

Attention Control Training for the Prevention of Posttraumatic Stress Disorder in Firefighters: A Randomized Controlled Trial

Xiwen Zhou^{1,a*}, Linlin Du^{1,b}, Hongxia Sun^{2,c}, Huaiyi Li^{1,d}, Xiang Liu^{3,e}, Ming Ma^{3,f}, Jilai Xie^{3,g}

¹Emergency Management Department Fire Rescue Bureau Kunming Training Corps, Kunming 650000, China

²Southwest JiaoTong University, Chendu 610400, China

³Adai Technology (Beijing) Co. Ltd., Beijing 100123, China

Abstract. Background: Firefighters are at high risk for developing posttraumatic stress disorder (PTSD), with attention bias being a contributing factor. Attention Control Training (ACT) is a cognitive behavioral intervention for PTSD treatment and prevention, but its effectiveness for firefighters is unverified. **Methods:** A randomized controlled trial involving the Kunming Training Brigade of the Fire Rescue Bureau assessed the impact of four weeks of ACT exercises on PTSD symptoms, attention bias, and attention-bias variability. **Results:** 180 individuals were randomized into two groups. Within groups, there was a significant decrease in PTSD symptoms from pre- to post-intervention for both the intervention and control groups. Additionally, a comparison of post-intervention PTSD symptoms between the intervention and control groups showed a statistically significant difference, with the intervention group showing lower levels of PTSD symptoms than the control group ($U = 4688$, $p = 0.048$, $r = -0.148$). The post-intervention analysis also revealed a statistically significant difference in ABV between the intervention and control groups, with the intervention group showing a greater reduction in ABV than the control group ($U = 4766$, $p = 0.041$, $r = -0.153$). **Conclusions:** The present study provides evidence that ACT can be an effective intervention for preventing PTSD among firefighters. The study highlights the importance of addressing mental health concerns among firefighters and contributes to the development of effective interventions for the prevention of PTSD among high-risk populations. Further research is needed to determine the long-term effectiveness of the intervention and to examine its generalizability to other populations.

1. Introduction

Research has consistently demonstrated that posttraumatic stress disorder (PTSD) may be one of the most prevalent mental problems following extreme life events^[1]. PTSD can cause significant distress and impairment in various domains of functioning, such as social, occupational, and interpersonal^[2]. Firefighters are exposed to various types of trauma regularly, such as witnessing death and injury, rescuing victims from life-threatening situations, and facing personal danger^[3]. According to previous studies, the prevalence of PTSD among firefighters ranges from 7% to 37%^[4-6]. Hence, developing efficacious strategies for the prevention and treatment of PTSD among this high-risk population is imperative.

Attention bias is one of the factors that may contribute to the development and maintenance of PTSD^[7]. Attention bias refers to the tendency to selectively attend to certain stimuli while ignoring others. In PTSD, attention bias is often directed toward trauma-related stimuli, which can lead to increased anxiety and avoidance behaviors^[8].

Several interventions have been developed to modify attention bias among individuals with PTSD or at risk for developing PTSD. One of them is attention-bias modification (ABM), which involves training individuals to direct their attention away from threat-related stimuli and toward neutral or positive stimuli using computerized tasks^[9]. ABM has been used to treat various mental health disorders, including PTSD. However, the efficacy of ABM for PTSD has been mixed. Some studies have found that ABM is effective in reducing PTSD symptoms, while others have found that it is invalid^[10,11].

Another intervention that targets attention bias is attention-control training (ACT), which is an intervention that targets attention bias by enhancing its flexibility between threatening and neutral stimuli using computerized tasks^[12]. Unlike ABM, which aims to reduce attention bias by altering its direction from threat to neutral, ACT aims to reduce attention bias by enhancing its flexibility between threat and neutral stimuli^[13]. ACT is based on the assumption that being able to flexibly shift one's attention between different types of stimuli can improve cognitive control and emotional regulation skills

* Corresponding author: zhouxiwen369@163.com

^bdl106010601@163.com, ^cs_hongxia33@163.com, ^d49902616@qq.com, ^eliuxiang@adai-tech.com, ^fmaming@adai-tech.com,

^gxiejilai@adai-tech.com

that are beneficial for coping with trauma.

ACT has been shown to be more effective than ABM in reducing PTSD symptoms. A randomized controlled trial (RCT) compares the efficacy of ACT and a novel bias-contingent-ABM (BC-ABM) in treating PTSD in a sample of civilian patients with PTSD^[14]. The study found that ACT yielded greater reductions in PTSD symptoms on both clinician-rated and self-reported measures compared with BC-ABM. This study adds to the growing body of evidence that ACT is an effective treatment for PTSD.

