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Relationship between problematic smartphone use and sleep problems: The roles of sleep-related compensatory health beliefs and bedtime procrastination

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Abstract

Objective: Concerns regarding sleep problems in emerging adults and their antecedents, such as problematic smartphone use (PSU), have been growing. This study tested the association between PSU and sleep problems and further investigated the mechanisms of this relationship based on the theory of compensatory health beliefs (CHBs).

Methods: This study included 999 participants (74.87% female) in China, aged 17 to 25 years (M = 21.16; standard deviation = 1.60), who voluntarily filled in an anonymous survey.

Results: The findings showed positive correlations between sleep problems and PSU, sleep-related CHBs, and bedtime procrastination ($rs = .25–.52$, $p < .001$). Furthermore, the positive link between PSU and sleep problems was mediated by bedtime procrastination alone (β=.21, 95% confidence interval (CI) [.17, .26]) or a serial path of sleep-related CHBs and bedtime procrastination (β=.04, 95% CI [.02, .05]).

Conclusion: This study provides a new perspective to understand the internal mechanism underlying the PSU-sleep problem link. Interventions for sleep disorders ought to consider the theoretical guidelines of the CHBs model to reduce the risk of bedtime procrastination and sleep disorders in emerging adults.

Keywords

Compensatory health beliefs, sleep problem, problematic smartphone use, bedtime procrastination, emerging adult

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Introduction

The increasing prevalence of sleep problems in recent years has attracted public concerns.[1] Sleep health in emerging adults should also be paid attention to as their sleep patterns dramatically change during the developmental transition from adolescence to adulthood (e.g. delays in falling asleep),[2] with the potential risks of sleep problems. Previous studies have shown that sleep problems have been prevalent and increasing in emerging adults over the past decade.[3–5] Sleep problems constitute a more holistic view of sleep, and mainly include poor subjective sleep quality, short sleep duration, difficulty falling asleep, and low sleep efficiency.[3,6] Furthermore, sleep problems can exert detrimental effects on physical health, potentially leading to an elevated risk of weight gain and cardiovascular disease,[7,8] as well as mental

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health, including depression and anxiety.[3] Therefore, it is necessary to identify sleep problems and their related risk factors among emerging adults.

With an increasing number of emerging adults possessing and immersing themselves in smartphones, problematic smartphone use (PSU) has become prevalent and negatively impacts health, including sleep health, among emerging adults.[9] A systematic review reported the increased risk of poor sleep among young adults with PSU.[10] Although many studies explored the relationship between PSU and sleep problems, limited research investigated the mechanisms underlying this relationship. Therefore, this study aimed to examine whether and how PSU is associated with sleep problems based on the theory of compensatory health beliefs (CHBs)[11] among Chinese emerging adults, with the mediating effects of sleep-related CHBs and bedtime procrastination. This study hypothesized that sleep-related CHBs and bedtime procrastination mediate the relationship between PSU and sleep problems among emerging adults. The findings of this study may offer valuable insights for devising potential interventions to enhance sleep health among emerging adults.

PSU and sleep problems

PSU (i.e. excessive and addictive smartphone use) is regarded as a generalized type of problematic internet use.[12] Individuals with PSU and other specific types of problematic internet use, such as problematic gaming and problematic social media use, have similar symptoms of impulse control problems, excessive use, withdrawal, and negative physical or mental consequences.[13–16] PSU is prevalent among emerging adults, who are the primary group of smartphone users.[17] For example, a systematic review reported that the prevalence of PSU was 36.5% to 67% (average 52%) among emerging adults.[18] An empirical study also found that 46.6% of British university students showed symptoms of PSU.[19] PSU is not only associated with psychological factors, such as fear of missing out, emotional dysregulation, and neurotic personality traits,[20,21] but also physical and mental health problems. For example, multiple studies found that individuals with PSU are more likely to have depression, anxiety, loneliness, and sleep problems in both the general population and clinical samples (e.g. people with attention deficit hyperactivity disorder).[22–24]

As sleep health is garnering increasing attention,[1] many studies have investigated the relationship between PSU (or specific types of problematic use) and sleep problems (e.g. poor sleep quality).[25] For example, a previous longitudinal research found that PSU and problematic social media use predicted poor sleep quality in people with schizophrenia.[26,27] A significant relationship is also observed between PSU (or problematic internet use) and poor sleep quality in individuals with substance use disorders.[28] However, these studies were conducted in clinical populations.

