using the website. However, an absence of significant time \times condition interaction (PHQ-9: $F(6,375.48) = .9$, $p = .493$; GAD-7: $F(6,357.31) = .62$,

TABLE 2 Baseline characteristics between retained and dropout participants at baseline.

Variable	Post-program			3-month follow-up			9-month follow-up		
	Retained (n = 157) M (SD)/n (%)	Dropped (n = 99) M (SD)/n (%)	t/ χ^2 , p	Retained (n = 152) M (SD)/n (%)	Dropped (n = 104) M (SD)/n (%)	t/ χ^2 , p	Retained (n = 96) M (SD)/n (%)	Dropped (n = 160) M (SD)/n (%)	t/ χ^2 , p
Age	27.88 (10.27)	27.25 (8.32)	-5.610	27.53 (9.43)	27.80 (9.77)	-2.824	28.55 (9.03)	27.09 (9.84)	1.19, .236
Gender			.1, .789			.5, .486			2.31, .128
Men	42 (26.8%)	28 (28.3%)		44 (28.9%)	26 (25%)		21 (21.9%)	49 (30.6%)	
Women	115 (73.2%)	71 (71.7%)		108 (71.1%)	78 (75%)		75 (78.1%)	111 (69.4%)	
Education			2.4, .496			5.5, .139			1.99, .574
Primary or below	1 (6%)	2 (2%)		2 (1.3%)	1 (1%)		0 (0%)	3 (1.9%)	
Secondary	13 (8.3%)	12 (12.1%)		10 (6.6%)	15 (14.4%)		9 (9.4%)	16 (10%)	
Bachelor/ diploma	110 (70.1%)	68 (68.7%)		106 (69.7%)	72 (69.2%)		69 (71.9%)	109 (68.1%)	
Master or above	33 (21%)	17 (17.2%)		34 (22.4%)	16 (15.4%)		18 (18.8%)	32 (20%)	
Rumination	52.62 (8.66)	53.11 (9.88)	.4, .679	52.55 (8.83)	53.2 (9.59)	-6.574	52.86 (8.95)	52.78 (9.27)	.07, .944
Worry	48.59 (6.80)	50.75 (6.88)	2.5*, .014	48.77 (6.80)	50.38 (6.96)	-1.8, .067	48.35 (6.09)	50.06 (7.29)	-1.93, .055
Depressive symptoms	8.15 (4.64)	9.06 (4.82)	1.5, .134	8.41 (4.75)	8.63 (4.70)	-4.715	8.09 (5.05)	8.75 (4.51)	-1.08, .282
Anxiety symptoms	7.41 (4.15)	9.16 (5.09)	2.9**, .005	7.66 (4.44)	8.71 (4.79)	-1.8, .074	7.45 (4.67)	8.48 (4.54)	-1.73, .084
Progress of completion	66.98 (36.35)	20.03 (22.97)	-11.4***, <.001	61.95 (37.60)	30.09 (33.10)	-6.7***, <.001	65.64 (38.04)	39.03 (36.25)	-5.58***, <.001

Abbreviations: M, mean; SD, standard deviation.

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

TABLE 3 Observed and estimated marginal means across conditions.