ACT is a cognitive-behavioral intervention that can be used to treat and prevent PTSD. Although ACT has been shown to be effective in treating PTSD^[15], its effectiveness in preventing PTSD among firefighters has not been verified yet. Therefore, the present study aimed to examine the impact of ACT intervention on the prevention of PTSD in firefighters. We hypothesized that firefighters who received ACT would show lower levels of PTSD symptoms than those who received a control condition at post-intervention and follow-up assessments.

The purpose of this research is to examine the effectiveness of ACT as an intervention for preventing PTSD among firefighters, who are regularly exposed to traumatic events and are at high risk for developing PTSD. The significance of this research is that it will contribute to the development of effective interventions for the prevention of PTSD among firefighters. This can help improve the mental health and well-being of firefighters by providing them with a tool to cope with trauma and reduce their risk of developing PTSD.

2. Methods

2.1 Study design

In Kunming, China, a two-armed randomized controlled trial was conducted, where an intervention group was compared to a control group. Ethical approval for the study was obtained from the Ethical Committee of the Training Brigade of the Fire Rescue Bureau of Kunming (2021#33). The study is registered at clinicaltrials.gov (NCT05754164).

2.2 Participants

Participants were firefighters from the Kunming Training Brigade of the Fire Rescue Bureau. The inclusion criteria for the study required that participants have no history of severe mental illness. Exclusion criteria included current suicidal ideation or intent, active psychotic disorders, and use of psychiatric medication.

2.3 Procedure

Following the completion of baseline assessments, participants were randomized to either the control or intervention condition. Subsequently, they were instructed to download a mobile application designed to facilitate both assessment and delivery of the intervention. The

intervention period lasted for four weeks, during which participants engaged in ACT exercises on an every-other-day basis.

2.3.1 ACT

The Dot-Probe Paradigm was employed in the ACT procedure^[14]. The training involved 80 trials that featured photographs of neutral and angry facial expressions. These photographs were taken from a collection of 10 actors with an even gender distribution of five males and five females. A fixed cross (+) was displayed in the center of the computer screen for 500 milliseconds before each stimulus display. This was followed by the presentation of two images showing different emotional expressions for a duration of 500 milliseconds. Once the images vanished, an arrow appeared in their place and participants were instructed to choose the arrow that matched the one shown (A diagram of the task is depicted in Figure 1). During ACT, arrows had an equal likelihood of appearing in both neutral and angry facial expressions.

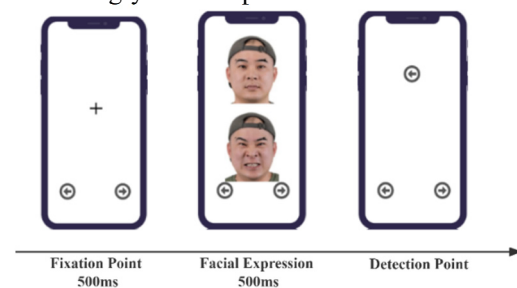


Figure 1. An ACT Trial

2.3.2 Attentional bias assessment

The difference between the Attentional Bias Assessment (ABA) and ACT conditions is that ABA included an additional 40 trials in which two images portraying neutral emotional expressions were displayed. Both ABA and ACT did not have a correlation between the type of stimulus and the location of the arrow's appearance. The probe appeared with equal frequency at both anger and neutral stimuli locations.

2.3.3 Outcomes

Before and after the 4-week intervention program, we conducted an evaluation using PCL-C, which is a 17-item self-report measure to assess the severity of PTSD symptoms experienced by the participants in the past month. The measure corresponds to the DSM-IV criteria for PTSD, and scores range from 17 to 85, with higher scores indicating greater symptom severity. The PCL-C has been shown to have good temporal stability, internal consistency, test-retest reliability, and convergent validity^[16].

2.4 Statistical Analysis

All statistical analyses were conducted utilizing R Version 4.2.1^[17]. Mann-Whitney U-tests were used to compare

non-normally distributed data within groups and between groups. For categorical data, we used Pearson's Chi-squared test. We considered a p -value of less than 0.05 to be statistically significant.

To assess attention bias (ABS), we examined the reaction times (RTs) from the threat-neutral trials. We discarded trials with incorrect responses or RTs that were exceptionally brief ($<150\text{ms}$) or extended ($>1200\text{ms}$)^[18]. Attention bias was determined by calculating the difference between the mean RT to probes following neutral words and those following threat words.

