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Journal of Affective Disorders

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Research paper

# The relationship between mindfulness and mental health among Chinese college students during the closed-loop management of the COVID-19 pandemic: A moderated mediation model

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## ARTICLE INFO

## Keywords:

Closed-loop management  
Mindfulness  
Perceived stress  
Cognitive reappraisal  
Mental health  
College student

## ABSTRACT

To prevent the spread of the COVID-19 epidemic on campus, universities in outbreak areas in China can implement closed-loop management. Objects: This study aimed to explore the relationship between mindfulness and mental health of college students under closed-loop management. Measures: 11,939 college students from a university in Changsha, China participated in the online survey during the closed-loop management period. The Chinese version of Perceived Stress Scale, the Emotion Regulation Questionnaire-Cognitive Reappraisal, the Mindful Attention Awareness Scale, the 7-item General Anxiety Disorder questionnaire, and the 9-item Patient Health Questionnaire were administered to the college students. Results: We found that mindfulness was negative association with mental health during the closed-loop management period. Perceived stress mediated the relationship between mindfulness and mental health. Cognitive reappraisal moderated the relationship between mindfulness and perceived stress. Specifically, when the level of mindfulness is the same, individuals with more cognitive reappraisal tend to experience a less perceived stress. Conclusion: The results of this study are of great significance to improve the mental health of college students during closed-loop management period.

## 1. Introduction

The first case of an unknown pneumonia in the city of Wuhan, Hubei was reported by the World Health Organization (WHO) China Country Office in December 2019. The disease has been named the coronavirus disease 2019 (COVID-19). It has since spread widely in China and even around the world. On March 11, 2020, the WHO declared the COVID-19 a global health crisis and a pandemic (WHO, 2020). Common symptoms of COVID-19 include fever, cough, sore throat, fatigue, and shortness of breath (Jamil et al., 2020). Since then, there have been 64.9 million confirmed cases of COVID-19 and 6.6 million reported deaths (WHO, 2022). Initially, most countries adopted strict quarantine measures, such as closing national borders, locking down cities, restricting private lives (Caro et al., 2022; Lemenager et al., 2021). Three years have passed since the outbreak, many countries are in various phases of relaxing

quarantine requirements while continuing some social distancing measures.

Education is one of the sectors most affected by COVID-19. Nearly 1.6 billion (91.3 %) learners in 194 countries have been affected by suspending schools and universities (UNESCO, 2020). After the initial closure, most universities are back open worldwide. In China, to prevent cross-infection and the spread of the epidemic, some colleges and universities implemented closed-loop management during the local epidemic outbreak.<sup>1</sup> That is, during closed-loop management period, students and teachers do not leave the school and outsiders do not enter the school. Although closed-loop management can effectively prevent the spread of the epidemic on university, the change of life style, temporary social distancing, and the uncertainty of the epidemic have a certain impact on the mental health of college students (Xiao et al., 2021; Yan et al., 2022).

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<sup>1</sup> In December 2022, with the change of China's epidemic control policy, universities no longer implement the closed-loop management policy.

<https://doi.org/10.1016/j.jad.2023.02.012>

Received 24 December 2022; Received in revised form 31 January 2023; Accepted 2 February 2023

Available online 6 February 2023

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### 1.1. The impact of COVID-19 and closed-loop management on the mental health of college students

A meta-analysis of college students' mental health during COVID-19 showed the prevalence of anxiety, depression, and stress was 29 %, 37 %, and 23 %, respectively, among 436,799 college students (Wang et al., 2021). College students' main concerns about COVID-19 are the impact on the economy, daily life, and the delay in their studies (Cao et al., 2020). In addition to anxiety and depression, college students can also suffer from externalization problems, attention problems and sleep problems during COVID-19 (Copeland et al., 2021; Lai et al., 2020). Besides worrying about epidemic, the social distancing brought by closed-loop management is also a source of stress (Brooks et al., 2020; Pfefferbaum and North, 2020; Tsamakis et al., 2020; Nkire et al., 2021).