Studies in recent years also showed that PSU has increasingly emerged as a risk factor for compromised sleep health among emerging adults.[10] For example, Sohn et al.[29] showed that 38.9% of young adults from a UK sample suffered from PSU, 68.7% of whom had poor sleep. Ozcan and Acimis[9] discovered that the rate of PSU among university students in Turkey was 34.6%, and that students with PSU experienced a significantly higher frequency of sleep problems. Moreover, a study found that the prevalence of PSU was 38.63% in China, with a higher risk of sleep problems in university students.[30] Additionally, a longitudinal study unveiled that the prevalence of PSU was 26.6% in Chinese university students, and 52.5% 1 year later; the results also showed that PSU would predict sleep problems 1 year later.[31] Concerning specific characteristics of sleep problems, previous studies have found that PSU is associated with lower subject sleep quality, longer sleep latency, and shorter sleep duration.[32] Therefore, this study hypothesized that PSU is positively associated with sleep problems in emerging Chinese adults (H1).

Regarding the possible mechanism underlying the relationship between PSU and sleep problems, blue light and electromagnetism from smartphones at night may disturb sleep.[33] Cortisol and melatonin could also influence sleep.[34] Additionally, other emotional factors, including depression and anxiety, have been observed.[10] According to the CHBs model, sleep-related CHBs and bedtime procrastination may play mediating roles underlying PSU–sleep problems relationship.

Applying the CHBs model to the PSU–sleep problems relationship

As suggested by Knäuper et al.,[11] CHBs refer to beliefs that the negative consequences of unhealthy behaviors would be compensated or neutralized through conducting health behaviors. The model was proposed by Rabia et al.[35] explaining how and why people employ CHBs when faced with temptation. Specifically, when an individual's desire to engage in tempting yet unhealthy behavior conflicts with their health-related goals, the result is a state of internal distress. These inconsistencies can lead to irrational or maladaptive outcomes. Chronic activation of CHBs can become an automatic response to help deal with dissonance.[36] However, several studies have demonstrated a positive association between CHBs and unhealthy outcomes, such as unhealthy eating,[37] and alcohol consumption.[38] Therefore, we proposed that individuals with higher sleep-related CHBs experience more sleep problems (H2). In addition, CHBs have been associated with addictive

behaviors (e.g. binge-watching).[39] PSU, a form of addictive behavior, has not been studied previously. To bridge this gap, we propose that sleep-related CHBs serve as mediators between PSU and sleep problems (H3).

Emerging adults who suffer from PSU are more likely to spend time on a smartphone, even delaying their bedtime.[40] The health goal of sleeping on time or keeping adequate sleep time would conflict with the desire to use a smartphone, and CHBs would be activated. However, individuals with sleep-related CHBs like to spend more time on their smartphones, even before or during sleep time, which may lead to bedtime procrastination with a greater tendency for sleep problems.[41] Therefore, bedtime procrastination should be further investigated.

