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# Combining internet-delivered cognitive behavioural therapy and attention bias modification for reducing depressive symptoms in firefighters: a randomized controlled trial

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## Abstract

**Background:** Firefighters are frequently exposed to traumatic events and stressful environments and are at particularly high risk of depressive symptoms.
**Aims:** The present study aimed to examine the impact of a combined internet-delivered cognitive behavioral therapy (iCBT) and attention bias modification (ABM) intervention to reduce depressive symptoms in firefighters.
**Method:** The study was a randomized controlled trial carried out in Kunming, China, and involved the recruitment of 138 active firefighters as participants. The intervention lasted for an 8-week duration, during which participants participated in ABM exercises on alternating days and concurrently underwent eight modules of iCBT courses delivered through a smartphone application. Baseline and post-intervention assessments were conducted to evaluate the effects of the intervention.
**Results and Discussion:** Results indicated that the combined iCBT and ABM intervention was significantly effective in reducing symptoms of depression compared with the no intervention control group ($U = 1644$, $p < 0.001$, Wilcoxon $r = 0.280$). No significant change was observed in attention bias post-intervention ($U = 2460$, $p = 0.737$, Wilcoxon $r = 0.039$), while a significant increase was observed in attention-bias variability ($U = 3172$, $p < 0.001$, Wilcoxon $r = -0.287$). This study provides evidence for the effectiveness of the combined iCBT and ABM intervention in reducing depressive symptoms among firefighters. This study provides conceptual support and preliminary evidence for the effectiveness of the combined iCBT and ABM intervention in reducing depressive symptoms among firefighters.

**Keywords:** CBT training; cognitive bias modification; depression

## Introduction

Depression, characterized by feelings of sadness and a lack of interest in activities that were once enjoyable (Herrman *et al.*, 2019), is a common mental health condition that affects nearly 300 million people globally (American Psychiatric Association, 2013; World Health Organization, 2017). In recent years, depression has emerged as the primary cause of long-term disability in the majority of middle- and high-income nations (Harvey *et al.*, 2009; Murray *et al.*, 2012). Furthermore, it has been reported that between 27 and 42% of individuals who experience a major depressive episode will experience additional episodes within the next 20 years, with 12–16% of

cases not achieving remission and ultimately experiencing chronic major depressive disorder (Hardeveld *et al.*, 2013; Hoertel *et al.*, 2017; ten Have *et al.*, 2018).

Considering the data, it is essential to implement effective interventions to prevent and treat depression (Deady *et al.*, 2022). Such preventive strategies are inherently valuable, given that subclinical symptoms are a significant risk factor for the emergence of a depressive episode (Joling et al., 2012). Consequently, within the scope of preventive measures, the focus should be directed towards interventions addressing subclinical depressive symptoms, with the aim of thwarting the evolution into major depressive episodes.

Firefighters, due to their consistent exposure to traumatic events and stressful situations, are at an elevated risk of both subclinical and clinical depression (Saijo *et al.*, 2007; Stanley *et al.*, 2018). A recent study found that the incidence of depression and anxiety in firefighters significantly surpasses that of the general adult population (Hu *et al.*, 2022). A systematic review further supports this, finding that work-related psychosocial stress could influence the likelihood of firefighters experiencing depressive symptoms (Igboanugo *et al.*, 2021). These conclusions highlight the pressing necessity for intervention measures aimed at reducing subclinical symptoms within the firefighting profession.

