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ORIGINAL RESEARCH

The Effect of Perceived Stress on Insomnia Symptoms Among College Students: A Moderated Mediation Model

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Background: College students' insomnia symptoms is a topic of growing interest and studies have begun to explore the factors that influence college students' insomnia symptoms. This study investigated the relationship between perceived stress and college students' insomnia symptoms, as well as the chain mediating roles of fear of missing out and mobile phone dependence, and the moderating roles of environmental sensitivity.

Methods: In this study, 748 college students (M = 20.59, SD = 2.65) as a sample for cross-sectional study. The Perceived Stress Questionnaire, Brief Fear of Missing Out Scale, Self-Rating Questionnaire for Adolescent Problematic Mobile Phone Use, Athens Insomnia Scale and Highly Sensitive Child Scale were used.

Results: (1) Perceived stress significantly positively predicts the insomnia symptoms of college students; (2) Fear of missing out and mobile phone dependence play a chain mediating role between perceived stress and the insomnia symptoms of college students; (3) environmental sensitivity moderated the pathways of mobile phone dependence on insomnia symptoms.

Conclusion: We revealed the underlying mechanisms between perceived stress and insomnia symptoms. The findings highlight the importance of interventions for fear of missing out and mobile phone dependence, as well as the role of environmental sensitivity in influencing insomnia symptoms.

Keywords: perceived stress, fear of missing out, mobile phone dependence, environmental sensitivity, insomnia symptoms, college students

Introduction

Sleep plays an essential role in individuals' survival and development. Previous studies have shown that long-term poor sleep can adversely affect physical and mental health,[1–3] and has even been associated with an increased risk of suicide.[4] Researchers have found that insomnia is a common problem among college students,[5–7] with over a quarter of them experiencing insomnia.[8] College students are in a crucial transition period from adolescence to adulthood, facing pressure from various aspects such as interpersonal relationships, academic pursuits, and personal development, which makes them more susceptible to insomnia.[9]

While numerous studies have explored the relationship between stress and sleep problems in college students, few studies have simultaneously examined potential mediators (ie, how) and moderators (ie, when). Therefore, this study examined two research questions based on the perspective of organism-environment interactions. Specifically, first, we explored the chain mediating role of fear of missing out and mobile phone dependence between perceived stress and insomnia symptoms. Second, we examined the moderating role of environmental sensitivity in the pathways of mobile phone dependence on insomnia symptoms.

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Perceived Stress and Insomnia Symptoms

Cohen et al believe that perceived stress is the degree to which people evaluate stimulating events as pressure, which depends on people's subjective interpretation and perception of various stimulating events and risk factors in life.[10] The empirical evidence indicates that perceived stress significantly negatively predicts sleep quality in college students.[11] Physiological mechanisms of stress may explain the relationship between stress and sleep. Stress causes the adrenal cortex and cortisol levels rise,[12,13] resulting in the individual hyper-arousal.[14] In addition to physical hyper-arousal, some psychological symptoms caused by stress, such as depression and anxiety, have also been shown to be directly related to poor sleep quality.[15,16] Combining the physical and psychological effects of stress, stress can be interpreted as a predictor of insomnia symptoms.

Therefore, hypothesis 1 of this study was proposed: Perceived stress was positively and significantly associated with insomnia symptoms.

The Mediating Role of Fear of Missing Out

In addition to the direct effect of perceived stress on insomnia symptoms, Fear of Missing Out (FoMO) may be an important mediating variable. FoMO is a negative emotional experience, defined as a pervasive apprehension that others might be having rewarding experiences from which one is absent.[17]

According to the social selection hypothesis, emotional problems primarily stem from non-adaptive cognitive biases, such as the perception of stressful events.[18] Previous studies have shown that stressful events or information from social networking sites (such as Facebook) are significantly positively correlated with adolescents' FoMO.[19] FoMO can lead to increased social network use in adolescents, particularly at night, and affect their cognitive arousal before going to bed, thereby delaying the time at which they go to sleep.[20] Furthermore, as an anxious type of emotion, the higher one's level of FoMO, the worse their quality of sleep. Cross-sectional studies have also found that FoMO can negatively predict college students' quality of sleep.[21]

Therefore, hypothesis 2 of this study was proposed: FoMO plays a mediating role between perceived stress and insomnia symptoms.