The role of bedtime procrastination

Bedtime procrastination refers to delaying bedtime for no external reasons.[42] Individuals engaging in bedtime procrastination go to bed later than planned. Bedtime procrastination can be regarded as a health-interfering behavior that negatively affects sleep health.[42,43] A study of meta-analysis showed a positive association between bedtime procrastination and sleep problems in many populations, including emerging adults.[44] Furthermore, bedtime procrastination was found to be related to PSU among emerging adults in both cross-sectional and longitudinal research.[32,45]

Previous research has also investigated the relationship among PSU, bedtime procrastination, and sleep quality. For example, two studies with samples of young people from Turkey and Spain found that bedtime procrastination had a mediating effect on the relationship between PSU and poor sleep quality.[46,47] Similarly, Zhang and Wu[48] identified this connection among Chinese college students. However, poor sleep quality was measured using three indicators of sleep problems (i.e. subjective sleep quality, sleep latency, and sleep duration), which are limited to representing only sleep problems. Therefore, it was proposed that bedtime procrastination served as a mediation in the link between PSU and sleep problems (H4). Furthermore, CHBs were shown to be positively associated with procrastination (i.e. academic procrastination).[39] Accordingly, we further hypothesized the serial mediation of sleep-related CHBs and bedtime procrastination underlying PSU–sleep problems relationship (H5). The conceptual model is presented in Figure 1.

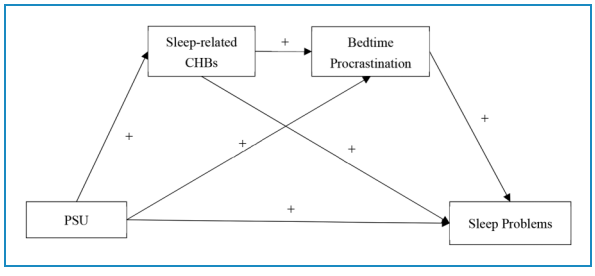

Figure 1. The conceptual model. CHBs: compensatory health beliefs; PSU: problematic smartphone use; .

Material and methods

Participants and procedure

This study utilized a cross-sectional design. In October 2022, 1017 emerging adults without any mental disorders from mainland China were recruited via a popular online platform (Credamo; https://www.credamo.com) using convenience sampling. Data from 18 participants were excluded (they responded in a set pattern or filled in the questionnaire abnormally) and 999 participants (74.87% female) aged 17 to 25 years ($M_{age} = 21.16$, standard deviation (SD) = 1.60) were included in the data analyses. After filling in a written consent form (electronic version) with the study's objectives and their rights (e.g. anonymous responses and withdrawal at any time without any punishment), all participants completed the online questionnaire. Participants received a compensation of RMB 10 (approximately USD 1.45) after completing the questionnaire. Ethical approval was granted by the Ethics Committee of the corresponding author's department.

Measures

Sleep problems. Sleep problems were assessed using the Pittsburgh Sleep Quality Index (PSQI),[49] which has been validated for the Chinese population and shows good reliability and validity.[50] The scale includes nine self-rated questions (e.g. "During the past month, how would you rate your sleep quality overall?"), with seven dimensions: subjective sleep quality, sleep duration, sleep latency, habitual sleep efficiency, step disturbances, use of sleep medication, and daytime dysfunction. Each dimension was scored on a scale of 0 to 3 points, with a higher total score (ranging from 0 to 21) indicating more severe sleep problems. In the current study, the Cronbach's alpha coefficient for the scale was 0.72.

PSU. It was assessed by Smartphone Addiction Scale-Short Version (SAS-SV).[51] This scale has been validated in Chinese samples.[52] Participants answered 10 items (e.g. "I miss planned work due to smartphone use") on a 6-point Likert scale, with 1 = strongly disagree to 6 = strongly agree. The score was summed, ranging from 10 to 60, and a higher total score indicated a more severity of PSU. This scale had a good reliability in this study ($\alpha = 0.90$).

Table 1. Sleep characteristics of emerging adults (n = 999).