To evaluate attention-bias variability (ABV), we partitioned the experimental data into 8 segments and calculated attention-bias scores for each segment. We then computed the standard deviation of these scores across segments and divided this value by all trials ABS to adjust for ABS variability^[19].

3. Result

3.1 Participant enrolment

Out of 196 individuals who completed the initial screening questionnaire and provided their demographic details, 180 met the study's eligibility requirements and were invited to participate. These participants were then randomized

into two groups: 90 in the intervention group and 90 in the control group. The progression of participants through the various phases of the study is depicted in Figure 2.

3.2 Descriptive Statistics

All participating firefighters were male, with a mean age of 25.13 years ($SD = 2.03$). The majority of participants were married (99.44%) and had obtained an undergraduate degree (92.18%), while a smaller proportion had achieved a graduate degree (7.82%). There were no notable differences between the two groups in terms of demographic characteristics or baseline PTSD symptoms. However, age was found to have statistical significance ($P < 0.001$). Table 1 presents descriptive statistics for the firefighter participants in this study.

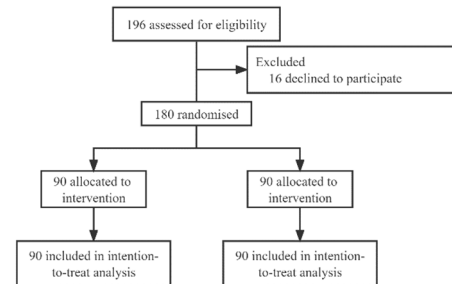


Figure 2. CONSORT Diagram

Table 1 Selected demographics of the participants

Variable	Control, N = 90 ¹	Intervention, N = 90 ¹	p^2
PCL-C Baseline	20.60 (5.11), [17.00,42.00]	22.47 (7.15), [17.00,49.00]	0.058
PCL-C Post-Intervention	19.37 (4.80), [17.00,42.00]	21.17 (7.84), [17.00,69.00]	0.048
Education			0.2
Graduate	10 / 90 (11%)	5 / 90 (5.6%)	
Undergraduate	80 / 90 (89%)	85 / 90 (94%)	
Marriage			>0.9
Married	90 / 90 (100%)	89 / 90 (99%)	
Unmarried	0 / 90 (0%)	1 / 90 (1.1%)	
Age	25.62 (2.18), [22.00,32.00]	24.64 (1.74), [22.00,30.00]	<0.001
ABV Baseline	0.09 (0.05), [0.03,0.42]	0.08 (0.03), [0.02,0.17]	0.469
ABS Baseline	-0.19 (25.40), [-66.34,62.72]	-2.84 (20.78), [-56.28,46.64]	0.718
ABV Post-Intervention	0.08 (0.05), [0.03,0.46]	0.09 (0.03), [0.03,0.17]	0.041
ABS Post-Intervention	-0.55 (27.40), [-56.97,156.94]	-5.64 (23.52), [-68.91,60.26]	0.154

¹ Mean (SD), [Minimum, Maximum]; n / N (%)

² Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test

3.3 Symptom change

A Kolmogorov-Smirnov test confirmed that the PCL-C

scores were not normally distributed ($P < 0.001$). Within groups, there was a significant decrease in PTSD symptoms from pre- to post-intervention for both the intervention groups ($U = 965$, $p < 0.001$, $r = 0.177$) and the control group ($U = 592$, $p < 0.001$, $r = 0.204$).

Additionally, a comparison of post-intervention PTSD symptoms between the intervention and control groups showed a statistically significant difference ($U = 4688$, $p = 0.048$, $r = -0.148$).

3.4 Change in ABV and ABS

Table 1 displays the outcomes for ABS and ABV. A Kolmogorov-Smirnov test indicated that the distribution of ABS and ABV scores was non-normal ($P < 0.001$). No significant intragroup differences were observed in either ABS or ABV from baseline to post-intervention for both the intervention group ($U = 2311$, $p = 0.741$, $r = 0.115$) and control group ($U = 2130$, $p = 0.290$, $r = 0.023$). Nonetheless, a significant difference in post-intervention ABV was found between the intervention and control groups ($U = 4766$, $p = 0.041$, $r = -0.153$).

4. Discussion

The present study aimed to examine the effectiveness of ACT as an intervention for preventing PTSD among firefighters. The results of this study provide evidence that ACT can be an effective intervention for preventing PTSD among firefighters. The findings showed that there was a significant reduction in PTSD symptoms from baseline to post-intervention in both the intervention and control groups. However, the post-intervention analysis revealed a statistically significant difference in PTSD symptoms between the intervention and control groups, with the intervention group showing lower levels of PTSD symptoms than the control group. These findings suggest that ACT may be a promising intervention for preventing PTSD among firefighters.

