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Original Article

Perceived stress and sleep quality among the non-diseased general public in China during the 2019 coronavirus disease: a moderated mediation model

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ABSTRACT

Background: The 2019 coronavirus disease (COVID-19) has spread worldwide, and its associated stressors have resulted in decreased sleep quality among front-line workers. However, in China, the general public displayed more psychological problems than the front-line workers during the pandemic. Therefore, we investigated the influence of perceived stress on the sleep quality of the non-diseased general public and developed a moderated mediation model to explain said relationship.
Methods: Questionnaire-based surveys were conducted online from February 18–25, 2020 with 1630 Chinese participants (aged 18–68 years).
Results: Around one-third (36.38%) of participants were poor sleepers during the COVID-19 pandemic. Moreover, higher perceived stress was significantly associated with higher anxiety levels, which, in turn, was associated with lower sleep quality. Self-esteem moderated the indirect effect of perceived stress on sleep quality through its moderation of the effect of perceived stress on anxiety. This indicated that the mediation effect of anxiety was stronger in those with low levels of self-esteem than in those with high levels of self-esteem.
Conclusions: These findings suggest that both the sleep quality and perceived stress levels of the non-diseased general public required attention during the COVID-19 pandemic. Our findings also identify personality characteristics related to better sleep quality, demonstrating the important role of self-esteem in environmental adaptation.

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1. Introduction

Since December 2019, the outbreak of the novel coronavirus disease (COVID-19) has infected more than 80,000 individuals in China, and it has since been declared a global pandemic [1]. According to the World Health Organization's report, by April 30, 2020, 3,090,445 confirmed cases and 217,769 deaths had been reported worldwide. As COVID-19 is highly contagious and no vaccine is currently available, it has become an uncontrollable stressor for many individuals [2].

Exposure to uncontrollable or unpredictable stressors (eg, hurricanes, earthquakes, tsunamis, etc.) can alter individuals' sleep (eg, leading to lower sleep quality, longer sleep latency, increased awareness during the night, and more sleep complaints) [3–5]. Previous studies showed that perceived stress is a major obstacle to sleep and eroded sleep quality [6,7]. Specifically, the higher the perceived stress, the worse the sleep quality [8–13], and the reduction in perceived stress predicted an improvement in sleep quality [7]. Notably, researchers revealed that front-line workers (eg, medical staff) had poor sleep quality during COVID-19 in China [2]; however, a recent study investigated the vicarious traumatization in the general public and front-line medical staff and found the general public displayed more vicarious traumatization than did front-line medical staff during the pandemic [14]. Therefore, we investigated the influence of perceived stress on the sleep quality of the non-diseased general public during the COVID-19 pandemic in China.

Anxiety is defined as an emotional state that includes worry, nervousness, apprehension, and physical arousal [15]. According to

the cognitive theory of emotion, cognitive appraisal is a key factor in determining one's emotional state [16–18]. Anxiety may occur when one's life is appraised as threatening or stressful. Some evidence shows that anxiety levels increase after exposure to stressful events (eg, war, earthquakes, violence, etc. [19–21]) and higher perceived stress is significantly associated with increased anxiety [22–25]. In contrast, it is increasingly clear that anxiety is negatively related to sleep quality. For example, higher anxiety is an important predictor of poor sleep quality, more insomnia symptoms, and longer sleep onset time [26,27]. Notably, higher anxiety predicted lower sleep quality among individuals during the COVID-19 [2]. Thus, we posit that anxiety mediates the influence of perceived stress on sleep quality.