Outcome	Time point	RFCBT		MBI		EDU	
		<i>M (SD)</i> — observed ^a	<i>M (SE)</i> — estimated	<i>M (SD)</i> — observed ^a	<i>M (SE)</i> — estimated	<i>M (SD)</i> — observed ^a	<i>M (SE)</i> — estimated
Rumination (RRS)	Baseline	51.78 (9.76)	-	53.07 (8.87)	-	53.73 (8.63)	-
	Post-program	43.84 (9.42)	43.71 (1.17)	45.47 (8.19)	45.64 (1.31)	45.20 (8.20)	45.51 (1.26)
	3-month follow-up	47.13 (10.97)	47.25 (1.24)	44.19 (9.86)	43.88 (1.38)	44.78 (10.53)	45.05 (1.39)
	9-month follow-up	44.00 (10.72)	44.45 (1.73)	49.23 (9.92)	48.93 (1.82)	44.90 (10.43)	45.95 (1.60)
Worry (PSWQ)	Baseline	49.60 (7.63)	-	49.63 (5.36)	-	49.00 (7.45)	-
	Post-program	43.67 (6.75)	44.05 (.87)	45.18 (5.00)	45.63 (.98)	44.40 (7.13)	44.71 (.94)
	3-month follow-up	45.04 (7.41)	45.18 (.92)	45.31 (7.20)	45.94 (1.02)	43.17 (8.57)	43.02 (1.03)
	9-month follow-up	44.21 (7.42)	44.28 (1.28)	45.86 (6.42)	46.92 (1.35)	42.73 (8.16)	43.76 (1.18)
Depressive symptoms (PHQ-9)	Baseline	8.08 (4.85)	-	8.96 (4.67)	-	8.53 (4.63)	-
	Post-program	4.86 (4.02)	4.94 (.52)	4.90 (3.60)	5.12 (.57)	4.61 (3.29)	4.78 (.56)
	3-month follow-up	5.58 (4.52)	5.65 (.54)	5.18 (3.74)	5.22 (.58)	4.52 (3.98)	4.47 (.59)
	9-month follow-up	4.93 (4.37)	4.92 (.72)	5.90 (4.13)	6.13 (.71)	4.39 (2.93)	4.93 (.66)
Anxiety symptoms (GAD-7)	Baseline	7.62 (4.48)	-	8.45 (4.80)	-	8.26 (4.56)	-
	Post-program	4.19 (3.61)	4.35 (.51)	4.33 (3.35)	4.87 (.56)	4.53 (3.65)	5.03 (.55)
	3-month follow-up	4.70 (3.55)	4.66 (.53)	4.24 (3.26)	4.38 (.57)	4.57 (4.59)	4.75 (.58)
	9-month follow-up	4.00 (4.27)	3.95 (.70)	5.06 (4.43)	5.41 (.68)	4.08 (3.71)	4.82 (.64)

Abbreviations: EDU, psychoeducation; GAD-7, Generalized Anxiety Disorder-7; M, mean; MBI, mindfulness-based intervention; PHQ-9, Patient Health Questionnaire-9; PSWQ, Penn State Worry Questionnaire; RRS, Rumination Response Scale; SD, standard deviation, SE, standard error; RFCBT, rumination-focused cognitive behavioral therapy.

^aSample size varied across time points.

TABLE 4 Within-group and between-group differences at various time points compared with baseline by conditions.

Condition	Outcome	Baseline to post-program			Baseline to 3-month follow-up			Baseline to 9-month follow-up		
		Mean diff (SE)	95% CI	Cohen's <i>d</i> (<i>d_{mt}^a</i> , <i>d_{between}</i>)	Mean diff (SE)	95% CI	Cohen's <i>d</i> (<i>d_{mt}^a</i> , <i>d_{between}</i>)	Mean diff (SE)	95% CI	Cohen's <i>d</i> (<i>d_{mt}^a</i> , <i>d_{between}</i>)
RFCBT (<i>n</i> = 93)	Rumination (RRS)	-8.08 (1.14)**	-11.11 to -5.04	.87, -.01	-4.54 (1.31)*	-8.03 to -1.05	.48, -.44	-7.33 (1.80)**	-12.11 to -2.55	.77, .05
	Worry (PSWQ)	-5.56 (.87)**	-7.88 to -3.24	.81, .19	-4.42 (.97)**	-6.99 to -1.84	.63, -.22	-5.32 (1.32)**	-8.83 to -1.81	.76, -.02
	Depressive symptoms (PHQ-9)	-3.14 (.52)**	-4.53 to -1.75	.76, -.14	-2.43 (.58)**	-3.97 to -.88	.58, -.40	-3.15 (.76)**	-5.18 to -1.13	.76, -.11
MBI (<i>n</i> = 82)	Anxiety symptoms (GAD-7)	-3.28 (.50)**	-4.60 to -1.95	.80, .01	-2.96 (.55)**	-4.41 to -1.51	.72, -.13	-3.68 (.72)**	-2.62 to -1.18	.90, .06
	Rumination (RRS)	-7.43 (1.29)**	-10.84 to -4.02	.79, -.09	-9.19 (1.45)**	-13.04 to -5.34	.96, -.04	-4.15 (1.90)	-9.18 to .89	.43, -.39
	Worry (PSWQ)	-4.01 (.98)**	-6.61 to -1.40	.58, -.04	-3.69 (1.07)*	-6.54 to -.85	.52, -.33	-2.71 (1.39)	-6.40 to .98	.38, -.36
EDU (<i>n</i> = 81)	Depressive symptoms (PHQ-9)	-3.84 (.57)**	-5.36 to -2.32	.93, .03	-3.75 (.63)**	-5.41 to -2.09	.90, -.08	-2.84 (.76)*	-4.84 to -.83	.68, -.19
	Anxiety symptoms (GAD-7)	-3.59 (.55)**	-2.14 to -5.04	.88, .09	-4.07 (.59)**	-5.63 to -2.51	.99, .14	-3.04 (.71)**	-4.92 to -1.16	.77, -.07
	Rumination (RRS)	-8.22 (1.23)**	-11.50 to -4.94	.88, /	-8.68 (1.46)**	-12.56 to -4.81	.92, /	-7.78 (1.68)**	-12.25 to -3.31	.82, /