The Mediating Role of Mobile Phone Dependence

Mobile phone dependence is defined as inappropriate use of mobile phones and is widely seen as a subset of behavioral or technology addiction.[22] According to a cross-sectional survey, 21.8% of the participating college students were dependent on their mobile phones.[23] In fact, according to the meta-analysis by Xiong et al, the prevalence of mobile phone dependence is increasing overall, which is closely related to people's increasing mental stress.[24] According to general strain theory, various strains or pressures experienced by individuals may lead to negative emotions, which in turn lead to problematic behaviors such as mobile phone dependence.[25] When faced with too much stress, individuals are more inclined to turn their attention to the Internet with the hope of relieving their stress.[26] As an excellent Internet access point, mobile phones are particularly favored by college students. Therefore, the more stress college students experience, the more likely they are to have phone-dependent behaviors.

According to immersion theory, college students who rely on their mobile phones become immersed in the pleasant experiences of using their mobile phones, which will gradually deprive them of their autonomy and sense of time, thus affecting their sleep timing.[27] In addition, nighttime exposure to the short-wave blue light emitted by mobile phones can inhibit the secretion of melatonin, the sleep-related hormone,[28] and the radiofrequency electromagnetic field generated by mobile phones can affect normal blood flow and metabolic function of the brain.[29] All these will have negative impacts on the sleep quality of college students. The meta-analysis conducted by Zhang et al also identified a significant correlation between adolescent mobile phone dependence and sleep disorder (r = 0.30, 95% CI [0.25, 0.34]).[30]

Based on existing empirical and theoretical evidence, we proposed hypothesis 3: Mobile phone dependence plays a mediating role between perceived stress and insomnia symptoms in college students.

The Chain Mediating Role of FoMO and Mobile Phone Dependence

Although previous studies have found that FoMO and mobile phone dependence may be important mechanisms in the relationship between perceived stress and insomnia symptoms, few studies have conducted an integrated examination of these mediating processes. Determining the particular mechanisms and processes can improve and expand our understanding of college students' physical and mental health, and provide basis for further research in the field. Therefore, this study incorporated perceived stress, FoMO, and mobile phone dependence to conduct an integrated test on the influencing mechanism of college students' insomnia symptoms, and explored whether the chain mediation model could be established. Additionally, in view of the negative impact of poor sleep in college students, it is of great practical significance for the physical and mental health of college students and their future development to be able to predict such negative impacts, to allow for the introduction of adjustments and interventions such as activities to relieve pressures and negative emotions, guiding college students to use their mobile phones responsibly, and improving their overall quality of sleep.

The meta-analysis conducted by Zhang et al revealed a high positive correlation between FoMO and mobile phone dependence (r = 0.47, 95% CI [0.44, 0.50]).[31] According to the theory of self-determination, FoMO stems from one's lack of basic psychological needs,[32] and social media can to some extent satisfy one's needs of individual relationships, interpersonal communications, autonomy, self-efficacy, and competence.[33] Therefore, college students who frequently experience FoMO have been shown to also use social media more often.[21] Smartphones are one of the primary ways that individuals access social media. Therefore, unhealthy use of social media increases one's risk of mobile phone dependence. Empirical studies have also shown that FoMO can significantly positively predict one's mobile phone dependence.[7] Therefore, individuals experiencing FoMO are more prone to use social media more frequently to obtain information, post updates, reply to comments, and so on, which then can increase their cognitive arousal and thus reduce their quality of sleep.

Therefore, hypothesis 4 was proposed: FoMO and mobile phone dependence in college students play a chain mediating role between perceived stress and insomnia symptoms.

The Moderating Effect of Environmental Sensitivity

Despite previous theoretical and empirical research suggesting that perceived stress may influence college students' insomnia symptoms through the mediating effects of FoMO anxiety and mobile phone dependency, the aforementioned chain of mediating relationships may vary due to individual differences in environmental sensitivity. Therefore, it is necessary to investigate whether these mediating processes vary in intensity according to one's sensitivity to their environment.