Self-esteem is conceptualized as an individual's sense of self-worth [28–30]. Individuals with high (vs. low) self-esteem can better respond to threats and frustrations and display stronger subjective well-being, meaning in life, positive emotions, and life satisfaction [31,32,29,33,34]. Of note, researchers who utilized Terror Management Theory (TMT) believe that high self-esteem is the result of an individual's adaptation to the environment and serves to buffer against potential anxiety [35,36]. Consistent with TMT theory, a meta-analysis of longitudinal studies showed that higher self-esteem significantly predicted lower anxiety levels [37]. Further, when manipulating self-esteem through personality feedback, researchers found that participants in the high self-esteem condition had lower anxiety levels when facing the stressful stimuli (eg, a video about death) than did participants in the low self-esteem condition [38]. Taken together, self-esteem may moderate the relationship between perceived stress and anxiety; further, it may moderate the indirect effect of perceived stress on sleep quality through anxiety.

Moreover, self-esteem may be a protective factor for sleep. For example, higher self-esteem was related to fewer insomnia symptoms in a large community-based sample of adults aged 30–84 years [39]. Lemola et al. [39], also found that short (<6 h) and long (>9 h) sleep duration that were harmful to health (eg, increasing mortality hazard [40]) were correlated with low self-esteem. Even when dealing with stressful events (ie, hospitalization), self-esteem was positively correlated with children's sleep efficiency [41]. Therefore, it is logical to speculate that people with low self-esteem will have lower sleep quality than people with high self-esteem, especially when facing stressful events. That is, the direct effect of perceived stress on sleep may be moderated by self-esteem.

Considering the above, we investigated the influence of perceived stress on sleep quality among the non-diseased general public during COVID-19 in China. We hypothesized that perceived would be an important predictor of sleep quality. Moreover, we posited that perceived stress would predict increased anxiety levels, which, in turn, would be associated with decreased sleep quality. Finally, we hypothesized that individuals' self-esteem would moderate both the relationship between perceived stress and anxiety and the relationship between perceived stress and sleep quality. In other words, higher perceived stress and lower self-esteem would be correlated with higher anxiety levels which,

in turn, would be associated with lower sleep quality. The moderated mediation model is shown in Fig. 1.

2. Materials and methods

2.1. Participants

A total of 1722 people from 32 provinces or political areas in China were recruited to complete a questionnaire survey. Participants were asked to report both their current health status (non-diseased individuals/individuals with pandemic-related symptoms (eg, fever/suspected patients/confirmed patients/cured cases of COVID-19) and their identity (front-line workers (eg, medical staff)/general public). Among them, 92 participants (13 participants with pandemic-related symptoms, one cured case of COVID-19, and 78 front-line workers) were excluded, resulting in a final sample of 1630 non-diseased members of the general public (mean age = 29.17 ± 10.58 years, age range = 18–68 years). Most participants (83.43%, n = 1360) had at least a college degree. Only 13.19% (n = 215) of participants had left the house to work. In addition, 71.84% (n = 1171) of the participants paid great attention to COVID-19.

2.2. Materials

2.2.1. Perceived Stress Scale (PSS)

Perceived stress levels over the past month were assessed with the Chinese version of the 10-item PSS, which was based on Cohen et al., [42]. This version of the PSS was reliable (Cronbach's α = 0.75) and had satisfactory construct validities in a study of 9507 Chinese individuals (aged ≥ 18 years; education ≥ junior high school; [43]). PSS assesses the extent that individuals believe their lives are overloaded, unpredictable, and uncontrollable (eg, in the last month, how often have you found that you could not cope with all the things that you had to do?). Participants rated the items on a 5-point Likert scale (0 = never, 4 = very often), with higher scores indicating higher perceived stress. Cronbach's α was 0.82 in this study.

2.2.2. Pittsburgh Sleep Quality Index (PSQI)

Global sleep quality over the past month was assessed with the Chinese version of the 19-item PSQI, which was based on Buysse et al., [44]. The Chinese version of the PSQI has good validity and internal consistency (Cronbach's αs = 0.75–0.85 [45–47] and test-retest reliability (0.85 over 14- and 21-day intervals [46]). The seven subscale scores (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction) were summed to calculate a global score. Scores on the PSQI ranged from 0 to 21, with higher scores indicating poorer sleep quality. People with a PSQI score greater than five were defined as "poor sleepers" [44]. Cronbach's α was 0.81 in this study.