Previous studies on the impact of the COVID-19 on college students' mental health have focused on the phase of the outbreak (Savage et al., 2020; Li et al., 2021a; Li et al., 2021b; Prowse et al., 2021; Lee et al., 2021), which took place in the first half of 2020. Many colleges and universities responded to the outbreak by suspending classes and offering online courses. But few studies have looked at the impact of the COVID-19 on college students' mental health when schools reopen. In particular, the effect of closed-loop management policies implemented by Chinese universities on the mental health of college students. Because of the closed loop management, students cannot enter and leave the school freely. To some extent, students' freedom is restricted. Hence, Closed-loop management puts students in a situation of relative social isolation. While not the same as social distancing and social isolation during the outbreak of COVID-19, both result in disengagement from social integration (Berkman et al., 2000). Closed-loop management makes college students unable to participate in social activities normally and reduce their contact with friends and family. Studies show people who experienced greater social connectivity disruption during COVID-19 lockdown displayed greater disruption to social processes (Bland et al., 2022), and emotional problems, such as depression, generalized anxiety disorder and acute stress (Marroquín et al., 2020).

### 1.2. Mindfulness and mental health

Mindfulness is defined as conscious non-judgmental attention in the present moment (Kabat-Zinn, 1994). Although levels of mindfulness can be improved through mindfulness-based training (Querstret et al., 2018), mindfulness may also be conceptualized as a psychological trait that refers to the tendency to be mindful in daily life (Brown and Ryan, 2003).

A significant body of research shows that mindfulness improves mental health (Mandal et al., 2012; Kallapiran et al., 2015; Duan, 2016; Bice et al., 2014). As a positive psychological trait, mindfulness disposition can protect individuals from psychological distress caused by social distancing and isolation during COVID-19 (Zhu et al., 2021). As an experience, after mindfulness intervention, participants reported higher mindfulness level and fewer COVID-19-related mental health problems (Weis et al., 2021; Farris et al., 2021; González-García et al., 2021). While the relationship between mindfulness and mental health has been well established, the mechanisms by which they work have not been thoroughly explored.

### 1.3. The mediating role of perceived stress

Perceived stress is the result of a person's appraisal of a stressor as threatening or non-threatening (S. Liu et al., 2021; Z. Liu et al., 2021). Although people may encounter the same life events, their perceived stress may be different (Cohen et al., 1983). Prolonged stress predicts poor mental health and lower quality of life (Marshall et al., 2008; Pidgeon et al., 2014; Prior et al., 2016). High levels of perceived stress increase a person's risk of anxiety and depression. This relationship was confirmed in patients, such as kidney transplant recipients, women with

breast cancer, patients with post-stroke (Laures-Gore and DeFife, 2013; Atas et al., 2021; Li et al., 2021a; Li et al., 2021b), and patients with COVID-19 (Zandifar et al., 2020). During the epidemic, as for the general public higher perceived stress was also found associated with more emotional distress including depression, fear, compulsion-anxiety, neurasthenia, and hypochondria (Yan et al., 2021). In terms of the college students, researchers have observed a positive effect of perceived stress on the anxiety (Zhang et al., 2021) and depression (S. Liu et al., 2021; Z. Liu et al., 2021).

Numerous studies have shown that mindfulness is negatively associated with perceived stress (Jedel et al., 2013; Palmer and Rodger, 2009; Dehghan et al., 2020; Prakash et al., 2015). With an increase in mindfulness as a result of interventions, perceived stress tended to decrease (Cordon et al., 2009; Manotas et al., 2014; Miller et al., 2022; Snippe et al., 2017). Mindfulness practices have also been suggested as a potential intervention to reduce stress during the COVID-19 pandemic (Ho et al., 2020; Lim et al., 2021; Bossi et al., 2022; Fazia et al., 2022). Bao et al. (2015) thought people with high levels of mindfulness are more likely to perceive a better ability to regulate their emotions, which leads to faster recovery from psychological distress and thus less perceived stress.