Environmental sensitivity refers to one's ability to perceive and process external information, which is a basic feature capable of adapting to one's environmental background.[34] Pluess et al compiled and revised the environmental sensitivity scale, dividing it into three dimensions: easy activation, aesthetic sensitivity, and low sensory threshold.[35] Previous studies have shown that a psychological sign of environmental sensitivity is Sensory Processing Sensitivity, which is characterized by a stronger awareness of sensory stimuli, deeper cognitive processing of environmental stimuli, and higher emotional and physiological responses.[36] Therefore, individuals with high environmental sensitivity are more likely to perceive the details of their environment, processing the external information at a deeper level, and thus become more deeply affected by their external environment.[37] Pluess et al verified that highly sensitive individuals are more profoundly affected by both positive and negative factors in the external environment.[38] Mobile phones, as an environmental stimulus, will also have a variety of different degrees of impact on individuals due to each person's different environmental sensitivities. Therefore, when individuals with high environmental sensitivity use mobile phones, they may become more excited and immersed in the sensory stimulation brought about by their mobile phones, leading to shorter sleep time and worsening sleep quality. In contrast, individuals with low environmental sensitivity may have a lower level of response to environmental stimuli, thus exposure to mobile phones may have relatively little impact on their sleep.

Therefore, we proposed Hypothesis 5: Environmental sensitivity regulates the second half of the mediation chain, in that mobile phone dependence is more likely to influence the insomnia symptoms of individuals with high environmental sensitivity than of those with low environmental sensitivity.

To summarize, this study proposed a moderated mediation model, and the model diagram is shown in Figure 1. First, the mediating effects of FoMO and mobile phone dependence on perceived stress and insomnia symptoms of college students were examined. Then, we explored whether individual sensitivity to the environment plays a moderating role in the relationship between mobile phone dependence and insomnia symptoms of college students. Finally, discussion of the results helps to clarify the "how" (mediating effect) and "when" (moderating effect) in terms of perceived stress affecting the insomnia symptoms of college students, which is also useful in formulating targeted intervention measures to help college students with sleep problems caused by stress.

Methods

Procedure

The study was conducted in two universities in Anhui province. Through the college counselor and the teaching teacher, students were publicized in open classes and volunteers were recruited to participate in the study, and all volunteers were provided with a link to the questionnaire. The present study was entirely voluntary and anonymous. Participants could withdraw from the study at any time before or after participation. All participants read the information at the beginning of the survey and indicated their consent to participate by completing the questionnaire. We assured all participants that their data would be kept anonymous and confidential.

Participants

The survey was completed on an online platform (www.wjx.cn). The estimated minimum sample size was 153, based on a moderate f effect size of 0.15, a of 0.05, power of 0.95, and total number of predictors of 7 using G*Power (developed by Faul et al).[39],769 college students self-reported their level of perceived stress, FoMO, mobile phone dependence, environmental sensitivity, and insomnia symptoms. All participants volunteered to participate in the study and were received informed consent and no reward was offered. After eliminating any questionnaires with a recorded response time of less than two minutes (ie, too fast to have focused on the questions and responses), 748 valid questionnaires were obtained, with an effective rate of 97.3%. Of the final sample, 69.3% female and 30.7% male, mean age was 20.59 years (SD = 2.65), and 38.8% were an only child. Students' majors were: 39.7% natural sciences (STEM), 55.5% humanities and social sciences, 4.8% arts. In terms of study year, 13.6% were in their first year of studies, 45.2% were in their second year, 11.5% were in their third year, and 29.7% were in their fourth year.