(Continues)

TABLE 4 (Continued)

Condition	Outcome	Baseline to post-program			Baseline to 3-month follow-up			Baseline to 9-month follow-up		
		Mean diff (SE)	95% CI	Cohen's d (d_{rm} , $d_{between}$)	Mean diff (SE)	95% CI	Cohen's d (d_{rm} , $d_{between}$)	Mean diff (SE)	95% CI	Cohen's d (d_{rm} , $d_{between}$)
	Worry (PSWQ)	-4.30 (.94)**	-6.80 to -1.79	.62, /	-5.98 (1.08)**	-8.84 to -3.12	.85, /	-5.24 (1.23)**	-8.50 to -1.97	.74, /
	Depressive symptoms (PHQ-9)	-3.75 (.56)**	-5.24 to -2.26	.90, /	-4.06 (.64)**	-5.76 to -2.36	.98, /	-3.60 (.72)**	-5.51 to -2.36	.87, /
	Anxiety symptoms (GAD-7)	-3.23 (.53)**	-4.65 to -1.81	.79, /	-3.51 (.60)**	-5.10 to -1.91	.85, /	-3.44 (.67)**	-5.22 to -1.65	.84, /

Note: Cohen's d_{rm} was computed by subtracting post-course/3-month follow-up score from pre-course score, divided by the pooled standard deviation; Cohen's $d_{between}$ was computed by subtracting the within-group effect sizes (Cohen's d_{rm}) from each other.

Abbreviations: CI: confidence interval; EDU: psychoeducation; GAD-7: Generalized Anxiety Disorder-7; MBI: mindfulness-based intervention; PHQ-9: Patient Health Questionnaire-9; PSWQ: Penn State Worry Questionnaire; RFCBT: rumination-focused cognitive behavioral therapy; RRS: Rumination Response Scale; SE: standard error.

^adirn: Within-group repeated measure effect size; dbetween: Between-group effect size as compared to control (EDU).