Cognitive behavioural therapy (CBT) is an evidence-based psychological intervention that is effective in reducing symptoms of depression. A meta-analysis review of the literature revealed that internet-delivered cognitive behavioural therapy (iCBT) interventions demonstrated a significant effect on psychological well-being, with reductions in depressive symptoms and improvements in work effectiveness (Carolan *et al.*, 2017). iCBT possesses a number of advantages over traditional face-to-face or guided iCBT modalities, including accessibility, anonymity, and cost-effectiveness (Fairburn and Patel, 2017). Studies indicate that iCBT can match the effectiveness of traditional CBT, offering a solution to common barriers such as geographical limitations and scheduling constraints, thus appealing to individuals who prefer digital platforms for intervention (Aemissegger *et al.*, 2022; Andersson and Berger, 2021; Linardon *et al.*, 2019). Attention bias modification (ABM) is another effective intervention in reducing depressive symptoms (Li *et al.*, 2016). Previous research has found that individuals with depression tend to pay more attention to negative stimuli (Peckham *et al.*, 2010). ABM works by training individuals to focus their attention on positive or neutral information rather than negative information (Mogg et al., 1995). While the efficacy of both CBT and ABM in mitigating depressive symptoms has been well-documented, research exploring the integration of these two therapies is not yet exhaustive. Recent studies suggest that the combination of ABM with CBT significantly enhances the improvement in depressive symptoms over the use of CBT alone (Zainal *et al.*, 2023). However, the effectiveness of this combined approach in reducing subclinical depressive symptoms has yet to be verified.

Consequently, the primary aim of this study is to investigate the combined effect of iCBT and ABM on reducing subclinical depressive symptoms among firefighters. This exploration aims to enrich our understanding of tackling subclinical depressive symptoms, offering insights that could potentially alleviate the high prevalence of depression within high-risk groups such as firefighters.

## Method

### *Study design*

A randomized controlled trial was conducted in Kunming, China, with two parallel arms, comparing an intervention group with a no intervention control group.

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### Participants

Participants were recruited from the Kunming Training Corps of the National Fire and Rescue Administration. Inclusion criteria included (a) being an active firefighter and age between 18 and 50, (b) having a score greater than zero on the PHQ-9, and (c) having no history of severe depression. Exclusion criteria for the study included: (a) having suicidal ideation or intent, (b) having an active psychotic disorder other than depression, (c) prior participation in a cognitive-behavioural intervention, and (d) concurrent participation in another study. The age 50 cut-off, as opposed to the more common age of 65 for working adults, was specifically chosen based on the demographic structure of frontline firefighters in China. According to Ji (2020), the age distribution of Chinese firefighters is generally younger, with the majority falling between the ages of 18 and 28, and over 30% are aged between 18 and 23 years. Therefore, limiting the age range to 18–50 years ensured that our participant pool was representative of this demographic. Prior to enrolment in the study, all participants were provided with detailed information about the study's aims, procedures, potential benefits, and risks associated with participation. To confirm their comprehension and voluntary agreement to partake in the research trial, informed consent was secured from each participant via an app.

In addition to these, demographic data such as age, marital status, and level of education were collected for each participant to better understand the sample characteristics and to potentially account for these variables in the final analysis. Furthermore, the participants undergo regular medical evaluations to ensure they do not have any mental disorders. This confirms that the participants in our study did not have a confirmed diagnosis of depression.

### Procedure

Following pre-assessment, participants were randomized into an intervention or no intervention control group using an online true random-number service, independent of the investigators. The no intervention control group served as a baseline for comparison with the intervention group to measure the effects of the intervention. This group did not receive any form of intervention and was only required to complete assessments. Following randomization, participants were instructed to download an app on a smartphone, through which they received both assessment and intervention.

The combined intervention lasted for 8 weeks. During the intervention period, participants were instructed to engage in ABM exercises on alternate days and complete the eight modules of the CBT courses over the course of 8 weeks.

### ABM

The dot-probe paradigm was utilized within the ABM procedure (Boettcher *et al.*, 2014). The training sessions consisted of 96 trials, which included facial expression photos depicting happiness, neutrality and sadness, sourced from four male and four female actors. A fixed cross (+) was presented on the centre of the computer screen for a duration of 500 ms before each stimulus display, followed by the presentation of two images portraying distinct emotional expressions, which persisted for 500 ms. After the disappearance of the images, an arrow appeared in the location where they had been displayed, and participants were instructed to select the arrow that corresponded with the presented arrow (a diagram of the task is depicted in Fig. 1). In the ABM procedure, the arrow was consistently presented following the display of a more positive facial expression, such that in the instance of a sad-neutral face pair, the arrow would always appear in the location of the neutral facial expression image.