	% (N)
Subjective sleep quality	
Very good	12.6 (126)
Fairly good	57.2 (571)
Fairly bad	27.6 (276)
Very bad	2.6 (26)
Sleep latency	
<=15 minutes	30.0 (300)
16–30 minutes	43.7 (437)
31–60 minutes	15.9 (159)
> 60 minutes	10.3 (103)
Sleep duration	
>7 hours	79.4 (793)
6–7 hours	17.8 (178)
5–6 hours	2.5 (25)
<5 hours	0.3 (3)
Habitual sleep efficiency	
>85%	94.7 (946)
75–84%	4.9 (49)
65–74%	0.2 (2)
<65%	0.2 (2)
Use of sleep medication	
Not during the past month	95.0 (949)
Less than once a week	2.8 (28)
Once or twice a week	1.2 (12)
Three or more times a week	1.0 (10)
Daytime dysfunction	
0	5.8 (58)
1	18.6 (186)
2	41.8 (418)
3	33.7 (337)
Step disturbances	
0	21.5 (215)
1	53.6 (535)
2	16.0 (160)
3	8.9 (89)

Note: The range of daytime dysfunction and step disturbances refers to better (0) to worst (3).

Sleep-related CHBs. In this study, two items from the Compensatory Health Beliefs Scale were used to measure sleep-related CHBs.[11] The Chinese version of this scale also demonstrated good reliability and validity.[53] Participants reported their sleep-related CHBs, such as "Too little sleep during the week can be compensated for by sleeping in on the weekends" and "It is okay to go to bed late if one can sleep longer the next morning (only the number of hours counts)," using a five-point Likert scale (1 = Never to 5 = Always). A higher total score indicated a stronger inclination towards sleep-related CHBs.

Bedtime procrastination. Bedtime procrastination was assessed using the Bedtime Procrastination Scale,[42] which has been validated for Chinese samples.[54] The scale has been widely used in previous research conducted in China.[43] Participants answered nine items (e.g. "I usually go to bed later than I planned") on a five-point Likert scale (1 = never to 5 = always). A higher total score indicates a higher level of bedtime procrastination. The internal reliability (Cronbach's alpha coefficient) of the scale was 0.91 in this study.

Demographic information. Information on the sex (male = 1 and female = 2) and age (years) was recorded.

Data analysis

There was no missing data in the dataset. The simr package was used to perform Monte Carlo simulation analysis to calculate the minimum sample size in R.[55] Parameters were set according to the medium effect size standards.

The results indicated that at least 600 participants are required to achieve a statistical power of 0.95 ($\alpha = 0.01$),[56,57] suggesting that our sample size meets this requirement. The descriptive statistics and correlational coefficients were calculated using SPSS version 22.0 in this study. The conceptual model was tested by R software with the lavaan package.[58] Model fit was assessed by Schreiber et al.,[59] using the following indices: chi-square test (χ^2/df), comparative fit index (CFI; >.90), Tucker-Lewis index (TLI; >.90), root mean square error of approximation (RMSEA; <.08), and standardized root mean square residual (SRMR; <.08). Additionally, the standardized coefficients of direct and indirect effects were calculated and a 95% confidence interval (CI) used the bias-corrected percentile method with 5000 bootstrap samples.

Results

Demographic and correlational findings

Descriptive statistics for each dimension of sleep problems among emerging Chinese adults are presented in Table 1. Table 2 illustrates the correlations between PSU and seven sleep problem dimensions. PSU was significantly and positively correlated with most sleep problems (rs = .08 to .47, $p < .01$) except for the use of sleep medication ($r = .06$, $p = .05$).

The results of preliminary analyses (i.e. M and SD) and correlational coefficients of all the variables are shown in Table 3. PSU and bedtime procrastination were positively associated with sleep problems ($r = .41$ and .52, $p < .001$), thus supporting H1. Sleep-related CHBs had positive correlations with sleep problems, bedtime procrastination, and PSU ($r = .25$ to .41, $p < 0.001$), meaning that H2 was supported.

Sex was positively associated with sleep problems ($r = .07$, $p = .02$), bedtime procrastination ($r = .13$, $p < .001$), and PSU ($r = .13$, $p < .001$), but not with sleep-related CHBs ($r = .04$, $p = .23$). Age was negatively associated with sleep-related CHBs levels ($r = -.09$, $p < .05$).