The results of this study are consistent with previous research that has shown the effectiveness of ACT in treating PTSD^[15]. The present study extends this research by demonstrating the effectiveness of ACT in preventing PTSD among firefighters.

The findings of this study also provide support for ACT being effective in reducing attention bias among firefighters, which may contribute to the prevention of PTSD. The results showed that there was no significant change in ABS or ABV from baseline to post-intervention in either the intervention or control groups. However, the post-intervention analysis revealed a statistically significant difference in ABV between the intervention and control groups, with the intervention group showing a greater reduction in ABV than the control group.

The present study has several limitations that should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, the study only included male firefighters, which may limit the generalizability of the findings to female firefighters or other populations. Third, the assessment of PTSD was limited to baseline and post-intervention evaluations, with no follow-up, which restricts the ability to determine the long-term effectiveness of the intervention.

Despite these limitations, the present study has important implications for the prevention of PTSD among

firefighters. The findings suggest that ACT may be an effective intervention for preventing PTSD among firefighters and that attention bias may be an important target for intervention. These findings have important implications for the development of interventions for the prevention of PTSD among high-risk populations, such as firefighters.

5. Conclusions

In conclusion, the present study provides evidence that ACT can be an effective intervention for preventing PTSD among firefighters. The findings suggest that ACT may be a promising method for improving the mental health and well-being of firefighters by reducing their risk of developing PTSD. The study also highlights the importance of attention bias as a target for intervention in the prevention of PTSD. The results showed that attention bias can be reduced through ACT, which may contribute to the prevention of PTSD. However, further research is needed to determine the long-term effectiveness of the intervention and to examine its generalizability to other populations. Overall, the present study contributes to the development of effective interventions for the prevention of PTSD among high-risk populations and underscores the importance of addressing mental health concerns among firefighters.

Acknowledgments

This paper is one of the phased achievements of the project "Development of Firefighter Intelligent Training and Evaluation Simulation System" (2020XFCX29) funded by Fire and Rescue Bureau of Ministry of Emergency Management.

References

1. An, Y., Wang, M., Ye, Y., & Chen, Y. (2022) The symptom network structure of posttraumatic stress disorder among Chinese firefighters. *Journal of Clinical Psychology*, 78: 1436–1450. <https://doi.org/10.1002/jclp.23305>
2. Jellestad, L., Vital, N. A., Malamud, J., Taeymans, J., & Mueller-Pfeiffer, C. (2021) Functional impairment in Posttraumatic Stress Disorder: A systematic review and meta-analysis. *Journal of Psychiatric Research*, 136: 14–22. <https://doi.org/10.1016/j.jpsychires.2021.01.039>
3. Yuan, H., Ren, L., Ma, Z., Li, F., Liu, J., Jin, Y., Chen, C., Li, X., Wu, Z., Cheng, S., Song, L., Wang, C., Liu, X., & Yang, Q. (2022) Network structure of PTSD symptoms in Chinese male firefighters. *Asian Journal of Psychiatry*, 72: 103062. <https://doi.org/10.1016/j.ajp.2022.103062>
4. Meyer, E. C., Zimering, R., Daly, E., Knight, J., Kamholz, B. W., & Gulliver, S. B. (2012) Predictors of posttraumatic stress disorder and other psychological symptoms in trauma-exposed