### 1.4. The moderating role of cognitive reappraisal

Emotion regulation refers to the use of emotion regulation strategies to modify the emotion dynamics and the situations (Gross, 1998; Gross, 2015). It is also considered to be an individual difference characteristic that tends to be relatively stable across time and situations (Gross and John, 2003). Cognitive reappraisal is one well-studied and frequently used emotion regulation strategy (McRae and Gross, 2020). It allows people to change the underlying evaluations that lead to negative emotions (Gross, 1998; Troy et al., 2018). Reappraisal positive emotions means changing the way one thinks in order to increase positive emotions. Reappraisal negative emotions means changing the way a person thinks in order to reduce negative emotions (Nezlek and Kuppens, 2008).

Cognitive reappraisal often is an adaptive option in the face of elevated perceived stress (Shahane et al., 2019). Individuals who believed they had higher cognitive reappraisal abilities tended to report significantly lower perceived stress (Moreira et al., 2022), and vice versa. Kuhlman et al. (2021) found greater COVID-19 impact was associated with more psychiatric symptoms among youth with lower cognitive reappraisal and less use of adaptive humor. Cognitive reappraisal can be improved with intervention. Preuss et al. (2021) conducted an online intervention for parents during the pandemic and found that compared with control group, parents in cognitive reappraisal group perceived less stress.

To investigate the mechanisms between mindfulness and mental health, we conducted this cross-sectional study with a large sample size of Chinese college students during the closed-loop management of the COVID-19 pandemic. Based on literature review, we propose the following hypothesis: (1) Mindfulness would significantly improve mental health, that is, mindfulness would be a significant negative predictor of mental health; (2) Perceived stress would mediate the relationship between mindfulness and mental health; (3) Cognitive reappraisal would moderate the relationship between mindfulness and perceived stress (see Fig. 1 for a visual representation of our hypotheses).

## 2. Methods

### 2.1. Participants

From November 1 to 7, 2022, 11,939 students were recruited from a university in Hunan province, China for the online questionnaires survey. The data were collected after the students went through two months

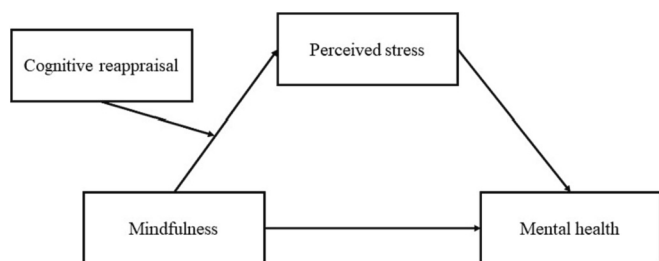


Fig. 1. Hypotheses model of the association between personality traits and stress.

of closed-loop management on university. After excluding participants with inconsistent answers or incomplete demographic questionnaire (minimal information), 11,542 valid questionnaires were obtained. Among them, 5981 were female, accounting for 51.8 %, while 5561 were male, accounting for 48.2 %. They were aged from 16 to 29, with an average age of  $20.21 \pm 4.46$  years old. There were 176 freshmen (1.5 %), 4026 sophomores (34.90 %), 4086 juniors (35.40 %), 3254 seniors (28.2 %). The number of freshmen was very small due to the delay in entering the school according to the COVID-19 prevention and control policies. All participants gave written informed consent in accordance with the Declaration of Helsinki. This study was approved by the Ethics Committee of the second author's university.

## 2.2. Measures

### 2.2.1. Perceived stress

The perceived stress was assessed by the Chinese version of Perceived Stress Scale (CPSS), which measures the degree to which situations in one's life are appraised as stressful (Cohen et al., 1983; Yang and Huang, 2003). The CPSS is a 14-item Likert five-point scale (1, 2, 3, 4 and 5), consisting of two subscales, nervousness and loss of control. The total score from 14 to 70. The higher the score, the more obvious the perceived stress of the participants. The Cronbach  $\alpha$  for the CPSS was 0.85 in this study.