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

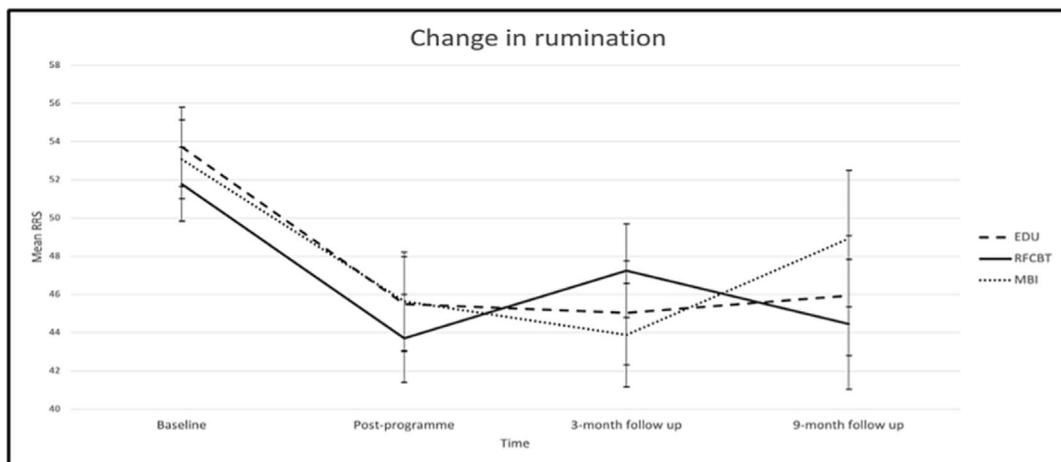


FIGURE 3 Changes in rumination.

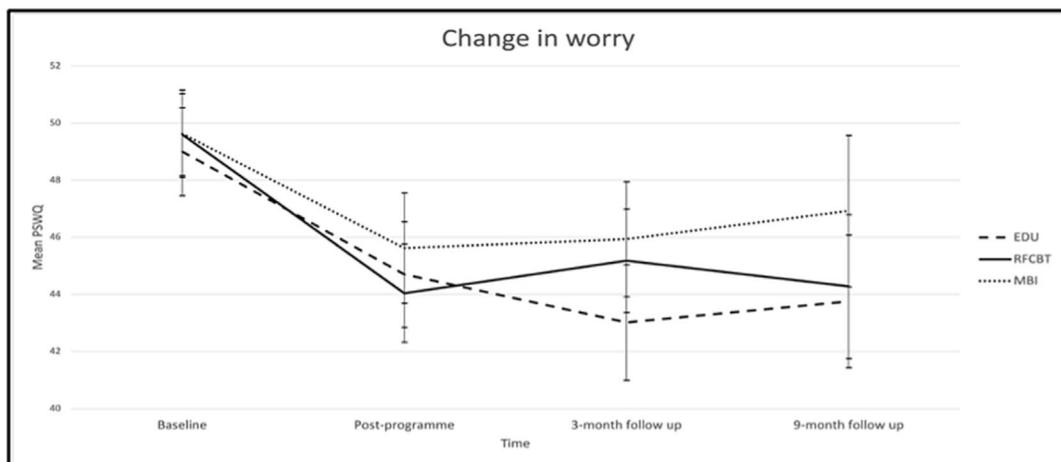


FIGURE 4 Changes in worry.

$p = .713$), indicated identical efficacy in reducing symptoms across the three conditions. Figures 5 and 6 show the illustrations of the change in symptoms across time in each condition.

DISCUSSION

Principal findings

Previous research has recognized rumination and worry as common risk factors for depression and anxiety, respectively (Calmes & Roberts, 2007; Nolen-Hoeksema, 2000). The present study investigated the efficacy of the three “TourHeart” built-in programs in reducing participants’ levels of rumination and worry and symptoms of depression and anxiety using an RCT design. Our primary hypothesis (H1) that MBI and RFCBT would demonstrate superior efficacy, as