Measures

Perceived Stress

The Perceived Stress Questionnaire (PSQ) as compiled by Levenstein et al was adopted in this study, which consists of 30 items (eg, "You feel rested", "You feel frustrated").[40] Items 1, 7, 10, 13, 17, 21, 25, and 29 are reverse-scored. Each item is rated on a four-point scale (1 = rarely; 4 = usually). The PSQ index is obtained by subtracting 30 from the original

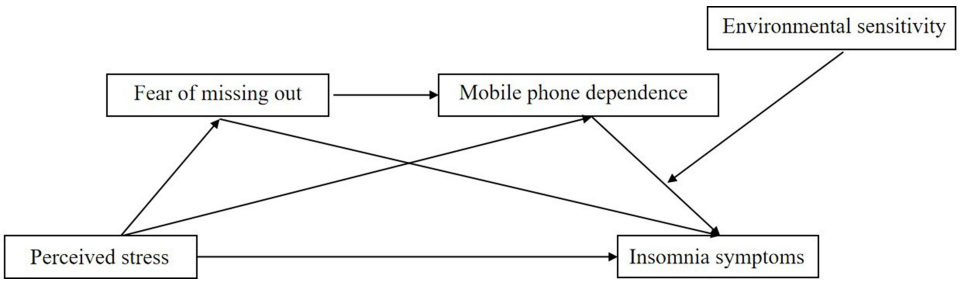

Figure 1 The proposed moderated mediation model.

score and then dividing the result by 90. The PSQ index ranges from 0 to 1. The higher the score, the higher the respondent's stress level. The Cronbach's alpha coefficient of the PSQ in this study was 0.90.

Fear of Missing Out

The Brief Fear of Missing Out Scale (BFoMOS) as compiled by Tang was used for this study.[41] The scale consists of six items which measure two dimensions: fear (eg, "I get worried when I find out my friends are having fun without me") and general (eg, "It bothers me when I miss an opportunity to meet up with friends"). Each item is rated on a five-point scale (1 = Not at all true of me; 5 = Extremely true of me). The higher the total score, the higher the respondent's degree of FoMO. The Cronbach's alpha coefficient of the scale in this study was 0.84.

Mobile Phone Dependence

The Self-Rating Questionnaire for Adolescent Problematic Mobile Phone Use (SQAPMPU) as compiled by Tao et al was used in this study.[42] The questionnaire consists of 13 items which measure three dimensions: withdrawal symptoms (eg, "I feel lost without my phone"), craving behaviors (eg, "I always feel like I don't use my phone enough"), and psychosomatic effects (eg, "My phone use directly affects my ability to study or work efficiently"). Each item is rated using a five-point scale (1 = never; 5 = always), with a higher total score indicating a greater dependence on one's phone. The Cronbach's alpha coefficient of the scale in this study was 0.92.

Insomnia Symptoms

Insomnia symptoms were measured using the Athens Insomnia Scale (AIS).[43] The scale consists of eight items which measure respondents' sleep difficulties over the previous month to assess the individual's insomnia symptoms (eg, "Sleepiness during the day"). Each item is rated using a four-point scale (0 = none; 3 = significant problem). The higher the total score, the more severe the insomnia symptoms. The Chinese version of the scale has been shown to have good reliability and validity,[44] and the Cronbach's alpha coefficient of the scale in this study was 0.79.

Environmental Sensitivity

The Highly Sensitive Child Scale (HSCS) was developed and revised by Pluess et al to measure the sensitivity of children and adolescents to their environment.[35] The scale measures three dimensions: susceptibility (five items; eg, "I am annoyed when people try to get me to do too many things at once"), aesthetic sensitivity (four items; eg, "Some music can make me really happy"), and low sensory threshold (three items; eg, "I don't like loud noises"). Each item is rated on a seven-point scale (1 = strongly disagree; 7 = strongly agree), with a higher total score indicating a higher sensitivity to the environment. The Cronbach's alpha coefficient of the scale in this study was 0.95.

Data Analysis

IBM's statistical application SPSS and Process 4.1, developed by Hayes,[45] were used for data analysis. Before beginning the analysis, the data of the five research variables (excluding the demographic variables) were standardized. Then, common method bias analysis was performed first. Second, descriptive statistics and Pearson correlation analysis were carried out for the main variables. Third, Model 6 of the Process macro as compiled by Hayes was used to analyze the data to test the mediating effect of FoMO and mobile phone dependence on perceived stress and insomnia symptoms.[45] Fourth, Model 87 of the Process macro was used to conduct moderated mediation effect analysis to test whether individual sensitivity moderated the predictive effect of mobile phone dependence on the college students' insomnia symptoms. If the moderating effect was significant, the Johnson-Neyman technique was used to detect the significant region. The bootstrap method was then used to test the regression coefficient, self-sampling 5000 times with a confidence interval of 95%. If a confidence interval does not include zero, the results are statistically significant. While analyzing the mediating and moderating effects, two demographic variables were controlled: gender and age.