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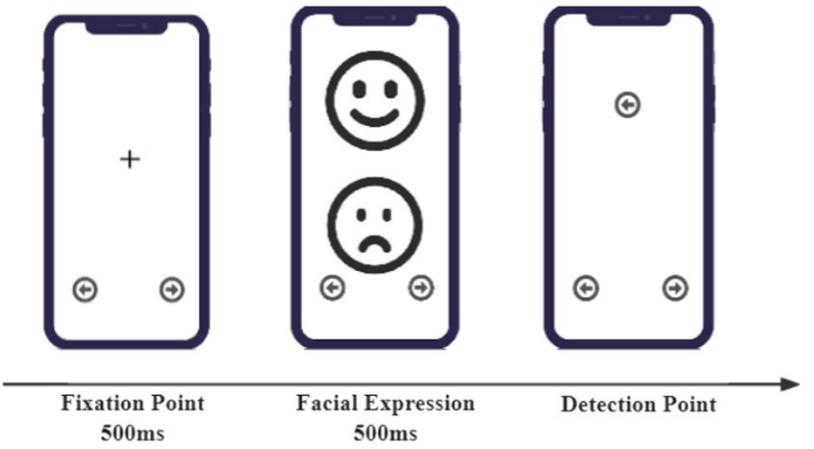


**Figure 1.** Trials of ABM and ABA.

### *Attentional bias assessment*

Attentional bias assessment (ABA) was utilized in both the intervention and control groups as part of the outcome assessments, specifically for the creation of two metrics: attention bias score and attention bias variability. ABA and ABM conditions differed only in the frequency with which the arrows replaced the facial expression photos and across all stimulus materials. In the ABM, the arrow consistently substituted the photos depicting more positive emotions, while in the ABA, there was no established correlation between the type of stimulus and the arrow's appearance location, with the probe appearing with equal frequency at the location of both more negative and more positive stimuli.

### *iCBT*

iCBT was administered in an unguided fashion without human therapeutic support. The iCBT techniques used were inspired by the book chapter *Cognitive-Behavioral Therapy* (Rothbaum *et al.*, 2000). The selection was made in collaboration with clinicians from Central South University's Xiangya Second Hospital and Peking University Sixth Hospital, among others. Furthermore, these techniques were specifically adapted to suit the needs of firefighters. Participants were instructed to progress through the eight core modules over an 8-week period. The modules consisted of psychoeducational content centred on CBT, aimed at promoting the development of skills such as self-monitoring of emotions, cognitive distancing, cognitive reframing/restructuring, problem-solving, and mindfulness. In the event of technical difficulties during the intervention, participants were able to seek assistance.

## Outcome assessments

### *Patient Health Questionnaire-9*

Assessment measures were administered at baseline and post-intervention following the completion of the 8-week intervention program. The Patient Health Questionnaire-9 (PHQ-9) was utilized to assess symptoms of depression. The PHQ-9 is a self-report questionnaire consisting of nine items, with a score range of 0–27, measuring depression-related symptoms experienced in the past 2 weeks (Levis *et al.*, 2019).

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### Attention bias score

To quantify attention bias, response times (RTs) were analysed in accordance with the established procedure to calculate the attention bias score (ABS). Trials characterized by inaccurate responses or RTs of exceptional brevity (<150 ms) or prolonged duration (>1200 ms) were disregarded (Boettcher *et al.*, 2014). The computation of attention bias entailed determining the discrepancy between the mean RT in response to relatively positive stimuli and the mean RT in response to relatively negative stimuli (MacLeod *et al.*, 1986). A preference for happy faces was indicated by an average RT for happy facial expressions that were shorter than the average RT for neutral or sad facial expressions.

### Attention bias variability

To quantify attention bias variability (ABV), the experimental data were divided into eight segments, and attention bias scores were computed for each segment. Subsequently, the standard deviation of attention bias scores across segments was determined, and this value was divided by all trials ABS to account for ABS variability (Epstein *et al.*, 2011).