Model testing

Path analysis, in which PSU was the independent variable and sleep problems constituted the dependent variables, demonstrated the mediating roles of sleep-related CHBs and bedtime procrastination. The effects of gender and age were controlled for during model testing. The results of the path analysis showed a good model fit: $\chi^2(4) = 16.47$, $\chi^2/df = 4.12$, $p < .01$, CFI = .99, TLI = .96, RMSEA = .06, 90% CI [.03, .09], SRMR = .02. In this model (see Figure 2), all standardized coefficients of the hypothesized relationships were statistically significant, except for the direct path from sleep-related CHBs to sleep problems ($\beta = .02$, $p = .43$).

As shown in Table 4, PSU had a significant direct effect on sleep problems ($\beta = .15$, 95% CI [.08, .22]). The relationship between PSU and sleep problems was mediated by bedtime procrastination ($\beta = .21$, 95% CI [.17, .26]), but not by sleep-related CHBs ($\beta = .01$, 95% CI [−.01, .03]), thus supporting H4. Moreover, the indirect effect of PSU on sleep problems via both sleep-related CHBs and bedtime procrastination was statistically significant ($\beta = .04$, 95% CI [.02, .05]), thus supporting H5.

Discussion

Sleep problems among emerging adults are currently prevalent and can co-occur or lead to physical and mental disorders, owing to which they have attracted increasing public attention.[1] This study tested the status quo of sleep problems from a comprehensive health-oriented perspective and investigated the correlation between PSU and sleep problems. Furthermore, we examined the mediation model of sleep-related CHBs and bedtime procrastination in the link between PSU and sleep problems based on the CHBs model.

Nearly one-third of this sample of emerging adults reported poor subjective sleep quality. This finding aligns with the results of prior research conducted with a sample of Chinese university students aged 18 to 26 years.[48] Regarding sleep latency, 26.2% of the participants reported longer than 30 minutes of latency before sleep, as the findings in a previous meta-analysis.[60] Whereas 20.6% slept less than 7 hours, which was far below the percentage for sleep duration of less than 7 hours (46%) in the study by Li et al.[61] A possible reason for this difference is the influence of protective measures (e.g. suspended offline teaching) during the COVID-19 pandemic. Previous studies also found that young adults, including university students, had longer sleep durations, whereas they continuously suffered from poor sleep quality and insomnia in the COVID-19 pandemic.[62] Chen et al.[5] argued that sleep problems are the most severe mental health problem among university students in mainland China, with an increasing trend over the past decade. To produce effective interventions, attention should be paid to the risk factors and underlying mechanisms of sleep problems.

PSU has also been identified as a vital factor in sleep problems among emerging adults.[10] This study found that PSU was positively associated with the summed score of sleep problems; specifically, emerging adults who had higher levels of PSU exhibited more sleep problems. Furthermore, we found a positive relationship between most characteristics of sleep problems (e.g. poor sleep quality, short sleep duration, long sleep latency, and daytime dysfunction) and PSU, except for the use of medicine. Regardless of the overall score for each characteristic

of sleep problems, its relationship with PSU was consistent with previous research,[30,31] providing more comprehensive empirical evidence for the positive relationship between PSU and sleep problems in emerging adults. However, there was no significant association between PSU and the use of medicine (a dimension of sleep problems). One possible reason for this is that the current study focused on a health-oriented perspective of sleep; therefore, we collected data from a general population of emerging adults, rather than those diagnosed with sleep problems or disorders. The general population of emerging adults tends to have mild or moderate sleep problems, with these people not usually resorting to medication to promote sleep.