2.2.3. Self-Rating Anxiety Scale (SAS)

Anxiety levels during the previous seven days were measured with the Chinese version of the 20-item SAS, which was based on Zung [48]. This version of the SAS is valid and reliable (Cronbach's α = 0.93 [49]. All responses were made using a 4-point Likert scale (1 = never, 4 = very often). Higher scores indicated higher anxiety levels. Cronbach's α was 0.79 in this study.

2.2.4. Rosenberg Self-Esteem Scale (RSE)

The Chinese revision of the RSE scale, based on Rosenberg [30], was used to measure overall self-esteem. Previous studies showed this version of the RSE to have good internal consistency
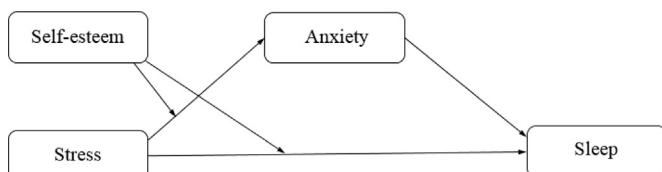

Fig. 1. The proposed moderated mediation model.

(Cronbach's α = 0.82; [50]) and test-retest reliability (0.78 over a 14-day interval; [51]). The Chinese version of the RSE consists of six positive items (items 1, 2, 4, 6, 7, and 8) and four negative items (items 3, 5, 9, and 10). Participants were asked to answer the items using a 4-point Likert scale (1 = *strongly agree*, 4 = *strongly disagree*). Higher scores indicated higher levels of self-esteem. Cronbach's α was 0.87 in this study.

2.3. Procedures

This study was approved by the review board of the Faculty of Psychology of Southwest University (no. IRB20200218). Anonymous questionnaires were conducted via an online survey platform—"SurveyStar"—from February 18–25, 2020. It took about 15 min for participants to complete all questionnaires. Upon completion, participants were paid five yuan as compensation (approximately $0.70 US).

2.4. Statistical analyses

All data were analyzed using IBM SPSS Statistics 22.0. We used Model 4 of the Hayes [52] PROCESS macro to examine the mediation effect of anxiety. Moreover, Model 8 of the PROCESS macro was used to test whether self-esteem moderated the mediation process. Bootstrapping (5000 bootstrap samples) with 95% confidence intervals (CIs) was conducted to test the significance of indirect effects [52]. The 95% CIs did not include zero, indicating a significant effect.

3. Results

3.1. Preliminary analyses

3.1.1. National epidemic trend of COVID-19 in China

Fig. 2 shows the national epidemic trend of COVID-19 in China from February 4 to March 10, 2020, with a peak (n = 58,016) in the number of existing confirmed cases on February 17, 2020. According to Fig. 2, the epidemic (the number of existing confirmed cases ranged from 45,604 to 57,805) remained severe during the questionnaire collection period.

3.1.2. Descriptive statistics for sleep quality

The distribution of PSQI scores is presented in Fig. 3. We also calculated the mean scores of the seven subscales: subjective sleep quality (mean = 0.94, SD = 0.76), sleep latency (mean = 1.24, SD = 0.96), sleep duration (mean = 0.13, SD = 0.44), habitual sleep efficiency (mean = 0.53, SD = 0.83), sleep disturbances (mean = 0.99, SD = 0.53), use of sleep medication (mean = 0.04, SD = 0.31), and daytime dysfunction (mean = 1.02, SD = 0.96). Among the 1630 participants, there were 1037 (63.62%) good sleepers and 593 (36.38%) poor sleepers.

3.1.3. Correlations for all variables

The results of Pearson's correlations are presented in Table 1. As expected, higher perceived stress was correlated with lower sleep quality. Higher anxiety was related to higher perceived stress and lower sleep quality. Moreover, higher self-esteem was associated with lower anxiety and better sleep quality.