### 2.2.2. Cognitive reappraisal

Emotion Regulation Questionnaire (ERQ, Gross and John, 2003; Wang et al., 2007) is a 10-item measure of two emotion regulation strategies, cognitive reappraisal (ERQ-CR) and expressive suppression (ERQ-ES). In this study, ERQ-CR was used to assess the ability of emotion regulation. The participants were instructed to rate on a 6-item Likert seven-point scale (1, 2, ...7). The total score ranges from 6 to 42. Higher scores indicate more frequent use of emotion-regulating strategies. The Cronbach  $\alpha$  for the ERQ-CR was 0.92 in this study.

### 2.2.3. Mindfulness

The mindfulness was measured by the Mindful Attention Awareness Scale (MAAS), which assesses individual differences in the frequency of mindful states over time (Brown and Ryan, 2003; Chen et al., 2012). MAAS is a six-point Likert scale (1, 2, ...6) with 15 items. The total score ranges from 15 to 90. The level of mindfulness can be seen as a self-regulating indicator of the individual's ability to adapt to stressful events. The higher the score, the better the self-regulation ability. The Cronbach  $\alpha$  for the MAAS was 0.96 in this study.

### 2.2.4. Mental health

Since anxiety and depression were the biggest concerns for researchers during the COVID-19 pandemic, we used anxiety and depression as indicators of mental health in this study.

**2.2.4.1. Anxiety.** The anxiety was assessed by 7-item General Anxiety Disorder (GAD-7) questionnaire (Spitzer et al., 2006; Qu and Sheng,

2015) which is a seven-item, four-point Likert scale, with options ranging from 0 (never) to 3 (nearly every day). The total score is from 0 to 21. As GAD-7 scores goes from mild to moderate to severe (total score 0–4 = minimal, 5–9 = mild, 10–14 = moderate, 15–21 = severe), there is a substantial stepwise increase in anxiety level. The Cronbach  $\alpha$  for the GAD-7 was 0.94 in this study.

**2.2.4.2. Depression.** The depression was assessed by 9-item Patient Health Questionnaire (PHQ-9). The PHQ-9 is a nine-item, self-report depression module of the full PHQ (Kroenke and Spitzer, 2002; Lai et al., 2010). PHQ-9 is based on the nine diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) and is used to diagnose major depressive Disorder (MDD). Each question is scored from "0" to "3" (0, not at all; 1, several days; 2, more than half of all the days; 3, nearly every day). The total scores from 0 to 27. As PHQ-9 scores goes from mild to moderate to severe (total score 0–4 = minimal, 5–9 = mild, 10–14 = moderate, 15–19 = moderately severe, 20–27 = severe) (Saragoussi et al., 2018), there is a substantial stepwise increase in anxiety level. The Cronbach  $\alpha$  for the PHQ-9 was 0.93 in this study.

## 2.3. Statistical analysis

The data were analyzed by SPSS 25.0 and Mplus 7.0. The quantitative data were expressed as mean  $\pm$  standard deviation. Correlation analysis of the variables was investigated by Pearson correlation analysis.  $p < 0.05$  means that the difference has statistical significance. Anxiety and depression, which researchers pay most attention to, are taken as manifest variables of mental health (latent variable). Path analyses were performed to test the mediating and moderating effects. The effects were estimated by applying the bootstrapping methods, which produces 95 % bias-corrected confidence intervals (CI) from 5000 resamples that determine whether the effects were significant (Hayes 2013). A significant effect occurred when the 95%CIs did not contain zero. The variables were standardized in the mediating and moderating analyses.

## 3. Results

### 3.1. Scores of participants in perceived stress, emotion regulation, mindfulness, anxiety and depression

Statistical analysis was conducted to measure scores of participants in perceived stress, emotion regulation, mindfulness, anxiety and depression. The results showed that the score in perceived stress was  $37.09 \pm 8.82$ ; the score in cognitive reappraisal was  $27.87 \pm 6.24$ ; the score in mindfulness was  $59.19 \pm 17.11$ ; the score in anxiety was  $4.19 \pm 4.12$ ; the score in depression was  $4.63 \pm 4.85$ . The scores in each dimension and of the total scale are shown in Table 1.