### Statistical analysis

All statistical analyses were carried out using R version 2.15 (R Development Core Team, 2010). The normality of the data was assessed using Kolmogorov–Smirnov tests. Attrition for the intervention group was measured using a drop-out rate, defined as the number of individuals who did not log in to the app up from this week to the eighth week. Within-group statistical analysis was performed using ANOVA, while between-group analysis was conducted using independent samples *t*-tests for normally distributed data, Mann–Whitney *U*-tests for non-normally distributed data, and Pearson's chi-squared test for categorical data. *Post-hoc* power for the non-parametric tests was measured using Wilcoxon *r*. The test measurement of the data is expressed as means and standard deviation (*SD*). A *p*-value of $<0.05$ was considered statistically significant.

## Results

### Participant enrolment

A total of 424 participants completed the screening questionnaire and provided demographic information. Of those participants, 138 who met the criteria for the study were invited to participate and were subsequently randomized. For intent-to-treat analysis, there were 69 participants in the intervention group and 69 in the control group. The flow of participants through the study phases is shown in Fig. 2. During the 8-week intervention period, the average usage time for the intervention group was 109 min ($SD = 53.67$).

### Descriptive statistics

All participating firefighters were male, with a mean age of 24.86 years ($SD = 2.17$); 97.10% were married, and the remaining were unmarried; 92.03% had an undergraduate degree, and the remaining 7.97% had a graduate degree. There were no significant differences between the two groups in demographic characteristics and depressive symptoms at the baseline. Descriptive statistics for the firefighter participants are presented in Table 1.

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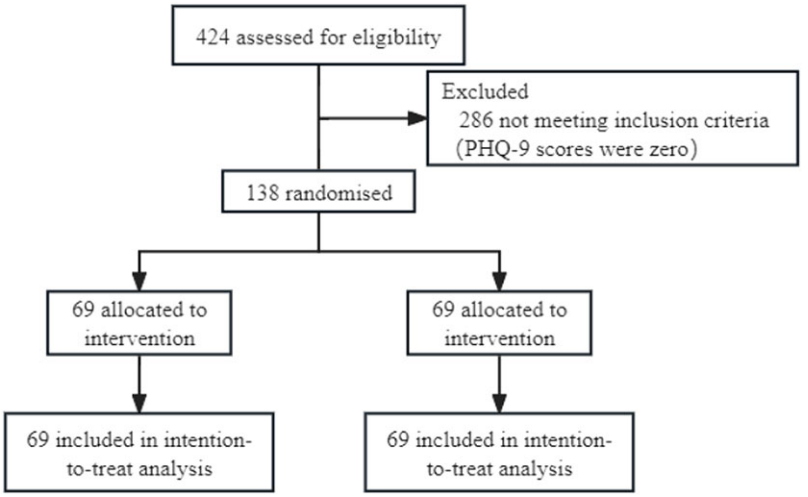


**Figure 2.** CONSORT diagram.

### *Change in depressive symptoms*

Due to non-normality, ANOVA is not applicable. With regard to intragroup variations, the results of the statistical analysis revealed a statistically significant reduction in depressive symptoms from baseline to post-intervention in the intervention groups, $U = 1801$, $p < 0.001$, Wilcoxon $r = 0.525$; in the control group, $U = 475$, $p = 0.060$, Wilcoxon $r = 0.182$. The results of the post-intervention analysis revealed a statistically significant difference in depressive symptoms between intervention and control groups, $U = 1644$, $p < 0.001$, Wilcoxon $r = 0.280$. Figure 3 shows mean scores of PHQ-9 at baseline or post-intervention in the two groups.