3.2. Mediation analysis

Controlling for age, education, working or not (ie, whether they left the house to work), and attention to COVID-19, the mediation effect of anxiety was examined. Results showed that a higher level of perceived stress significantly predicted lower sleep quality (see Model 1 of Table 2). Higher perceived stress was also a predictor of higher anxiety (see Model 2 of Table 2). When controlling for perceived stress, higher anxiety significantly predicted lower sleep quality (see Model 3 of Table 2). Moreover, bootstrapping indicated that the mediation effect of anxiety was significant (ab = 0.13, Boot SE = 0.01, Boot 95% CI = [0.11, 0.15]), and it accounted for 66.29% of
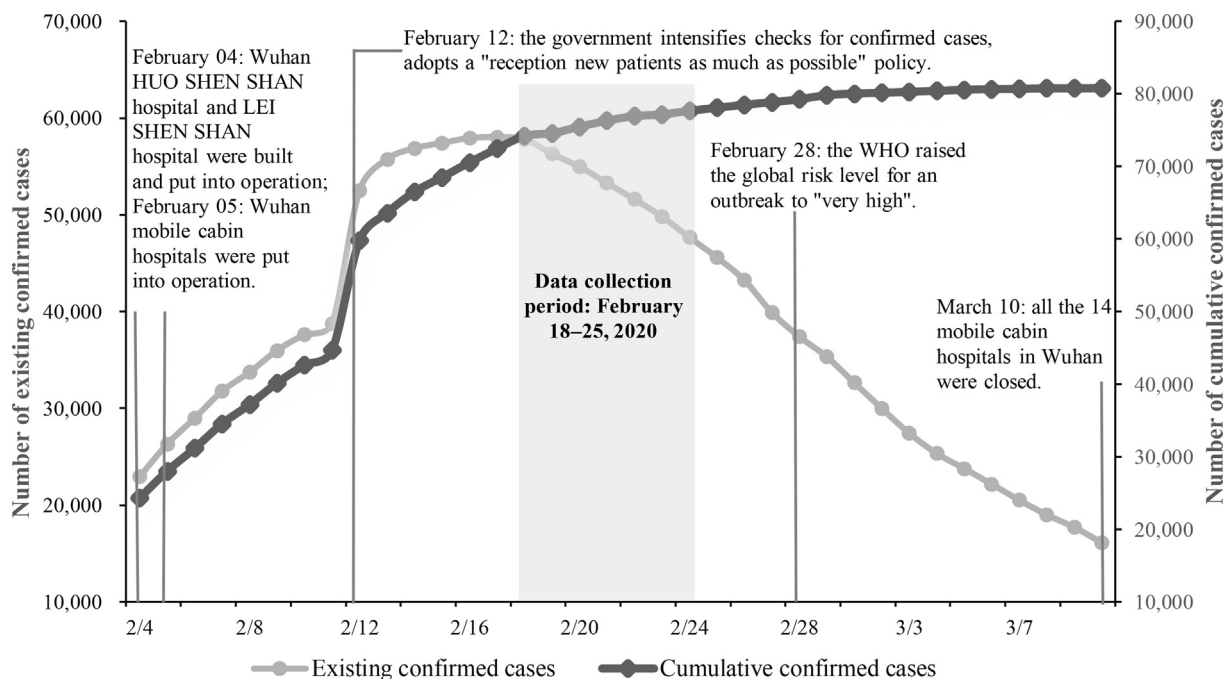