### 3.2. The score distribution in anxiety and depression

Descriptive analysis of the total scores of GAD-7 showed that 57.8 % of the participants had minimal anxiety, 34.0 % had mild anxiety, 5.6 % had moderate anxiety, 2.6 % had severe anxiety. In term to the PHQ-9, the results showed 57.8 % of the participants had minimal depression, 30.9 % had mild depression, 7.2 % had moderate depression, 2.6 % had

Table 1  
Descriptive analysis of variables.

	Minimum value	Maximum value	M	SD
Perceived stress	14.00	70.00	37.09	8.82
Cognitive reappraisal	6.00	42.00	27.87	6.24
Mindfulness	15.00	90.00	59.19	17.11
Anxiety	0.00	21.00	4.19	4.12
Depression	0.00	27.00	4.63	4.85

moderately severe depression, and 1.6 % had severe depression (see Fig. 2.).

3.3. Correlations among perceived stress, cognitive reappraisal, mindfulness, anxiety and depression

Correlation analysis showed that there was significant correlation among mindfulness, perceived stress, cognitive reappraisal, anxiety, and depression. The correlation coefficients are shown in Table 2.

3.4. Testing for mediation effects

The present study first ran a path analysis to test the hypothesized mediation model, after controlling for gender. The results (Table 3) showed that mindfulness negatively predicted perceived stress ( $\beta = -0.26, p < 0.001$ ), and mental health ( $\beta = -0.03, p < 0.01$ ). Perceived stress positively predicted mental health ( $\beta = 0.68, p < 0.001$ ).

The study then used the bootstrapping method to calculate the mediation effects. For the mediation effects from mindfulness to mental health, the results showed that perceived stress mediated the relation between mindfulness and mental health, indirect effect =  $-0.008$ , 95% CI =  $[-0.086, -0.073]$ , accounting for 86.6 % of the total effect.

3.5. Testing for moderated mediation effects

A path analysis was conducted to test the moderating role of cognitive reappraisal. As presented in Table 4, the results indicated that cognitive reappraisal moderated the link between mindfulness and perceived stress ( $\beta = -0.12, p < 0.001$ ). Fig. 3 illustrates the results of our testing more clearly.

For clarity, this study plotted mindfulness on perceived stress, separately at high and low levels of cognitive reappraisal (1 SD below the mean and 1 SD above the mean; see Fig. 4). Simple slope analyses revealed the effect between mindfulness and perceived stress was negative and significant among college students with high levels of cognitive reappraisal ( $\beta_{simple} = -2.89, p < 0.001, 95\%CI = [-3.069, -2.698]$ ), and among college students with low levels of cognitive reappraisal ( $\beta_{simple} = -1.90, p < 0.001, 95\%CI = [-2.094, -1.692]$ ).

The bootstrap analyses showed that the indirect effect of mindfulness on mental health via perceived stress was moderated by cognitive appraisal. For college student with high levels of cognitive appraisal, the indirect relationship was significant (indirect effect =  $-0.84, SE = 0.031, 95\%CI = [-0.898, -0.778]$ ). For college student with low levels of cognitive reappraisal, the indirect association was also significant (indirect effect =  $-0.55, SE = 0.030, 95\%CI = [-0.610, -0.491]$ ).

Table 2 Pearson bivariate and bilateral correlation coefficient table.

	1	2	3	4	5
1 Perceived stress	–				
2 Cognitive reappraisal	–0.45**	–			
3 Mindfulness	–0.60**	0.33**	–		
4 Anxiety	0.63**	–0.30**	–0.67**	–	
5 Depression	0.61**	–0.33**	–0.63**	0.83**	–

\*\*  $p < 0.01$ .