### *Change in attention bias and attention bias variability*

The results of ABS and ABV are presented in Table 1. Non-normality of ABS and ABV scores was established via a Kolmogorov–Smirnov test ($p < 0.01$). Analysis of ABS was performed using a repeated measures ANOVA, revealing a group×time interaction ($F_{1,136} = 0.291$, $p = 0.590$), a significant time effect ($F_{1,136} = 1.776$, $p = 0.185$), and a non-significant group effect ($F_{1,136} = 0.110$, $p = 0.740$). A repeated measures ANOVA was also conducted on ABV, indicating a group×time interaction ($F_{1,136} = 1.754$, $p = 0.188$), a significant time effect ($F_{1,136} = 10.824$, $p < 0.001$), and a non-significant group effect ($F_{1,136} = 1.997$, $p = 0.160$).

With regard to intragroup differences, results showed no significant change in ABS from baseline to post-intervention in either the intervention ($U = 1405$, $p = 0.239$, Wilcoxon $r = 0.079$) or control ($U = 1300$, $p = 0.582$, Wilcoxon $r = 0.038$) groups. However, a statistically significant change was found in ABV from baseline to post-intervention in the intervention group ($U = 569$, $p < 0.001$, Wilcoxon $r = -0.278$), while no significant difference was noted in the control group ($U = 1162$, $p = 0.788$, Wilcoxon $r = 0.007$).

### *Attrition*

The attrition analysis for the intervention group revealed that app usage data was available for 68 participants, with one user's data being unavailable. The detailed attrition diagram for the intervention group is depicted in Fig. 4.

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**Table 1.** Sociodemographic characteristics of the participants

| Variable | Control, $N = 69$[a] | Intervention, $N = 69$ | $p$ |
|---|---|---|---|
| **Age** | 25.03 (2.16) [22.00, 32.00] | 24.68 (2.17) [22.00, 33.00] | 0.215 |
| **Marital status** | | | >0.900 |
| Married | 67/69 (97%) | 67/69 (97%) | |
| Unmarried | 2/69 (2.9%) | 2/69 (2.9%) | |
| **Education** | | | 0.346 |
| Graduate | 7/69 (10%) | 4/69 (5.8%) | |
| Undergraduate | 62/69 (90%) | 65/69 (94%) | |
| **PHQ-9 baseline** | 3.25 (2.65) [1.00, 17.00] | 3.45 (2.69) [1.00, 13.00] | 0.647 |
| **PHQ-9 post-intervention** | 3.12 (4.38) [0.00, 26.00] | 1.43 (2.42) [0.00, 9.00] | <0.001 |
| **ABS baseline** | 0.68 (16.01) [−44.14, 42.06] | 1.30 (19.08) [−63.97, 41.58] | 0.737 |
| **ABV baseline** | 0.07 (0.03) [0.03, 0.18] | 0.07 (0.03) [0.03, 0.19] | 0.873 |
| **ABS post-intervention** | −2.02 (27.05) [−130.31, 58.94] | −5.08 (45.76) [−204.06, 120.95] | 0.646 |
| **ABV post-intervention** | 0.11 (0.19) [0.03, 1.07] | 0.14 (0.16) [0.03, 0.85] | <0.001 |

[a]Mean (*SD*) [minimum, maximum]; *n*/*N* (%).