Results

Testing for Common Method Bias

The data collected in this study were all self-reported by the subjects, so common method bias could exist. To test whether the common method bias was serious, the Harman's single factor test was used. The results showed that there were eight factors with characteristic roots greater than 1, and the interpretation rate of the first factor was 25.49%, which is less than 40%, indicating that there was no serious common method bias present.[46]

Descriptive Statistics and Correlation Analysis

Descriptive statistics and correlational analyses were conducted to examine the relationships among the variables in this study, as shown in Table 1. Specifically, significant positive correlations were found between perceived stress, FoMO anxiety, mobile phone dependency, and insomnia symptoms ($p < 0.001$). Furthermore, environmental sensitivity was significantly positively correlated with perceived stress ($r = 0.17$, $p < 0.01$) and FoMO anxiety ($r = 0.08$, $p < 0.05$), and significantly negatively correlated with insomnia symptoms ($r = -0.13$, $p < 0.001$).

The distribution's normality was assessed with the Kolmogorov–Smirnov test, skewness, and kurtosis value. Although the Kolmogorov–Smirnov test showed statistical significance, the absolute values of skewness and kurtosis were less than 1.96. Therefore, it was found that the variables of perceived stress, fear of missing out, mobile phone dependence, environmental sensitivity and insomnia symptoms no violation of normality assumption. For all variables multicollinearity test, maximum variance inflation factor is 1.27, indicating that there was no obvious multicollinearity problem.

Mediation Effect Analysis

We had hypothesized that FoMO and mobile phone dependence mediated the predictive effect of perceived stress on college students' insomnia symptoms. Model 6 of the Process macro was used to test the mediation effect, and the results are shown in Figure 2. After controlling for gender and age, the results showed that the total effect of perceived stress on insomnia symptoms was significant (β = 0.37, 95% CI [0.30, 0.44]), and the direct effect was also significant (β = 0.27, 95% CI [0.20, 0.34]); see Table 2. The mediating effect of Path 1 FoMO was significant (β = 0.02, 95% CI [0.01, 0.04]), accounting for 5.86% of the total effect. The mediating effect of Path 2 mobile phone dependence was also significant (β = 0.06, 95% CI [0.04, 0.09]), accounting for 16.21% of the total effect. Path 3 FoMO and phone dependence had a significant chain mediation effect (β = 0.02, 95% CI [0.01, 0.03]), accounting for 5.43% of the total effect. The above results support our hypothesis regarding the mediating role of FoMO and mobile phone dependence.

Testing of the Moderated Mediation Effect

Model 87 of the Process macro was used to test the moderated mediation effect of environmental sensitivity on the relationship between mobile phone dependence and college students' insomnia symptoms. As seen in Table 3, the results showed that after controlling for gender and age, mobile phone dependence had a significant positive predictive effect on

Table 1 Descriptive Statistics and Related Matrices for the Variables (N = 748)

Variables	*M* ± *SD*	1	2	3	4	5	6	7
1. Gender	0.31 ± 0.46	1						
2. Age	20.59 ± 2.65	− 0.05	1					
3. PS	0.45 ± 0.15	0.01	0.12***	1				
4. FoMO	2.50 ± 0.83	0.03	0.14***	0.30***	1			
5. MPD	2.52 ± 0.80	0.01	0.16***	0.36***	0.39***	1		
6. IS	1.91 ± 0.53	0.15***	0.12***	0.38***	0.26***	0.37***	1	
7. ES	4.91 ± 1.36	− 0.41***	0.12**	0.17**	0.08*	0.04	− 0.13***	1

Notes: Gender coded as 0 = female, 1 = male; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Abbreviations: PS, perceived stress; FoMO, fear of missing out; MPD, mobile phone dependence; IS, insomnia symptoms; ES, environmental sensitivity.