4. Discussion

The current cross-sectional study explored the relationship between mindfulness and mental health during the closed-loop management of the COVID-19 pandemic in China, and the mediating effect of perceived stress on the mindfulness-mental health relationship as well as the moderating effect of cognitive reappraisal on the mindfulness-perceived stress relationship. The results showed that participants with a higher level of mindfulness reported less mental health problems, including anxiety, depression. Moreover, the mediation model indicated that mindfulness may exert influence on mental health through perceived stress. Furthermore, the relationship of mindfulness and perceived stress was moderated by cognitive reappraisal, to be specific, when the level of mindfulness is the same, individuals with more cognitive reappraisal tend to experience a less perceived stress.

The relative quarantine brought about by closed-loop management has an adverse impact on students' mental health, although closed-loop management is an effective way to prevent students on campus from being infected. Higher levels of anxiety and depression were found among college students in this study compared to surveys conducted during the COVID-19 pandemic in 2020 (Cao et al., 2020; Sun et al., 2021; Chen et al., 2020; Qi et al., 2020). The COVID-19 outbreak coincided with the Chinese New Year holiday, so college students were at home with their families during the quarantine period. As we know, social support is an important protective factor for mental health (Harandi et al., 2017; Qi et al., 2020). While during closed-loop management period, college students are isolated in the school, away from parents and friends, so anxiety and depression levels may be higher.

College students with higher mindfulness experienced less emotional distress during the closed-loop management of COVID-19 outbreak. This finding is in line with previous research (Matiz et al., 2020; Conversano et al., 2020; Zhu et al., 2021). The relationship between mindfulness and mental health is mediated by perceived stress. Stress is associated with the development of number of mental disorders, including clinical depression, anxiety, sleep problems (Bergdahl and Bergdahl, 2002; Zhang et al., 2018). Studies have shown that people who are mindful are

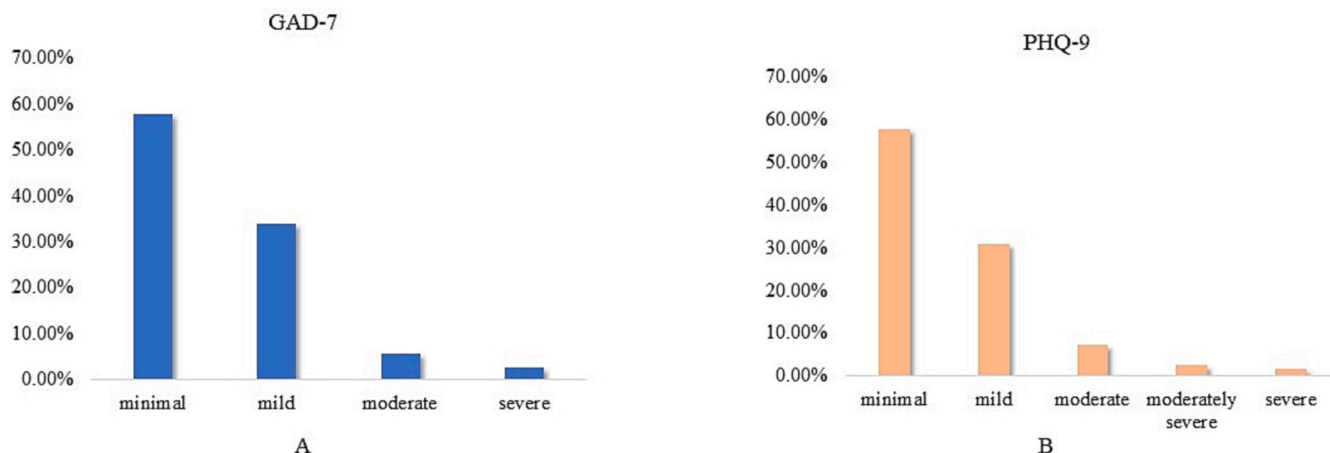


Fig. 2. The distribution of anxiety (A) and depression (B) scores.