Fig. 2. The national pandemic trend of the 2019 coronavirus disease (COVID-19) in China from February 4 to March 10, 2020; existing confirmed cases = cumulative confirmed cases - cured cases - death cases.
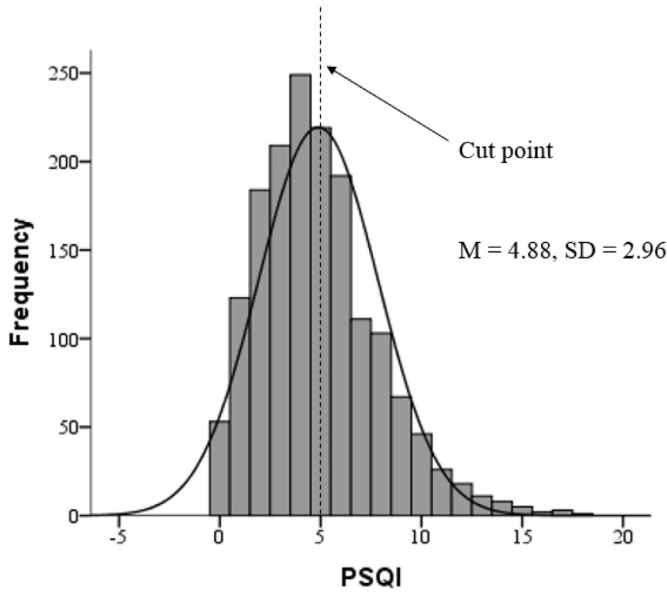
Fig. 3. Distribution of Pittsburgh Sleep Quality Index (PSQI) scores. People with scores greater than five were defined as "poor sleepers."

the total effect. Taken together, anxiety mediated the relationship between perceived stress and sleep quality.

3.3. Moderated mediation analysis

Controlling for age, education, working or not, and attention to COVID-19, we conducted the moderated mediation analysis. As Table 3 shows, the interaction (Model 1) between perceived stress and self-esteem significantly predicted anxiety, suggesting that self-esteem moderated the effect of perceived stress on anxiety. Simple slope tests suggested that, for individuals with high (Mean + SD; $B_{simple} = 0.59$, $t = 13.06$, $p < 0.001$) and low (Mean - SD; $B_{simple} = 0.73$, $t = 16.80$, $p < 0.001$) self-esteem, higher perceived stress predicted higher anxiety (Fig. 4a). Nevertheless, the slope for individuals with low self-esteem was larger than that for individuals with high self-esteem. Further, self-esteem significantly moderated the effect of perceived stress on sleep through anxiety. There was a significant indirect effect at each level of self-esteem (Table 4); however, the indirect effect of perceived stress on sleep quality through anxiety was stronger at low levels of self-esteem.

Table 3 also shows the interaction (Model 2) between perceived stress and self-esteem, which significantly predicted sleep quality. This suggests that self-esteem moderated the direct effect of perceived stress on sleep quality. Simple slope tests (Fig. 4b) showed that, for individuals with low self-esteem, higher perceived stress predicted lower sleep quality ($B_{simple} = 0.76$, $t = 4.53$, $p < 0.001$); however, for individuals with high self-esteem,

Table 1
Correlations between all variables.

	Mean	SD	PSS	PSQI	SAS	RSE
PSS	15.82	5.56	1.00			
PSQI	4.88	2.96	0.35***	1.00		
SAS	39.96	8.34	0.52***	0.53***	1.00	
RSE	29.35	4.27	−0.43***	−0.27***	−0.36***	1.00

Note. N = 1630. SD = standard deviation; PSQI = Pittsburgh Sleep Quality Index; PSS = Perceived Stress Scale; SAS = Self-Rating Anxiety Scale; RSE = Rosenberg Self-Esteem Scale; ***$P < 0.001$.

Table 2
Testing the mediation effect of perceived stress on sleep quality.

Predictor	Model 1 (PSQI)		Model 2 (SAS)		Model 3 (PSQI)	
	B	t	B	t	B	t
Age	0.03	3.65***	−0.05	−2.88**	0.04	5.46***
Education	0.04	0.57	−0.99	−6.01***	0.21	3.55***
Work or not	0.02	0.09	−0.56	−1.08	0.12	0.64
Attention to COVID-19	0.07	0.74	0.26	1.11	0.02	0.28
PSS	0.20	15.52***	0.75	23.38***	0.07	5.04***
SAS					0.17	19.76***
R^2	0.13		0.29		0.30	
F	49.01***		131.08***		115.69***	

Note. N = 1630. PSQI = Pittsburgh Sleep Quality Index; PSS = Perceived Stress Scale; SAS = Self-Rating Anxiety Scale; ***$P < 0.001$; **$P < 0.01$.

perceived stress was not related to sleep quality ($B_{simple} = 0.03$, $t = 1.56$, $p = 0.12$).