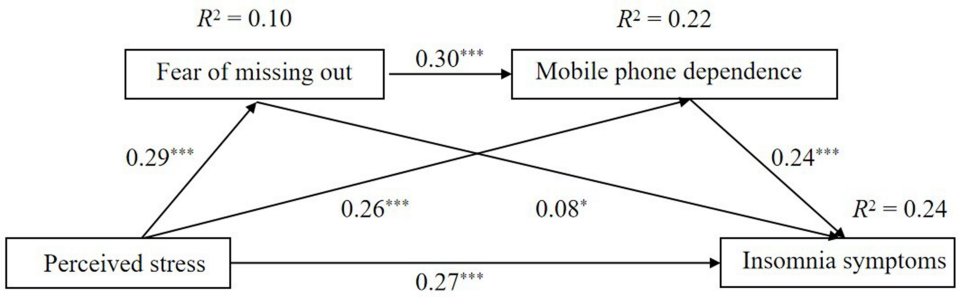

Figure 2 Mediation Effect Diagram of FoMO and Mobile Phone Dependence.
Note: ***$p < 0.001$.

insomnia symptoms (β = 0.24, $p < 0.001$), environmental sensitivity negatively predicted insomnia symptoms (β = − 0.18, $p < 0.001$), and the interaction of mobile phone dependence and environmental sensitivity positively predicted the insomnia symptoms of college students (β = 0.06, $p < 0.05$). To further explore the nature of this interaction effect, the Johnson-Neyman technique was used to detect the significant region. As Figure 3 shows, when the environmental sensitivity score was higher than the standard score of − 1.88, the 95% confidence interval of the prediction effect of mobile phone dependence on insomnia symptoms did not include 0, meaning that mobile phone dependence significantly positively predicted the insomnia symptoms of college students. With the increase of one's individual sensitivity level, the positive predictive effect of mobile phone dependence on insomnia symptoms was enhanced, but

Table 2 Mediation Effect Analysis of Model (N = 748)

	β	*SE*	95% CI
Total effect	0.37	0.33	[0.30, 0.44]
Direct effect	0.27	0.04	[0.20, 0.34]
Total indirect effect	0.10	0.02	[0.07, 0.14]
Path 1.PS → FoMO → IS	0.02	0.01	[0.01, 0.04]
Path 2.PS → MPD → IS	0.06	0.01	[0.04, 0.09]
Path 3.PS → FoMO → MPD → IS	0.02	0.01	[0.01, 0.03]

Abbreviations: 95% CI, 95% confidence interval; PS, perceived stress; FoMO, fear of missing out; MPD, mobile phone dependence; IS, insomnia symptoms; ES, environmental sensitivity.

Table 3 Results of the Moderated Mediation Effect Test (N = 748)

	FoMO			MPD			IS		
	β	*SE*	t	β	*SE*	t	β	*SE*	t
Sex	0.07	0.08	0.87	0.01	0.07	0.18	0.16	0.08	2.11*
Age	0.04	0.01	3.05**	0.03	0.01	2.60**	0.03	0.01	2.04*
PS	0.28	0.04	8.20***	0.26	0.03	7.51***	0.29	0.04	8.19***
FoMO				0.30	0.03	8.65***	0.07	0.04	1.86
MPD							0.24	0.04	6.66***
ES							−0.18	0.04	−5.16***
MPD*ES							0.06	0.03	2.14*
R^2	0.10			0.22			0.26		
F (df1, df2)	28.17 (3, 744)***			52.01 (4, 743)***			38.05 (7, 740)***		

Notes: Gender coded as 0 = female, 1 = male; *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
Abbreviations: PS, perceived stress; FoMO, fear of missing out; MPD, mobile phone dependence; IS, insomnia symptoms; ES, environmental sensitivity.