**Table 3**  
Testing the mediation effect of perceived stress on mental health via mindfulness.

Predictors	Perceived stress				Mental health			
	Est.	SE	LLCI	ULCI	Est.	SE	LLCI	ULCI
Gender	-0.11***	0.009	-0.124	-0.088	-0.02*	0.008	-0.034	-0.003
Perceived stress					0.68***	0.007	0.660	0.688
Mindfulness	-0.26***	0.009	-0.276	-0.240	-0.03**	0.010	-0.047	-0.007
Anxiety					0.92***	0.004	0.915	0.931
Depression					0.90***	0.004	0.889	0.905
R <sup>2</sup>	0.08***				0.47***			

N = 11,542. Est. standardized coefficients, SE standard error, LLCI lower limit of the 95 % confidence interval, ULCI upper limit of the 95 % confidence interval.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .

**Table 4**  
Testing the moderated mediation effect of emotion regulation on mental health.

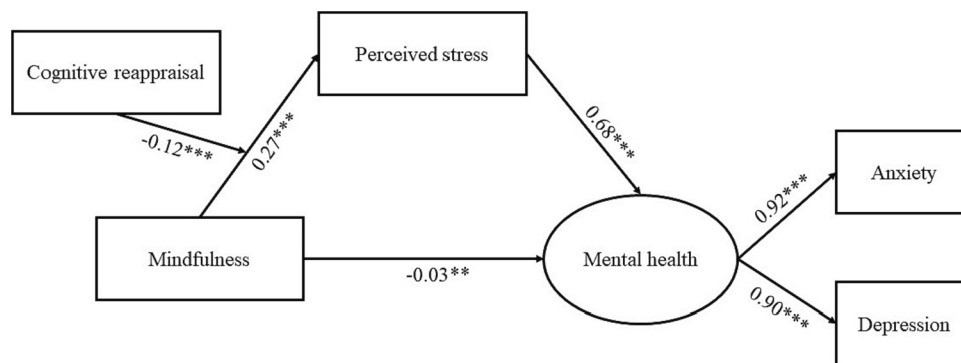
Predictors	Perceived stress				Mental health			
	Est.	SE	LLCI	ULCI	Est.	SE	LLCI	ULCI
Gender	-0.09***	0.008	-0.109	-0.077	-0.02*	0.008	-0.034	-0.004
Perceived stress					0.68***	0.007	0.660	0.688
Mindfulness	-0.27***	0.009	-0.288	-0.254	-0.03**	0.010	-0.047	-0.007
Cognitive reappraisal	0.46***	0.011	0.434	0.478				
Int	-0.12***	0.017	-0.152	-0.087				
Anxiety					0.92***	0.004	0.915	0.931
Depression					0.90***	0.004	0.888	0.904
R <sup>2</sup>	0.26***				0.47***			

N = 11,542. Int = Mindfulness × Emotion regulation, Est. standardized coefficients, SE standard error, LLCI lower limit of the 95 % confidence interval, ULCI upper limit of the 95 % confidence interval.

\*  $p < 0.05$ .

\*\*  $p < 0.01$ .

\*\*\*  $p < 0.001$ .



**Fig. 3.** The results of mediation testing.

more likely to evaluate adverse situations as less stressful and less threatening, and they are more likely to respond to stress in adaptive ways (Weinstein et al., 2009). The mindfulness stress buffering model proposed by Creswell (2015) explains the mechanism of mindfulness in protecting mental health. According to mindfulness stress buffering model, mindfulness alleviates stress appraisals and reduces reactivity to stress, and that these stress-relieving effects partially or completely explain how mindfulness improves mental health. The mindfulness stress buffering model works through two neural circuits: Mindfulness may increase the recruitment of top-down regulatory regions of prefrontal cortex, which may inhibit the reactivity of stress-processing regions (Hölzel et al., 2013; Modinos et al., 2010). At the same time, mindfulness may have direct effects on modulating the reactivity of stress-processing regions (e.g., amygdala, anterior cingulate cortex, ventromedial prefrontal cortex, hypothalamus, parabrachial pons; for a review, see Ulrich-Lai and Herman, 2009).