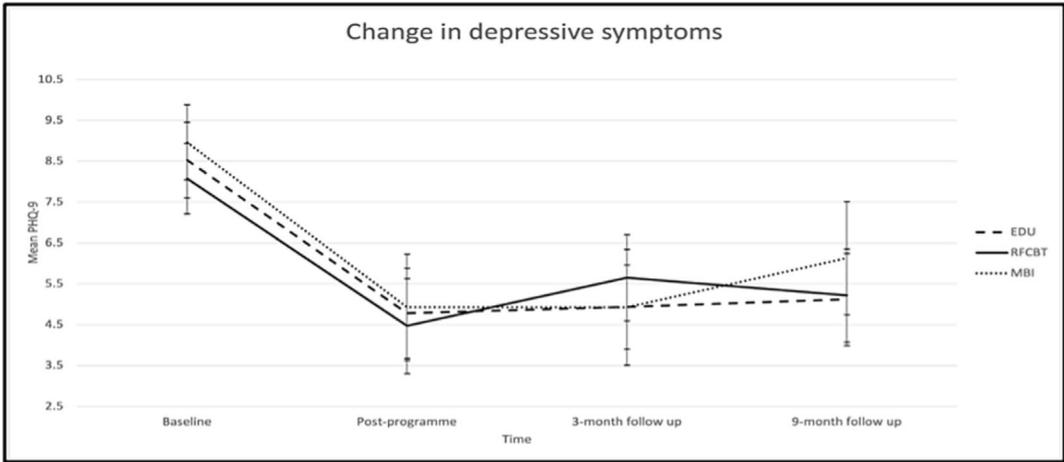


FIGURE 5 Changes in depressive symptoms.

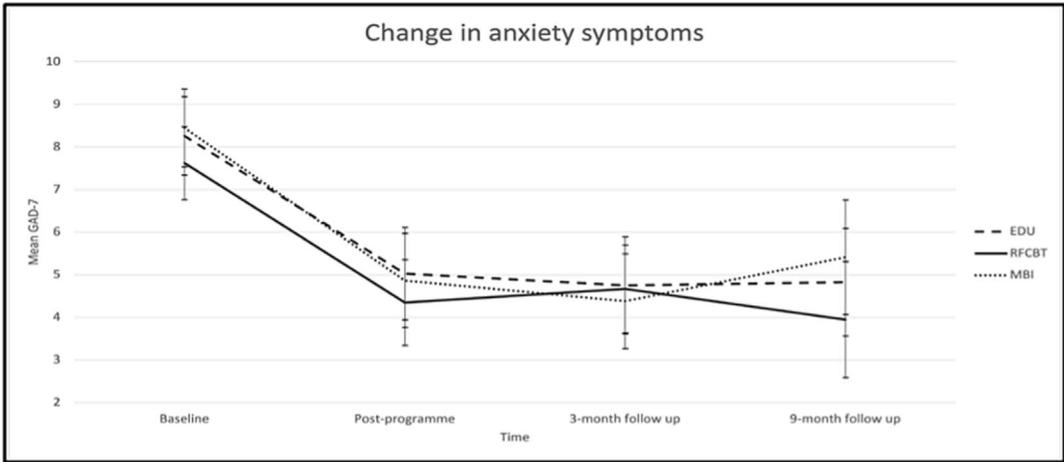


FIGURE 6 Changes in anxiety symptoms.

compared with EDU, was not supported as all three conditions significantly reduced rumination and worry, as well as depressive and anxiety symptoms at post-program and follow-ups with comparable effect sizes. This is in contrast with the majority of previous work that found RFCBT and MBI to be more efficacious in reducing rumination and worry as compared with a waitlist or usual care control (Cook et al., 2019; Gu et al., 2015; Topper et al., 2017). This finding points to the possibility that either the two active interventions were not efficacious or EDU was therapeutic.

Control conditions in digital-based psychological intervention studies were found to be therapeutic to a certain extent. For example, a waitlist control has an effect size of around -0.23 immediately and -0.29 after an approximate 8 weeks after baseline assessment (Tong et al., 2023). Originally intended to be a placebo control, the EDU condition included factual information related to depression and anxiety, including signs and symptoms, evidence-based treatment options, available resources in the community, stigma, and personal recovery,

without active intervention elements included in RFCBT and MBI. These materials were expected to improve on participants' mental health literacy but not directly on risks and symptoms. Although previous research studies have suggested EDU to be therapeutic (Josephine et al., 2017; Stasiak et al., 2014), we anticipated its effect to be smaller than that of the two active interventions but it was not the case in the present study. One possible explanation could be an encouraging effect of being enrolled in a clinical trial (Andrews, 2001). In the present study, participants were recruited using posters, print, and online advertisements describing an intervention study for people at risk. Given all three programs were delivered under the same website, participants assigned to the EDU browsed the EDU contents on the same website as those in the other two conditions. They might have an impression of receiving an "intervention" and, thus, improve because of an encouraging effect.