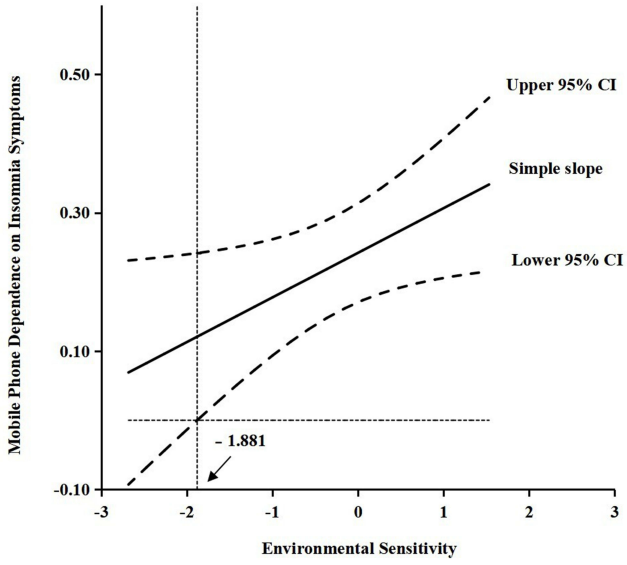

Figure 3 The Moderating Role of Environmental Sensitivity.

when the sensitivity level was lower than the standard score of − 1.88, the predictive effect of mobile phone dependence on insomnia symptoms was not significant. Therefore, hypothesis 5 was supported.

Discussion

Based on the organism-environment interaction model, this study constructed a moderated mediation model. First, the mediating process of FoMO and mobile phone dependence between perceived stress and insomnia symptoms of college students was investigated. Then, the moderating effect of individual environmental sensitivity between mobile phone dependence and insomnia symptoms was investigated. Our study focused on two key questions: through what (ie, "how") and under what (ie, "when") conditions does perceived stress affect the insomnia symptoms of college students?

The Mediating Role of FoMO and Mobile Phone Dependence

The results of this study showed that both FoMO and mobile phone dependence played mediating roles between perceived stress and insomnia symptoms of college students. This study will discuss the separate mediating effects of FOMO and mobile phone dependence, as well as the chained mediating effect of both.

This result is consistent with that of Jin et al, who found that anxiety mediates the influence of perceived stress on sleep quality among company employees.[47] This suggests that as FoMO, an anxious state, is essentially a negative emotion, it will in itself have a negative impact on one's quality of sleep, such as causing a longer latency period and shorter sleep duration.[48] Furthermore, stress will cause emotional problems in individuals.[49] When individuals perceive too much stress, negative emotions will occur. When individuals use social networking sites, if they do not receive likes, replies, or comments from their peers, they will feel stronger social stress, which may cause some people to feel anxious about missing out on their friends' novel experiences or being unable to participate in social activities.[19] When individuals experience FoMO, they keep their mobile phones within reach to avoid missing news.[21] This desire to stay connected can also delay bedtime, and thus affect insomnia symptoms. The consistency in the results of this study and those of previous studies indicate that FoMO is an important mediating process in how perceived stress affects the insomnia symptoms of college students.

Our findings are also consistent with those of previous studies on middle school students which found that perceived learning stress can affect insomnia symptoms through mobile phone dependence.[50] College students have not yet learned the correct methods to deal with stress. When facing pressure, they tend to choose passive solutions rather than actively seeking problem-solving methods and also prefer online spaces that offer anonymity and easy access as a means to

release stress.[51] Previous studies have also pointed out the stimulating effect of the strong light of mobile phones at night, especially short-wave blue light, which may mislead the brain's processing by causing it to mistakenly think that it is still daytime, thus suppressing the secretion of melatonin.[28] If an individual is exposed to such stimulation for a long time, it will become more difficult for them to fall asleep, perhaps even needing medication. At the same time, when mobile phone use encroaches on one's sleep time, it may also lead to insufficient sleep, difficulties waking up, and other problems. Therefore, mobile phone dependence is also an important mediating process in the way that perceived stress affects the insomnia symptoms of college students.

Most importantly, our results support our Hypothesis 4, that FoMO and mobile phone dependence have a chain mediation effect between perceived stress and college students' insomnia symptoms. This result is also consistent with that of previous studies on college students, which found that FoMO and mobile phone dependence play a chain mediating role in the influence of negative emotions on sleep quality.[7] According to the theory of self-determination, FoMO is an unstable phenomenon of self-regulation caused by unsatisfied psychological needs.[32] Individuals experiencing FoMO need to communicate with others through the Internet to relieve their anxiety,[52] using specific social media channels or platforms to meet their basic psychological needs.[33] Mobile phones are easily accessible and portable, and have become an important access point for social networks. Social networking apps are convenient and fast, which can lead to individuals experiencing FoMO anxiety to become eager to use their mobile phones more frequently to find or share updates that meet their basic psychological needs, thereby leading to an excessive dependence on mobile phones. Therefore, the chain mediating effect of FoMO and phone dependence was established.