In this study, we also found the moderating effect of cognitive reappraisal on the relationship between mindfulness and perceived stress. Exposure to daily stressors may be associated with a wide range of negative outcomes, including decreased well-being and increased social and health problems (Richardson, 2017). However, not all people exposed to high levels of stressors experience negative outcomes. It is well established that cognitive reappraisal has a protective effect in the development of both internalizing and externalizing psychopathology (Pepping et al., 2016). For college students with high cognitive reappraisal ability, the negative correlation between mindfulness and perceived stress is stronger, while for college students with low cognitive reappraisal ability, the negative correlation between mindfulness and perceived stress is weaker. Training college students to use this skill effectively may have the potential to provide them with lifelong protection from long-term stressors such as the global COVID-19 pandemic.

Our research results can not only increase our theoretical

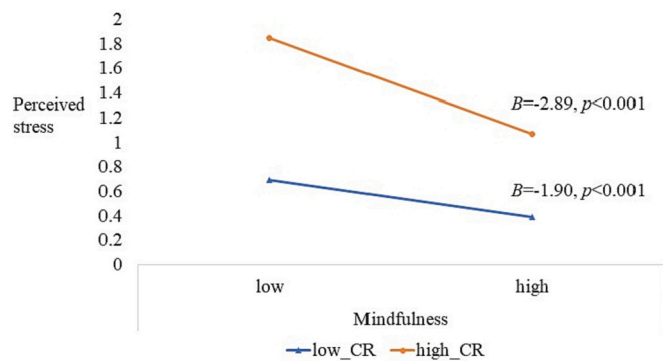


Fig. 4. Cognitive appraisal moderated the relationship between mindfulness and perceived stress. CR = cognitive reappraisal.

understanding, but also have practical significance. Our research sheds light on the relationship between mindfulness and mental health and the role of perceived stress and cognitive reappraisal, which enriches the stress buffering model and provides a reference for further relevant empirical investigations. Additionally, our findings have a direct implication for promoting cognitive reappraisal training among college students (Smith et al., 2019).

These findings should be considered in the context of their limitations. First, the present study was cross-sectional and cannot determine causal relationships among mental health during closed loop management of the COVID-19 pandemic, mindfulness, perceived stress and cognitive reappraisal. Future studies should employ a longitudinal design to examine the mediating and moderating effect. Second, the data might involve subjectivity due to self-reporting by college students in this study. More objective methods should be employed in the future study. Third, we only considered the mediating effects of perceived stress, and there are other roles such as sleep disturbances that should be taken into account in future studies. Last but not least, gender differences were not considered in this study. However, researchers found that females reported the more negative impact of COVID-19 pandemic on their academics, social isolation, stress and mental health compared to males (Prowse et al., 2021). Therefore, the gender differences in stress and coping styles should be further explored in future studies.

In summary, perceived stress and cognitive reappraisal could affect the effect of the closed-loop management during COVID-19 pandemic on college students' mental health. Developing cognitive reappraisal training might be a practicable way of maintaining and improving their mental health during a public health emergency.

## Funding

This research was supported by Hebei Educational Science Planning Project (Grant No. 2203204), Medical Science Foundation of Hebei Education Department, China (Grant No. 2022X04) and Advanced Talents Incubation Program of the Hebei Education Department, China (Grant No. 521100222074).

## CRedit authorship contribution statement

**Jing Yuan:** Conceptualization, Writing – original draft, Funding acquisition. **Fang Sun:** Investigation, Data curation. **Xiaomin Zhao:** Formal analysis. **Zejun Liu:** Writing – review & Editing. **Qing Liang:** Writing – review & editing.

## Conflict of interest

The authors report there are no competing interests to declare.

## Data availability statement

Data, analytical methods, and study materials in this study are available from the corresponding author upon reasonable request.

## Acknowledgement

Thanks to Jing Lv, Yina Chen, Jiawen Han, Yuzhuo Han and Wenjing Liu for their contributions to data input for this study.

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