This empirical study is the first to demonstrate a positive relationship between sleep-related CHBs and sleep problems in emerging Chinese adults. Emerging adults with higher sleep-related CHBs reported more sleep problems, which strongly supports the assumption that CHBs are related to unhealthy outcomes in daily life,[37] including sleep in the present study. Moreover, there is also a positive relationship between CHBs and addictive behaviors (i.e. PSU), as previous research by Paulus and Aziz[39] that CHBs have been associated with binge-watching. The possible reason is that individuals with PSU would reduce self-efficacy, which leads to the activation of CHBs and further engaging in tempting activities.[35] More importantly, this is

Table 2. Correlation between PSU and different dimensions of sleep problems.

	1	2	3	4	5	6	7	8
1. PSU	–							
2. Subjective sleep quality	0.35***	–						
3. Sleep latency	0.16***	0.41***	–					
4. Sleep duration	0.12***	0.21***	0.10**	–				
5. Habitual sleep efficiency	0.08**	0.14***	0.06	0.29***	–			
6. Step disturbances	0.27***	0.62***	0.41***	0.12***	0.12***	–		
7. Use of sleep medication	0.06	0.19***	0.14***	0.16***	0.18***	0.23***	–	
8. Daytime dysfunction	0.47***	0.42***	0.17***	0.18***	0.08*	0.33***	0.12***	–

Note: *p < .05; **p < .01; ***p < .001.
The higher the score on each dimension of sleep problems, the severer in this sleep problem.
PSU: problematic smartphone use.

Table 3. Mean, standard deviation, and intercorrelation coefficients of the major variables.

	M	SD	1	2	3	4	5	6
1. Sleep problems	5.80	2.78	–					
2. Bedtime procrastination	29.30	7.71	.52***	–				
3. Sleep-related CHBs	6.94	1.71	.25***	.41***	–			
4. PSU	40.23	9.66	.41***	.59***	.38***	–		
5. Sex#	–	–	.07*	.13***	.04	.13***	–	
6. Age	21.16	1.60	.01	−.02	−.09**	−.02	−.11***	–

Note: *p < .05; ***p < .001. #1= male, 2 = female.
CHBs: compensatory health beliefs; PSU: problematic smartphone use.

the first study to apply the CHBs model to explain the mechanisms underlying PSU–sleep problems relationship. According to the CHBs model,[35] CHBs constitute a coping strategy to deal with uncomfortable feelings of cognitive dissonance when individuals with long-term health goals engage in unhealthy behaviors. Emerging adults with PSU tend to spend more time on their smartphones, especially when they have sleep conflicts. The cognitive dissonance between smartphone use and sleep activates sleep-related CHBs. Compensatory beliefs negatively impact sleep behaviors, with procrastination during sleep time (attention diverted to other affairs) and more sleep problems in the long run.

The findings of this study demonstrated that bedtime procrastination serves as a mediator between PSU and sleep problems. Previous research has identified the role of bedtime procrastination in the relationship between PSU and sleep quality. However, these studies either involved nonemerging adult samples from Western countries[46,47] or had certain limitations in the measurement of sleep problems.[48] Our study used the complete PSQI with seven dimensions. Emerging adults with higher PSU prefer to spend more time on their smartphones, which makes them unable to control their use patterns successfully, even before or during bedtime.[48] Therefore, they tend to develop a higher level of bedtime procrastination (for smartphone use), which further contributes to sleep problems. Additionally, this study found that the relationship between PSU and sleep problems is mediated through a serial path of sleep-related CHBs and bedtime procrastination; this highlights the underlying mechanism of the relationship between PSU and sleep problems. Emerging adults exhibiting PSU are more likely to develop sleep-related CHBs, which allows them to indulge in more smartphone use before bedtime, with longer procrastination, as they prefer to believe that the negative effects of bedtime procrastination related to PSU may be compensated for by getting up late the next day or sleeping more during weekends. However, compensatory sleep behaviors occur less or the negative consequences of bedtime procrastination are difficult to compensate for.[11] As a result, these individuals exhibit higher levels of bedtime procrastination and are more susceptible to experiencing additional sleep problems.