Several RCTs conducted in Hong Kong also showed a lack of differences when comparing EDU with active interventions such as mindfulness-based cognitive therapy or self-compassion training (Mak et al., 2018; Wong et al., 2017, 2016). This might point to the general dearth of mental health literacy in Hong Kong (Lui et al., 2016), which makes systematic delivery of scientifically based EDU particularly appealing to the target population and able to instill individuals with hope and encouragement to tackle their risk factors and attend to their well-being. Research also indicated that people in Hong Kong prefer educational contents as they appeared to be scientific and align with the modern Western approach (Wong et al., 2016). These may provide an alternative explanation on why EDU appeared to be effective in this study.

Nonetheless, regression-to-the-mean and spontaneous remission could also be possible. Kendler et al. (1997) found that the median time to naturalistically remit from a depressive episode is about 6 weeks. Therefore, the absence of an absolute no-intervention control comparator leaves open the possibility that these individuals might have been improved anyway during the study period. However, this time effect explanation was insufficient to explain the differential patterns of change on rumination. We speculated that the analytical nature of if-then plans exclusive in RFCBT may contribute to a temporary rebound of rumination at 3 months. During the construction of if-then plans, participants actively analyzed the content of their ruminative thoughts and tried to implement the learned skills to change them. These thoughts might become more salient in their minds. Moreover, difficulties in practicing these plans might be more difficult to overcome without active guidance from the coaches after the intervention was over. This might lead to more ruminations temporarily.

RFCBT is explicitly designed to change the repetitive negative thinking habit, and this might take more time to consolidate. Although rumination may reduce within a short period of time, only with meaningful habit change could these improvements be maintained in the long run. As the time impact fades, those who have internalized the change strategies (i.e. if-then plans) taught in RFCBT might show a "second-wind" reduction in rumination at a longer term such as at 9 months later. This is consistent with the argument of rumination being a habit (Watkins & Nolen-Hoeksema, 2014; Watkins & Roberts, 2020). That said, it is still unclear why participants in the EDU can maintain their improvements through 9 months. The long-term efficacy of fully unguided EDU warrants future exploration.

Our second hypothesis (H2) regarding the comparable efficacy between RFCBT and MBI was partially supported as RFCBT and MBI did not significantly differ in their effects on worry but on rumination. MBI failed to produce a long-term effect on rumination, contrasting with the latest meta-analysis that found sustained long-term benefits of online MBIs on psychological outcomes (Sommers-Spijkerman et al., 2021).

The low module completion rate of MBI may be one reason. Some researchers (Crane et al., 2017; Del Re et al., 2013; Goldberg et al., 2014, 2020) highlighted the importance of practice quality to bring about long-term effects. High-quality practice requires appropriate effort and attitudes during mindfulness practice. In doing so, practitioners acquire and sustain a different mindset through mindfulness practices. In the present study, the average completion rate among MBI participants was the lowest (35.79%) and only 9.8% of them (8/82) completed all six modules, implying that a substantial proportion of participants in MBI did not go through later sessions and missed the opportunities to learn important concepts such as non-reactivity to negative thoughts, acceptance of emotions, and interconnectedness. They have also missed the planning exercise that aims to promote regular practice in the final module. These might negatively impact their practice frequency and quality and, as a result, diminish the long-term benefits of MBI.

Limitation

One major limitation of the study was the high attrition rates, with about 30% lost at post-program, 40% lost at 3-month follow-up, and as high as 70% lost at 9-month follow-up. Despite using maximum likelihood modeling to handle missing data, the interpretation of the findings should be made with caution. It has long been suggested that Internet-based mental health interventions are prone to having high dropout rates (Christensen et al., 2009). Richards and Richardson (2012) reported an overall dropout rate of 57% in their meta-analysis on 40 computer-based intervention studies that provided such data. Interventions that provided support, administrative or therapeutic, were found to have fewer dropouts (28%–38%). Despite we have provided administrative support in the forms of email reminders and coach feedbacks, the dropout rate was still high. From our own experience and other online intervention studies in Hong Kong, high attrition was not uncommon (Lau et al., 2008; Mak et al., 2018). Even if the participants were retained at follow-up assessments, poor engagement during the interventions was observed (Ip et al., 2016; Lau et al., 2015). These suggested a general tendency of low adherence among Hong Kong participants in online intervention studies. For our study, given the focus is on selective prevention for those with elevated risks but not yet experienced diagnosable disorder, their motivation to stay may be even lower and their likelihood of dropping out may be higher given prevention is usually harder to retain users and participants may not perceive an imminent need to engage in the interventions. Nevertheless, such low uptake and engagement are very common in the use of digital self-help interventions for depression and anxiety in the real world (Fleming et al., 2018).