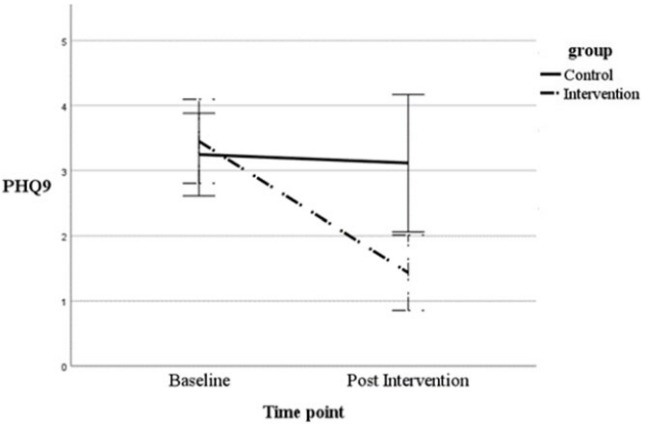


**Figure 3.** Mean scores of PHQ-9 at baseline or post-intervention in different groups.

## Discussion

The present study aimed to investigate the effectiveness of incorporating ABM and CBT interventions to reduce depressive symptoms among firefighters. Participants were recruited from the Kunming Training Corps of the National Fire and Rescue Administration and were administered an 8-week intervention protocol, consisting of an iCBT program and ABM. The findings from the post-intervention assessments suggest that there may be a positive impact on the reduction of depressive symptoms compared with the control condition. The results of this study are consistent with previous findings. Firstly, Zainal *et al.* (2023) demonstrated that integrating ABM with CBT significantly enhances the improvement of depressive symptoms. Secondly, studies by Blairy (2017) and Bodicherla *et al.* (2021) have indicated that ABM can reduce bias towards negative stimuli, which is effective for people with mild depression, and that CBT is effective in reducing depressive symptoms in adolescents.

Similar to the present study, McDermott and Dozois (2019) also focused on the efficacy of ABM and iCBT in reducing depressive symptoms. Participants with subthreshold depression were recruited from first- and second-year undergraduate students and allocated into iCBT, ABM, or

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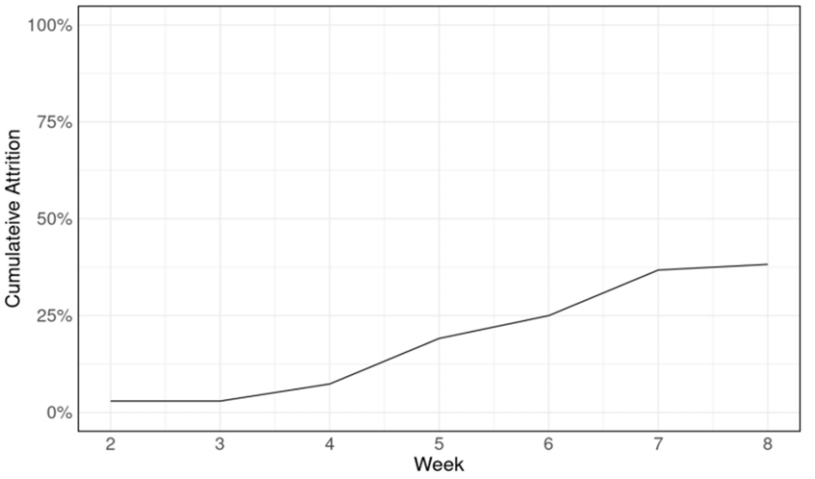


**Figure 4.** Attrition diagram for the intervention group.

control groups. Following a 6-week intervention, the results showed a more substantial improvement in symptoms of depression in the CBT group compared with the ABM group. However, it is important to note that their study differentiated between iCBT and ABM effects by establishing separate groups for each, whereas the present study's unique contribution lies in its examination of the combined effects of iCBT and ABM.

No significant differences in ABS were noted in both intergroup and intragroup. In contrast, a significant difference was observed in ABV baseline and post-intervention, with individuals exhibiting a marked increase in their ABV scores following the intervention. This observation suggests that the intervention did not alter individual attentional biases but increased their fluctuation. The increase in ABV can partially account for the previously reported inconsistencies in the efficacy of attentional bias modification in prior research.

It is important to note that depressive symptoms are not unique to firefighters; they are prevalent among various front-line emergency responders. Paramedics also experience significant mental health challenges. Nguyen *et al.* (2023) found that paramedics exhibited increased symptoms of insomnia and depression across the first 6 months of emergency work. This highlights the broader relevance of our findings and suggests that similar interventions could be beneficial for other front-line emergency responders, who are frequently exposed to high-stress situations and traumatic events.