The Moderating Effect of Environmental Sensitivity

This study found that the predictive effect of mobile phone dependence on the insomnia symptoms of college students was moderated by the individual's sensitivity to the environment. Specifically, when an individual has a high level of environmental sensitivity (ie, higher than the standard score of −1.88), the positive predictive effect of mobile phone dependence on that individual's insomnia symptoms was significant, and the predictive effect was further enhanced with the increase of the individual's level of environmental sensitivity. However, in individuals with a low level of environmental sensitivity (ie, lower than the standard score of −1.88), the predictive effect of mobile phone dependence on the insomnia symptoms of college students became insignificant. The results of this study also support the Diathesis-Stress Model, which suggests that some individuals are more sensitive to negative environments due to their own individual factors (ie, temperament, genes, etc) and are therefore more susceptible to adverse effects in negative environments.[53] This theory can also be used to explain our results that show that individuals with high environmental sensitivity are more likely to be affected by the risk factor of mobile phone dependence, leading to negative consequences and a greater likelihood that they will have insomnia symptoms; meanwhile individuals with low environmental sensitivity are less likely to be affected by mobile phone dependence. However, high environmental sensitivity does not always have a negative impact on the individual. According to differential susceptibility theory, individuals with higher sensitivity also have higher plasticity. While high sensitivity does increase the extent to which individuals are affected by negative environments, it also makes these same individuals more likely to benefit from positive environments.[54] Although the current study did not discuss the influence of environmental sensitivity on individuals in a positive environment, our results are nonetheless of great significance to our understanding of individual development, providing new reference points as to how individuals "seek advantages and avoid disadvantages" in various environments.

Limitations and Future Directions

The current study explored the mechanism of perceived stress on the insomnia symptoms of college students using a moderated mediation model. Although some valuable findings have been obtained, there are still some shortcomings to our study. First, this study adopted a cross-sectional design, which is unable to infer a causal relationship between perceived stress and the insomnia symptoms of college students. Furthermore, it cannot be used to conduct in-depth process analysis on the relationship between perceived stress and the insomnia symptoms of college students, the mediating roles of FoMO and mobile phone dependence, and the regulating role of environmental sensitivity. Future research should consider using a longitudinal tracking design to explore these issues. Second, FoMO can be divided into trait-FoMO and state-FoMO,[52]

both of which might have different impacts on the effect of perceived stress on the insomnia symptoms of college students. Future studies should adopt new measures of FoMO which can be used to discuss both trait-FoMO and state-FoMO individually. Third, the data collected in this study were self-reported by the subjects, which can lead to bias or underreporting. A multi-party evaluation method should be adopted in future research. Finally, according to the differential susceptibility model, although individuals with high environmental sensitivity are more likely to be adversely affected by a negative environment, they are also more likely to benefit from a positive environment. Future research should investigate whether individuals with different sensitivities benefit from positive environment variables, as well as their degrees of difference.

Conclusion

Perceptual stress significantly positively predicts the insomnia symptoms of college students, and one's fear of missing out and mobile phone dependence play a chain mediating role between perceived stress and the insomnia symptoms of college students. Environmental sensitivity plays a significant moderating role in the prediction of insomnia symptoms of college students based on mobile phone dependence; furthermore, environmental sensitivity aggravates the influence of mobile phone dependence on insomnia symptoms of college students. Based on the findings, not only schools should reduce the stress of students' external environment, but also adolescents themselves should reduce their dependence on mobile phones and their fear of missing out, so as to improve their sleep quality.

Data Sharing Statement

The data presented in this study are available on request from the corresponding author.

Ethics Approval and Informed Consent

The studies involving human participants were reviewed and approved by the Ethics Committee of Anhui Normal University (No. AHNU-ET2024065), and adhered rigorously to the ethical tenets of the Helsinki Declaration. All participants provided online informed consent before formally engaging in the survey.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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