4. Discussion

The current study investigated the influence of perceived stress on sleep quality in the non-diseased general public during the COVID-19 pandemic in China and the mediating effect of anxiety and moderating mechanisms of self-esteem. Results showed that about one-third of participants were poor sleepers during the pandemic. Moreover, people's anxiety significantly mediated the relationship between perceived stress and sleep quality. Further, people's self-esteem moderated the indirect effect of perceived stress on sleep quality through its moderation of the effect of perceived stress on anxiety, indicating the mediation effect of anxiety was stronger at low levels of self-esteem than at high levels of self-esteem. The direct effect of perceived stress on sleep quality was moderated by self-esteem.

The number of poor sleepers in the current study was much higher than the proportion reported in previous Chinese studies, which were not related to COVID-19. For example, Zhang et al. [53], surveyed the sleep quality of 27,912 Chinese rural individuals aged 18−79 years and found that 21.80% of participants were getting poor sleep. Ning et al. [54], found that 24.10% of 1469 HIV-infected Chinese adults (aged 18−80 years) and 19.90% of 2938 HIV-uninfected participants had poor sleep quality. Jiang et al. [55], calculated the global PSQI score only based on six subscale scores (subjective sleep quality, sleep latency, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction), and found that 27.44% of 28,202 Chinese rural participants aged 18−79 years were poor sleepers. The current results thus suggest that the sleep quality of the non-diseased general

Table 3
Testing the moderated mediation effect of perceived stress on sleep quality.

Predictors	Model 1 (SAS)		Model 2 (PSQI)	
	B	t	B	t
Age	−0.05	−2.58**	0.04	5.65***
Education	−0.85	−5.18***	0.22	3.78***
Work or not	−0.52	−1.01	0.12	0.65
Attention to COVID-19	0.39	1.67	0.06	0.68
PSS	1.14	6.10***	0.22	3.28**
RSE	−0.03	−0.28	0.03	0.83
SAS			0.17	18.82***
PSS x RSE	−0.02	−2.61**	−0.01	−2.57**
R^2	0.31		0.31	
F	103.43***		90.25***	