Without in-depth informatics, for example, the time spent on browsing the contents and the frequency of logins but only an overall completion indicator, the impact of nonadherence was not conclusive in this study. Although the sensitivity analysis showed that the progress on each condition did not significantly impact our results, nonetheless, the considerable attrition and weak engagement have limited the generalizability of this study and our confidence in drawing further conclusions based on what we have. Future attempts should investigate more effective ways to engage participants in Internet-based interventions.

In addition, our sample consisted predominantly of women, which may limit the generalizability of the findings. Rumination, worries, depression, and anxiety were found more prominent in women than in men (Cook et al., 2019; Robichaud et al., 2003; Santomauro et al., 2021; Topper et al., 2017). Thus, women may be more inclined to participate in mental health-related

studies because of their higher demand for interventions. Future studies may account for this gender effect by applying stratification to increase the generalizability of study results.

Last but not least, we invited the registrants to our lab for the M.I.N.I. assessment and had trained helpers brief them on using the website for the first time. This was intended to gain participants' trust by demonstrating our rigor. However, considering help-seeking stigma prevails in the Hong Kong community, this face-to-face meeting may be a challenge for some people. An alternative could be to screen over the phone or via virtual meeting so that the registrants would not have to reveal their identity throughout the entire study.

Implications

Given the high levels of help-seeking stigma for mental illness and existing mental health services are insufficient to meet the demands in Hong Kong (Yu & Mak, 2022), selective prevention programs may mitigate the risks and reduce symptoms of depression and anxiety in the community. Moreover, a massive demand on Internet-based interventions is observed since the COVID-19 pandemic when lockdowns stalled many face-to-face services. More importantly, the pandemic has enabled wide-scale acceptance of e-mental health (Wind et al., 2020). The present study provides a timely example that transdiagnostic risks and symptoms of depression and anxiety among people at risk may be reduced after 6 weeks of online psychological interventions and EDU. Although the two active interventions did not demonstrate superior efficacy, they may as well suggest a great potential in unguided EDU on risk reduction and prevention of depression and anxiety.

Conclusion

In conclusion, our results showed that Internet-based RFCBT, MBI, and EDU did not differ in terms of efficacy. There are signs that RFCBT may have more sustaining benefits in reducing rumination and worry compared with that of MBI. Despite our hypotheses failed to gain empirical support, this study added to the literature by addressing the need for effective, easily accessible, and scalable interventions that can help reduce risks and prevent anxiety and depression in the general population. Future studies should explore the role of placebos and the potential of unguided EDU. Researchers should also find ways to improve on uptake and adherence by actively accounting for user experience and conducting user experience testing.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

Data are only available upon request.

ETHICS STATEMENT

Clinical ethics approval was obtained from the Joint Chinese University of Hong Kong, New Territories East Cluster Clinical Research Ethics Committee (Reference No.: CRE- 2014.063), and the Kowloon Central/Kowloon East Cluster Research Ethics Committee of the Hospital Authority (Reference No.: KC/KE-16-0213/ER-3).

CLINICAL TRIAL REGISTRATION

Trial Registration: Chinese Clinical Trial Registry (Trial no: ChiCTR-IOR-15006470).

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

Upon request.

ORCID

Winnie W. S. Mak  <https://orcid.org/0000-0002-9714-7847>

Alan C. Y. Tong  <https://orcid.org/0000-0002-3158-0939>

Edward R. Watkins  <https://orcid.org/0000-0002-2432-5577>

Wacy W. S. Lui  <https://orcid.org/0000-0003-1006-1707>

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