- firefighters. *Psychological Services*, 9: 1–15. <https://doi.org/10.1037/a0026414>
5. Call, D., Pitcock, J., & Pyne, J. (2015) Longitudinal Evaluation of the Relationship Between Mindfulness, General Distress, Anxiety, and PTSD in a Recently Deployed National Guard Sample. *Mindfulness*, 6: 1303–1312. <https://doi.org/10.1007/s12671-015-0400-0>
6. Sun, X., Li, X., Huang, J., & An, Y. (2020) Prevalence and predictors of PTSD, depression and posttraumatic growth among Chinese firefighters. *Archives of Psychiatric Nursing*, 34: 14–18. <https://doi.org/10.1016/j.apnu.2019.12.007>
7. Todd, J., Wilson, E., Coutts-Bain, D., & Clarke, P. J. F. (2022) Attentional bias variability and its association with psychological and health symptoms: A meta-analysis. *Neuroscience and Biobehavioral Reviews*, 140: 104812. <https://doi.org/10.1016/j.neubiorev.2022.104812>
8. El Khoury-Malhame, M., Lanteaume, L., Beetz, E. M., Roques, J., Reynaud, E., Samuelian, J.-C., Blin, O., Garcia, R., & Khalfa, S. (2011) Attentional bias in post-traumatic stress disorder diminishes after symptom amelioration. *Behaviour Research and Therapy*, 49: 796–801. <https://doi.org/10.1016/j.brat.2011.08.006>
9. Mogg, K., Waters, A. M., & Bradley, B. P. (2017) Attention Bias Modification (ABM): Review of Effects of Multisession ABM Training on Anxiety and Threat-Related Attention in High-Anxious Individuals. *Clinical Psychological Science*, 5: 698–717. <https://doi.org/10.1177/2167702617696359>
10. Kuckertz, J. M., Amir, N., Boffa, J. W., Warren, C. K., Rindt, S. E. M., Norman, S., Ram, V., Ziajko, L., Webb-Murphy, J., & McLay, R. (2014) The effectiveness of an attention bias modification program as an adjunctive treatment for Post-Traumatic Stress Disorder. *Behaviour Research and Therapy*, 63: 25–35. <https://doi.org/10.1016/j.brat.2014.09.002>
11. Niles, A. N., Woolley, J. D., Tripp, P., Pesquita, A., Vinogradov, S., Neylan, T. C., & O'Donovan, A. (2020) Randomized Controlled Trial Testing Mobile-Based Attention-Bias Modification for Posttraumatic Stress Using Personalized Word Stimuli. *Clinical Psychological Science: A Journal of the Association for Psychological Science*, 8: 756–772. <https://doi.org/10.1177/2167702620902119>
12. Gladwin, T. E. (2017) Negative effects of an alternating-bias training aimed at attentional flexibility: a single session study. *Health Psychology and Behavioral Medicine*, 5: 41–56. <https://doi.org/10.1080/21642850.2016.1266634>
13. Østergaard, T., Lundgren, T., Zettle, R., Jonassen, R., Harmer, C. J., Stiles, T. C., Landrø, N. I., & Haaland, V. Ø. (2018) Acceptance and Commitment Therapy preceded by an experimental Attention Bias Modification procedure in recurrent depression: study protocol for a randomized controlled trial. *Trials*, 19: 203. <https://doi.org/10.1186/s13063-018-2515-9>
14. Lazarov A., Suarez-Jimenez B., Abend R., Naim R., Shvil E., Helpman L., Zhu X., Papini S., Durosoki A., Rom R., Schneier F. R., Pine D. S., Bar-Haim Y., & Neria Y. (2019) Bias-contingent attention bias modification and attention control training in treatment of PTSD: a randomized control trial. *Psychological Medicine*, 49: 2432–2440. <https://doi.org/10.1017/S0033291718003367>
15. Metcalf, O., O'Donnell, M. L., Forbes, D., Bar-Haim, Y., Hodson, S., Bryant, R. A., McFarlane, A. C., Morton, D., Poerio, L., Naim, R., & Varker, T. (2022) Attention-control training as an early intervention for veterans leaving the military: A pilot randomized controlled trial. *Journal of Traumatic Stress*, 35: 1291–1299. <https://doi.org/10.1002/jts.22828>
16. Moodliar, R., Russo, J., Bedard-Gilligan, M., Moloney, K., Johnson, P., Seo, S., Vaziri, N., & Zatzick, D. (2020) A Pragmatic Approach to Psychometric Comparisons between the DSM-IV and DSM-5 Posttraumatic Stress Disorder (PTSD) Checklists in Acutely Injured Trauma Patients. *Psychiatry*, 83: 390–401. <https://doi.org/10.1080/00332747.2020.1762396>
17. R Core Team, R. (2013) *R: A language and environment for statistical computing*. <https://www.r-project.org/>
18. Boettcher, J., Hasselrot, J., Sund, E., Andersson, G., & Carlbring, P. (2014) Combining Attention Training with Internet-Based Cognitive-Behavioural Self-Help for Social Anxiety: A Randomised Controlled Trial. *Cognitive Behaviour Therapy*, 43: 34–48. <https://doi.org/10.1080/16506073.2013.809141>
19. Iacoviello, B. M., Wu, G., Abend, R., Murrough, J. W., Feder, A., Fruchter, E., Levinstein, Y., Wald, I., Bailey, C. R., Pine, D. S., Neumeister, A., Bar-Haim, Y., & Charney, D. S. (2014) Attention Bias Variability and Symptoms of Posttraumatic Stress Disorder. *Journal of Traumatic Stress*, 27: 232–239. <https://doi.org/10.1002/jts.21899>