Note. N = 1630. PSQI = Pittsburgh Sleep Quality Index; PSS = Perceived Stress Scale; SAS = Self-Rating Anxiety Scale; RSE = Rosenberg Self-Esteem Scale; ***$P < 0.001$; **$P < 0.01$.
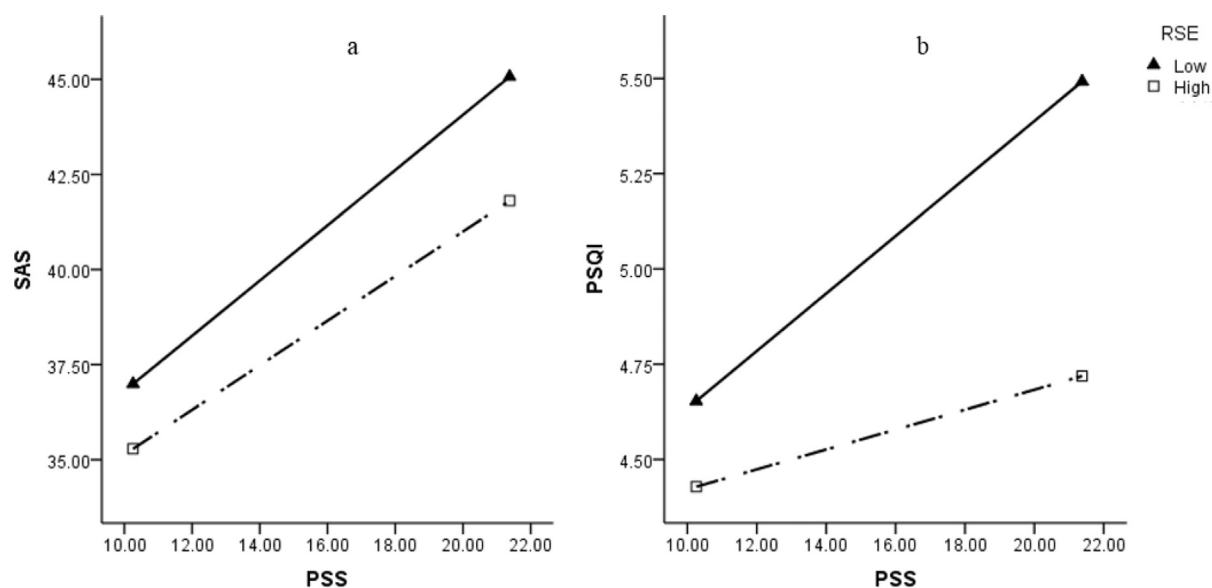
Fig. 4. The moderation effect of self-esteem. (a) self-esteem moderated the relationship between perceived stress and anxiety. (b) self-esteem moderated the relationship between perceived stress and sleep quality. PSQI = Pittsburgh Sleep Quality Index; PSS = Perceived Stress Scale; SAS = Self-Rating Anxiety Scale; RSE = Rosenberg Self-Esteem Scale; Low RSE = Mean −1 SD; High RSE = Mean + 1 SD; SD = standard deviation.

public during COVID-19 was worse than usual. This study was conducted when the pandemic was severe, which may explain the decline in participants' sleep quality. In line with this notion, previous studies showed that exposure to stressors (eg, hurricanes) leads to lower sleep quality, longer sleep latency, increased awareness during the night, and more sleep complaints [3–5].However, our results suggested that, during COVID-19, the sleep quality of the non-diseased general public (mean PSQI = 4.88) was better than that of the front-line medical staff (mean PSQI = 8.58; [2]). We cautiously speculate that the countermeasures for COVID-19 may reduce the impact of the pandemic on the sleep quality of the general public. On one hand, to cut-off the transmission of the virus, the general public was encouraged to practice home-isolation and wear masks, which effectively reduced the risk of infection. On the other hand, during the period of home-isolation, the state has implemented many measures to ensure that the daily lives of the general public are as normal as possible; for example, college students can take classes online at home.

We found that higher levels of perceived stress predicted lower sleep quality, which is consistent with previous studies [8–13]. Moreover, perceived stress affected sleep quality through anxiety, indicating that perceived stress increased feelings of anxiety, which, in turn, decreased sleep quality. These results were consistent with Stress and Coping Theory, which proposes that stress occurs when individuals perceive that the demands of environmental stimuli exceed or tax their resources, which results in a changed emotional state (eg, anxiety) that, in turn, affects one's

Table 4
Bootstrap results for the moderated mediation effect.

| | RSE | Effect | Boot SE | Boot 95% CI | |
				Low	High
Conditional indirect effects	Low RSE	0.12	0.01	0.10	0.14
	Medium RSE	0.11	0.01	0.09	0.13
	High RSE	0.10	0.01	0.08	0.12

Note. N = 1630. RSE = Rosenberg Self-Esteem Scale; Medium RSE = Mean of RSE; Low RSE = Mean −1 SD; High RSE = Mean + 1 SD; SD = standard deviation; CI = confidence interval.

health [56–59,18]. Since perceived stress was measured by the degree of unpredictability, uncontrollability, and overload [42] in the current study, participants with higher stress perceived lower control over their lives. Accumulating evidence has demonstrated that lower perceived control is associated with higher anxiety levels and more anxiety symptoms [60–64]; therefore, our results were consistent with these models of anxiety, which suggests that control over life plays an important role in anxiety development [65]. Additionally, we found that higher anxiety levels predicted worse sleep quality. In line with this study, previous studies have consistently found that higher anxiety levels were associated with worse self-reported health, decreased well-being, higher levels of depression, increased disability, and cognitive impairment [66–72].