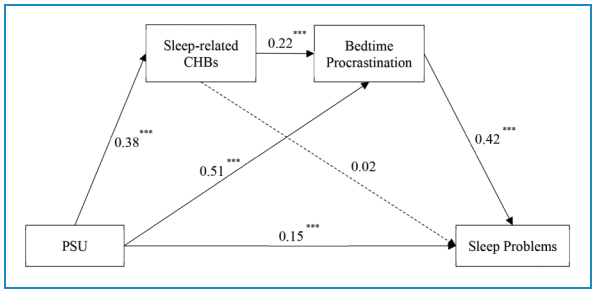

Figure 2. The final model. Note: *p < .05; ***p < .001. The path coefficient is a standardized coefficient. CHBs: compensatory health beliefs; PSU: problematic smartphone use.

Table 4. Results of path analysis.

Path	β	95% CI Lower	Upper
Direct effect:			
PSU → sleep problems	.15***	.08	.22
Indirect effect:			
PSU → sleep-related CHBs → sleep problems	.01	−.01	.03
PSU → bedtime procrastination → sleep problems	.21***	.17	.26
PSU → sleep-related CHBs → bedtime procrastination → sleep problems	.04***	.02	.05

Note: ***p < .001; β is the standardized coefficient.
CHBs: compensatory health beliefs; CI: confidence interval; PSU: Problematic smartphone use.

This study has theoretical implications, as it extends the applications of the CHBs model to explain the risk factors of sleep problems. This study further identified risk factors associated with sleep problems, including PSU, bedtime procrastination, and sleep-related CHBs. Specifically, it clarified the mediating influence of sleep-related CHBs and bedtime procrastination on the relationship between PSU and sleep problems in emerging adults. In terms of practical implications, the findings not only strongly support the positive correlation between PSU and sleep problems among emerging adults, but also reveal the effects of sleep-related CHBs and bedtime procrastination. Interventions related to lower bedtime procrastination will be effective in decreasing sleep problems among emerging adults (e.g. using mental contrasts with implementation intentions).[63] And interventions can be considered to influence the development of CHBs according to the CHBs model (e.g. improving self-efficacy),[35] decreasing compensatory beliefs or facilitating the implementation of compensatory behaviors (e.g. making action plans).[64] Moreover, cognitive behavioral therapy for insomnia is a possible method for treating sleep problems.[65]

This study had certain limitations. First, there was subjective bias in the self-reported method for measuring PSU and sleep problems. Further studies should consider other objective methods (e.g. smartphone program recording). Second, the sample in this study was recruited by

convenience sampling, which limits the generalizability of the findings. Therefore, future research should test findings in more samples from emerging adults. Third, this cross-sectional study design is limited to testing reciprocal or causal effects of PSU on sleep-related beliefs, behaviors, or problems; thus, longitudinal or experimental research ought to be conducted to explore the interrelationships or causal relationships among these variables. Lastly, one study showed that children aged 3 to 5 years had a PSU tendency with adverse consequences for cognitive development and mental health.[66] Future studies on PSU should also expand studies on multiple samples, including children.

Conclusions

This current study found the status quo of sleep problems and a positive link between PSU and sleep problems among Chinese emerging adults. Based on the CHBs model, this study discovered that sleep-related CHBs were negatively correlated with sleep problems and further investigated the psychological mechanisms between PSU and sleep problems, specifically bedtime procrastination alone or a serial path of sleep-related CHBs and bedtime procrastination underlying the PSU–sleep problem relationship. This study extends the application of the CHBs model to unhealthy behaviors (i.e. sleep problems). To promote sleep health in emerging adults, more interventions should be employed to reduce bedtime procrastination and sleep-related CHBs, or to promote the implementation of compensatory behaviors. Furthermore, cognitive behavioral therapy for insomnia is a possible treatment method for sleep problems.

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Authors' contribution: YA contributed to formal analysis, methodology, and writing—original draft. MXZ was involved in conceptualization, writing—review & editing, supervision, and project administration. Both the authors contributed to and approved the final manuscript.

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