The limitations of this study must be considered when interpreting the findings. Firstly, the inability to disentangle the individual contributions of ABM and CBT to the overall efficacy of the intervention. Given that both ABM and CBT were administered concurrently, it remains unclear whether one treatment was more effective than the other or if the combination of both was necessary for the observed improvements. To elucidate this, a more rigorous experimental design incorporating a four-arm comparison is warranted. This would include a placebo control, standalone ABM, standalone CBT, and a combination of ABM and CBT. Such a design would allow for a more precise understanding of the mechanisms underlying the intervention's success and clarify the individual and synergistic effects of ABM and CBT. Another limitation that must be noted is the lack of an *a priori* power analysis, which could have guided the sample size determination and thus affected the statistical significance of our findings. Moreover, the sample was homogenous, primarily consisting of married, highly educated individuals from a single fire brigade, which may indeed confer a degree of protection against developing depressive symptoms, as marital status and educational attainment are known influencers of mental health outcomes, and the high level of education may have facilitated better engagement with our online

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intervention components. Furthermore, the exclusive inclusion of male participants in our study limits the generalizability of our findings. This demographic composition reflects the current gender distribution within the firefighting profession, which is predominantly male (Sun *et al.*, 2020). However, it is important to note that depression and the effectiveness of interventions such as iCBT and ABM may differ across genders due to biological, psychological, and social factors. Another limitation is the evaluation of the PHQ-9 scale, which was conducted only at baseline and post-intervention, with no follow-up, limiting the assessment of the durability of the intervention effects over time. Thus, future research can consider including more comprehensive evaluations of socio-demographic factors in larger samples, conducting an *a priori* power analysis, and scheduling multiple follow-ups to address these limitations.

Although there are certain limitations to consider, the two-pronged approach shows promise in reducing depressive symptoms within the studied group. This initial success lays a foundation for further research in this area.

**Data availability statement.** The original contributions presented in the study are included in the article. Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data are not available. Further inquiries can be directed to the corresponding author.

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**Author contributions.** **Xiwen Zhou**: Conceptualization-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Project administration-Equal, Writing - original draft-Equal; **Chengxiong Zhou**: Conceptualization-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Writing - original draft-Equal; **Yexing Zheng**: Conceptualization-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Writing - original draft-Equal; **Huaiyi Li**: Conceptualization-Equal, Data curation-Equal, Formal analysis-Equal, Investigation-Equal, Methodology-Equal, Writing - original draft-Equal; **Chao Tang**: Formal analysis-Equal, Methodology-Equal, Project administration-Equal, Writing - original draft-Equal; **Xiang Liu**: Data curation-Equal, Formal analysis-Equal, Methodology-Equal, Resources-Equal, Software-Equal, Supervision-Equal, Writing - original draft-Equal; **Ming Ma**: Conceptualization-Equal, Data curation-Equal, Formal analysis-Equal, Writing - original draft-Equal; **Jilai Xie**: Conceptualization-Equal, Project administration-Equal, Writing - original draft-Equal; **Dai Li**: Conceptualization-Equal, Data curation-Equal, Methodology-Equal, Project administration-Equal, Software-Equal, Writing - original draft-Equal; **Yuanhui Li**: Data curation-Equal, Formal analysis-Equal, Methodology-Equal, Project administration-Equal, Software-Equal, Writing - original draft-Equal; **Liqun Zhang**: Conceptualization-Equal, Data curation-Equal, Formal analysis-Equal, Methodology-Equal, Software-Equal; **Linlin Du**: Formal analysis-Equal, Funding acquisition-Equal, Methodology-Equal, Project administration-Equal, Supervision-Equal, Writing - original draft-Equal.

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**Competing interests.** Dai Li is the CEO of Adai Technology (Beijing) Co., Ltd. Xiang Liu, Ming Ma, Yuanhui Li, Liqun Zhang and Jilai Xie are employees of Adai Technology (Beijing) Co., Ltd.

**Ethical standards.** The authors have abided by the Ethical Principles of Psychologists and Code of Conduct as set out by the BABCP and BPS. Ethical approval for the study was obtained from the Ethical Committee of the Kunming Training Corps of the National Fire and Rescue Administration (2021#33). The study is in accordance with the Declaration of Helsinki and registered at clinicaltrials.gov NCT05741684.

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