Our results showed that self-esteem moderated the relationship between perceived stress and anxiety, which, in turn, moderated the indirect effect of perceived stress on sleep quality through anxiety. Specifically, the effect of perceived stress on anxiety was stronger in those with low self-esteem vs. high self-esteem. These findings are consistent with TMT theory, which suggests that high self-esteem helps buffer against anxiety [35,36]. Accordingly, faced with the stressors induced by COVID-19, participants with low self-esteem were more likely to experience anxiety than were participants with high self-esteem. Individuals with high self-esteem typically hold more positive beliefs (eg, intelligent, popular, attractive, etc.) about themselves relative to those with low self-esteem [73–75]. Similarly, compared with individuals with low self-esteem, those with high self-esteem are more confident in their ability and more optimistic about their performance on future tasks, even following a failure [76]. Further, participants with high self-esteem display more self-protection and attribute failure more to external factors than participants with low self-esteem [74,77]. These characteristics of high self-esteem may help reduce anxieties related to threats. In addition, we also found that self-esteem moderated the relationship between perceived stress and sleep quality, indicating that higher perceived stress predicted lower sleep quality in those with low self-esteem, but not in those with high self-esteem. These findings are consistent with previous studies, suggesting that self-esteem is a protective factor for sleep [39,41].

This study had several limitations. Previous studies showed that, compared with women, men have shorter sleep quantity and lower sleep quality [78,79]. Results also suggest that sleep problems are more common among women, especially those with depression [78,79]. However, owing to data collection problems, 795 participants did not report their sex, which prevents analyzing any possible sex differences. To control for the potential influence of sex on the current results, we only analyzed the data with sex information (n = 835, 254 men and 581 women). The results indicated that the mediation effect of anxiety (ab = 0.137, Boot SE = 0.02, Boot 95% CI = [0.11, 0.17]) and the moderated mediation analysis of self-esteem (the effect of the interaction between perceived stress and self-esteem on anxiety: $B = -0.02$, $t = -2.00$, $p < 0.05$) were both stable. Second, we did not have data from front-line workers, which prevents directly analyzing the difference in sleep quality between front-line workers and the non-diseased general public. Third, the measure of sleep was based on individuals' subjective sleep reports. Previous studies showed that subjective sleep reports could underestimate or overestimate sleep quality compared to objective sleep assessments owing to psychological factors, such as mood [80−82]. Thus, future studies should try to objectively measure sleep (eg, polysomnography or actigraphy). Finally, this study employed a cross-sectional design; thus, we cannot infer causality. Further research should adopt experimental or longitudinal designs to explore the causal implications of this study.

5. Conclusion

In sum, this study suggests that, owing to the increase in perceived stress during the 2019 COVID-19 pandemic, the sleep quality in the non-diseased general public deteriorated. Moreover, high levels of anxiety may be an explanation for the higher levels of stress associated with worse sleep quality. Further, high self-esteem helped reduce people's anxiety induced by perceived stress and lead to better sleep quality. These findings suggest that both the sleep quality and the perceived stress levels of the non-diseased general public required attention during the COVID-19 pandemic. We also identified personality characteristics related to better sleep quality, demonstrating the important role of self-esteem in environmental adaptation.

CRediT authorship contribution statement

Xiaolin Zhao: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Mengxue Lan:** Conceptualization, Investigation, Formal analysis. **Huixiang Li:** Investigation, Formal analysis. **Juan Yang:** Conceptualization, Writing - review & editing, Supervision, Funding acquisition.

Conflict of interest

None.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2020.05.021.

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